THE MODIFICATION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR USE WITH WHITE, ENGLISH-SPEAKING SOUTH AFRICAN CHILDREN AGED EIGHT TO FOURTEEN YEARS

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DECLARATION OF ORIGINALITY

I hereby declare that this thesis, unless specifically indicated to the contrary in the text, is my own original and that it has not been submitted for any degree at another university.

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ABSTRACT

Alexandria Luria's approach to neuropsychological assessment and his theory of brain functioning have been exploited in order to develop a neuropsychological evaluation procedure for children which incorporates a conceptualization of brain-behaviour development.

Luria's Neuropsychological Investigation for adults was administered to intact children aged eight to 14 years in order to ascertain which tasks were beyond their capabilities. These were then adapted or deleted. The adapted version of the protocol was then administered to a second group of intact children to determine that the proposed adaptations were appropriate. This process was guided by the results of a statistical analysis which revealed significant findings with respect to age, socioeconomic status, and task performance.

A model of brain-behaviour development and interpretive protocol were devised. Together these provide a conceptual and interpretive framework for the battery. Developmental trends which emerged whilst developing Luria's Neuropsychological Investigation for Children (LNI-C) were consistent with the progressive development of successively more complex forms of information processing as depicted in this model. They were also in keeping with prominent developmental theories such as those of Piaget and Vygotsky. These trends revealed that children made most mistakes on adult LNI tasks involving abstract reasoning, the simultaneous synthesis of data, and complex goal-directed behaviour — all of which apparently reflect tertiary cortical zone functioning. Fewer mistakes were related to a lack of training and inability to process the same quantity of information as adults — difficulties which seemed related to secondary zone functioning. None of the mistakes made appeared to reflect subcortical or primary zone functioning.

The LNI-C was applied to brain-damaged children who had had a CT scan in order to demonstrate its application and the hypothetico-deductive process of interpreting findings using the concepts of syndrome analysis and double dissociation. The LNI-C findings were consistent with the general pattern of symptoms Luria described for different brain disorders and lesion localities in children, although additional insight into the nature of the sequelae present was gained in each case. In early brain damage,

the most frequent disturbances were a disruption in the role played by executive functions and the ability to process data simultaneously — both of which are associated with the tertiary zones of the brain. Furthermore, these disturbances appeared to be important factors underlying disturbances to language and educationally acquired skills.

The qualitative, process-orientated nature of the LNI-C proved effective for identifying the factors underlying disturbances described in paramedical reports. These seemed to be the linchpins on which retraining should focus. It was argued that the CT scan was limited in its ability to identify the type of diffuse and/or multifocal brain pathology frequently found in children.

The usefulness of the model of brain-behaviour ontogeny and interpretive protocol for diagnosis, understanding and predicting the developmental consequences of childhood brain pathology was demonstrated on the basis of nine brain disorders.

Finally, areas of future research were highlighted by the study.

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CHAPTER 1

INTRODUCTION

> "The study of brain-behaviour relationships in the developing child is a unique area of inquiry."
>
> (Rourke *et al.* 1983 p.4.)

Sir John Eccles (1981) has pointed out that the tragedy of brain damage is particularly arresting when we consider what the brain is:

> "The brain literally gives us everything. It gives us the whole wonder of our existence, our individual conscious existence, everything we are — our own self and personality. ... Our brain gives us all of our intelligence and all of our emotions; it gives us the ability to participate in our rich cultural heritage."
>
> (p.vii)

Brain damage is thus "far more crippling than any other physical damage" (Sir John Eccles 1981 p.vi). Children sustain brain injury every year from occurrences such as trauma and infection. As such, the need to understand brain-behaviour relationships in children, and to develop appropriate neuropsychological assessment techniques for evaluating the consequences of childhood brain damage, for the formulation of adequate treatment and rehabilitation programmes, is underlined.

A review of the literature indicates that although there has been a noticeable increase of interest in the field of child neuropsychology during the past decade or so (e.g. Benton 1974; Black 1981a; Boll 1974; Gaddes 1980; Hartlage and Telzrow 1985; Hynd and Obrzut 1981; Knights and Bakker 1976; Reitan 1974; Rourke 1975; Rourke *et al.* 1983; Rourke, Fisk and Strong 1986; Rutter 1984; Spreen *et al.* 1984), the area does, however, remain less well developed than that of adult neuropsychology. As Rourke *et al.* (1983) have indicated theory, research and practice appear poorly integrated and as Obrzut (1981) argued, the conceptual framework remains underdeveloped. A possible reason for this relative dearth of information is that development is itself a confounding and complicating factor.

Within the assessment sphere, no satisfactory child neuropsychological assessment approach linked to a coherent developmental theory of brain functioning seems to have emerged. Traditionally, neuropsychological evaluations have tended to include tests, such as the Wechsler scales and Bender-Gestalt, which were not specifically designed for the evaluation of brain-behaviour processes. Current neuropsychological models, such as the widely used Halstead-Reitan (Klesges 1983; Reynolds 1982) and the more recently developed Luria-Nebraska (Golden 1981b) batteries, are downward extensions of adult batteries and focus on the product rather than the process by which a task is performed. Consequently, although differentially sensitive to brain integrity, these batteries do not adequately detail the nature of the impairment associated with brain damage, which is necessary for rehabilitation (Milberg, Hebben and Kaplan 1986; Satz and Fletcher 1981).

Alexandria Luria has been described as "the founder, in the Soviet Union, of the new discipline of neuropsychology" (Zaporozec 1980, p.104). His work, which spanned some 45 years, concentrated on developing a theory-based conceptual scheme of the functional organization of the adult brain and a procedure for evaluating the effects of brain injury through studies conducted on brain-damaged adults (Luria 1970a, 1973a, 1980). Early in his career Luria, together with Vygotsky, began to develop a scheme of the development of higher mental functions which focused on the development of the child's inner processes and concept formation capabilities at different ages. However, Vygotsky's untimely death in his thirties and the subsequent advent of World War II led Luria to leave this line of study and focus his attention on the dissolution of higher mental processes in brain-injured adults (Luria 1979). As a result of this work on children, however, the origin of Luria's theoretical model is implicitly developmental and it would seem specially suited for the application to children. The present study thus represents an attempt to develop, within the context of the neuropsychological model devised by Luria (1970a, 1973a, 1980), an integrated theoretical and assessment approach to the field of child neuropsychology, which incorporates a conceptualization of the development of brain-behaviour processes.

This dissertation begins with a discussion of approaches to neuropsychological assessment. Within this context Luria's mode of assessment, together with the general principles on which it is based, is outlined. As Luria's approach is derived from an essentially clinical tradition, it conflicts with the prevailing Western psychometric orientation, The appropriateness of the psychometric model for neuropsychological assessment is thus discussed in the light of the controversy surrounding the development, in America, of a standardized version of Luria's approach to neuropsychological assessment.

Thereafter in Chapter 3, literature pertaining to the neuropsychological assessment of children is reviewed. Issues related to the evaluation of children which are important for understanding the behavioural sequelae of brain injury in the developing individual are also addressed, and Luria's work with children is described.

An initial study designed to adapt Luria's Neuropsychological Investigation (LNI) for use with South African adults is outlined in Chapter 4. Chapter 5 contains a delineation of the development of the LNI for use with white, English-speaking South African children aged eight to 14 years. In addition, a model of brain-behaviour ontogeny which provides a developmental framework for the procedure, is presented. Information concerning the neuropsychological development and functioning of the normal child generated in the course of developing the children's battery is discussed in relation to Luria's and Vygotsky's work with children, and possible parallels with prominent developmental theories explored.

Within Chapter 6, the application of the adapted LNI for children to a group of brain-damaged children is discussed and an interpretive protocol, which has been developed for the battery, presented. The findings are examined in terms of the extent to which responses relate to brain injury during development in the broad way proposed by Luria and Vygotsky. The usefulness of the battery for providing information for retraining purposes - an area which appears to be untapped by other procedures - is also examined.

This research study and its implications for child neuropsychology are evaluated and directions for future research proposed in Chapter 7. Finally, a summary of the work and conclusions drawn are presented in Chapter 8.

CHAPTER 2

NEUROPSYCHOLOGICAL ASSESSMENT

> "Much of the emphasis in clinical neuropsychology has been on *assessing* behavioural change."
> (Lezak 1983 p.7, author's emphasis.)

2.1 INTRODUCTION

Historically the theoretical and experimental emphasis in clinical neuropsychology appears to have been on the evaluation of the behavioural consequences of known brain damage in adults (e.g. head injuries, strokes). (Evans *et al.* 1982; Lezak 1983; Sutter and Battin 1984, Teeter 1983). Consequently a considerable advancement in the understanding of brain-behaviour relationships in the mature individual seems to have evolved in contrast to comparatively little consideration of brain-behaviour relationships in the child. Relatively well defined syndromes associated with damage to different brain systems have been documented in the literature (e.g. Frank Benson 1979; Hecaen and Albert 1978; Heilman and Valenstein 1985; Luria 1980; Walsh 1978) and several approaches to assessment developed which are described in a number of publications (e.g. Christensen 1979a; Filskov and Boll 1981; Golden 1978; Lezak 1983; Reitan and Davison 1974, Walsh 1985).

As neuropsychological assessment procedures have largely been developed on adults (Hartlage and Telzrow 1981) and then applied to children (e.g. the Halstead-Reitan and Luria-Nebraska Neuropsychological Batteries), it seems pertinent to discuss these batteries before focusing more specifically on approaches to the neuropsychological assessment of children in the next chapter.

The chapter begins with an outline of the purposes for which neuropsychological assessments appear to be conducted. Thereafter approaches to adult neuropsychological assessment are surveyed. This research project focuses on the application of Luria's "monumental work" (Griesel 1982 p.23) to the neuropsychological assessment of children. In view of this, the main thrust of the literature discussed is concerned with

Luria's theoretical and clinical orientation, as well as the controversy surrounding the standardization of his assessment approach.

2.2 THE UTILITY OF NEUROPSYCHOLOGICAL ASSESSMENT

> "The promise of neuropsychology is not another label, but better understanding."
> (Selz 1981 p.202.)

The role of the neuropsychologist in assessing persons with brain-behaviour disturbances is increasingly being recognised and acknowledged (e.g. Boyar 1981; Filskov and Boll 1986; Golden 1978; Golden, McLaughlin, Gudeman and Craine 1977; Hammeke, Golden and Purisch 1978; Hevern 1980; Lezak 1983; Rourke *et al.* 1983; Walsh 1978). This appears to be related to two factors:

Firstly, the inadequacies associated with the neurological assessment of brain-damaged individuals. The standard physical neurological examination is designed to test primarily sensation, movement, reflexes and tones and yields very little information regarding higher mental functions (Luria 1973b, 1980). Similarly, whilst sophisticated electrophysiological and radiographic techniques such as the electro-encephalogram and computerized axial tomographic scanner impart valuable information concerning the location of the lesion within the central nervous system (Russell, Neuringer and Goldstein 1970), they provide no information regarding changes in behavioural functioning which may accompany such damage (Watts and Tollman 1980a).

Secondly, there are conceptual and methodological problems associated with the use of many psychodiagnostic procedures traditionally used by psychologists to examine brain-behaviour disturbances. Their application appears to have been based on the erroneous view of "brain damage" as a unitary concept. In addition many were not specifically developed for the purpose of evaluating brain-behaviour disturbances and lack the comprehensiveness required for such an assessment. These issues are discussed in Section 2.3

The main purposes of a clinical neuropsychological examination would thus appear to be:

- To provide a detailed description of the areas of behavioural functioning which are impaired and preserved. (Brinkman 1979; Brooker 1984; Crockett, Clark and Klonoff 1981; Davison 1974; Golden 1978; Goldstein 1979; Kolb and Whishaw 1985; Lezak 1983; Luria 1980; Smith 1975; Walsh 1978, 1985.) This information is important for:

  a) planning management, treatment and rehabilitation programmes (Brinkman 1979; Crockett, Clark and Klonoff 1981; Davison 1974; Golden 1978; Goldstein 1979; Kolb and Whishaw 1985; Lezak 1983; Luria 1963a, 1980; Rourke and Brown, 1986; Sbordone 1984; Smith 1975; Walsh 1978, 1985);

  b) attempting to formulate a prognosis as to the degree of recovery that a patient is likely to show (Brinkman 1979; Crockett, Clark and Klonoff 1981; Davison 1974; Golden 1978; Kolb and Whishaw 1985; Lezak 1983; Smith 1975; Walsh 1978, 1985). This is necessary for patient and family counselling (Brinkman 1979; Kolb and Whishaw 1985; Lezak 1983; Tollman 1988) and for the law suits (e.g. personal injury claims) (Davison 1974; Lezak 1983; McMahan and Satz 1981; Wasyliw and Golden 1985).

- To assist the neurological diagnosis and localization of brain damage in cases of controversy (Crockett, Clark and Klonoff 1981; Davison 1974; Golden 1978; Goldstein 1979; Kolb and Whishaw 1985; Lezak 1983; McFie 1975; Smith 1975; Walsh 1978, 1985). For example, in disorders such as epilepsy, the primary evidence confirming a pathological focus on the EEG may be behavioural, because radiological techniques, such as brain scans, often fail to indicate abnormal tissue giving rise to the seizure (Kolb and Whishaw 1985).

- To establish baselines against which recovery of function and the effectiveness of rehabilitation programmes and treatment procedures (such as drug therapy and surgery) can be evaluated (Davison 1974; Golden 1978; Kolb and Whishaw 1985; Lezak 1983; Smith 1975; Walsh 1978, 1985).

- For research into brain functioning and organization (Davison 1974; Lezak 1983; Luria 1973a, 1980). For example, to identify unusual brain organization that may occur in left handers or in people with childhood brain injury — this information being of particular value to the surgeon, who would not want to inadvertently remove primary speech zones (Kolb and Whishaw 1985).

- To extend our knowledge of the mechanisms underlying psychological processes (Davison 1974; Luria 1980) such as speech, memory, thinking and perception (Luria 1980).

2.3 APPROACHES TO ADULT NEUROPSYCHOLOGICAL ASSESSMENT

"Neuropsychology needs more theory to organize and guide the development of assessment tools."
(Satz and Fletcher 1981 p.860.)

Several authors (e.g. Craig 1979; Golden 1978; Goldstein 1979; Satz and Fletcher 1981) have indicated that neuropsychologists are divergent in their opinions concerning the best method of conducting a neuropsychological examination. Many approaches to neuropsychological evaluation exist (Satz and Fletcher 1981) and numerous assessment procedures are now used for this purpose (Craig 1979; Goldstein 1979). The type of approach used appears, however, to depend largely on the personal orientation of the examiner and the question being asked (Goldstein 1979). Lezak (1983) identified two kinds of examination questions:

1. diagnostic questions which are concerned with the presence of brain damage and/or the disease process in terms of their etiology and prognosis; and
2. descriptive questions which focus on elucidating impaired and preserved behavioural functions in order to formulate a rehabilitation programme.

Within the Western literature on neuropsychological assessment the following trends appear to have emerged.

Traditionally, psychologists seem to have used the same group of psychodiagnostic procedures utilized for all other forms of assessment, to diagnose "brain damage". In addition, they have tended to search for a single test which may be used for the same purpose. The application of such procedures appears, however, to be based on the inaccurate views of brain damage as a unitary concept (see Section 2.3.1). Standardized neuropsychological test batteries have subsequently been developed for the purpose of detecting brain damage. The Halstead-Reitan Neuropsychological Battery (HRNB) is an example of this trend (see Section 2.3.2) as is the more recently developed Luria-Nebraska Neuropsychological Battery (LNNB) (see Section 2.4.3.1). Whilst no attempt seems to have been made to relate early standardized batteries such as the HRNB to any theoretical framework (Luria and Majovski 1977), endeavours have been made to do so with the newer LNNB (Golden 1981a, 1981b).

More recently, the use of a flexible battery of tasks has been advocated (Christensen 1975, 1979a; Lezak 1983; Walsh 1978, 1985) (see Section 2.3.3). These authors have emphasized the need to understand the nature of deficits and for an evaluation to comprehensively investigate impaired and preserved functions for rehabilitation purposes. Assessment procedures are usually related to a conceptual model of brain-behaviour relationships. Such models tend to be based primarily on that developed by Luria during his research into the effects of brain damage (see Section 2.4).

Each of these trends will be discussed.

2.3.1 Traditional and single psychodiagnostic test approach

> "Single tests used against an assumption of a unitary concept of brain damage are to be decried."
>
> (Walsh 1978 p.288.)

Several authors (e.g. Brooker 1982; Davison 1974; Goldstein 1981; Satz and Fletcher 1981) have indicated that psychologists customarily used the same group of psychodiagnostic procedures for all types of assessments, including the evaluation of brain-behaviour relationships. The most frequently used appear to be the Wechsler Intelligence Scales for both adults and children, the Bender Visual-Motor Gestalt Test, the Minnesota Multiphasic Personality Inventory (MMPI), the Thematic Apperception Test, the Rorschach Test and the Draw-a-Person Test (Davison 1974; Hartlage 1966). The use of these procedures for the evaluation of the brain injured individual has been discussed by many authors (notably, Lezak (1983) and e.g. the Wechsler Scales by McFie (1975), Murdock (1982) and Warrington, James and Maciejewski (1986), the Bender-Gestalt Test by Bigler and Ehrfurth (1980); Lacks (1979, 1984), and McCann and Plunkett (1984), the Rorschach by Aita, Reitan and Ruth (1947) and

Velez-Diaz (1973) and the MMPI by Golden, Sweet and Osman (1979) and Osman and Golden (1978)). As asserted earlier (see Section 2.2), however, there are conceptual and methodological problems associated with the use of many of these procedures for the examination of brain-behaviour relationships.

General limitations are that many were not devised specifically for the purpose of assessing people with brain-behaviour disturbances (Davison 1974; Reitan 1975) and thus have little known relationship to brain damage (Evans *et al.* 1982). Further intelligence tests are unlikely to evaluate the type of cognitive ability disturbed by damage to the frontal lobes (Gardner 1974; Zangwill 1966) and temporal lobes (Milner 1969). Damasio (1985) has argued that this criticism can also be applied to most objective assessments of brain-behaviour disturbances. As such they lack the comprehensiveness required for an adequate neuropsychological assessment (Davison 1974; Reitan 1975; Tramontana 1983).

Such evaluations appear to have originally been concerned with the diagnosis of "brain-damage" or "organicity" (Chadwick and Rutter 1984; Herbert 1964). An assumption inherent in this approach is that "brain-damage" or "organicity" is a unitary concept (Herbert 1964; Hartlage 1966; Reitan 1975; Smith 1979; Walsh 1978). Historically, this view appears to have been perpetuated by the work on adults by Goldstein (e.g. Goldstein 1936a, b; 1942; 1944; 1948; Goldstein and Scheerer 1941) and on children by Strauss and his associates (e.g. Strauss and Kephart 1955; Strauss and Lehtinen 1947; Werner and Strauss 1941, 1943), in which they asserted that all brain damage results in similar behavioural disturbances. The unitary psychiatric diagnosis of "organic brain syndrome" (e.g. The Diagnostic and Statistical Manual of Mental Disorders 1980) (Craig 1979) seems to have also been instrumental in developing this idea.

This premise of "organicity" as a unitary concept stimulated the search for a single test or measure for identifying the brain-damaged individual (e.g. the Memory-for-Designs Test (Graham and Kendall 1960)). Inherent in the use of these tests was the assumption that heterogeneous types of diffuse and focal injury in different parts of the brain produce similar patterns of behavioural pathology and that the behavioural differences between individuals with brain damage are due to the severity of the injury and premorbid personality characteristics (Davison 1974; Smith 1962, 1975, 1979, 1981). This reflects the view of brain damage as a unitary construct and tacitly assumes the functional equipotentiality of all parts of the brain (Smith 1979).

In addition to this conceptual shortcoming, there are methodological limitations associated with the use of single tests. Tramontana (1983) indicated that the extent to which they produce false positives and false negatives is problematic, whilst Craig (1979) has pointed out that as such tests frequently rely on only one response modality (e.g. visual-motor co-ordination in the case of the Bender Gestalt Test), they are often highly invalid. In addition, single tests obviously do not allow for a comprehensive description of the neuropsychological consequences of brain dysfunction (Lacks 1984). Further, as Chadwick and Rutter (1984) pointed out, also intrinsic to this position is the assumption that brain damage invariably leads to psychological sequelae and that these uniform psychological changes are only explicable in terms of brain damage. The literature, however, abounds with examples of symptoms usually regarded as indicative of brain damage which may also be psychogenic in origin (e.g. amnesia may be associated with either brain damage or depression (Lezak 1983; Lishman 1978)). In addition many forms of brain damage are static conditions which produce few psychological sequelae (Chadwick and Rutter 1984).

Craig (1979 p.5) has argued that the "single test approach to the diagnosis of organic brain syndrome" is now "a relic of the past" and as Reitan (1975) and Tollman and Watts (1982) have pointed out, the emphasis has changed from a unitary concept of brain damage which can be represented by a single test to viewing the brain as a complex, dynamic, multi-dimensional system which, as indicated by Birch (1964), Reitan (1975) and Talland (1963), subserves a wide range of behaviours. Concomittently it has been recognized that lesions of different etiology and location result in markedly different behavioural disturbances (Anastasi 1982; Birch 1981; Black 1981b; Reitan 1975; Rutter *et al.* 1970; Yates 1966) and the necessity for a neuropsychological examination to evaluate the full range of basic behavioural abilities represented in the brain has now been acknowledged (Boll, O'Leary and Barth 1981; Brinkman 1979; Christensen 1979a; Craig 1979; Golden 1978; Lezak 1983; Luria 1980; Walsh 1978, 1985).

Despite these changes, as Walsh (1978) has indicated, the unitary concept of brain damage has been one of the most difficult to eradicate and publications continue to appear on the efficacy or otherwise of tests for "organicity" and advocating the continued use of single tests, although in most instances the use of such instruments is suggested primarily for the purpose of screening for brain damage. For example, Herman *et al.* (1983) proposed the use of an "Organic Mental Syndrome Battery" to screen for the presence of "organicity", whilst Lacks (1982) recommended the use of the Bender-Gestalt Test as an instrument for screening for brain damage. Plunkett (1982) has, however, argued that whilst the administration of such tests is quick and easy, they are not sufficiently accurate for screening purposes.

2.3.2 The standard battery approach

> "Clinical neuropsychology relies on standardized behavioural observations, emphasizing norms and cutting scores. Behaviour, in the context of this approach, is defined in operational terms and, usually, quantified on continuous distributions."
>
> (Davison 1974 p.3.)

The standard battery approach is strongly influenced by psychometric considerations and the need for objectivity in assessment (Goldstein 1981). The "most significant standard battery influencing neuropsychology today is the Halstead-Reitan Neuropsychological Battery" (Hammeke, Golden and Purisch 1978 p.136) and as it exemplifies this approach, standard batteries will be discussed relative to it. The more recently developed Luria-Nebraska Neuropsychological Test Battery is discussed in Section 2.4.3.1.

The Halstead-Reitan Neuropsychological Test Battery (HRNB) was originally designed to identify the presence of brain damage (Brinkman 1979; Delis and Kaplan 1983; Satz and Fletcher 1981) and as such would seem to be an outgrowth of the single test approach (Osman 1983). It consists of a standardized collection of tests which are routinely administered to all patients and the nature, site and presence of a lesion is evaluated according to the resultant test score (Lezak 1983; Luria and Majovski 1977), whilst behavioural deficits are determined on the basis of the profile of sub-test scores (Goldstein 1981). The battery is not related to any overall theory of brain functioning (Kolb and Whishaw 1985; Luria and Majovski 1977; Osman 1983; Russell, Neuringer and Goldstein 1970) and in view of the standardized administration procedure is frequently administered by trained technicians rather than clinical neuropsychologists (Goldstein 1981).

The tests comprising the battery have been described by several authors, notably Reitan and Davison (1974) and Boll (1981). As Neuger *et al.* (1981) indicated, the tests range from simple motor tasks (e.g. the Finger Tapping Test (Boll 1981; Lezak 1983) which measures fine motor speed (Painter 1982)) to complex tasks involving higher conceptual and problem-solving abilities (e.g. the Category Test which measures concept formation, abstraction (Boll 1981; Lezak 1983; Painter 1982) and recent memory (Painter 1982)). Authors have, however, indicated that it is unsuitable for a thorough examination of motor, sensory (Griesel 1982; Kolb and Whishaw 1985; Lezak 1983; Luria and Majovski 1977), speech (Griesel 1982; Luria and Majovski 1977; Swiercinsky 1979) or memory disturbances (Dodrill 1978; Kolb and Whishaw 1985; Osman 1983; Swiercinsky 1979). Reitan (1986) has acknowledged these shortcomings of the HRNB and suggested that additional tasks be used in cases where a more comprehensive evaluation of these functions is deemed necessary.

The HRNB attempts to discriminate three forms of brain dysfunction using four methods of inference (Boll 1981; Boll, O'Leary and Barth 1981; Golden 1979; Reitan 1986; Russell, Neuringer and Goldstein 1970). The three forms of brain dysfunction are:

1. brain damaged versus non-brain damaged;
2. static versus rapidly growing lesions;
3. right versus left cerebral involvement.

The four methods of inference are:

1. level of performance;
2. differential scores and patterns of performance;
3. pathogenic signs;
4. the comparative functional efficiency of left and right sides of the body.

Interpretation of the battery is based on the cojoint use of these four methods of inference (Reitan 1975, 1986) and blind interpretation (which involves interpreting a patient's performance on the battery in the absence of knowledge about the patient's presenting complaint, medical history and neuroradiological test results) (Luria and Majovski 1977). Cutting scores are used to determine the level of severity of the disturbance and the Halstead Impairment Index for making gross diagnostic discriminations (Griesel 1982; Lezak 1983; Luria and Majovski 1977). Theoretically, the battery thus incorporates both the interindividual (normative) and intraindividual approaches — the latter involving a comparison of the results obtained from examinations of the functions of the left and right sides of the same individual (Painter and Murdoch 1976).

The two children's batteries (The Reitan Indiana Test Battery for Children and the Halstead Neuropsychological Test Battery) which have been developed are discussed in Section 3.3.

The HRNB is the most widely used, researched and discussed standard battery for assessing brain damage (Boll 1981; Boll, O'Leary and Barth 1981; Griesel 1982), and there is a large body of research concerning validity, reliability and such potentially confounding factors as age and education (Boll 1981). These studies have been discussed by Reitan and Davison (1974), Filskov and Goldstein (1974), Golden (1979), Hevern (1980), and more recently by, for example, Reitan (1986). They have, however, been criticised on the basis that subject characteristics (Hevern 1980) and sampling procedures are inadequately described in many of them, with the result that the generalizability of this work is seriously restricted (Reynolds 1982). Reynolds (1982) has additionally criticized the battery on the basis that it is poorly normed by psychometric standards. More recent studies have suggested that norms for some of the battery's subtests need to be adjusted for subject variables such as age (e.g. Bornstein 1986, Heaton, Grant and Matthews 1986; Yeudall *et al.* 1987), education (e.g. Bornstein 1986; Heaton, Grant and Matthews 1986), and sex (e.g. Yeudall *et al.* 1987). In addition, Adan (1986) indicated that the diagnostic efficacy of the battery may be affected by cross-cultural factors. She argued that there is consequently a need, in South Africa, for cross-cultural validation studies involving the HRNB so that suitable norms can be developed for this country. Notwithstanding these considerations, Golden (1979 p.197) proposed that as the battery has been validated on a wide variety of clinical populations, the examiner is able to base diagnostic conclusions on "proven relationships" between and within tests. It is thus one of the more reliable procedures for identifying brain damage (Lezak 1983). However, as Osman (1983) has indicated, whilst the battery is able to identify a deficit, no attempt is made to determine why the deficit occurred.

Osman (1983) further pointed out that as construction of the HRNB was not guided by any unifying theory of brain functioning, tasks incorporated into the battery are not systematically related to one another. As a result "conceptual gaps plague the neuropsychologist when attempting to understand relationships between various tests on the battery" (Osman 1983 p.129). Furthermore, this type of psychometric instrument is frequently administered in a routine and unquestioning way by individuals or technicians with insufficient knowledge of brain-behaviour relations. Vital information may thus be lost and interpretation of results may be inadequate (Griesel 1982).

The HRNB has additionally been criticized on practical grounds. It has been indicated that equipment is unwieldy (Griesel 1982; Kolb and Whishaw 1985; Lezak 1983) and expensive (Kapur 1978) whilst administration time is lengthy (6-8 hours) (Golden 1979; Kapur 1978; Lezak 1983; Luria and Majovski 1977). In an attempt to overcome the first two criticisms, a portable, inexpensive version of the HRNB Category test, has, however, now been developed (Slay 1984).

Buffery (1980 p.4) argued that although, at the time of its development, the HRNB "represented a considerable advance upon tests designed to probe simply for the presence or absence of 'organicity'", it has now, together with others (e.g. Russell, Neuringer and Goldstein 1970) been "overtaken by advances in neuropsychology over the past decade" and they "have become relatively blunt instruments either for the delineation of the degree and nature of the brain's functional impairment or for the elucidation of the idiosyncratic characteristics of a particular patient's functional recovery" (Buffery 1980 p.4). In this respect, Kolb and Whishaw (1985) have suggested that the HRNB needs to be completely updated, norms revised and extended, and a new set of validation studies conducted.

Lezak (1983) proposed that the lasting and most important contribution of the HRNB may be due, not to diagnostic efficiency, but to making neuropsychologists aware of the need for a neuropsychological examination to explore a wide range of behaviours. She further argued that:

> "The popularity of ready-made batteries attests to the need for neuropsychological testing and to a general lack of knowledge about how to do it."
> (Lezak 1983 p.110.)

She additionally suggested that a standardized battery may be of value in research programmes which require standardized, comparable data collection so that patient groups can be compared. An example of such work would seem to be the trend in neuropsychological research discussed by Poeck (1969) to re-examine old concepts in an attempt to develop generally accepted classifications of disorders like aphasia.

The actuarial approach embodied by the HRNB has encouraged efforts to develop computerized interpretations of the battery (e.g. Gregory 1976; Russel *et al.* 1970; Swiercinsky 1979; Swiercinsky and Warnock 1977). The best developed of these attempts is probably the taxonomic key approach (Walsh 1978) developed by Russell, Neuringer and Goldstein (1970). Attempts at cross validation have, however, in general been only partially successful (e.g. Anthony, Heaton and Lehman 1980; Goldstein and Shelly 1982). Heaton *et al.* (1981) have also compared the diagnostic accuracy of two fairly experienced clinicians with that of the key approach in terms of the presence, laterality and chronicity of brain damage. Whilst the clinician's independent ratings of the HRNB data was found to be more accurate than the key system in predicting the presence and laterality of a lesion, neither the clinicians nor the key predicted any better than the base rate for chronicity. Heaton *et al.* (1981) argued that the clinicians' superiority on two of the prediction tasks may have been due to their "ability to analyze and weigh flexibly the significance of complex, highly variable combinations of HRNB data" (p.146) as well as to "the relatively crude nature of the actuarial competition" (p.146). These authors questioned, however, whether this finding would hold with future improvements to actuarial methods. A more recent study by Adams and Brown (1986) has nevertheless yielded similar findings, and none of the programmes to date have produced results that are either satisfactory or equal in accuracy to those achieved by clinicians (e.g. Adams 1986; Adams and Heaton 1985; Kleinmuntz 1987).

Walsh (1978) argued that multiple discriminant functional analysis is the most sophisticated of the attempts to apply an actuarial system to HRNB scores (see for example studies by Swiercinsky and Leigh 1979; Swiercinsky and Warnock 1977; Wheeler and Reitan 1963). It is thus of interest to note that Wedding (1979, cited by Lezak 1983) found discriminant functional analysis to be superior to both other statistical procedures used to obtain diagnostic information from HRNB scores and clinical judgement.

There seems, however, to be no general agreement between the findings of different studies regarding the relative efficacy of the different actuarial approaches and other methods of interpreting HRNB data. This is perhaps partially due, as Lezak (1983) pointed out, to the fact that HRNB variables and their interrelationships have not all been sufficiently standardized and validated (Davison 1974).

2:3.3 The flexible battery approach

> "The enormous variety of neurological conditions, patient capacities and examination questions necessitates a flexible, open and imaginative approach."
>
> (Lezak 1983 p.98.)

Several neuropsychologists have assembled their own informal, flexible test batteries for the purpose of examining brain and behaviour relationships (e.g. Muriel Lezak 1983; Aaron Smith 1975, 1981; Kevin Walsh 1978, 1985). In such an approach, the examiner selects the tests and assessment techniques on the basis of their appropriateness for the purpose for which the examination is being conducted and the specific needs of the patient (Lezak 1983; Walsh 1978, 1985). Lezak (1983) additionally advocated that assessment techniques be adapted, by means of flexible, innovative administration, to suit the condition of each patient. Administration of a battery like this is an inductive-deductive procedure in that the examiner generates hypotheses which are then tested sequentially (Buffery 1980; Walsh 1978). Each assessment is thus flexible and individualized, enabling the examiner to concentrate on areas he considers important for the patient's prognosis (Golden 1978; Lezak 1983). There is therefore no overall statistical evaluation procedure for such batteries.

The advantage of using an informal, flexible battery tailored *"to the patient's needs, abilities and limitations"* (Lezak 1983 p.98 Author's emphasis) is that individuals presenting a variety of cognitive deficits can be examined more efficiently and impaired functions explored more comprehensively so that more meaningful recommendations for rehabilitation programmes can be formulated (Delis and Kaplan 1983; Lezak 1983). Furthermore, the evaluation tends additionally to be guided by the examiner's conceptualization of brain-behaviour relationships.

Walsh (1978, 1985) has, for example, based his approach to assessment on Luria's concept of functional systems as he argued that such a theoretical orientation enables one to gain an understanding of the reason(s) for the manifest deficit(s).

Golden (1978, 1979) cautioned, however, that a danger inherent in the use of this technique is that the test selection may be biased towards confirming the examiner's original hypothesis. Further, not all behavioural functions may be assessed and interpretation is more difficult as the relationships between the individual tests comprising the battery may be unknown, except on a theoretical basis. It would, however, seem that this could be avoided if the clinician works within the framework of a theory of brain functioning such as that of Alexandria Luria (see Section 2.4.1.).

2.4 LURIA'S APPROACH TO NEUROPSYCHOLOGICAL ASSESSMENT

> "The extensive work of A.R. Luria has long been recognised as a seminal contribution to our understanding of the functions of the brain and to the psychological evaluation of neurological disorders."
>
> (Golden 1981a p.608.)

Alexandria Luria is acknowledged as the founder of neuropsychology within the Soviet Union (Zaporozec 1980) and has generally been "a major force in the development of the scientific discipline of neuropsychology" (Reynolds 1981 p.100). In contrast to the approaches to neuropsychological assessment reviewed in Section 2.3, Luria's approach to the study of brain and behaviour relations was qualitative, individualized and ideographic. In developing his clinical research methods he used to investigate the effects of brain lesions on behaviour, Luria developed a "rich battery" (Reynolds 1981 p.101) of neuropsychological tasks which qualitatively evaluate an individual's neuropsychological status (Christensen 1979a; Luria 1980; Reynolds 1981). In addition he has formulated a comprehensive theory for the functioning of the brain and the rehabilitation of functions disturbed by brain damage (e.g. Luria 1963a, 1973a, 1980).

Interest in Luria's work appears to have developed amongst Western neuropsychologists during the late 1960's following the publication in 1966 of the English translation of his book *Higher Cortical Functions in Man* in which his theory of brain functioning and clinical neuropsychological procedures are described. This interest appears to have been further stimulated in the 1970's by the publication of Luria's book *The Working Brain* in 1973 and the publication in 1974 of *Luria's Neuropsychological Investigation* by Anne-Lise Christensen (e.g. Golden 1981a, Lezak 1983; Reynolds 1981).

Gray indicated in 1966 that Soviet psychology is generally not well known within the West and argued that this was partially attributable to the language barrier and generally poor quality of translations. In addition, however, he pointed out that Soviet psychology has developed out of a markedly different intellectual and philosophical orientation to that pervasive in the West. For this reason it seems relevant to set Luria's work within the context of his times.

Luria's views appear to have been influenced by the ideas of several other prominent Soviet workers — notably Pavlov and Vygotsky — as well as by the socio-political changes occurring, and doctrine of Marxism prevailing, in the Soviet Union during his life time (1902-1977).

Luria regarded Vygotsky as his mentor (see Section 3.4) and he and Vygotsky, together with Leontev formed a "troika" (Luria 1979; Radzikhovskii and Khomskaya 1981; Zaporozec 1980) which aimed to develop a new and comprehensive conceptualization of higher mental processes within the context of Marxism and Pavlovian physiology (Luria 1979).

It is thus not surprising that several aspects of Luria's theoretical orientation (see Section 2.4.1) seem to be attributable to the Marxist principle of dialectical materialism. In terms of this doctrine man is viewed as an active initiator, rather than a passive reactor to his environment. Further, mental activity is conceptualized as being based on the brain — in other words higher mental activity is portrayed in terms of the organization of matter. Finally, mental processes and their development are regarded as being determined by the material conditions of life in a given society at a given stage of historical development (Simon 1957; Slobin 1966).

Pavlov's influence on Luria seems to be, at least partially, attributable to the 1950 "forced Pavlovianization" (Cole and Maltzman 1969 p.7) of Soviet psychology by Stalin in terms of which Soviet psychologists were required to incorporate Pavlovian theory into their conceptual frameworks (Cole and Maltzman 1969). Tucker (1963, cited by Cole and Maltzman 1969) suggested that this was done as Stalin was confronted with domestic problems he wished to alter. Pavlov's theory of the conditioned reflex was made the model for this intended change as it was believed that by understanding the laws of conditioning, the behaviour of man could be controlled and modified.

Luria thus appears to have interwoven prominent Soviet views — such as those of Vygotsky — in developing a clinical-theoretical approach to brain-behaviour relationships within a Marxist-Pavlovian materialistic framework.

As Luria's theory of brain functioning underlies his assessment procedure, the general principles it involves are outlined in the next section.

2.4.1 Luria's theory of brain functioning

> "Currently, the most comprehensive neuropsychological model of human information-processing and brain-behaviour relationships is the Luria model."
> (Hartlage and Reynolds 1981 p.357.)

In formulating his theoretical approach, Luria rejected both the narrow localizationist view that complex behavioural processes could be localized in narrowly circumscribed areas of the brain, and the holistic view of "diffuse equipotentialism" (Luria 1980 p.34) which assumed that complex behaviour was the result of the brain as a whole. Instead he has postulated an alternative model which is eclectic in the sense that, as Christensen (1979a) pointed out, it combines, comprehends and extends previous theories — thus providing a balanced approach to this controversial subject.

In keeping with the Marxist principle of dialectical materialism and Vygotsky's views (see Section 3.4.1), Luria conceptualized the brain as an active system which regulates the behaviour of the individual in relation to conditions in the historical, social and cultural environment (Majovski 1981). He argued that higher mental functions (e.g. memory and reasoning) are mediate in nature and the result of complex socio-historical development. They are "social in origin, systematic in structure and dynamic in development" (Luria 1978e p.277). In other words, Luria viewed them as complex and mobile functional systems, formed in the past and changing during development and training. As such, they cannot be localized in narrowly delineated areas of the brain in the same way as can elementary processes, but are based on a dynamic constellation of synchronously working zones of the brain, each of which contributes its own particular factor to the organization of the functional system (Luria 1973a, 1974, 1978e, 1980). Luria (1980) also emphasized the role of feedback in regulating the activity between different functional regions.

The dynamic, as opposed to concrete, static nature of the structure of these functional systems means that their working is, according to Luria, distinguished by the following features, which have important implications for the recovery and rehabilitation of functions following brain injury:

- No one part of any functional system is involved in only one system. Under certain conditions a particular zone may participate in other functional systems and thus the performance of other tasks. This principle of "functional pluripotentialism" was introduced by Filimonov (1951, 1957, cited by Luria 1980 p.25).

- Although an overt behaviour (e.g. walking) may remain the same, the way in which the brain carries out the behaviour may vary. In other words alternative functional systems may, under certain conditions, be used to perform a particular task (Luria 1963a, 1980).

Luria argued that the recovery of a function following a brain lesion involves "the reorganization of that function, with the formation of a new functional system" (Luria 1980 p.28). Thus, in Luria's view the brain-damaged individual does not cease functioning but finds alternative ways to achieve a particular goal (e.g. Luria 1963a; Luria *et al.* 1969).

According to this theoretical formulation, circumscribed damage to any one of the areas comprising a functional system will remove its contribution and result in a primary disturbance in the functioning of the entire system. In addition, such damage will cause secondary disturbances in all the functional systems which require the participation of the damaged area and leave intact any functional systems which are not involved. H.L. Teuber (cited by Luria 1973a p.40; Luria 1973b p.960) referred to this as "the principle of double dissociation".

Thus damage to a particular area of the brain will produce a whole array of overtly different symptoms all of which will have a particular factor in common (e.g. simultaneous spatial analysis and synthesis). Damage to different zones will result in the functional system being disturbed in different and special ways. Luria (1974) further argued that circumscribed brain damage cannot be related to a symptom (such as aphasia) as this may be the result of damage to various parts of the brain. It must rather be attributed to the basic factor underlying the appearance of the observed symptom. A careful qualitative analysis and description of the structure of the group of symptoms (e.g. aphasia) will reveal the basic factor underlying the disturbances (e.g. a disturbance of phonemic hearing) and the factor can then be used to determine the particular area of the brain within the systems which have been affected (e.g. the secondary area of the left temporal lobe). (Luria 1972b, 1973a, 1974, 1979, 1980.)

Luria divided the "working brain" (Luria 1973a) into three basic functional units. He emphasized that the participation of all three is necessary for any type of behaviour — each unit making its own special contribution to the process in question (Luria 1972b, 1973a, 1980). The three units (Luria 1965a, 1972b, 1973a, 1977, 1980) are:

1. An arousal unit for regulating the tone and energy level of the cortex which is located in the upper and lower formations of the brain stem, particularly the reticular formation and limbic system;

2. A unit for obtaining, processing and storing information arriving from the outside world situated in the posterior (temporal, parietal and occipital) parts of the cerebral cortex; and

3. A unit for programming, regulating and verifying voluntary behaviour which is located in the anterior (premotor and frontal) parts of the cerebral cortex. According to Luria (1980) this unit is characterized by complex reciprocal connections both vertically with lower

levels of the brain (Unit 1) and horizontally with the rest of the cortex (Unit 2).

Within the second and third units, Luria (1973a, 1980) described three cortical areas:

1. Primary areas which receive sensory input from or convey motor impulses to the periphery;
2. Secondary areas which process incoming sensory information and prepare motor programmes of action; and
3. Tertiary areas which integrate information derived from different sensory modalities and are responsible for the formation of intentions.

According to Luria (1980) these three cortical zones arise in definite order during ontogenetic development. The primary areas together with the systems connecting them to the subcortical areas of the first unit are the first to mature and become myelinated — a process which begins during the prenatal period. The secondary zones arise next, passing through an initial period of rapid myelization during the first few weeks and months of life. According to Luria (1980 p.58) myelinization of these areas continues "during later periods", although he does not specify the time period involved. Finally, the tertiary fields develop during the first few years of life and, especially in the frontal region, are the last cortical areas to attain maturity.

Luria (1973a) identified three basic laws which he suggested control the functioning of the second and third units:

1. The law of the hierarchical structure of cortical zones (p.74);
2. The law of diminishing specificity of the hierarchically arranged cortical zones (p.75); and
3. The law of progressive lateralization of function (p.77).

Luria (1963b, 1973a, 1977, 1980) argued that the acquisition and use of higher mental processes requires that the "neurodynamic" (Luria 1977 p.15) processes of the brain exhibit a high degree of selectivity and plasticity. Pavlov (cited by Luria 1973a, 1977) demonstrated that in the intact cerebral cortex all neurodynamic processes obey the "law of strength" (Luria 1973a p.44) according to which strong or significant stimuli evoke strong responses, whilst weak or insignificant stimuli evoke weak responses. Thus if brain damage causes changes in neurodynamic processes, it alters the law of strength and the selectivity of all mental processes is disturbed. Irrelevant stimuli are evoked with the same probability as significant ones with the result that organized intellectual activity is no longer possible (Luria 1963b, 1973a, 1977). Plasticity, on the other hand, refers to the ability of nervous processes to rapidly and easily block patterns of excitation already used and to smoothly change from a state of excitation to one of inhibition or to switch from one pattern of arousal to another. Loss of neural plasticity manifests behaviourally as pathological inertia or perseveration (Luria 1963b, 1973a, 1977).

According to Luria (1966b, 1980) the cortex is involved in both simultaneous and successive forms of information processing. Simultaneous integration, which refers to the synthesis of separate elements into groups that are frequently spatial in nature, enables any part of the whole system to be perused, irrespective of its position within the system. Damage to the occipital-parietal zones disturbs this form of processing. In contrast, successive processing, which is disrupted by fronto-temporal lesions, involves the synthesis of separate elements in serial order. As such the entire system cannot be viewed at any point in time and elements are consecutively activated by cues (Luria 1966b, 1980).

J.P. Das and his colleagues have developed "one of the most promising models of cognitive processing" (Merritt and McCallum 1983 p.117) based on Luria's theory of simultaneous and successive synthesis. This model is described and discussed by Das, Kirby and Jarman (1975, 1979).

Luria's theory of brain functioning is heuristically valuable (Damasio 1985) in that, as indicated by Golden (1978), it seems to account for most of the observations on brain damaged individuals and explains the effect of widely varying lesions on a single behaviour, such as writing. In addition, Walsh (1978) has indicated that a systemic approach to brain functioning such as that of Luria's enables one not only to determine that there is a change in a particular function after brain damage, but also to determine the qualitative aspects of the functional disturbance. Further, the concept of reorganization accounts for individuals who recover from brain damage and Luria's theory suggests ways to establish treatment and rehabilitation programmes (Golden 1978).

Luria thus appears to have made a tremendous contribution to the field of neuropsychology. His work includes publications on frontal lobe disorders (e.g. Luria 1965d, 1969b; Luria and Homskaya 1963; Luria *et al.* 1967; Luria and Pribram 1963; Luria, Pribram and Homskaya 1964) and disturbances associated with brain damage in speech (e.g. Luria 1958, 1965c, 1970c, 1972a, 1973d, 1976a, 1977; Luria and Hutton 1977; Luria *et al.* 1977; Luria and Tsvetkova 1967, 1968a; Luria, Tsvetkova and Futer 1965; Luria and Vinogradova 1959), memory (e.g. Luria 1971, 1976d; Luria and Karasseva 1968; Luria *et al.* 1978; Luria, Sokolov and Klimkowski 1967), constructive activity (e.g. Luria and Tsvetkova 1964), ocular movements (e.g. Luria, Pravdina-Vinarskaya and Yarbus 1963, 1978), and visual perception (e.g. Luria 1959c; Luria, Karpov and Yarbus 1966, 1968).

Notwithstanding this, Luria admitted that his work does have shortcomings. He has indicated that his theory deals primarily with the left hemisphere, whilst right hemisphere and mediobasal cortical areas have received minimal emphasis (Luria 1973a, 1980). Luria has however more recently displayed some interest in inter-hemispheric relations and the functions of the minor hemispheres (see Luria and Simernitskaya 1977).

Several authors have failed to replicate some of Luria's findings — notably aspects of his work on aphasia, frontal lobe functioning and interhemispheric relations. Hatfield (1981) reviewed criticisms of Luria's aphasia research and argued that some of his work is an over-simplification of the complex process of speech. A study by Caplan (1984) failed to support Luria and Simernitskaya's (1977) proposed functional division between the cerebral hemispheres in terms of automatic versus volitional operations. Drewe (1979), in an attempt to replicate Luria's work on the disturbance of verbal self-regulation with frontal lobe damage, found the inability to use overt verbalizations to regulate motor performance to be less general than suggested by Luria. In addition, both Denny-Brown (cited by Hecaen and Albert 1978) and Goldberg and Tucker (1979) have questioned the relationship between perseveration and frontal lobe damage proposed by Luria (e.g. Luria 1965d) and pointed out that perseveration is not only limited to such damage. Malloy, Webster and Russell (1985) more recently found, however, that the pattern of deficits displayed by individuals with frontal lobe damage was in keeping with that suggested by Luria. Discrepancies in some of these replication studies do nevertheless appear to be partially accounted for by subject differences, in that Luria primarily used individuals with penetrating missile wounds for his aphasic studies (Hatfield 1981), and patients with massive frontal lobe tumours which probably extended beyond the frontal lobe both cortically and subcortically for his frontal lobe work (Hecaen and Albert 1978). Furthermore, Caplan (1984) suggested that his failure to replicate Luria's aforementioned work on interhemispheric functioning may be attributable to differences in both subjects and tests used.

The qualitative nature and presentation of Luria's work together with the lack of normal controls and, in the case of his frontal lobe work, comparisons with brain-damaged subjects with non-frontal damage, has also been criticized (Hecaen and Albert 1978). Throughout his writings Luria does, however, make frequent reference to performance differences between brain-damaged subjects and that to be expected by intact individuals (e.g. Luria 1973a, 1980). In addition, Luria and Tsvetskova (1978), for example, directly compared disturbances in intellectual functioning associated with frontal and parieto-occipital lesions, which thus negates Hecaen and Albert's (1978) criticism concerning the lack of comparative data for individuals with frontal and non-frontal damage.

In contrast to these criticisms, Hagberg (1980) attempted to test Luria's model of brain functioning by examining the relationship between performance during psychological assessment and regional cerebral blood flow (rCBF) in a series of patients with presenile dementia. His findings supported the central concepts of Luria's theory of dynamic localization.

As Hatfield (1981 p.338) concluded, it is in Luria's "integration of theory and therapeutic practice that his enduring strength lies".

2.4.2 Luria's Neuropsychological Investigation

> "It is not these items, per se, but the manner in which Luria made use of them as a means of testing hypotheses concerning various abilities, deficits, or functions that is his own unique contribution to neuropsychological assessment."
> (Spiers 1981 p.339.)

In 1936 the Marxist Party's Central Committee on pedagological perversions banned all forms of psychometric testing in the Soviet Union on the grounds that it was antithetical to Marxist-Lennist ideology (Cole and Maltzman, 1969)[1]. Cole and Maltzman (1969, p.5) described this as "The single most important event in the development of Soviet psychology during that era". Although not explicitly stated as such in the literature, this event would seem to have been influential in the development of Luria's qualitative, flexible approach to neuropsychological evaluation. Furthermore, it perhaps, in part accounts for Luria's criticism of the use of psychometric tests to evaluate both psychological processes and the effects of brain injury on such processes (e.g. Luria, 1961a, 1979, 1980). See also Section 2.4.3.

Luria (1979) acknowledged that the largely qualitative experimental techniques devised by Vygotsky and his students in the course of their investigation of the development of higher mental processes provided him with a set of examination procedures which he used throughout his career in neuropsychology — especially in the area of assessment.

The neuropsychological techniques used by Luria were described in the first edition (1966a) of *Higher Cortical Functions in Man.* These procedures were, however, little used in the West as none were readily available and little was known about them. Since the publication of

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1. According to Cole and Maltzman (1969 p.6) the Marxist party described as a "bourgeois hoax" the view that, on the basis of a test, a number could be determined which provided a measure of a person's inherited capacities. Testing was therefore banned and journals pertaining to it subsequently disbanded as it was regarded as counter to the Marxist view of man as a product of his socioeconomic environment and the idea that the new Socialist environment would create a "new Soviet man".

these techniques as *Luria's Neuropsychological Investigation* by Anne-Lise Christensen in 1974 this situation nevertheless appears to have changed. According to Christensen (1979a) the LNI is now widely used in Europe. In addition, the procedure has apparently stimulated much interest in America where the trend has been towards standardization and quantification of the technique (see Section 2.4.3). In South Africa its utilization also seems to be increasing as evidenced, for example, by the number of research papers utilizing this procedure presented at The First South African Neuropsychology Conference held in Durban, South Africa in 1981 (e.g. Kagan 1982a; Reef *et al.* 1982; Tollman 1982; Wade and Penn 1982; Watts and Tollman 1982).

A discussion of the LNI by the author has been published (Watts and Tollman 1982, 1983).

Luria's Neuropsychological Investigation is a wide-ranging guided evaluation which provides a comprehensive, qualitative description of a wide range of behaviours which have been pathologically disturbed as a result of brain damage (Watts and Tollman 1980b, 1982, 1983). Furthermore, it is related to Luria's theory of brain functioning (Luria and Majovski 1977). (See Section 2.4.1.)

The LNI as per Christensen "represents an attempt at *formalization* rather than *standardization*" (Kagan 1982a p.231, author's emphasis) of Luria's approach to assessment. It consists of a series of tasks designed to evaluate all the basic verbal and non-verbal skills and ".... is probably the most thorough battery available" (Kolb and Whishaw 1985 p.678).

A neuropsychological evaluation utilizing the LNI is divided into three stages. The first stage of the assessment is designed to obtain information regarding the history of the patient's present condition and "the general state and particular aspects of the patient's mental activity" (Christensen 1979a p.24). In addition "the state of the individual analyzers (optic, auditary, kinaesthetic and motor)" (Christensen 1979a p.36) is determined by administering a relatively large group of "general screening tasks" (Christensen 1979a p.36) — namely the simple tasks from the sections investigating motor functions, acousticɔ-motor organization, higher cutaneous and kinaesthetic functions and higher visual functions. The information concerning the areas of behavioural pathology obtained during this stage then serves as an important guide to areas on which subsequent systematic examination should concentrate.

The second stage is more complex, strictly individualized and involves an indepth probing of any areas where behavioural pathology became apparent during the initial phase of the examination. Tasks for this phase examine impressive and expressive speech, reading and writing, arithmetic, mnemonic and intellectual abilities.

The emphasis of all the tasks is on observing the qualitative nature of the patient's performance. The rationale behind the tasks is that a "normal" individual should be able to complete them with relative ease, although Luria does stress that the patient's premorbid level of functioning must always be taken into considerabion both during the assessment and subsequent analysis of the results (Luria and Majovski 1977; Luria 1980).

Luria (1980) stresses the importance of observing *how* a subject completes a task as this information is frequently more important for analysis than whether or not a task is correctly completed. Items are also presented in a variety of ways in an attempt to get at the basic nature of any deficits the patient may exhibit. The LNI is additionally constructed in such a way that "testing-the-limits" procedures can be used (especially during the second stage of the examination) in an attempt to clarify and illuminate areas of observed pathology.

Each investigation is thus tailored to the needs, abilities and limitations of the individual. "Each patient analysis is a theoretically based dynamic experiment on the behavioural effects accrued from a disturbance of the brain " (Luria and Majovski 1977 p.962) in which the patient serves as his own control whilst predictions based on the assessment are "tested, reformulated and validated against actual behaviour" (Spiers 1981 p.340).

The final stage in a clinical assessment with the LNI is the interpretation of the results. This requires a careful comparative analysis of the areas of behavioural deficit in order to identify the fundamental defect, or basic "factor" underlying the observed group of symptoms, and to describe how this is manifested across the behavioural areas assessed. Symptoms must be examined in the light of the principle of double dissociation (see Section 2.4.1). Finally, a suggestion can be made as to the possible area of the brain involved (Christensen 1979a; Luria 1980).

Luria (1972b, 1973a, 1979, 1980) and Luria and Artem'eva (1978) argued that this procedure, which he calls "syndrome analysis", ensures the reliability of the results in neuropsychological examinations where, because the number of cases dealt with are invariably small, the usual statistical approaches are inapplicable. In addition, this process enables one to go from a clinical description of the patient's disorders to an analysis of the fundamental factors at the basis of the observed group of symptoms (Luria 1979).

The LNI has been criticized by several authors and these criticisms appear to broadly relate to the qualitative nature of the procedure, the content of the battery and the paucity of validation studies. The issue concerning the qualitative nature of the battery is addressed in Section 2.4.3, whilst the remaining criticisms will be discussed in turn.

Lezak (1983) has criticized the LNI on the grounds that the content is not sufficiently comprehensive. She pointed out that attention, concentration and mental tracking are not evaluated. However, although not specifically examined it would seem that information regarding these functions should be elicited in the course of observing, as Luria (1980) emphasized, how tasks are performed. Lezak (1983) has further indicated that the procedure includes only a few tasks to examine non-verbal memory and non-verbal concept formation. Luria (1973a, 1980) acknowledged that his work is incomplete and not without limitations. He pointed out that his assessment techniques mainly evaluate the functions of the dominant (left) hemisphere, and that in contrast very little attention is paid to the processes of the non-dominant (right) hemisphere. This would seem to be in keeping with the emphasis placed on language by Luria and other Soviet psychologists (Cole and Maltzman 1969). Luria (1973a, 1980) further acknowledged that personality and complex forms of emotion are not included in the assessment.

Finally, Lezak (1983) argued that as LNI tasks evaluate abilities which all intact adults can perform, deficits elicited by such sections reflect either extremely circumscribed or severe damage and are therefore of only limited value for detecting mild or diffuse impairments. To date there appears to be no published research dealing with this issue.

Kolb and Whishaw (1985) considered the most serious limitation of the LNI to be that no validation studies are included in the manual. Several studies have however now been conducted (e.g. Diamant 1981; Kagan 1982a, 1982b; Sharma, Nandkumar and Mazumdar 1981; Watts and Tollman 1980b). In similar studies Kagan (1982a, 1982b) and Watts and Tollman (1980b, see also Chapter 4) both found a good correspondence between LNI findings and CT scan results, which as Kagan (1982a) argued, suggests that clinical symptoms do relate to underlying brain injury in the manner proposed by Luria. In this regard, Wolk (1986) reported that LNI symptomotology was consistent with EEG findings in a male with a cluttering speech disorder. Sharma, Nandkumar and Mazumdar (1981) found that the LNI correctly detected "organicity" in all 25 patients evaluated, whilst Diamant (1981) found a high degree of agreement between the HRNB and LNI in this respect, as well as regarding the laterality of the damage. Both studies would, however, seem to be antithetical to Luria's orientation in that they used the LNI as a test for diagnosing "brain damage" or "organicity", rather than for determining impaired and preserved functions and relating these to underlying brain pathology as suggested by Luria (e.g. 1973a, 1980). Finally, McCaffrey and Walter (1985) found the LNI to be useful for classifying mental retardation as well as for developing individualized special education programmes and vocational planning in such people.

The controversy surrounding the standardization of the LNI by American neuropsychologists is discussed in the next section.

2.4.3 Luria's Neuropsychological Investigation : The standardization controversy

> ".... the qualitative nature of Luria's neuropsychological examination has fostered the reluctance to adopt his techniques in American neuropsychology."
>
> (Reynolds 1981 p.101.)

Golden and his co-workers (e.g. Golden, 1981a, 1981b; Hammeke, Golden and Purisch, 1978; Moses and Golden, 1979) have argued that the flexible, individualized, qualitative nature of Christensen's version of Luria's approach to neuropsychological assessment (Christensen 1975, 1979a), has restricted its use in America as firstly, both the administration and interpretation of the results is not easy to learn and secondly, American neuropsychologists seldom have the opportunity to develop the skills of "judgement and clinical intuition" (Golden 1981a p.609) which are necessary to evaluate the tasks. American neuropsychological diagnosticians have traditionally used formal, standardized batteries such as the Halstead-Reitan Neuropsychological Battery (HRNB) (see Section 2.3.2). This situation appears to have been paralleled in South Africa (Watts 1985). In an attempt to reconcile the theoretical and clinical insights of Luria with the standardized psychodiagnostic tradition of American clinical neuropsychology, Golden, Hammeke and Purisch in 1978 developed a standardized version of the LNI — the Luria-Nebraska Neuropsychological Test Battery (hereafter referred to as the LNNB) (Golden, Hammeke and Purisch 1980).

In developing the LNNB, Golden and his colleagues thus attempted to apply the HRNB quantitative methodology to Luria's qualitative assessment techniques (Golden *et al.* 1982b). They argued that this would have the advantage of, firstly, enabling clinicians who have not had the opportunity to develop sophisticated neuropsychological assessment skills to use the battery, and secondly, permitting detailed statistical analyses to be conducted on items in the battery in order to scientifically examine the effectiveness of both Luria's theories and techniques. Golden's (e.g. 1981a, 1981b) contention that the clinician using the LNNB still needs to have a knowledge of Luria's theory of brain functioning appears, however, to contradict the former reason for developing the battery.

Use and acceptance of the LNNB appears to be growing amongst clinicians (e.g. Gilandas *et al.* 1984; Goldstein 1981) who, in South Africa at least, seem to be attracted by its relative ease of administration and scoring (Watts 1985). Of interest in this respect is that the battery has now, for instance, been adapted for use in China (Yun, Yao-Xian and Matthews 1987). Golden and his co-workers, besides publishing general texts in the field of neuropsychology (e.g. Golden 1978; Golden, Moses, Coffman, Miller and Strider 1983), have conducted a number of investigations on the LNNB which include reliability and validity studies (e.g. Golden, Berger and Graber 1982; Golden, Hammeke and Purisch 1978; Maruisch *et al.* 1985; Moses and Schefft 1985; Plaisted and Golden 1982), the development of lateralization and localization scales (e.g. Golden *et al.* 1981a; Lewis *et al.* 1979a; McKay and Golden 1979a, 1979b; Osman *et al.* 1979), factor analytic studies (e.g. Golden *et al.* 1980a, 1980b, 1980c; Moses 1983, 1984a, 1984b, 1984c, 1986a, 1986b); studies on epileptics (e.g. Berg and Golden 1981), alcoholics (e.g. Chmielewski and Golden 1980), schizophrenics (e.g. Golden *et al.* 1980d, 1980e; Golden *et al.* 1982a; Langell, Purisch and Golden 1987; Lewis *et al.* 1979b, Moses 1984d, 1984e; Purisch, Golden and Hammeke 1978); paranoid disorders (e.g. Strider *et al.* 1985), syphilis (e.g. Golden *et al.* 1979); neurological examination findings (e.g. Moses 1985b); and investigation of the relationship between neuropsychological deficits, learning disability and violent behaviour (e.g. Bryant *et al.* 1984). The battery has also been compared, for example, to the HRNB (e.g. Golden, Gustavson and Ariel 1982; Golden *et al.* 1981b; Kane *et al.* 1981); the WAIS (e.g. Moses 1985b, 1986c) and an alternative form of the battery (e.g. Ariel and Golden 1982) and children's version (e.g. Golden 1981c; Plaisted *et al.* 1982; see also Section 3.3) developed. These studies have consistently demonstrated the clinical utility of the LNNB[1)] (e.g. Moses and Maruisch 1987).

Despite this and the fact that Gilandas *et al.* (1984 p.12) have hailed Golden's attempt at integrating quantitative and qualitative assessment strategies as "One of the most promising current trends in clinical neuropsychology", the LNNB has become the focus of a major controversy within the field of neuropsychological assessment. Since 1980 a succession of articles strongly criticizing the battery on both conceptual and methodological grounds have been published in the *Journal of Consulting and Clinical Psychology* (e.g. Adams 1980a, 1980b; Crosson and Warren

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1. It is of interest that the chapter on cerebral tumours in Golden, Moses, Coffman, Miller and Strider (1983) appears to be a summary of a chapter with the same title written by Lishman (1978 pp.262-294).

1982; Delis and Kaplan 1982, 1983; Spiers 1981, 1982, 1984). These criticisms broadly relate to the structure of the battery, the methodology and results of studies on various aspects of the battery and theoretical considerations. Issues relating to each of these will be dealt with in turn.

2.4.3.1 The Luria-Nebraska Neuropsychological Battery

Structure of the battery

According to Golden and his colleagues (Golden *et al.* 1982b) the LNNB was designed to use a broad range of items to identify all the major areas which Luria (1966a) regarded as important. Items comprising the LNNB were adapted from the LNI as per Christensen (1975) and the work of Luria (1966a, 1973a) (Golden 1981b). In order to control for the length of the test, items on the LNI that were repetitive in terms of measuring specific functional areas were deleted. Items finally incorporated into the battery were those which were shown to adequately discriminate between brain-damaged individuals and neurologically normal controls. Crosson and Warren (1982) acknowledged that this process probably makes the battery relatively efficient for identifying brain damage *per se*. Delis and Kaplan (1982), however, argued that this procedure of including and excluding items was not based on any appreciation of present knowledge about brain-behaviour relationships and Luria's theory of functional systems. As a result all major syndromes are not adequately assessed. Items that are available to assess them, are frequently too few to provide a comprehensive evaluation (e.g. limb apraxia, non-verbal memory (Crosson and Warren 1982)). This means that mild impairment may not be picked up or the nature of the cognitive deficit may be misdiagnosed. Delis and Kaplan (1982) cited a case where the LNNB misdiagnosed an aphasic patient, whilst Mittenberg, Kasprisin and Farage (1985) found the battery to lack localizing and diagnostic specificity in aphasia, although it was sensitive to many core aphasic symptoms.

Further, one of the so-called strengths of the LNNB is its brevity (Crosson and Warren 1982). However, Anastasi (1982) pointed out that a reduction in the number of items used to measure a function normally results in a corresponding decrease in the reliability of the measure.

Items selected for the battery have been organized into 11 scales which derive their names from the LNI as per Christensen (1975). Christensen, however, cautioned that the division of LNI items into sections is an artificial organization in relation to neuropsychological syndromes and was done purely for didactic reasons (Delis and Kaplan 1982). Golden *et al.* (1982b p.295) defended the organization of LNNB items by arguing that a "rational-empirical" methodology was used to determine their placement. Initial item placement was decided "rationally" on the basis of Christensen's (1975) organization and Luria's theory. This was then empirically investigated. They hypothesized that although each LNNB item taps a variety of elementary skills, it would correlate most highly with the scale to which it had been assigned. A study by Golden, Fross and Graber (1981) which examined item-scale correlations, confirmed this hypothesis. Golden and his co-workers have nevertheless replaced descriptive scale names with letter-number combinations (e.g. C1 for Motor Scale) in a new form of the LNNB they have developed (e.g. Purisch and Sbordone 1986).

Administration has been strictly standardized which is antithetical to Luria's flexible approach. Christensen 1979a p.26) stated that "static standardized techniques must be entirely discouraged". Administration has been designed to take approximately 2 hours although Golden (1981b) pointed out that this varies from approximately 80 minutes for an intelligent "normal" individual to 3-5 hours for a severely impaired person. This time is very similar to the time required to do a comprehensive assessment with the LNI (Watts 1985).

Items are scored in terms of dimensions such as time, accuracy, frequency, rate, speed, quality and appropriateness. Raw scores are then converted to scale scores of 0 (unimpaired), 1 (borderline) or 2 (impaired). These scaled scores for each item are then summed to give a score for each behavioural scale. These scores are then converted to T-scores which are plotted on an MMPI-type profile (Golden 1981b).

This scoring system has been criticized for several reasons:

- Spiers (1981) conducted a detailed item analysis of the behavioural scales and observed that many items within each scale could be failed as a result of a wide range of cognitive deficits e.g.

on the receptive speech scale, poor performance could be due to language comprehension deficits, as well as to perceptual, memory, sequencing or motor deficits. As a result, scales do not measure the functions implied by their names — a fact acknowledged by Hutchinson (1984) in his response to Spiers' critique of the LNNB. The summary scale score thus seriously limits an interpretation of a patient's deficits and may even result in misdiagnosis (e.g. Delis and Kaplan 1982) as it masks such information. Furthermore, Russell (1987) has argued that as the LNNB does not utilize homogeneous scales, it is inadequate in terms of psychometric design.

- Alternative means of responding are not taken into account by the scoring system. For example as Crosson and Warren (1982) indicated there is an emphasis on verbal comprehension and expression on all items with no provision made for alternative forms of answering which means that the battery is not suitable for the accurate diagnosis of aphasics. In response to this criticism, Golden and his colleagues have, however, developed a second form of the LNNB in which the scoring procedure has been adapted to give credit for non-verbal responses (e.g. Purisch and Sbordone 1986).

- Scoring responses to items in terms of 0, 1, or 2 provides no indication concerning *how* a patient solved a problem (Spiers 1981) —— information which Luria (e.g. 1980) emphasized is frequently more important than whether or not an item is correctly completed. To quote Spiers (1982 p.333): "We must be concerned, not with some scaled score, but with the behaviour and problem-solving strategies produced by the patient in response to the task".

- Spiers (1981) pointed out that the scoring system is a deficit one in that high scores reflect long response times or a large number of mistakes —— a point conceded by Hutchinson (1984) in his reply to Spiers' criticisms of the LNNB. It is thus possible to get a high score on a task whilst giving a correct response (e.g. delay of responses is characteristic of many patients with a word-finding problem (Crosson and Warren 1982)). Thus whilst a long response time may be indicative of brain damage, timing prevents one from gaining a comprehensive evaluation of a patient's deficits and may additionally lead to a misdiagnosis.

- Perhaps the most damaging criticism leveled at the scoring system is that voiced by Crosson and Warren (1982). Performance on items of the LNNB is recorded in terms of nominal categories (impaired, borderline, unimpaired) to which numbers (0, 1, 2) are then assigned so that the categories probably meet ordinal requirements. Scores for the behavioural scales are then obtained by summing the values assigned to such ordinal categories. At least an interval level of measurements is needed, however, to perform such arithmetic operations. Crosson and Warren (1982) argued that this problem is further compounded by the fact that the scales are heterogeneous so that the score for, for example, the visual scale is obtained by summing items measuring different visual abilities, which makes it harder to accept the assumption of nominal or ordinal categories.

Golden and his colleagues (e.g. Bryant, Maruish, Sawicki and Golden 1984; Golden *et al.* 1982a, 1982b) have responded to these criticisms by emphasizing firstly the importance of "testing-the-limits" during administration, and secondly integrating a sophisticated qualitative analysis as per Luria of the patient's performance on the battery with an examination of the LNNB scales. In order to facilitate this analysis, Moses, Golden, Ariel and Gustavson (1983) and Moses, Golden, Wilkening, McKay and Ariel (1983) have published a two volume guide to interpretation of the battery. Golden and his co-workers (e.g. Bryant, Maruish, Sawicki and Golden 1984; Golden *et al.* 1982a, 1982b; Knippa, Golden and Franzen 1984; Purisch and Sbordone 1986), argued that some users may misuse the LNNB through lack of sophistication and training and that "This misuse is an indictment of the user, not the test" (Golden *et al.* 1982a p.41). This argument contradicts one of the reasons cited by Golden in 1978 (Golden, Hammeke and Purisch 1978) for developing the LNNB —— namely to make Luria's techniques available for use by the "average" clinician who had not been afforded the opportunity to acquire the skills necessary to use the LNI.

Delis and Kaplan (1983) thus argued that standardization has created a paradox in that it was necessary to initially make the battery available for use by clinicians who have not received a thorough training in Luria's neuropsychological orientation and techniques. It is precisely these clinicians however who, having been provided with a relatively short, standardized instrument, are most easily misled by the battery's inadequate profiles.

Studies on the Luria-Nebraska Neuropsychological Test Battery

The rapidly growing body of studies on the LNNB by Golden and his colleagues have been criticized on the grounds of inadequate sample selection, methodology and statistical analysis. The following criticisms cast doubt on the claims Golden and his colleagues make regarding the clinical utility of the battery:

- Adams (1980a and 1980b) has criticized a group of studies conducted by Golden and his colleagues in 1978 and 1979 (e.g. Golden, Hammeke and Purisch 1978, 1979; Moses and Golden 1979; Purisch, Golden and Hammeke 1978) which indicated that the LNNB could discriminate between various neurological populations and controls with high hit-rates. Adams argued that sample selection in these studies was inadequate as age, education, medication, psychopathology, chronicity, number of hospitalizations and age at onset were not controlled for — all of which have been found to influence neuropsychological testing (e.g. Parsons and Prigatano 1978). Further, supposedly independent standardization samples may actually have included the same subjects. Adams additionally pointed out that the statistical analyses in the 1978 studies (Golden, Hammeke and Purisch 1978, 1979; Purisch, Golden and Hammeke 1978) were inadequate in that approximately 285 separate t-tests were run on each scale without an overall multivariate ANOVA. Such overuse of t-tests is a serious methodological error. In an attempt to overcome this error, Golden (1981b) drew another sample of subjects and used a multivariate ANOVA in the analysis of the data. Essentially the same discriminations were obtained as in the earlier studies, which tended to negate this criticism. Furthermore, an independent cross-validation of the LNNB by Sears, Hirt and Hall (1984) reported similar findings to those of Golden in terms of the battery's effectiveness in discriminating between brain-damaged and normal controls. In contrast to Golden's work, however, they found the protocol to be relatively ineffective for distinguishing the laterality of brain-damage.

Discriminations in these studies were made between patients with obvious neurological impairment and normal controls. As a result Lezak (1983) has indicated that the battery is only capable of identifying brain damage in cases that were so obviously impaired that ".... most would be identified as impaired within the first few minutes of observation and questioning" (p.570). She thus argued that when a patient has impairments that are obvious on observation, the ability of an assessment instrument to make the same discriminations does not make it a valuable diagnostic tool.

- Spiers (1982) pointed out that studies involving item correlations (e.g. Golden and Berg 1980a, 1980b, 1980c, 1980d, 1981a, 1981b) and factor analyses (e.g. Golden *et al.* 1980a, 1980b, 1980c) which are attempting to statistically identify the internal consistency, composition and reliability of the test have used mixed populations of normal, psychiatric and brain-damaged subjects whose results were not treated independently. It is therefore not clear whether factors or intercorrelations identified are due to psychopathology or brain damage. The same criticism seems applicable to more recent item correlation studies by Golden and Berg (e.g. 1981c, 1982a, 1982b, 1983a, 1983b, 1983c). Subsequent factor-analytic work by Moses (e.g. 1983, 1984a, 1984b, 1984c, 1986a, 1986b) has, however, shown a hierarchical grouping of skills which are consistent with Luria's theory and as predicted by Golden and his associates when designing the test.

- Finally, Spiers (1982) criticized studies which attempt to relate patterns of clinical or statistically derived subscale performance to various lesion sites (e.g. Golden *et al.* 1981a; Lewis *et al.* 1979a; McKay and Golden 1979a, 1979b). The sample composition of these studies was once more criticized as factors associated with drug, developmental and psychiatric histories were ignored and handedness was not controlled for, nor taken into consideration in relation to the findings. However, Lewis *et al.* (1979a), for example, looked at LNNB scale patterns relating to eight areas of the brain —— namely left and right frontal, temporal, sensorimotor, and parietal-occipital areas. Locality of lesion was determined on the basis of operative notes, and/or angiogram and CT scan reports. The location of a lesion was defined by the proportion of damage present in the areas of the brain just mentioned e.g. a patient was classified as having a temporal lesion if 50 percent of the lateral surface area of the lesion was located in the temporal lobe and no more than 25 percent of the lesion extended into another single area. Spiers (1982) pointed out that it is theoretically possible that some patients in this study had lesions extending from Wernicke's area to the supramarginal gyrus to Broca's area —— all functionally significant structures —— and yet to have been classified as having a temporal lesion only. Further, the extent to which lesions extended into subcortical areas was not considered.

Finally, localization in these studies was fairly gross —— whereas using the LNI it is possible to make very specific localizations. A lesion can be localized to a specific area of for example the frontal lobe, not just to a left or right lobe of the brain (Watts, 1985).

Theoretical considerations

Golden and his associates (e.g. Golden *et al.* 1982; Hutchinson 1984; Purisch and Sbordone 1986) agreed with many of the criticisms relating to the understanding, interpretation and validity of the LNNB. Golden *et al.* 1982b) argued, however, that many of the issues are due to theoretical differences in neuropsychology relating to the qualitative versus quantitative issue. These authors advocated, as did Lezak (1983), that both techniques are needed for effective assessment. As applied to the LNNB, they argued that the use of both quantitative and qualitative procedures permits the rapid and reliable collection of empirical information, whilst permitting a qualitative analysis of the patient's problem. Both methods can then be integrated with relevant factors relating to the patient's history, emotional status, culture and so forth.

As Goldstein (1981) has indicated, the qualitative versus quantitative issue is similar to the clinical versus statistical debate in psychology (e.g. Holt 1958; Loro 1977, Meehl 1954; Miller 1974, Sawyer 1966), a topic which has also been discussed within the field of clinical neuropsychology (e.g. Goldstein 1981; Goldstein, Deysach and Kleinknecht 1973; Heaton *et al.* 1981; Wedding 1983). The issue would seem, however, not to merely revolve around the relative efficacy of qualitative versus quantitative assessment techniques, or as Spiers (1981) prefered to refer to them — descriptive and actuarial representations. It appears instead to concern the appropriateness of the psychometric model for neuropsychological assessment — given the heterogeneity of brain-damaged individuals (see Section 2.3.1) and the growing emphasis in neuropsychology on rehabilitation as opposed to diagnosis (see Section 2.3).

Psychometric tests are designed to reflect an individual's manifest level of performance relative to a representative, normally distributed population. As such the psychometric approach focuses primarily on the product of a person's performance (Feuerstein *et al.* 1981). The psychometric model would thus seem inadequate for neuropsychological evaluations for the following reasons.

Firstly Spiers (1982) pointed out that the actuarial approach as epitomized by the HRNB has, in retrospect, been of only limited value. In both neurology and neuropsychology it is the descriptive approach which has led to the accurate identification of syndromes and development of theories. Shallice (1979) further argued that the use, in neuropsychology, of procedures which involve averaging and comparison of group performances will inevitably miss patients with unique, specific focal deficits, such as alexia without agraphia, which have contributed most to the understanding of brain-behaviour relationships. This appears to support the contention of Anastasi (1982) that the clinical method is best suited to "the processing of rare and idiosyncratic events whose frequency is too low to permit the development of statistical strategies" (p.491). She further argued that even if individual events occur frequently, particular combinations of these events may not occur often enough to meet the requirements of actuarial prediction. In addition, as Lezak (1983) has indicated, the uniqueness of each brain-damaged individual's specific needs, situation, capacity, premorbid personality characteristics and reaction to the particular constellation of brain-behaviour disturbances present, needs to be considered.

Secondly, if the purpose of an assessment is to delineate impaired and preserved functions in order to relate them to a particular syndrome (Christensen 1979a; Heilman and Valenstein 1985; Luria 1980; Walsh 1978, 1985) and to develop an appropriate rehabilitation programme and monitor an individual's progress during this, then it would seem necessary to understand the reasons for the person's successes and failures on the test instrument. In other words, as emphasized by Luria (see Sections 2.4.1 and 2.4.2) the underlying processes affecting performance should be understood in order to determine how these have changed as a result of brain injury and may and do change during a retraining programme. Whilst the profile of scores yield by psychometric tests will provide a measure of changes in higher mental functions, they appear to yield virtually no information concerning how these occurred (Feuerstein *et al.* 1981; Osman 1983).

In view of the above arguments the usefulness of the psychometric model would thus seem to be limited to answering questions such as whether or not brain damage is present.

As indicated earlier, however, American neuropsychology's main concern has traditionally been with the application of quantitative, standardized techniques to problems of diagnosis (Davison 1974; Halstead 1947; Luria and Majovski 1977; Reitan 1955). American neuropsychological tests such as the HRNB were thus originally designed and validated for the purpose of predicting the *presence* of brain damage and not to comprehensively evaluate spared and impaired cognitive functions (Brinkman 1979; Delis and Kaplan 1983) (see Section 2.3.2). More recently however the use of flexible, informal batteries of tests have been advocated by, for example, Muriel Lezak (1983) and Kevin Walsh (1978, 1985) (see Section 2.3.3). This step appears related to a de-emphasis of the role of the neuropsychologist as diagnostician since the advent of advanced radiographic diagnostic techniques such as computerized axial tomographic (CAT) scanning, positron-emission transaxial tomographic (PETT) brain scanning and nuclear magnetic resonance (NNR) tomography of the brain, except perhaps in cases of controversy, and the growing emphasis in neuropsychology on rehabilitation (e.g. Diller and Gordon 1981; Golden 1978). Concomittently it has been recognized that the formulation of adequate treatment and rehabilitation programmes necessitates the comprehensive evaluation of a patient's strengths and weaknesses. A flexible battery would seem to be most appropriate for this purpose. The LNNB is obviously not in keeping with these trends as, in the light of the criticisms reviewed, its utility and validity for examining functional deficits seems to be limited, and its appropriateness in terms of its adherence to the psychometric model appears questionable. As Stambrook (1983) has indicated, it is at present not clear whether the LNNB, a standardized instrument, is able to provide information which has direct treatment implications. He further argued that additional research is needed to determine how accurately and comprehensively the battery evaluates the behavioural consequences of brain injury. Adams (1984) has argued that it is the responsibility of Golden and his colleagues to conduct such research.

A flexible battery requires greater skill to administer and interpret than does a standardized battery (Kolb and Whishaw 1985, Lezak 1983). Perhaps the answer then, as argued by Watts (1985), is not to standardize assessment techniques for brain damage in order to facilitate administration and interpretation and thus make them available for use or even misuse by possibly inexperienced clinicians. Since each case possesses unique features, this would seem to be a disservice to the patient as vital decisions regarding treatment and rehabilitation programmes are made on the basis of the assessment and an inadequate or inaccurate evaluation will obviously affect the effectiveness of such programmes. Greater benefit would perhaps be derived from the development of specialized training programmes (e.g. Meier 1981; Costa, Matarazzo and Bornstein 1986); and credentialling for neuropsychologists (e.g. Nell 1985). The importance of this is perhaps most clearly expressed by Kolb and Whishaw (1985 p.673):

> 'Hebb once wrote, "a half-baked psychologist is worse than none at all". It is also true that "a half-baked neuropsychologist is worse than none at all". Neuropsychological assessment is complex and requires extensive training to properly evaluate the results. Experience in interpreting personality or intelligence tests is not sufficient background to begin neuropsychological assessment.'

CHAPTER 3

THE NEUROPSYCHOLOGICAL ASSESSMENT OF CHILDREN : A REVIEW OF THE LITERATURE

> "The whole field of neuropsychological assessment in childhood is in a stage of transition."
> (Chadwick and Rutter 1984 p.206.)

3.1 INTRODUCTION

As Lezak (1983) has indicated, child neuropsychology has evolved in conjunction with progress in the study of mental retardation, learning disabilities and behavioural problems. A review of the literature indicates that there has been a marked increase of interest, research and knowledge relating to brain-behaviour relationships in children during the past 10-15 years (Reynolds 1982; Rourke *et al.* 1983; Rourke, Fisk and Strang 1986) — especially in relation to learning disabilities and the application of neuropsychological knowledge to education (e.g. Denkla 1979, Gaddes 1980: Hartlage and Telzrow 1983; Hinshaw, Carte and Morrison 1986; Hynd and Obrzut 1981; Knights and Bakker 1976; Nussbaum and Bigler 1986; Pirozzolo and Harrell 1985; Rourke *et al.* 1983; Rourke, Fisk and Strang 1986; Rutter 1984; Spreen *et al.* 1984). Despite this, on the basis of the literature reviewed, the area of child neuropsychology seems to have remained less well developed than that of adult neuropsychology and comparatively less work has been produced.

A possible reason for this is that development is itself a confounding factor (Watts and Tollman 1980a). As Hecaen and Albert (1978) pointed out, brain damage in adults disrupts established behaviour patterns, whilst injury in childhood affects a developing brain and therefore the development of psychological processes. Several authors (e.g. Barth and Boll 1981; Boll 1974; Luria 1963b; Vygotsky 1965) have also indicated that brain damage has different effects at different ages and these interact with the type, severity and location of the lesion (Barth and

Boll 1981; Golden 1978; Hecaen and Albert 1978; Lezak 1983; McFie 1975; Rourke, Fisk and Strang 1986; Rutter *et al.* 1970). Although such influences are relevant for both adults and children, Boll (1974) argued that they seem to play a far more crucial role in the latter group where the number of potentially interfering factors is greater. To quote Barth and Boll (1981 p.422):

> "The large differences in both quantitative and qualitative psychological capacity and accomplishment that characterize children's development for at least the first twelve years present a double demand on any attempt to assess the effect of brain damage."

In addition, Rutter (1982) pointed out that many disturbances in brain-behaviour relations in children are the result of abnormal conditions during the intrauterine and perinatal periods. Research is complicated, therefore, because of the many influences impinging on the child's development and, in cases of congenital brain injury, there is no available information concerning the child's premorbid status which can be compared with posttraumatic assessment findings.

Further, World War I and World War II provided a wealth of clinical material and great impetus for the development of assessment procedures and rehabilitation techniques for traumatically brain injured soldiers (e.g. Goldstein 1942; Luria, 1963a, 1970c, 1980). No comparable event has occurred in the history of child neuropsychology to give impetus to the field. The encephalitis epidemics in Europe and North America between 1916 and 1924, and resultant surviving children with personality and intellectual sequelae does, however, appear to have stimulated interest in the area (e.g. Benton 1985; Lishman 1978).

The neuropsychological assessment of children, which is reviewed in this chapter, therefore seems to have developed out of adult neuropsychological evaluation (Schachter 1983; Teeter 1983) and, as indicated in the previous chapter, (see Section 2.3), major work in the field of neuropsychological assessment has focused on adults. However, as Chadwick and Rutter (1984) have pointed out, the neuropsychological examination of children differs from that of adults in that the child's developmental level must be taken into consideration. For this reason, the review begins with a discussion of important issues associated with the neuropsychological assessment of children, all of which implicitly involve the differential effects of brain damage at different developmental stages. Thereafter approaches to the neuropsychological evaluation of children are examined. Finally, Luria's work with children is reviewed.

3.2 ISSUES ASSOCIATED WITH THE NEUROPSYCHOLOGICAL ASSESSMENT OF CHILDREN

> "Damage at the earliest age afflicts an incomplete brain as well as an obviously incomplete behavioural repertoire."
>
> (Barth and Boll 1981 p.419.)

There is controversy in the literature as to whether brain damage sustained early in life results in greater or less impairment than equivalent damage in adults (e.g. Rourke, Fisk and Strang 1986). Authors (e.g. Kolb and Whishaw 1985) who have argued that the effects of brain damage on the young brain are less severe than those on the adult central nervous system have emphasized the plasticity of the immature nervous system. Others (e.g. Luria 1963b; Reitan 1974) have suggested that the consequences of brain injury in young children are more severe as damage to the immature brain, in addition to having direct effects on the nervous system, also affects subsequent psychological development.

3.2.1 Age of child at onset of brain damage and subsequent recovery of function

> "The developmental stage at which the brain injury is sustained has a major influence on both the short-term and long-term consequences of brain damage."
>
> (Rutter *et al.* 1970 p.13.)

Animal studies

Research with animals has revealed the following trends:

- Studies involving *cortical* ablations to: 1) motor and sensory areas, and 2) association areas, have suggested that brain injury sustained early in life has less severe consequences than comparable damage incurred at later stages (e.g. unilateral and bilateral motor and sensory cortical ablations in monkeys (Kennard 1938, 1942); somato-sensory ablations in cats (Benjamin and Thompson 1959); striate cortical lesions in cats (Doty 1971) and in hamsters (Schneider 1969), bilateral pyramidotomies on monkeys (Lawrence and Hopkins 1972); auditory cortex ablations in cats (Sharlock, Tucker and Stromiger 1963); bilateral dorsolateral frontal ablations in monkeys (Harlow *et al.* 1970; Goldman 1971)). The consistency of the results has, however, varied depending on the site and extent of the lesion. For instance, studies involving prefrontal lesions have generally yielded the clearest findings although findings depend on the extent of the lesion (Hecaen and Albert 1978). Residual disabilities have been less severe after dorsolateral as opposed to orbital frontal lesions (e.g. Mishkin 1957; Goldman, Rosvold and Mishkin 1970).

  Hecaen and Albert (1978) noted that the literature concerning the concept of the plasticity of the developing brain appears to be inconclusive and contradictory. Despite this, they feel that the results of animal studies tend to support the concept. Rutter *et al.* (1970), however, argued that it remains unclear whether the marked differences between early and late brain injury are due to more diffuse organization of function in the immature nervous system or to re-organization of function as a result of greater neuronal plasticity.

- Studies involving *subcortical* lesions have generally found "functional sparing" (Hecaen and Albert 1978 p.395) to occur partially and infrequently — an exception perhaps being amygdaloid and quadrigeminal lesions (Hecaen and Albert 1978). Johnson (1972) (cited by Hecaen and Albert 1978) contended that this finding is in part due to the different maturational rates between subcortical and cortical structures (e.g. morphological differentiation continues after early cortical damage). Further, subcortical structures are functionally more committed than the cortex and associated behaviours tend to be species-specific and stereotyped in nature. In contrast, behaviours connected with the cortical areas incline towards flexibility.

To a great extent the results of these animal studies reflect the findings of studies with brain-damaged humans (Rutter *et al.* 1970).

Human studies

- *Aphasia studies*

  Studies of children with unilateral aphasia-producing lesions have generally indicated that:

  - Such injury sustained in early childhood seldom leaves permanent language impairment (e.g. Alajovanine and Lhemitte 1965; Basser 1962; Boone 1965; Geshwind 1972; Hecaen 1976; Kinsbourne 1975b; Sugar 1952);
  - Aphasia associated with damage to the right hemisphere is a far more frequent occurrence in children than adults (e.g. Basser 1962; Kinsbourne 1975b, 1976; Hecaen 1976).

On the basis of evidence from studies, such as those cited above, and his own clinical experience (Kinsbourne and Hiscock 1981), Lenneberg (1967, 1968) has argued that brain damage to either hemispheres prior to the age of approximately three results in rapid recovery of function, as the two cerebral hemispheres are equipotential for language at this stage (although the left hemisphere has a predisposition for language development) and language can be acquired by the intact brain tissue. Between the ages of three and ten, damage may produce aphasia, but gradual recovery usually occurs as the opposite hemisphere is still able to take over the function of language. Damage after the age of ten produces language disturbances which resemble those seen in adults as the developing brain becomes progressively less able to adapt and reorganize. By the age of approximately 14, according to Lenneberg (1967, 1968) the ability to reorganize is lost and the prognosis for recovery is poor. Lenneberg thus considered the age span of about two to 14 years to be the critical period for language development and more broadly, for cerebral localization.

Lenneberg's hypothesis of progressive lateralization has been strongly criticized by several authors. Krashen (1976) argued that the time span of the critical period may be shorter than Lenneberg suggested as aphasia associated with right hemisphere damage nearly always occurs before the age of five. (He pointed out that Basser (1962), for example, observed no cases of aphasia associated with right-sided lesions after the age of five.) Further, he compared the frequency of right-sided lesions in a series of childhood aphasias and found that in older children the percentage of right hemisphere lesions producing aphasia is similar to that observed in adults.

Kinsbourne and Hiscock (1981) pointed out that many of the case reports on which Lenneberg based his conclusions are fraught with methodological problems. Firstly, in many of the case reports of apparent right hemisphere aphasia the possibility of bilateral damage cannot be excluded (Kinsbourne 1976; Kinsbourne and Hiscock 1981; Woods and Teuber 1978). Secondly, the high incidence of language disorders associated with right hemisphere damage in young children may be an artefact of selective reporting as unusual cases (e.g. aphasia with right hemisphere damage) are likely to be reported more frequently than more usual cases (e.g. aphasia after left hemisphere damage or the absence of aphasia after right-sided damage) (Kinsbourne and Hiscock 1981). Thirdly, criteria for reporting aphasia are often "loose, sparse or ambiguous" (Kinsbourne and Hiscock 1981 p.147) and failure of a child to talk to the clinician may be taken as evidence of aphasia. Mutism may, however, be caused by situational stress (e.g. emotional trauma) as well as damage to the central nervous system (Geshwind 1972; Kinsbourne 1976; Kinsbourne and Hiscock 1981).

The finding that aphasia associated with unilateral damage is usually less severe and of shorter duration the younger the individual at the time of injury has generally been interpreted as evidence for the concepts of early hemisphere functional equipotentiality and progressive lateralization (Hecaen 1976; Hecaen and Albert 1978). In view of the aforementioned limitations of the studies on which this hypothesis was based, Kinsbourne (1975a, 1976) argued that it has largely been discredited. He contended that available evidence suggests that "Cerebral dominance for language does not develop, it is there from the start" (Kinsbourne 1976 p.189). Hecaen (1979) pointed out that both clinical (e.g. McFie 1951a; Woods and Teuber 1973) and anatomical (e.g. Geshwind and Levinsky 1968; Wada 1968 —— cited by Geshwind 1972; Wada, Clark and Hamm 1975) evidence exists which tends to support Kinsbourne's contention that hemispheric specialization is innate.

Springer and Deutsch (1981) have suggested that the observed functional sparing after unilateral aphasia-producing lesions in young children could also be attributed to the greater neural plasticity of the young brain — which decreases with age. As Golden (1978) pointed out, the "takeover" phenomenon appears to occur primarily in very young children with large unilateral lesions which leave the opposite hemisphere intact (e.g. Reed and Reitan 1969). Such lesions rarely occur in children who sustain damage at or shortly after birth (Golden 1978, Spreen *et al.* 1984).

- *Hemispherectomy studies*

Studies of individuals who have undergone hemispherectomies have generally indicated that if the operation is performed in early infancy the remaining hemisphere can assume some of the functions of the removed hemisphere and that there is less impairment than in adults who have had the same hemisphere removed (e.g. Annett 1973; Basser 1972; Hecaen 1979; McFie 1961b; Neville 1976; Nottebohm 1979; Smith 1975). The consequences of hemispherectomy are thus related to the age of the individual at the time of the operation. According to Springer and Deutsch (1981 p.136) the "severity of the impairment is directly related, and the prognosis for recovery of language is inversely related, to the age of the child at the time of surgery".

Neither hemisphere is capable of assuming all the missing hemisphere's functions (Kolb and Whishaw 1985). This either suggests that while the hemispheres may be functionally similar at birth (as opposed to adulthood) they are not really equipotential (Nottebohn 1979) or that both hemispheres are functionally specialized at, or shortly after birth, although there is some degree of functional plasticity (Kinsbourne 1976; Kinsbourne and Hiscock 1981). The complexity of the relationship between early versus late brain damage is illustrated by the following studies:

- Dennis and Whitaker (1976) compared cases of left and right hemispherectomies and found that whilst the phonemic and semantic abilities of both groups were similar, the left hemispherectomy group was deficient in complex syntactic tasks.

- Similarly, Kohn and Dennis (1974) found that patients with right hemispherectomies experienced no difficulty with simple visuospatial tasks involving abilities which developed before the age of 12 (i.e. tactile form matching - 6 years; bodily orientation - 10 years), but performed poorly on more complex visuospatial tasks which required the development of mental levels over 12 years (e.g. map reading tests - 16 years).

Individuals who have undergone hemispherectomies are generally of low- or below-average intelligence (Golden 1978; Kolb and Whishaw 1985; McFie 1961b; Milner 1974; Woods and Teuber 1973), which suggests that one hemisphere is unable to entirely assume the functions of both (McFie 1961b). At present the reason for this, according to Nottebohm (1979) is unclear. He indicated that the lowered intelligence of hemispherectomy cases has been attributed to: 1) incompatibility between "analytic" and "holistic" modes of processing sensory inputs; 2) interference between verbal and non-verbal long-term memory processes from attentional conflicts, and 3) a subnormal hemisphere. As regards the latter point, conditions resulting in the removal of one hemisphere may also have affected the organization of the opposite one. In addition, during the operation, axons are severed and this probably causes substantial cell death in the remaining hemisphere. Further, the effects the loss of such inhibitory and excitatory contacts may have on the performance of the surviving hemisphere are unknown (Nottebohm 1979).

In the absence of conclusive evidence in the literature, Nottebohm (1979) argued that any one of these factors alone or in combination, may account for the lowered intelligence observed in the majority of hemispherectomy patients. Golden (1978) has, however, pointed out that a few cases with above-normal IQ's have been reported (e.g. Smith 1976 cited by Golden 1978).

- *Neuropsychological studies*

Whilst animal experiments and human studies of unilateral aphasia-producing lesions and hemispherectomies have suggested that brain damage sustained in early life has less effect than comparable injury incurred at later stages, neuropsychological studies of individuals with bilateral damage have tended to imply the converse. Ounsted, Lindsay and Norman (1966), for example, in a study of children with temporal lobe epilepsy with or without a history of cerebral insult or status epilepticus, found that the earlier the onset of seizure, the greater the depression of IQ —— and the greater the severity of the underlying cerebral dysfunction, the more pronounced the age effect. This study would seem to partially propitiate the findings of Graham *et al.* (1962) and Ernhart *et al.* (1963) (John Hutt 1976). Graham *et al.* (1962) reported that children with brain damage due to perinatal anoxia had lower IQ's overall than normal children and were more impaired on verbal and conceptual as opposed to perceptual-motor tasks. Ernhart *et al.* (1963) studied children who had sustained brain damage at a later age (i.e. the first three years of life) and found that the brain-damaged children were more impaired than the normals in all areas of performance. Verbal, conceptual and perceptual-motor tasks were equally impaired. Chelune and Edwards (1981) in their review of childhood brain lesions suggested that age at injury and type (e.g. diffuse or focal) of injury interact as follows: younger children with diffuse injuries (e.g. meningitis, Reye's syndrome) tend to display poorer recovery of function than older children, whilst younger children with focal injuries (e.g. closed head injury) show better recovery of function than their older counterparts.

That the differing effects of brain injury depend on the developmental stage and chronological age at which the injury occurred is further illustrated by the study of Boll (1973). He evaluated the effects of brain damage sustained at birth, after 2-4 years of normal development and after 5-7 years of normal development and found that the later the onset of damage (and thus the longer the period of normal development prior to injury), the more adequate was the children's performance across a broad range of tasks. The "age-of-onset effect" (Boll 1973 p.510) was most marked on complex tasks requiring abstract thinking, verbal processing and problem-solving, as opposed to simpler sensori-motor tasks.

Teuber and Rudel (1962) suggested that in evaluating the effects of brain damage, it is important to take into consideration not only the age at injury, but also the age at testing. They found different manifestations of early brain injury, depending on which version of a simple perceptual-motor task was used to evaluate children equated for age at injury:

1. On a body-tilt task, the effects of early injury were not apparent before the age of 11 years, but became increasingly obvious thereafter.

2. When a starting-position-effect task was used, the level of impairment was virtually the same at all age levels.

3. A self-right task revealed the effects of brain injury only up to the age of 11, after which no abnormality was observed.

Thus different patterns of impairment may be observed depending on whether the child is studied soon after injury or later. Further, these age-related effects seem to be task specific — tasks which are sensitive to the effects of brain damage at one age may not be so at another (John Hutt 1976).

3.2.2 Generalization from adults to children

> ".... in the child and adult one and the same brain injury leads to very different results ...."
>
> (Luria 1963b p.17.)

Several factors limit the generalization of knowledge obtained from the study of adults with brain-behaviour disturbances to children.

Firstly, the states of anatomical and behavioural development differ between the two (see Section 3.1). Secondly, neuropathological states differ as the type of damage most typically experienced in adulthood differs from that usually experienced in childhood (e.g. tumours occur less frequently, generalized degenerative and demyelinating diseases such as Parkinson's disease and multiple sclerosis usually occur after the age of 16, while anoxia and inborn metabolic disorders (e.g. Phenylketonuria) are more common in children) (Barth and Boll 1981). In addition, major localized lesions are less common in children than adults so that many early childhood disorders are far more likely to produce diffuse disturbances (Barth and Boll 1981; Benjamins 1984;

Gardner 1974; Golden 1978; Lenneberg 1968). Lenneberg (1968 p.161) pointed out that lesions to the adult brain are accompanied by a certain sequence of events which include "transgression of fluids into the interstitial spaces, softening of tissue, cavitation, necrosis and gliosis". Despite this, most lesions do, however, remain relatively confined to specific structures. In contrast, lesions occurring during the prenatal or early postnatal period are usually followed by more widespread pathology as tissues are still interacting in morphogenetic and developmental growth processes.

Accompanying these differences in nature of the lesions in children's and adult's brains are important differences in the ensuing clinical symptomology (Lenneberg 1968). Motor disturbances due to birth injuries are, in the main, not immediately noticeable. For example, in the case of hemiplegia, aberration is rarely noted for at least the first three months of development. Abnormalities in the arms are usually first observed between 4-6 months of age and in the legs between 9 and 12 months (Lenneberg 1968). Kennard (1938, 1942) reported similar findings when he ablated the motor cortex of monkeys. Childhood hemiplegia is at variance with that found in adults, as although the affected limb is not used, spontaneous movements and movements in response to noxious stimuli may occur. Further, abnormalities of gait differ markedly from those observed in adult hemiplegics (Lenneberg 1968).

As regards sensory deficits, lesions to the primary zones of the occipital cortex generally produce the same field defects in adults and children (Paine 1960). Lenneberg (1968), however, indicated that hemianopias and scotomata occur less frequently as a result of birth injuries and that hearing defects involving sound pattern perception are a more frequent occurrence. This appears to be in keeping with the findings of Reed, Reitan and Kløve (1965) that the second greatest difference between brain-damaged and normal children (after the Wechsler scales) was obtained on the Halstead speech sound perception test. Somatosensory losses (e.g. two point discrimination, stereognosis), in comparison to motor, speech and intellectual symptoms, are very similar to those observed in adults (Lenneberg 1968).

In terms of language, fluent aphasias are not observed in children (e.g.

Gardner 1976; Geshwind 1972; Lenneberg 1968). Adult aphasics are seldom mute, whereas children with acquired aphasia are more likely to be mute (Gardner 1974; Geshwind 1972; Hecaen 1976, 1983). According to Geshwind (1972), the most frequent cause of Korsakoff's syndrome is trauma, rather than a metabolic disorder. He pointed out that despite the high incidence of head injuries in children, this syndrome is very rarely observed.

Studies in which brain-injured children and adults have been assessed on a neuropsychological battery of tests have suggested the behavioural deficits in the two may be different (Reed, Reitan and Kløve 1965).

Several authors (e.g. Ernhart *et al.* 1963; Graham *et al.* 1962, Reed, Reitan and Kløve 1965) have reported that brain-damaged children perform more poorly than control groups on all test variables than is generally the case for brain-damaged adults. Reitan (1974) considered these findings as indicative that the general effect of brain damage to the young brain is to limit the potential for the normal development of abilities. Luria (1963b) expressed a similar view when he argued that brain injuries occurring in early childhood remove the basis on which future development depends and thus have more serious consequences than injury sustained in adulthood.

Brain-damaged children tend to have lower overall IQ's than do normal children (Ernhart *et al.* 1963; Reed, Reitan and Kløve 1965; Reitan 1974). Barth and Boll (1981) indicated that whilst this is often the case in adults as well, there have been fairly frequent reports of IQ scores not affected after brain damage in adults (e.g. Lezak 1983; Walsh 1985). A finding related to this is that Reitan (1959) reported the Halstead Impairment Index to be significantly more sensitive to the effects of brain damage in adults than were measured on the Wechsler-Bellvue scales. In contrast, Reed, Reitan and Kløve (1965) and Reitan (1974) have found the Wechsler scales to be more sensitive than the Reitan Battery in distinguishing brain-damaged and normal children. Boll (1978) argued that this could reflect:

- Qualitative differences between the psychological functioning of brain-damaged adults and children. Reitan (1958) reported that inter-correlations among an extensive battery of psychological tests were essentially similar in normal and brain-damaged adults, which he argued suggested that the same abilities were being measured in the two groups. (The level of ability between the groups was, however, different.) Boll and Reitan (1972b) performed a similar study on brain-damaged and normal children (aged nine to 14 years) and found a lack of similarity between intercorrelations in the two groups, which suggests that different abilities were being measured. The authors interpreted these results as being possibly indicative of a qualitative as opposed to quantitative difference existing between children and adults (as, for example, suggested by Piaget (Flavell 1963)). Thus, in addition to lowering the level of ability, brain damage in children may also result in changes in the strategies used to solve problems and the basic pattern of ability development. If this is so, the confidence with which one can generalize from the known performance of adults to the expected performance of children is limited (Boll and Reitan 1972a, 1972b).

- The possibility that IQ tests measure different types of intelligence at different ages. Hebb (1942) argued that there are two components to intelligence: 1) intelligence A which is an innate potential for intellectual development and is immediately diminished by brain injury; and 2) intelligence B which is an estimated level of intellectual functioning at maturity and thus develops with experience. It is relatively impervious to the effects of brain damage. IQ tests primarily measure intelligence B. Children have less type B intelligence than adults and rely mainly on type A intelligence when taking IQ tests. Their performance, according to Hebb, on these tests is thus poorer than that of adults as the tests reflect type A intelligence in children which, as mentioned, is more susceptible to the effects of brain injury than intelligence B, which adult IQ tests reflect. Hebb's position is similar to that of Halstead (1947) who distinguished between biological and psychometric intelligence, and in keeping with Cattell's (1963, 1971) concept of fluid and crystallized intelligence.

Brain-injured children have also been found to differ from adults in the pattern of deficits observed. In the main, the results of studies have supported the postulate by Vygotsky (1965) that early brain injury has less effect on simple than on complex functions (see Section 3.4.1).

Boll (1972) found tasks measurin' concept formation to be more sensitive to the presence of brain damage in children than tasks of auditory, visual and tactile perception. Several authors have reported that performances involving the use of verbal and conceptual skills are more impaired in brain-injured children than are perceptual-motor and adaptive problem-solving abilities. The converse is generally true for adults (Boll 1974; Reed, Reitan and Kløve 1965; Graham *et al.* 1962). Graham *et al.* (1962) pointed out that as the vocabulary sub-test of the Wechsler is relatively insensitive to brain damage in adults, it can be used to establish prior levels of functioning. This is the concept behind the Wechsler Deterioration Index (e.g. Lezak 1983; Walsh 1978).

For instance, findings regarding the effects of brain damage on motor functions in children tend to be equivocal. Reitan (1974) and Reed, Reitan and Kløve (1965) reported that motor functions are not especially sensitive to the effects of brain-damage in children. In contrast, Tushima and Scott Towne (1977) contended that motor disabilities were an important feature in young brain-injured children and suggested that motor tasks can also be used in the discrimination of brain damage. More recent work by Reitan and a colleague (Nici and Reitan 1986) appears to support the latter finding. They found that measures of motor functions, as well as of general neuropsychological ability, best discriminated a brain-damaged group of children from the control group. In adults, the results have tended to vary depending on the type of brain injury sustained (Reitan 1974). For instance, Reitan and Fitzhugh (1971) found that motor deficits were more severe than deficits in higher mental processes in adults with cerebral vascular disease, whilst adults with traumatic injuries displayed far less motor impairment.

Thus, the results of studies of children regarding the patterns of psychological deficit do suggest that the interaction of brain injury and development leads to rather different patterns of deficits from those found in adults and seem to suggest that brain damage has more serious consequences for children than adults (Reitan 1974). This point is well illustrated by Luria (1963b p.16-17) who described the consequences of damage to the occipital lobes in adults and children. He indicated that injury to the occipital lobes in adults disturbs the ability to perceive clearly and analyze visual stimuli. Auditory and tactile perception, writing, speech and the ability to understand abstract material, however, remain intact and these abilities can be used to partially compensate for difficulties experienced with visual perception. Thus in adults, whose major functional systems have already developed, brain damage tends to affect abilities directly associated with the injured area and alternative functional systems can be used to compensate for the deficit. In contrast, the basic functional systems fail to develop in the brain-injured child. Damage to the occipital areas at an early stage in a child's development results in the loss of the ability to compare, analyze, synthesize and systematically store afferent visual stimuli. As a result speech, which usually develops on a foundation of clear and continuous visual perception, cannot develop properly and is vacuous and devoid of required structure. Consequently, all of the child's thinking and behaviour is underdeveloped.

> "In sum even a small locus of injury which disrupts the normal function of those processes necessary for future mental development leads to a delay and disturbance of development with the consequence that the child's mental life is far more barren than it might have been."
>
> (Luria 1963b p.17.)

On the basis the studies described the generalization of information obtained from the investigation of adults with brain-behaviour disturbances to children would seem to be invalid. Approaches to the neuropsychological assessment of children are discussed in the next section.

3.3 APPROACHES TO THE NEUROPSYCHOLOGICAL ASSESSMENT OF CHILDREN

> "The neuropsychological assessment of children is a very complex undertaking."
>
> (Rourke *et al.* 1983, p.112.)

As indicated earlier (See Section 2.1), most neuropsychological procedures have been developed for use with adults. Although several approaches appropriate for use with school-age children now seem to exist (see, for example Golden 1981b; Hynd and Obrzut 1981; Rourke *et al.* 1983; Rourke, Fisk and Strang 1986), as Chadwick and Rutter (1984) have pointed out, the range of standardized tests available for use with children is at present much narrower. This appears to be especially true for preschool children (Hartlage and Telzrow 1981).

Furthermore, many of the tests used in the neuropsychological investigation of children appear to be simplifications (Schachter 1983) and/or downward extensions (Telzrow 1983) of tests originally developed for use with adults. However, as indicated in the previous section, brain damage has different effects at different ages. A range of functions which change with age thus need to be evaluated (Chadwick and Rutter 1984). It would therefore seem important to devise assessment procedures which take cognisance of the differences between adults and children (Schachter 1983) and can thus evaluate the differential effects of brain damage at different age levels (Gaddes 1981; Rourke, Fisk and Strang 1986; Schachter 1983).

Within the field of child neuropsychological assessment clinicians seem, however, to differ in regard to the type of evaluation procedure to use for such an examination. As with adults, the use of single and traditional psychodiagnostic procedures has been proposed (e.g. Sutter and Battin 1984). Drawbacks associated with the use of such instruments were discussed in Section 2.3.1 and will not be reviewed again. Suffice to say that, as argued by Weiner (1967 p.367), their use frequently results in "dead end diagnostic labelling".

Several clinicians have developed their own, frequently flexible, battery from available tests for children. In this instance, the rationale governing test selection appears to vary, apparently depending primarily on the clinician's conceptualization of the development of brain-behaviour relationships.

For instance, as regards preschool children, Hartlage and Telzrow (1981) suggested a localizationist-type approach in which test selection was based on the ability of the procedures to evaluate frontal, temporal and parietal lobe functioning. This approach does not, however, appear to take cognisance of the fact that the relationship between various neuropsychological measures and brain functioning in children is not well known, as it has not received the same degree of attention as in adults (e.g. Rourke, Strang and Fisk 1986). Telzrow (1983) has further proposed that an appropriate assessment procedure for very young children should be both developmentally relevant and sensitive to basic biological processes. She argued that reaction and movement time possess these qualities. Such an approach would not, however, be appropriate for a comprehensive evaluation of neuropsychological functioning.

Obrzut (1981) suggested that a comprehensive battery of tasks should be selected in terms of their ability to evaluate hierarchies of information processing in the sensori-motor, cognitive and language spheres. An allied approach would seem to be that of Rourke and his associates (e.g. Rourke 1976; Rourke *et al.* 1983; Rourke, Fisk and Strang 1986) who, in their work with children, have advocated the use of a battery designed to examine a wide range of skills, such as all modalities of sensory-perceptual skills, motor and visual-motor abilities, language, problem-solving and concept formation skills, as well as attention and sequencing capacities. In apparent contrast to other workers, their emphasis has been on assessing children in order to devise an appropriate treatment programme (Rourke, Fisk and Strang 1986). Test selection does not appear, however, to have been guided by a comprehensive scheme of brain-behaviour development. Rourke *et al.* (1983) further argued that the most effective neuropsychological approach to examine such a broad range of skills in children, is one which combines the standard battery and flexible approaches. According to these authors the best features of the two can be capitalized on, whilst the drawbacks can be avoided (see Sections 2.3.2 and 2.3.3). They thus advocated that an initial assessment with a standard battery be followed by probing of specific areas of dysfunction with a flexible battery of tasks.

Currently, the standard battery most widely used for the neuropsychological evaluation of children appears to be the Halstead-Reitan tests (Klesges 1983; Reynolds 1982). Two batteries have been developed for children.

1. The Halstead Neuropsychological Test Battery for Older Children (nine to 14 years). This battery is very similar to the adult one described in Section 2.3.2 and basically consists of modified and simplified versions of the adult subtests (Reitan 1975; Reitan and Davison 1974; Selz 1981);

2. The Reitan Indiana Neuropsychological Test Battery for Children (five to eight years). This battery comprises downward extensions and simplifications of the tests in the battery for older children as well as several new tests which Reitan developed specifically for children in this age range (Reitan 1975; Reitan and Davison 1974; Selz 1981).

A description of the tests comprising these batteries may be found in Boll (1981), Golden (1979), Reitan and Davison (1974) and Selz (1981).

As in the adult battery, interpretation of the children's batteries involves blind analysis and attempts to discriminate the three forms of brain dysfunction using the four methods of inference described in Section 2.3.2.

Although there has been less experimental verification of the children's batteries than of the adult form, studies completed have generally shown the battery to be effective in discriminating between brain-damaged and normal children (e.g. Boll 1972, 1974; Boll and Reitan 1972b; Klonoff and Low 1974; Nici and Reitan 1986; Reed, Reitan and Kløve 1965; Reitan 1974). In addition, studies have been reported on the efficacy of the battery for, for example, evaluating children with mental retardation (e.g. Matthews 1974), mild cerebral dysfunction (e.g. Klonoff and Low 1974), learning disabilities (e.g. Selz and Reitan 1979; Tsushima and Towne 1977), asthma (Dunleavy, Hansen and Baade 1981), and phenylketonuria (Pennington *et al.* 1985). The battery has also been compared to other procedures such as the Luria-Nebraska Neuropsychological Battery —— Children's Revision (LNNB-C) (discussed later on in this section) and the Wechsler Intelligence Scale for Children —— Revised (WISC-R) (Klesges 1983). In the latter study, many Halstead Reitan Neuropsychological Battery (HRNB) subtests were found to correlate significantly with the WISC-R IQ scores. In addition, Reitan and Herring (1985) have produced a short screening protocol, drawn from the battery, that is able to differentially diagnose brain-damaged and normal children with a high degree of accuracy. Furthermore, in an attempt to make the battery more portable, a booklet version of the Halstead Category Test has been devised for nine to 14 year old children (Byrd and Warner 1986).

Selz and Reitan (1979) have also developed a system of 37 rules which discriminate between normal, learning-disabled and brain-damaged children with 73 percent accuracy. These rules are based on the four methods of inference advocated by Reitan (see Section 2.3.2). Hevern (1980) has suggested that additional research is needed in order to identify the nature of the cerebral dysfunction underlying the types of learning disabilities identified by this approach to neuropsychological assessment. Reitan (1984) has more recently developed an impairment index of brain functioning in children based on these rules. His findings suggest that it may be a valid and objective indicator of brain functions in older children, although he indicated that cross-validation is still required. Of note, however, is an attempt by Coolidge *et al.* (1985) to cross-validate one of the Selz and Reitan rules —— namely the "pattern IQ" rule that extreme subtest scatter on the WISC-R is indicative of brain dysfunction. These authors failed to find this rule sensitive to brain impairment in children.

The criticisms discussed in Section 2.3.2 in terms of the adult Halstead-Reitan battery are also applicable to the children's forms. In addition, as Majovski *et al.* (1979a) have pointed out, neither of the children's batteries incorporate developmental concepts of the child's brain-behaviour processes.

Several attempts appear to have been made to utilize Luria's theoretical and assessment approach for children. In contrast to the approaches described above, these protocols are based on Luria's theory of brain-behaviour functioning. In Poland, for instance, Kaczmarek (1986) has devised a flexible, qualitative procedure, on the basis of Luria's adult work, for examining language disabled children. The emphasis in this protocol is consequently on non-verbal tasks. In America, the Kaufman Assessment Battery for Children (K-ABC) has been developed (e.g. Kamphaus 1985; Kaufman *et al.* 1982; Kaufman and Reynolds 1984; Majovski 1984). This instrument is designed to evaluate intelligence and achievement in two and a half to 12½ year olds. Although not based directly in Luria's assessment approach, the theoretical view underlying the procedure is Luria's conceptualization of simultaneous and sequential modes of information processing (see Chapter 2, Section 2.4.1). The K-ABC is thus not a comprehensive neuropsychological battery, but is suitable for inclusion in a large battery of tests (Majovski 1984). Preliminary research has shown that it has predictive, construct and concurrent validity and shows particular promise for the design of remedial programmes (Kaufman and Reynolds 1984). Two attempts to adapt Luria's assessment approach for children have also been made in America. Majovski and his co-workers in doing so, have retained the flexible nature of Luria's approach (Majovski *et al.* 1979a, 1979b), whilst Golden and his associates have developed a standardized battery (Golden 1981; Golden and Wilkening 1981).

Theoretically, the Clinical Neuropsychological Evaluation (CNE) developed by Lawrence Majovski and his colleagues (Majovski *et al.* 1979a, 1979b), is based on the developmental scheme of brain-behaviour relationships of Luria and Vygotsky (see Sections 2.4.1 and 3.4). These authors indicated that it was developed for use as a clinical research tool and screening instrument for pinpointing areas of behavioural deficit for further indepth evaluation with additional procedures such as standardized psychological tests (e.g. WISC-R, Illinois Test of Psycholinguistic Abilities (IPTA)) and/or neuropsychological batteries (e.g. Luria's Neuropsychological Investigation (LNI), Luria-Nebraska Neuropsychological Battery (LNNB), HRNB).

The CNE is designed for use with school-age children and adolescents (i.e. aged ten years and older). The organization of the protocol was derived from Christensen's (1975) LNI, whilst items were selected and adapted from both the LNI and Luria's Russian publication *Scheme of Neuropsychological Investigation* (Luria 1951 cited by Majovski *et al.* 1979a). In addition, the authors have devised several new items and incorporated a few items from other psychological tests (e.g. items from the WISC-R Block Design subtest). Although administration is flexible, a simple scoring system has been developed to enhance interrater agreement (Majovski *et al.* 1979a, 1979b). A preliminary investigation of the inter-rater reliability of this scoring system by Majovski *et al.* (1979a) suggested that the CNE can be reliably administered by trained researchers and clinicians.

Watts and Tollman (1980a) have argued that the major limitation of this instrument in its present form is that at no point during its development was it administered to normal children. "Test items were initially piloted and revised amongst the author's themselves" (Majovski *et al.* 1979a p.5). This has been confirmed by Tanguay (pers. comm. 1979), a co-author of the publication. The initial pilot subjects comprised five adolescent psychiatric inpatients. Thus whilst most tasks are probably within the capabilities of adolescents, Watts and Tollman (1980a) pointed out that several items from the LNI (Christensen 1975) have been included in the protocol which their research (see Chapter 5) has revealed to be beyond the capabilities of ten to 12 year olds. Majovski and his colleagues are, however, pursuing validity and reliability studies (Majovski *et al.* 1979a; Tanguay pers. comm. 1979). Goehring and Majovski (1984) reported a study in which 20 11 to 19 year old males with "soft" neurological signs were tested with the CNE and scored independently and simultaneously by three clinical psychology graduate students. The findings indicated a high level of interrater reliability for the test and supported its potential as a clinical research tool.

Golden (1981b) has more recently developed the Luria-Nebraska Neuropsychological Battery for Children (LNNB-C) which is largely a downward extension of the adult battery (Tramontana, Sherrets and Wolf 1983) discussed in Section 2.4.3.1.

The modification of the LNNB for children has, according to Golden (1981b), been based on a neuropsychological developmental model. He argued that the rationale on which the Halstead-Reitan Batteries for children are founded is that children and adults are quantitatively different. According to this view, the child possesses the potential to acquire adult abilities which develop sequentially over time. The complexity of the child's abilities thus increases at each developmental stage (Golden 1981b; Golden and Wilkening 1981). Inherent in this conceptualization is the idea that a simplified version of an adult test battery can be used to assess a child (Golden 1981b).

In contradistinction to the Halstead-Reitan children's batteries, Golden (1981b) has indicated that the LNNB-C is based on a qualitative conceptual framework similar to that advocated by Piaget and Vygotsky. According to this position qualitatively different neurodevelopmental stages exist and it is assumed that a child can only acquire certain skills when the appropriate level of neurological development is reached. Further, although the complexity of the tasks which a child can perform increases with age, children at different stages of development also use different strategies to solve them (Golden 1981b; Golden and Wilkening 1981). Golden (1981b) thus argued that, although a simplified version of an adult battery can be used for the assessment of children, the nature of the functional system underlying a behaviour changes as the child passes through developmental stages and, for this reason, the tasks will measure different functions in adults and children of different ages.

Golden has suggested that Luria's theory of brain-behaviour relationships differentiates the following five stages in neurodevelopment (Golden 1981b; Golden and Wilkening 1981):

1. The maturation and operation of the reticular activating system and associated structures, early in the first year of life.
2. The development of the four primary areas, (i.e. motor, visual, auditory and tactile) which usually proceeds concomittently with the first stage.
3. The development of the secondary cortical areas which begins concurrently with the first two stages, but continues through to the preschool period (about age five).
4. The maturation of the tertiary parietal area which is not psychologically active until the child is five to eight years old.
5. Development of the tertiary prefrontal areas which begins in adolescence.

The LNNB-C has been developed for use with eight to 12 year old children although the structure of the battery, including administration and scoring procedures is based on that of the adult battery. Golden has indicated that items comprising the battery are simple enough for a normal eight year old to complete. Items in the adult battery designed to measure abilities of higher developmental levels were therefore eliminated — notably tasks designed to evaluate prefrontal lobe activity. Golden argued that as frontal lobe skills only develop at 12 years, tests of frontal lobe ability are inappropriate in a battery designed for eight year olds. Although children may respond to the tasks, responses will not be indicative of prefrontal lobe activities as the area is not functional at this age. Children with damage exclusively to the prefrontal areas can therefore not be examined on the battery as the theoretical conceptualization on which it is founded precludes the evaluation of this area in children of eight to 12 years. He further argued that effects of early frontal lobe damage may only become evident when the area becomes operational at 12 to 15 years or older (Golden 1981b).

Luria (1979) has however indicated that at the age of three to three and a half years mylenization of neurons of the frontal lobes is in progress and that at this age young children begin to control their behaviour on the basis of verbal instructions (although he places the age at which the verbal mediation of behaviour is fully developed at five to six years) (see Section 3.4.2). Luria additionally pointed out that such behaviour is disturbed in adults with frontal lobe damage. This would seem to suggest, in contrast to Golden's contention, that whilst the frontal area may not be fully functional until much later, Luria views the region as at least partially operational as early as three years of age. Items from the adult LNNB which, for example, evaluate the speech regulation of the motor act should thus perhaps have been simplified, rather than deleted from the children's battery.

The controversy surrounding the development of the adult battery reviewed in Section 2.4.3 appears not yet to have reached the children's version. Golden does seem, however, to have heeded at least some of the criticisms directed at the sample characteristics of research studies conducted on the adult battery. Initial validation studies by Golden and his co-workers have indicated that the children's battery seems effective in discriminating between brain-damaged and normal children (e.g. Gustavson *et al.* 1982; Wilkening *et al.* 1981). These authors have emphasized that these results were obtained on a sample of children with mild functional impairment rather than obvious brain damage, and that different samples of children were used for cross-validation studies. More recently Tramontana and Hooper (1987) have, for instance, found that the battery could identify brain-damage in psychiatric referals. Furthermore, Carr, Sweet and Rissini (1986) reported that the battery was able to identify psychiatric and neurological groups of children. They were also able to demonstrate interrater reliability. In addition, the LNNB-C has been shown to be able to discriminate between normal and learning-disabled children (e.g. Geary *et al.* 1984; Nolan, Hammeke and Barkley 1983; Snow and Hynd 1985), and to distinguish learning-disabled children deficient in reading and spelling from those deficient in maths (Nolan, Hammeke and Barkley 1983). In contrast to these findings, Snow, Hynd and Hartlage (1984) found, however, that although the battery could identify learning-disabled children, it was not sensitive enough to discriminate between different severities of learning impairment. Finally Snow and Hynd (1985) identified three factors which provided some evidence for the factor validity of the battery.

Several studies have compared the LNNB-C to other procedures and found, for example, that the battery effectively predicts Wechsler Intelligence Scale for Children-Revised (WISC-R) and Wide Range Achievement Test Scores (Wilkening *et al.* 1981) although the LNNB-C and WISC-R contain unique information (Sweet *et al.* 1986); that the LNNB-C and HRNB for older children yield similar results (Tramontana, Sherrets and Wolf 1983); that there is a significant, but small correlation between the receptive language, visual, memory, arithmetic and intellectual scales of the LNNB-C and the Peabody Picture Vocabulary Test-Revised (Quattrocchi and Golden 1983); and that although the LNNB-C is a fairly comprehensive battery, the Minnesota Percepto-Diagnostic Test provides information about dimensions of perceptual organization not measured by the test (Snow *et al.* 1983). In terms of the latter finding, Plaisted *et al.* (1983) have acknowledged that the LNNB-C does not measure all neuropsychological skills in children and suggested that additional neuropsychological tests may be used in conjunction with the battery in order to evaluate skills which it does not assess. Finally, Gilger and Geary (1985) have suggested that the LNNB-C may be differentially sensitive to verbal and non-verbal cognitive deficits.

A review of Luria's work with children follows in the next section.

3.4 LURIA'S WORK WITH CHILDREN

> "Psychologically, a child is not an adult in miniature. He fashions his own primitive culture."
>
> (Luria 1977/1978 p.64.)

Vygotsky was Luria's teacher and mentor (Luria 1979; Radzikhovskii and Khomskaya 1981) and as such it is at times difficult to determine where Vygotsky's ideas end and Luria's begin. For this reason pertinent aspects of Vygotsky's work will be reviewed prior to discussing Luria's work with children.

3.4.1 Vygotsky's influence

> "The names Luria and Vygotsky are traditionally linked."
>
> (Radzikhovskii and Khomskaya 1981 p.3.)

As Vygotsky's conceptualization of the development of brain and behaviour relations is the aspect of his work that is primarily relevant to child neuropsychology, it will form the main focus of this review.

Vygotsky's Marxist position seems to be exemplified by the emphasis he placed on the social environment for development (Luria 1978e, 1979, 1980; Vygotsky 1962, 1965, 1978). In keeping with the Marxist principle of dialectical materialism (see Section 2.4) he argued that, during development, man is both a product and active creator of his environment (Luria 1979). Development is viewed as a process which involves the merging of biological maturation with sociohistorical cultural development (Meacham 1977). By means of sociohistorically developed and culturally transmitted tools (both physical and mental, such as language) a child learns to master both his environment and his own behaviour (Luria 1979; Vygotsky 1978).

Vygotsky (1962, 1978) thus theorized that higher mental processes develop during the social interaction between an adult and a child and emphasized the role of verbal communication[1] in the formation and mediation of higher mental processes (see Vygotsky (1962, 1978) and Segal (1982) for an indepth discussion of this viewpoint). Vygotsky's basic idea was that an external or outer regulation (e.g. adult instruction) is internalized by the child so that the regulation becomes inner directed or "voluntary". Thus "a function which was previously divided between two people later becomes an internal function of human behaviour" (Luria 1959a p.341). In other words, during ontogenetic development an interpersonal (societal) process is converted into an intrapersonal process (Vygotsky 1978). In this respect Vygotsky (1978 p.85) described a "zone of proximal development" according to which activities the child can initially only complete with the aid of an experienced learner, he later accomplishes alone[2].

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1. Although textbooks generally refer to the role of *speech* or *language*, Miller (pers. comm. 1986) has indicated that this is an artefact of translation, and that Vygotsky was in fact referring to *communication*.

2. Vygotsky (1978 p.85-90) described the "zone of proximal development" as the distance between a child's actual level of development (as indicated by his ability to solve certain problems independently) and the level of potential development (as determined by the child's ability to solve other, more complex problems with either adult assistance or the help of a more capable peer). Vygotsky thus argued that the process of development lags behind learning and that this sequence creates a zone of proximal development.

In terms of the relationship between language and thought, Vygotsky viewed them as being interdependent but having different genetic roots (Vygotsky 1962 p.33). He proposed that there is a prelinguistic period in the development of thought and a preintellectual stage in the ontogeny of speech and that they initially developed independently. However, gradually after basic spoken language is mastered the two processes merge such that language functions as a tool in the sense that it can transform thought — the underlying organizing structure of these two processes being word meaning. Thinking is thus initially externalized, but gradually becomes internalized and more condensed in nature for efficiency — and this silent verbal thought is what Vygotsky calls inner speech. Although he pointed out that thought is primarily internalized by seven to eight years, it can be externalized by problems at any age. Vygotsky viewed egocentric speech as a form of transition between overt verbal thought and inner speech (Vygotsky 1962).

Vygotsky (1962) and Piaget (1962) have criticized each others' conceptualization of egocentric speech. In part this may relate to the different philosophical traditions in which these two worked. Piaget, for example, in contrast to Vygotsky, regarded society in merely a supportive context rather than the active force in the development of the individual (Meacham 1977). For Piaget, egocentric speech did not play a specific role in a child's thought or activities, but merely accompanied them (Vygotsky 1962). As such Piaget and Vygotsky would seem to differ not only in terms of their conceptualization of the function of egocentric speech, but also in their view on the relation between thought and language (Zivin 1979).

Vygotsky, like Piaget, proposed that during ontogeny higher mental processes pass through a series of stages (Luria 1980). He did, however, differ from Piaget somewhat in this respect in that he emphasized the importance of critical periods, which alternate with stable ones. He argued that during critical periods, children lose many past acquisitions, rather than acquire new ones and consequently, in contrast to stable periods, achieve comparably less and become relative problems. He identified five critical periods occurring at birth, one year, three years, seven years and 13 years (Zender and Zender 1974). It is of interest to note that those periods of crises do seem to broadly coincide with the end/start of Piaget's four developmental stages (see e.g. Flavell 1963), and roughly correlate with episodes of spurts in brain growth (e.g. Epstein 1974).

The question as to how different Vygotsky and Piaget in fact are, thus seems to arise.

According to Vygotsky, both the structure and cortical organization of higher mental processes varies at different stages during their development. A task is therefore carried out by different groups of cortical zones at different stages of ontogeny (Luria 1978g, 1980; Vygotsky 1965). This suggests that the effects of damage to a particular area of the brain will differ at different stages of development (Luria 1980).

Vygotsky (1965) argued that the maturity of elementary functions is a prerequisite for the formation of higher mental processes and that once the latter have matured they organize and influence the former. Vygotsky thus proposed a rule as to the effects of brain damage in adults and children. According to this, brain damage to a particular zone in adults whose functional systems are fully developed will mainly affect a lower centre regulated by the damaged area and undamaged higher functional systems can, within certain limits, compensate for the deficit. In the child, however, damage to the same cortical area will affect a higher functional system which is developmentally dependent on it. This prevents the development of the basic functional systems and results in general mental underdevelopment and disturbances (Luria 1969b, 1973b, 1979, 1980; Vygotsky 1965). As Vygotsky (1965 p.385) wrote: "Development goes upward, dissolution downward."

Vygotsky (1965) further pointed out that identical disorders occurring in children and adults can be the result of damage to different areas of the brain, whilst damage to the same area in adults and children can result in very different behavioural deficits. This obviously has important implications for the accurate evaluation of brain damage and subsequent recovery of function in children and the issue is addressed further in Chapter 6.

3.4.2 Luria's work

> "the basic form of mental development becomes acquisition of the experiences of other people through joint practice and speech."
> (Luria and Yudovich 1959, p.22.)

According to Luria (1979), in studying the nature of mental processes, he and Vygotsky initially investigated both their ontogenetic development and dissolution with brain damage. However, with the advent of World War II the latter work, which was discussed in Section 2.4.1, took precedence. It is his work on the development of mental activity, however, that is discussed in this section.

Whilst the troika of Vygotsky, Luria and Leont'ev developed Vygotsky's concepts, a student group, formed by Luria at the Pedagogical Institute in Moscow, undertook to devise experimental models for the development of mental activity, based on Vygotsky's ideas (Luria 1979). Several tasks used by Luria in his neuropsychological investigations (see Luria 1980) and subsequently incorporated into the LNI by Christensen (1975, 1979a) appear to have originated from this experimental work (e.g. tasks to investigate verbal self-regulation of behaviour (Luria 1979), mediated memory using the pictogram method (Luria 1979) and visual-spatial functions by means of the honeycomb task and tasks involving the discrimination of a figure in a uniform background (Luria 1978d, 1979)).

A basic principle guiding these studies appears to have been the distinction made by Vygotsky between natural (biological) and cultural (environmental) processes. He pointed out that natural processes, which are dominant during the five to seven year age period, change quantitatively during development (e.g. the brain becomes increasingly myelinated and mental processes increase in capacity). In contrast, cultural processes, which are dominant during the 11 to 13 age range change qualitatively (e.g. in terms of memory, the child's natural capacity to retain and retrieve information not only increases, but the strategies the child uses to do so alter) (Luria 1979).

Luria and his co-workers conducted a number of investigations into the development of mediated mental processes such as thinking (Luria 1978b), writing (Luria 1977/1978, 1978c), memory (Luria 1979; Zaporozec 1980) and counting (Luria 1977/1978). All these studies appear to have demonstrated the importance of the social environment for the ontogenesis of higher mental activity and to have traced their development from an initially external, interpersonal activity to an internal, mediated process in the manner proposed by Vygotsky (see Section 3.4.1).

Luria has also investigated the role of hereditary and environmental factors in mental development. This work has primarily involved twin studies in which one monozygotic twin received specialized training in a particular mental process such as language (see Luria and Yudovich 1959) and constructive activity (see Luria 1978d), whilst the other did not. He has shown that despite the identical genetic make up of the twins, the twin who received special training achieved a higher level of functioning than the one who did not, thus suggesting that environmental, rather than genetic factors are important for the development of higher mental functions. Luria's studies on adult individuals living under different socio-economic and cultural conditions in the Central Asian Republic of Uzbekistan have further supported his emphasis on the importance of the social environment as opposed to hereditary in the formation of psychological characteristics. (See Luria (1976b) for a description of this work.)

Luria's work with children which appears to have generated the most interest and controversy is his work on the development of the verbal regulation of behaviour (e.g. Luria 1959a, 1961a, 1979). In this work he made use of the so-called combined motor method originally developed by Ivanov-Smolensky (Bronckart and Ventouras-Spycher 1979; Luria 1979) and initially used by Luria in his work on the nature of emotions which is described in his book *The Nature of Human Conflicts* (Luria 1976c). This technique primarily involves the child's ability to follow instructions in pressing or not pressing a rubber bulb in response to the appearance of a light. Children may also be required to make discriminatory responses according to the colour of the light (Luria 1979).

On the basis of this work Luria has developed a three-stage theory of the development of the verbal regulation of behaviour which seems to parallel Vygotsky's (1962) conceptualization of the development of language and thought. In the first stage (one and a half to three years) language is used only for communication and cannot be used to modify behaviour. During stage 2 (three to four and a half years) the inhibitory (suppression of unwanted motor responses) and initiating (ability of speech to both enhance and begin motor responses) aspects of a child's overt verbalizations can serve to aid the performance of certain motor acts. However, the child responds merely to the vocalization and not to the semantic aspect of it. In the third and final stage (five to six years) speech becomes internalized and the semantic aspect begins to regulate behaviour. As Tinsley and Waters (1982) have pointed out, this work of Luria has focused primarily on the 18 months to six year old age range, perhaps as it is the period within which language develops.

Luria's findings have been difficult to replicate and several authors have argued that this is because he has failed to supply procedural and statistical details (e.g. Bronckart and Ventouras-Spycher 1979; Johnson 1980; Tinsley and Waters 1982). Initial replication studies by, for example, Jarvis (1968); Miller, Shelton and Flavell (1970) and Wilder (1969), produced primarily negative results. Wozniak (1972) reviewed these studies and argued that their failure to replicate Luria's work has primarily been due to the differing interpretations of Luria's ideas and methodology used to investigate them. At the same time other studies have been published (e.g. Bronckart 1973; Johnson 1980) which have tended to support Luria's findings.

Luria (1963b) studied the effects of childhood brain damage on the brain-behaviour relationships of children. He argued that such injuries *"remove the healthy foundation of all future development"* (Luria 1963b p.16 author's emphasis). According to Luria, the same injury in a child and an adult can have different effects. For this reason he emphasized that in order to appreciate the implications of an injury for the child it is important to not only consider the severity of the injury and the initial functional systems damaged, but to *"refract the appraisal of the results of brain injury through the prism of development"* (Luria 1963b p.17 author's emphasis).

Luria used the combined motor method described earlier to investigate brain-injured, mentally-retarded children. He demonstrated that lack of plasticity and inertia of their neural processes, together with disturbances in the regulating function of speech and abstraction and generalization resulted in impaired behavioural organization (Luria 1963b, Luria and Yudovich 1959). He additionally found that the orientating reflex was disturbed in these children, whilst electroencephalographic studies revealed impaired brain electrical activity (Luria 1963b). He stressed, however, that mentally retarded children are not a homogeneous group but differ with respect to the nature of the aforementioned behavioural, neurophysiological and electrical changes depending on the type of injury and developmental stage at which it occurred.

Luria (1960) used Vygotsky's distinction between behaviour based on natural processes and that organized on the basis of higher, mediated processes to distinguish between different forms of retardation. He broadly differentiated two types — general asthenia and feeble-mindedness or retardation. General asthenia is usually caused by malnutrition and some somatic diseases, whilst feeble-mindedness is generally attributable to genetic disorders and intrauterine trauma or toxicity. Using the combined motor method, Luria demonstrated that in children with general asthenia lower behavioural processes are primarily disturbed. The more intact higher verbal system could therefore be used to compensate for the lower motor system dysfunctions. In contrast, the higher behavioural processes were more impaired than the lower ones in feeble-minded children and speech could not be used to compensate for their deficits (Luria 1960).

This work of Luria's with brain-injured children seems to have been conducted primarily on pre-school children and children in the first few years of school. In this research project an attempt to investigate the brain-behaviour relationships of brain-injured children of different ages (eight to 14 years) within the framework of Luria's work with children has thus been made. Information concerning the neuropsychological development of normal children within this age range derived whilst adapting Luria's assessment procedures for children will be discussed in the context of Luria's studies of the development of natural and higher, mediated processes within the next chapter.

CHAPTER 4

PRELIMINARY STUDY: THE ADAPTATION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR USE WITH WHITE, ENGLISH-SPEAKING SOUTH AFRICAN ADULTS

4.1 INTRODUCTION

In this chapter a study conducted by the author in 1977 shortly after *Luria's Neuropsychological Investigation* (LNI) (Christensen 1974a, 1974b)[1] had become available in South Africa is discussed. At this time no research utilizing this procedure seemed to have been published in South Africa and this study was carried out in an attempt to determine the validity and suitability of the LNI for use in South Africa. As such it appeared to be a preliminary step in the present research programme designed to adapt the LNI for use with South African children (see Chapters 5 and 6). This research has been published (Watts and Tollman 1980b),

The objective of this chapter is to outline the aims of this study, the procedure used and to describe and then discuss the results obtained when the underlying structural pathology as suggested by the LNI behavioural reports was compared with CT scan reports on the locality of the lesion and medical files. It is additionally argued that minor modifications will make Christensen's LNI suitable for use with white, English-speaking South African adults.

4.2 RESEARCH OBJECTIVES

In order to adapt the LNI for use with white, English-speaking South African adults, it was decided to administer the battery in the form published by Christensen and to compare the results with CT scan reports on the site of the lesion.

The aims of this study were therefore:

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1. The 1974 publications of Christensen's LNI Text and Manual were used during this preliminary study as the 1975 publication of the Manual and 1975 and 1979 publications of the Text were not yet available.

1. To ascertain to what extent the results of the LNI agreed with CT scanner reports on locality of the lesion, and medical files;

2. On the basis of 1., to adapt the LNI for use with white, English-speaking South African adults.

4.3 PROCEDURE

4.3.1 Subjects

All brain-damaged and healthy subjects were white, English-speaking South African adults. Please turn to Table 1 over for individual profiles of each subject in terms of age, education, socioeconomic status, medical and assessment information.

Brain-damaged subjects

Ten brain-damaged subjects were selected during the time period July - September 1977 by the staff of the Department of Neurosurgery, Wentworth Hospital, Durban, on the basis of the following specifications as laid down by the author:

- The patient had suffered some form of brain disease or head injury; and
- The patient had had a brain scan.

TABLE 2 : CHARACTERISTICS OF THE BRAIN-DAMAGED ADULT SAMPLE

SAMPLE SIZE	n = 10
AGE (YEARS)	Range: 20 - 69 Mean: 36,8
SEX	Male: n = 7 Female: n = 3
LEVEL OF EDUCATION	Range: Std. 6 - Std. 10 Mean: Std. 8
SOCIO-ECONOMIC STATUS	Upper white collar : n = 1 Lower white collar : n = 3 Upper blue collar : n = 3 Lower blue collar : n = 3
MARITAL STATUS	Married: n = 4 Single : n = 6
PATHOLOGY	Head injury - Closed : n = 6 - Penetrating : n = 1 Cerebral tumour (frontal lobe): n = 2 Epilepsy (frontal): n = 1

Table 2 describes the characteristics of the sample. Several aspects of the sample require further clarification.

TABLE 1 : INDIVIDUAL PROFILES OF EACH ADULT SUBJECT IN TERMS OF AGE, EDUCATION, SOCIOECONOMIC STATUS, MEDICAL AND ASSESSMENT INFORMATION

TABLE 1.1 : ADULT BRAIN-DAMAGED SUBJECTS

SUBJECT	SEX	AGE (YEARS)	LEVEL OF EDUCATION	SOCIOECONOMIC STATUS	MARITAL STATUS	PATHOLOGY	DATE OF INJURY AND/OR OPERATION	DATE(S) OF BRAIN SCAN(S)	TIME AFTER INJURY	DATES OF ASSESSMENT	PLACE OF ASSESSMENT	TOTAL TIME TAKEN TO ASSESS (HOURS)
1	Male	55	Matric	Upper white	Married	Penetrating head injury	12.03.1977	20.04.1977	4 months	19.07.1977 21.07.1977	Home	5,0
2	Male	25	Std. 8	Upper blue	Single	Closed head injury	27.02.1977	07.04.1977	5 months	26.07.1977 27.07.1977	Wentworth Hospital	4,0
3	Female	20	Std. 7	Upper white	Single	Epilepsy (frontal); right frontal amygdaloidectomy	03.02.1977	05.02.1977	5 months	27.07.1977 28.07.1977	Home	4,5
4	Female	39	Std. 8	Lower white	Single	Closed head injury	± 1959	18.06.1976	27 years	03.08.1977 05.08.1977	St. Giles Association for the Handicapped	5,5
5	Female	48	Std. 8	Lower white	Married	Tumour (left frontal lobe)	12.04.1977	14.04.1977 12.05.1977	4 months	08.08.1977 09.08.1977	Home	5,0
6	Male	33	Std. 7	Lower blue	Single	Closed head injury	± 1969	22.10.1975	8 years	16.08.1977 17.08.1977	St. Giles Association for the Handicapped	4,0
7	Male	69	Std. 6	Upper blue	Married	Tumour (right frontal lobe)	17.05.1977	26.05.1977	2,5 months	18.08.1977 19.08.1977	Home	5,5
8	Male	37	Std. 8	Upper blue	Married	Closed head injury	23.03.1977	08.05.1977 18.07.1977	4 months	29.08.1977 30.08.1977	Wentworth Hospital	5,5
9	Male	21	Matric	Lower blue	Single	Closed head injury	30.05.1976	07.06.1976	15 months	01.09.1977 02.09.1977	Home	2,0
10	Male	21	Std. 8	Lower blue	Single	Closed head injury	26.06.1977	07.07.1977	2 months	12.09.1977 13.09.1977	Wentworth Hospital	5,0

TABLE 1.2 : ADULT HEALTHY SUBJECTS

SUBJECT	SEX	AGE (YEARS)	LEVEL OF EDUCATION	SOCIOECONOMIC STATUS	MARITAL STATUS	DATES OF ASSESSMENT	PLACE OF ASSESSMENT	TOTAL TIME TAKEN TO ASSESS (HOURS)
11	Male	23	Std. 9	Lower white	Single	05.09.1977 06.09.1977	Home	2,5
12	Female	21	Std. 9	Lower white	Single	07.09.1977 08.09.1977	Home	2,5

Healthy subjects

Two healthy adults with no known history of brain dysfunction were included in the study as it seemed necessary to confirm that the "normal" subject could complete all the items with relative ease. One subject was male and one female and they were aged 23 and 21 respectively. Both were unmarried, had passed standard nine and were lower white collar workers (see Table 1).

4.3.2 Method

4.3.2.1 Administration of Luria's Neuropsychological Investigation

The LNI was administered as per Christensen (1974) by the author. The procedure used to determine cerebral dominance (Christensen 1974a p.37) and the musical instrument used in the investigation of acoustico-motor functions (Christensen 1974a p.56; 1974b p.19) are described in Chapter 5 Section 5.3.1.2.

Brain-damaged patients were assessed "blind" — i.e. with no knowledge of medical or neurological findings. A suggestion as to the location of the lesion was then made on the basis of their LNI behavioural performance. Only then was this diagnosis compared with CT scanner reports on the locality of the damage and medical files.

Information concerning the place, duration and number of assessment sessions for both the brain-damaged and healthy subjects is detailed in Table 3.

TABLE 3 : INFORMATION PERTAINING TO THE PLACE, DURATION AND NUMBER OF ASSESSMENT SESSIONS FOR BRAIN-DAMAGED AND HEALTHY ADULT SUBJECTS

SUBJECTS	PLACE OF ASSESSMENT			TIME TAKEN TO ASSESS (HOURS)			MEAN NUMBER OF ASSESSMENT SESSIONS
	HOME	WENTWORTH HOSPITAL	ST. GILES ASSOCIATION FOR THE HANDICAPPED[1]	RANGE	MEAN	TOTAL	
BRAIN-DAMAGED	5	3	2	2,0-5,5	4,6	46,0	2
HEALTHY	2	0	0	2,5	2,5	5,0	2

1. St. Giles Association for the Handicapped is an institution providing

- *Sample size*

  The LNI was administered to ten patients. (Mean time taken to assess: 4,6 hours.) Only brain-damaged patients available at the time of the study who had had a brain scan were included in the sample.

- *Socio-economic status*

  Socio-economic status was determined as per H.L. Watts (1976 p.63) on the basis of occupation as follows:

  1. Male:
     a. working - present occupation
     b. not working - last permanent occupation
     c. retired - highest previous occupation
  2. Female:
     a. married - husband's highest previous or present occupation
     b. widowed - husband's highest previous occupation
     c. divorced - own occupation unless husband's was higher
     d. unmarried dependent - father's highest previous or present occupation
     e. unmarried, independent - own occupation

Four categories of socio-economic status were delineated (Watts, pers. comm. 1977):

1. Upper white collar - executive, managerial, senior administrative and professional workers.
2. Lower white collar - subordinate administrative, clerical, commercial and non-manual technical workers.
3. Upper blue collar - skilled and supervisory manual workers.
4. Lower blue collar - semi-skilled and unskilled workers.

- *Marital status*

  All single patients had never been married

- *Pathology*

  Disorders are as given in the medical files, Wentworth Hospital, Durban. All closed head injuries were the result of motor vehicle accidents and the penetrating head injury, a self inflicted missile wound. Cerebral tumours had been surgically removed at the time of this study in both patients in which they were diagnosed. The epileptic patient had undergone a frontal amygdaloidectomy.

4.3.2.2. Data recording

To simplify and enhance the accuracy of recording and analysing each subject's responses and behaviour during assessment, recording sheets were constructed. These sheets are an expansion and, for the purposes of this study and the Neuropsychology Unit in the Psychology Department, University of Natal, Durban, an improvement of those supplied by Christensen (1974) (see Appendix 1). In addition, each subject's verbal responses were taped to facilitate a later, more detailed analysis of the results and to enable repeated analyses in cases of ambiguity and, if necessary, to obtain interobserver agreement. Copies of the completed LNI record forms and reports, CT scan reports and transcriptions of the medical files for each subject participating in the research programme have been stored at the Neuropsychology Unit, Department of Psychology, University of Natal, Durban. They are available from the head of the Unit, Dr. S.G. Tollman, on request.

4.3.3 Modification of the tasks

Although Christensen recommended the LNI for use in the West, it was found that several items had to be changed and adapted to a white, English-speaking South African culture. The way in which this was done is described in Section 4.4.3.

4.4 RESULTS

4.4.1 Comparison between Luria's Neuropsychological Investigation results, brain scanner reports on locality of damage and medical files

The locality of the lesion as suggested by each brain-damaged subject's performance on the LNI are compared with CT scan reports in Table 4. Please refer to Appendix 2 for a description of the behavioural performance of each subject on the LNI. In addition, summaries of CT scan reports and medical files for each brain-damaged subject have been included in this appendix.

TABLE 4 : COMPARISON BETWEEN LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION (LNI) FINDINGS AND CT SCAN REPORT

SUBJECT	LNI FINDINGS		CT SCAN REPORT AS TO SITE OF LESION	COMPARISON
	PRIMARY BEHAVIOURAL DISTURBANCE(S)	SUGGESTED SITE OF LESION		
1	Frontal dynamic aphasia	Left frontal lobe	Left frontal region.	+
2	Higher mental processes intact. Damage to peripheral innervation of articulatory apparatus causing salivation, indistinct and expressionless speech, deviance of tongue to side. Paralysis to right side of face.	Nucleii of nerves controlling salivation, facial movement and sensitivity of face and tongue situated in pons.	Pons.	+
3	Pathological inertia of previously formed programme of action which manifested as motor perseveration.	Both frontal lobes.	Right frontal lobe.	+
4	Disturbance of spatial abilities; ready distractability.	Parieto-temporal regions and diffuse pathology.	Bilateral cortical atrophy.	+
5	Disturbance of phonemic hearing and resultant sensory (acoustic) aphasia.	Left temporal lobe	Scan 1: left frontal tumour Scan 2: (following surgical removal of tumour) left frontal lobe.	-
6	Higher mental processes intact.	No evidence of brain damage.	No abnormalities demonstrated.	+
7	Pathological inertia of motor processes which manifested as motor perseveration.	Both frontal lobes.	Right frontal lobe.	+
8	Pathological inertia which appeared as perseveration of the programme of action.	Both frontal lobes.	Scan 1: Parietal region Scan 2: No abnormalities Scan 3: Slight increase in size of 3rd and 4th ventricles, although they are within normal limits.	-
9	Higher mental processes intact.	No evidence of brain damage.	No abnormalities demonstrated.	+
10	Pathological inertia in the form of an inability to create a stable intention to remember, together with a failure to "shift" recall from one group of traces to another.	Both frontal lobes.	Left and right frontal lobes.	+

* KEY

+ agreement between CT scan report and LNI findings

- disagreement between CT scan report and LNI findings

There was a significant agreement between the results of the LNI and brain scanner reports on locality of lesion. (Sign test; $x = 2$; $n = 10$; $p = 0{,}055$; one-tailed test.) There was complete agreement in eight out of the ten cases investigated. In the remaining two cases (Subjects 5 and 8), the results of the LNI correctly suggested brain damage, but there was a discrepancy as to the *location* of the damage (see Table 4). The behavioural disturbances described in the medical files, were, however, compatible with those revealed by the LNI.

In the first case (Subject 5) there was a discrepancy between the results of the LNI and the brain scanner reports as to the location of the damage within the left hemisphere. The results of the LNI suggested a lesion in the left temporal lobe with a resultant speech deficit — the brain scans revealed a tumour occupying almost the entire left frontal lobe and the medical file described the patient as "aphasic". This discrepancy could probably be accounted for by one of the following:

- The patient was assessed four months after having had a brain scan. In the interim the tumour had been surgically removed from the left frontal lobe. No subsequent brain scan was done — thus the extent of the damage caused by surgery was unknown.
- Tumours are sometimes accompanied by hypertension and dislocation which could cause changes in cerebrospinal fluid circulation. Tumours in some instances also affect the blood supply and vascular system which would result in a disturbance of the normal nutrition of the brain beyond the area of the lesion. Rapidly expanding and disintegrating tumours may, in addition, be accompanied by a general toxic factor. The effect of such general cerebral abnormalities on the disturbance of those functions affected by the circumscribed cerebral tumour may thus considerably complicate the topical diagnosis (Lishman 1978; Smirnov 1951, cited by Luria 1966a). This was confirmed by Thorne (pers. comm. 1979) although he cautioned against overgeneralization. The patient under discussion exhibited an extensive tumour.
- Speech is the result of a highly complex integration of nervous processes instigated by the combined activities of different parts of the brain. Although damage to any one of these areas results in a specific form of aphasia, there is considerable overlap between them (Luria 1966a[1]).

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1. At the time of conducting the research project the second, 1980, edition of A.R. Luria's *Higher Cortical Functions in Man* was not yet available. The 1966 edition of this book was therefore used for the study reported in this chapter.

Speech is thus a highly pervasive phenomenon and this fact complicates the topical diagnosis of the effects of circumscribed brain lesions. The speech areas of the left frontal and temporal lobes lie very close together and it is possible that in this subject there was a certain degree of overlap between them.

The behavioural profile of this patient did, however, reflect the defects reported in the medical file.

In the second case (Subject 8) where there was disagreement, the subject had had three brain scans prior to assessment, suggesting some confusion regarding the brain scan result. The first scan revealed an extradural haematoma of the left parietal region and considerable cerebral oedema. The extradural haematoma was drained and the second brain scan revealed no abnormalities. According to the medical file, the patient continued to display behavioural disturbances and to complain of severe headaches. A third brain scan revealed slight dilation of the third and fourth ventricles, but they were within normal limits. The results of the LNI suggested damage to the frontal lobes. The behavioural disturbances revealed were, however, compatible with those described in the medical file and by the occupational therapist treating the patient.

4.4.2 Healthy subjects : Performance on Luria's Neuropsychological Investigation

Both healthy subjects completed the LNI without error rapidly and with relative ease. During the investigation they did, however, indicate that the objects, words and expressions listed in Table 5 were unfamiliar to them.

4.4.3 Modification of tasks

Table 5 describes the adjustments which were found necessary in order to render the LNI suitable for adult, white, English-speaking South Africans. The alterations in each case consist of objects, words or expressions which all subjects (healthy and brain-damaged) had indicated during the investigation were unfamiliar to them.

TABLE 5 : ADAPTATIONS REQUIRED TO RENDER LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION (LNI) APPROPRIATE FOR SOUTH AFRICAN USE

TASK (AS SUGGESTED BY LURIA 1966a)	SECTION*	TASK (AS PER CHRISTENSEN 1974a)		
		TASK	CARD, WORD, EXPRESSION	SUBSTITUTION
Naming the dates of well-known events (No examples given) (p.310)	B	Naming the dates of American holidays	1. Washington's Birthday 2. Labour Day 3. Guy Fawke's Day	1. The Day of the Covenant 2. Republic Day 3. Christmas Day
Naming clearly drawn objects in pictures (No examples given) (p.360)	G	Naming objects in pictures	Card G5: two glass measuring cylinders	Card G5: glass measuring jug (see plate 1.1)
1. Identification of picture, whose title has been given from among other pictures (No examples given) (p.379) 2. Stating the meaning of the words caterpillar, centipede, magnolia, etc. (p.380)	H	1. Identification of 'the stove' from among other objects 2. Defining words	1. Card H12: Open iron 'fireplace' 2. Magnolia	1. Card H12: modern electrical stove (see plate 1.2) 2. Protea
Naming objects (with names that are not particularly familiar) in pictures e.g. a mortar, a book-case, a poker (p.398)	J	Naming objects in pictures	a. Card J14 (& H13): pestle and mortar b. Card J16 (& H15): pepper grinder c. Card J18: Stand for holding eggs	a. Card J14 (& H13): ice-bucket (see plate 1.3) b. Card J16 (& H15): pepper cellar (see plate 2.1) c. Card J18: egg container in refrigerator (see plate 2.2)
1. Explaining the meaning of well-known metaphors e.g. stony heart, iron hand, green thumb (p.453) 2. Relating word in a given series to a more general category, e.g. a flower — a rose; a fish — a card (p.458)	N	1. Explaining the meaning of common expressions 2. Naming group of objects to which item belongs	1a. iron hand b. green thumb 2. carp	1a. iron fist b. green fingers 2. salmon

* Sections refer to Christensen (1974a) LNI Manual.

Section B : Preliminary Conversation (p. 9)
Section G : Higher Visual Functions (p.23)
Section H : Impressive Speech (p.26)
Section J : Expressive Speech (p.31)
Section N : Intellectual Processes (p.47)

PLATE 1.0

ADAPTED STIMULUS CARDS FOR THE PROPOSED LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR SOUTH AFRICAN ADULTS : CARDS G5, H12 AND J14.

1.1 Card G5 : Glass measuring jug.

1.2 Card H12 : Modern electric stove.

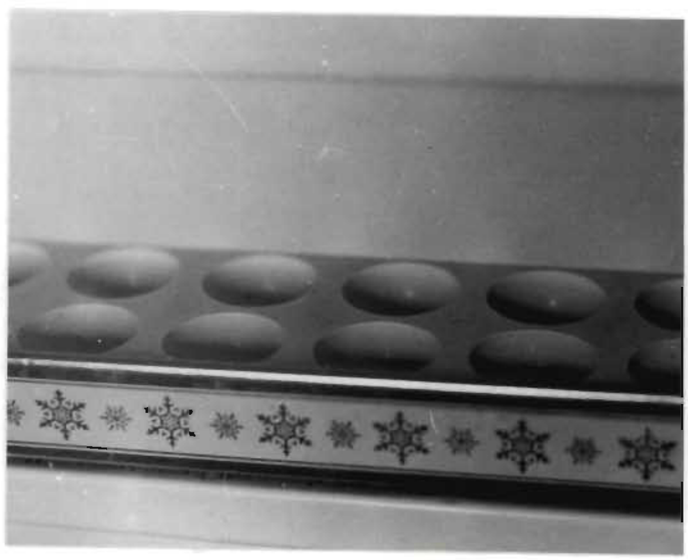
1.3 Card J14 (and H13) : Ice-bucket.

PLATE 2.0

ADAPTED STIMULUS CARDS FOR THE PROPOSED LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR SOUTH AFRICAN ADULTS : CARDS J16 AND J18.

2.1 Card J16 (and H15) : Pepper celler.

2.2 Card J18 : Egg container in refridgerator.



The LNI as per Christensen (1974) is based on Luria's original work. In his book *Higher Cortical Functions in Man* Luria (1966a) outlines the type of task the subject must perform in the neuropsychological investigation he has developed — only sometimes citing examples of actual items which may be used. Following Luria, Christensen has suggested specific examples for all the tasks included in the investigation. However, in her interpretation of Luria's work, she has not always rigidly adhered to Luria's examples. For instance, in the preliminary conversation, Luria (1966a) requires the examiner to determine if the patient can name the dates of well-known events. He does not specify what these events should be.

Christensen (1974a) has used American holidays and seems to have chosen them on an *ad hoc* basis. Similarly, during the investigation of expressive speech, Luria requires the patient to name objects (with names which are not particularly familiar) in pictures, and gives as examples, a mortar, a bookcase and a poker. Christensen has, however, used pictures of a pestle and mortar, a table, a pepper-grinder, a paper punch, and a stand for holding eggs.

Adaptations in this study were thus based on both Luria's description of his techniques and Christensen's interpretation of them. Similar items which are familiar to South Africans were substituted, e.g. American holidays were replaced by South African ones.

4.5 DISCUSSION

In the present study a significant relationship was found between brain scanner reports, medical files and the underlying structural pathology as suggested by the LNI. Thus it would seem that the LNI is an effective procedure for describing the behavioural disturbances which are associated with specific lesions and therefore, also for effectively localizing the size of the lesion. It would additionally seem to suggest that clinical symptoms do relate to underlying brain structure in the way suggested by Luria (see Section 2.4.1). There was agreement between behavioural disturbances revealed by the LNI and those described in the medical files in the two cases where there was a discrepancy between the scan report and LNI results as to the location of the lesion. The LNI therefore appears to extend knowledge of a subject's behavioural profile — an advantage for rehabilitation purposes.

An important principle underlying the LNI is that the tasks should present no difficulty to healthy subjects (Luria 1966a; Luria and Majovski 1977). As the LNI originated in Russia and was suggested for the West it is not surprising that minor modifications to the procedure were found necessary. These appeared culturally specific to South Africa (see Table 5). Care was taken to ensure that these modifications did not alter the tasks in question, but merely involved the substitution of objects, words or expressions of the same kind, but familiar to white, English-speaking South African adults. The modified version of the LNI has been successfully employed in a number of research projects within the Neuropsychology Unit of the Psychology Department, University of Natal, Durban. For example, research has been initiated into the neuropsychology of ageing (Tollman 1985; van Zyl 1981), Down's Syndrome (Chrystal 1979) and alcoholism (Tollman 1982) and the test-retest issue investigated (Bosch 1980; Tollman *et al.* 1980). In addition the adapted version of the LNI has been translated into Afrikaans (Craig *et al.* 1983; du Preez 1980; Tollman 1982). Finally, as indicated in Section 2.4.2 studies published subsequent to this one have generally confirmed the efficacy of the LNI for diagnosing brain-damage in adults.

Methodological problems entailed in such a study are discussed in Chapter 7.

To conclude, only minor modifications to the procedure were found necessary to render the LNI suitable for use in South Africa. Furthermore, the modified version of the LNI was found to yield a wide-ranging and accurate description of behavioural disturbances from which the specific site of the lesion can be inferred. Thus this behavioural profile could be a useful adjunct to the clinician's report — providing additional information for the evaluation and rehabilitation of each patient.

This research project thus provided a preliminary step in the adaptation of the LNI for use with South African children.

CHAPTER 5

THE DEVELOPMENT OF A CHILDREN'S VERSION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION

5.1 INTRODUCTION

The aim of this dissertation is to develop within a Lurian framework, an integrated theoretical and assessment approach to the neuropsychological evaluation of children. A research programme was therefore designed to:

- Adapt Luria's Neuropsychological Investigation (LNI) for use with children;
- Assess its ability as an instrument for delineating impaired and preserved functions in children with disturbed brain-behaviour relations; and
- Use it as a research tool for trying to understand brain-behaviour relationships in children with and without known brain damage.

This chapter outlines the first stage in this programme - the development of a children's version of the LNI. It was comprised of three phases:

1. Administration of the suggested LNI for South African adults (see Chapter 4) to a sample of children with no known history of brain dysfunction;
2. Deletion or adaptation of tasks these children completed incorrectly; and
3. Administration of the adapted version of the procedure to a second sample of children with no known history of brain dysfunction in order to ascertain that the proposed modifications were within the range of competence of each particular age group.

This chapter commences with an outline of the objectives of this step of the research programme. Thereafter each phase in the development of Luria's Neuropsychological Investigation for children is described in turn and the results presented. A theoretical-developmental framework for the proposed battery for children, based on Luria's work, is outlined next. The adapted protocol is then evaluated in relation to other prominent children's batteries. Finally, the conceptual framework is discussed in terms of the developmental trends which emerged in the course of this step of the project and other influential views of brain and behavioural development cited in the literature.

5.2 RESEARCH OBJECTIVES

This step of the research programme was designed to develop a children's version of the LNI. In keeping with the rationale underlying the procedure - namely that the tasks can be correctly completed by intact individuals (Luria 1980) - the intention was to adapt tasks to be within the capabilities of all non brain-damaged children of a particular age.

The aims of this study were therefore:

1. To adapt the LNI for use with white, English-speaking South African children aged eight to 14 years such that the tasks are within the capabilities of all intact children within each age group; and
2. On the basis of information obtained in the course of 1, to develop, within Luria's framework, a scheme of the development of brain-behaviour relationships in normal children aged eight to 14 years.

5.3 PROCEDURE

5.3.1 Phase 1 : Administration of Luria's Neuropsychological Investigation for adults to a sample of children with no known history of brain dysfunction

5.3.1.1 Subjects

Ten children (five male and five female) within each age group between the ages of eight to 14 years were assessed.

Subject selection

Two different sampling techniques were used to select children for inclusion in this phase of the study.

1. Durban school principals who had agreed to participate in the research project selected pupils on the basis of criteria supplied by the author (which are described below). These children were assessed at school.
2. The technique which Goodman (1961) described as "snowball sampling"[1] in which an initial group of children who were known to the author and fulfilled the selection criteria were assessed. Their parents were then asked to supply the names of children they knew who qualified for inclusion in the sample. These children were assessed and their parents in turn asked to identify more children, and so on (Baily 1978, Goodman 1961, Kish 1967). Children selected in this manner were assessed at home on week day afternoons and week-ends.

The number of children selected by means of each of these sampling techniques is given in Table 6.

Selection criteria

Children were selected for inclusion in phase 1 on the basis of the following criteria supplied by the author:
- They had no known history of brain dysfunction;
- They had not failed a standard;
- They were the correct age for their standard;
- They were English-speaking whites.

Sample composition

The composition of sample 1 is detailed in Table 6. Several aspects of the sample require further clarification.
- *Socio-economic status*

  This was determined on the basis of father's occupational status at the time of the study or his highest previous occupation if he was deceased, unless the mother's was higher (Watts 1976). The four categories of socio-economic status delineated in the preliminary study were used (see Section 4.3.1).

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1. "The term 'snowball' stems from the analogy of a snowball, which begins small but becomes bigger and bigger as it rolls downhill" (Baily 1978 p83).

TABLE 6 : CHARACTERISTICS OF SAMPLES 1 AND 2

VARIABLES		SAMPLE 1		SAMPLE 2	
		Number of Subjects (n)	% of total Subjects	Number of of Subjects (n)	% of total Subjects
Sample Size		70	100	70	100
Age (years)	8	10	14,3	10	14,3
	9	10	14,3	10	14,3
	10	10	14,3	10	14,3
	11	10	14,3	10	14,3
	12	10	14,3	10	14,3
	13	10	14,3	10	14,3
	14	10	14,3	10	14,3
Sex	Male	35	50,0	35	50,0
	Female	35	50,0	35	50,0
Socio-economic status	Upper white	33	47,1	25	35,7
	Lower white	23	32,9	22	31,4
	Upper blue	13	18,6	17	24,3
	Lower blue	1	1,4	6	8,6
School[1]	Government	33	47,1	56	80,0
	Private	37	52,9	14	20,0
School performance	Top third	15	21,4	16	22,9
	Middle third	25	35,7	27	38,6
	Bottom third	30	42,9	27	38,6
Place of abode	Home	64	91,4	61	87,1
	Institution	6	8,6	9	12,9
Religious affiliation	English Protestant	34	48,6	47	67,1
	Roman Catholic	14	20,0	12	17,1
	Jewish	22	31,4	11	15,7
Sampling technique	School principal	51	72,9	54	77,1
	Snowball sampling	19	27,1	16	22,9

1. Table 7 contains detailed information about this variable

- *School performance*

  See Table 7 for schools. School principals at the schools and parents of children selected by the snowball sampling technique, were asked, by the author, to rank the children according to whether they came in the top third, middle third or bottom third of their standard.

- *Place of abode*

  Six of the children lived in a Catholic institution for orphaned and underprivileged children. The remaining 64 resided at home with their parents.

TABLE 7 : DURBAN SCHOOLS ATTENDED BY CHILDREN IN SAMPLES 1 AND 2

TYPE OF SCHOOL ATTENDED[1]		SAMPLE 1			SAMPLE 2		
		Number of Schools	Number of Subjects	% of total Subjects	Number of Schools	Number of Subjects	% of total Subjects
GOVERNMENT:	Co-educational primary day	5	18	25,7	4	28	40,0
	Girls' primary day	1	3	4,3	2	6	8,6
	Boys' primary day	0	0	0	1	6	8,6
	Boys' secondary day and boarding	2	6	8,6	2	8	11,4
	Girls' secondary day and boarding	2	6	8,6	2	8	11,4
		10	33	47,1	11	56	80,0
PRIVATE:	Jewish co-educational primary day	1	3	4,3	1	1	1,4
	Jewish co-educational secondary day	1	18	25,7	1	7	10,0
	Roman Catholic boys' primary and secondary day and boarding	1	8	11,4	0	0	0
	Roman Catholic girls' primary and secondary day and boarding	1	2	2,9	1	4	5,7
	English protestant boy's primary day	1	6	8,6	1	2	2,9
		5	37	52,9	4	14	20,0
		15	70	100,0	15	70	100,0

Note:

1. This is discussed further in Section 5.3.3.1.

5.3.1.2 Method

Administration of Luria's Neuropsychological Investigation

The suggested LNI for South African adults (see Chapter 4 and Watts and Tollman 1980b) was administered as per Christensen (1975; 1979a). Prior to administration it was deemed necessary to alter several tasks in the protocol which were not relevant for children as indicated in Table 8 below. Tasks/questions were reformulated in terms of a child's position rather than an adults's. This is discussed further in Section 5.6.1.

TABLE 8 : ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS ALTERED PRIOR TO ITS ADMINISTRATION TO CHILDREN

LNI TASK (AS PER CHRISTENSEN, 1975)			ALTERATIONS
SECTION*	PAGE(S)	TASK/QUESTION	
B	9	"Are you married?" - "When were you married?" "Do you have any children?" - "How old are they?"	"What work does your father do?" - Your mother?" - "Do you have any brothers or sisters?" - "What are their names and how old are they?"
B	9	"Where did you go to school?" - "Did you pass any exams?" - "When?" - "What is your occupation?" - "How long have you had this job?" - "Where did you work before?"	"Where do you go to school?" - "How long have you been at this school?" - "What school did you go to before?" - "What standard are you in?" - "What class in that standard?" - "Have you ever failed a standard?" - "When?"
B	10	"Are there any changes in your sexual behaviour?"	Deleted
C	37	Determination of cerebral dominance by means of the dichotic listening test (Kimura 1961; 1967)	Dichotic listening test; Halstead-Reitan Test for Cerebral Dominance: selected portions (Reitan undated); Luria's (1980 pp.411-413) - tasks for detecting latent or partial left handedness: selected tasks (see LNI-C manual, Part 2.1 for a copy of the procedure used).
E	19-20	Musical instrument required to play musical notes not specified	Musical instrument used: xylaphone
K	36	"Will you write a few words about your main ideas on bringing up children?"	"Will you write a few words about your main ideas on looking after pets?"

*KEY

B : Preiiminary Conversation (Christensen 1975 p.9)

C : Determination of Cerebral Dominance (Christensen 1979a) p.37)

E : Acoustico-motor Organisation (Christensen 1975 p.19)

K : Writing and Reading (Christensen 1975 p.35)

Information concerning the school term and number of assessment sessions in which the LNI was administered to the children in Sample 1 is detailed in Table 9.

Total assessment time for Sample 1: 198 hours
Mean assessment time per child: 2 hours 48 minutes

TABLE 9 : INFORMATION PERTAINING TO THE SCHOOL TERM AND NUMBER OF ASSESSMENT SESSIONS FOR SAMPLES 1 AND 2

VARIABLE		SAMPLE 1		SAMPLE 2	
		Number of Subjects	% of total Subjects	Number of Subjects	% of total Subjects
Term assessed	First	6	8,6	8	11,4
	Second	59	84,3	53	75,7
	Third	5	7,1	9	12,9
Number of assessment sessions	One	14	20,0	7	10,0
	Two	56	80,0	63	90,0

5.3.1.3 Data recording and processing

Each subject's responses and behaviour during the assessment were recorded onto the record forms developed for this purpose during the pilot study (see Section 4.3.2.2 and Appendix 1, which contains a copy of these forms). In addition, each subject's verbal responses were audiotaped to permit a more detailed analysis of the results.

Responses to each item on each subject's set of LNI record forms were marked as correct or incorrect. These results were then entered onto a set of charts developed for this intent. As can be seen from the specimen provided in Chart 1, results were recorded onto these charts using a simple system of ticks (✓) and dashes (-). A tick indicated that the item had been correctly completed when administered as per Christensen (1975), whilst a dash signified that the item was 1. incorrectly completed, 2. too difficult to be attempted, or 3. could only be completed if the instructions were simplified.

CHART 1 : SPECIMEN OF CHARTS USED FOR RECORDING THE RESPONSES OF INTACT CHILDREN (SAMPLE 1) ON ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS

AGE AND STANDARD	SEX	SUBJECT	SCHOOL	POSITION IN CLASS
8 YEARS OLD (STANDARD I)	MALE	1 2 3 4 5	P P G P P	1 1 2 2 2
8 YEARS OLD (STANDARD I)	FEMALE	6 7 8 9 10	P P P G G	2 3 3 3 1
9 YEARS OLD (STANDARD II)	MALE	11 12 13 14 15	P P G G G	1 2 3 2 3
9 YEARS OLD (STANDARD II)	FEMALE	16 17 18 19 20	P P P G G	2 1 2 3 2
10 YEARS OLD (STANDARD III)	MALE	21 22 23 24 25	P P P G G	1 1 3 2 3
10 YEARS OLD (STANDARD III)	FEMALE	26 27 28 29 30	P P G G G	1 2 1 3 2
11 YEARS OLD (STANDARD IV)	MALE	31 32 33 34 35	P P G G G	1 3 3 1 2
11 YEARS OLD (STANDARD IV)	FEMALE	36 37 38 39 40	P P P G G	2 1 3 2 3
12 YEARS OLD (STANDARD V)	MALE	41 42 43 44 45	P P P G G	1 2 2 1 3
12 YEARS OLD (STANDARD V)	FEMALE	46 47 48 49 50	P P G G P	2 3 3 2 2
13 YEARS OLD (STANDARD VI)	MALE	51 52 53 54 55	P G G G P	1 3 3 3 2
13 YEARS OLD (STANDARD VI)	FEMALE	56 57 58 59 60	P G G G P	2 3 3 3 3
14 YEARS OLD (STANDARD VII)	MALE	61 62 63 64 65	P P G G G	2 2 3 3 3
14 YEARS OLD (STANDARD VII)	FEMALE	66 67 68 69 70	G P P G G	3 3 3 2 2

Totals (M = male total, F = female total, G = grand total):

LNI ITEMS	8 M	8 F	8 G	9 M	9 F	9 G	10 M	10 F	10 G	11 M	11 F	11 G	12 M	12 F	12 G	13 M	13 F	13 G	14 M	14 F	14 G
2. MUSCLE AND JOINT SENSATION																					
KINESTHETIC SENSATION																					
Movement of limb: (i) upward	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(ii) downward	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(iii) sideways	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
Reproduction of given position of one limb by opposite limb:	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
Repetition of consecutive, passively induced movements with opposite arm:	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
Distinguish between two passively induced, consecutive positions of elbow:	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
3. INVESTIGATION OF STEREOGNOSIS																					
Naming of objects placed in palm: (i) rubber	5	4	9	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(ii) pencil sharpner	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	3	5	8
(iii) paper-clips	5	2	7	4	3	7	4	2	6	4	2	6	5	5	10	4	5	9	3	5	8
(iv) penknife	5	2	7	5	2	7	5	3	8	3	3	6	5	5	10	5	5	10	5	4	9
Naming of same objects placed in opposite hand: (i) rubber	5	4	9	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(ii) pencil sharpener	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	4	9	3	5	8
(iii) paper-clips	5	2	7	4	3	7	4	2	6	4	2	6	5	5	10	4	5	[illegible]	3	5	8
(iv) penknife	5	2	7	5	2	7	5	3	8	3	3	6	5	5	10	5	5	10	5	4	9
Selection of object in hand from objects on table:	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
G HIGHER VISUAL FUNCTIONS																					
1. VISUAL PERCEPTION																					
OBJECTS AND PICTURES																					
Naming of objects: (i) pencil	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(ii) penknife	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10	5	5	10
(iii) rubberband	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iv) coin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Naming of pictures: Card G1:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G2:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G3:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G4:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G5:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G6:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G7:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G8a:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G8b:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G9a:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G9b:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G9c:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G10:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Card G11:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Poppelreuter's Test: (i) Card G12:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) Card G13:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) Card G14:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gottschaldt: (i) Card G15:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) Card G16:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Raven: (i) Card G17:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) Card G18:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) Card G19:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. SPATIAL ORIENTATION																					
Mirror images: (i) Card G20:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) Card G21:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) Card G22:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Drawing from memory: (i) Card G23:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) Card G24:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) Card G25:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Time: (i) 8,57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) 5,09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) 1,25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iv) 11,35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Indicating positions of hands on clock: (i) 12,50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) 16,35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) 11,10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Direction: (i) North	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(ii) East	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(iii) West	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Drawing plan of bedroom :	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. INTELLECTUAL OPERATIONS IN SPACE																					
Koh's Test: Design 1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Design 2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Design 3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Rupp's Test:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Yerkes' Test: (i) Card G29:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The entering of LNI results onto the charts was checked for accuracy by the author on a subsequent separate occasion.

The information on the charts was analysed quantitatively, as well as qualitatively in terms of the age at which each child could correctly complete the adult LNI tasks (see Table 13).

Copies of the completed charts and computerised print-outs have been stored at the Neuropsychology Unit, Department of Psychology, University of Natal, Durban. They are available from the head of the Unit, Dr. S.G. Tollman, on request.

5.3.2 Phase 2 : Adaptation of adult Luria's Neuropsychological Investigation tasks

The second step in developing an LNI for children involved adapting the adult LNI on the basis of the results obtained in phase 1.

Items correctly completed by all eight to 14 year olds and which therefore required no alteration were retained. The adult task was also retained in instances where it was correctly completed by all children of a particular age group or range (e.g. ten to 14 years). Items incorrectly performed by any child below this age group or range (in the present example, eight to nine year olds) or any age group in the entire eight to 14 year old range were adapted as follows:

1. Deleted if they were beyond the capabilities of a particular age group (e.g. eight year olds cannot perform complex arithmetic operations).
2. Adapted by:
   a) replacing some of the stimulus material with that more appropriate for children;
   b) simplifying items by substituting simpler words or examples, reducing the length of sequential tasks and simplifying the procedure and instructions; and
   c) elaboration of tasks.

The LNI as per Christensen (1975, 1979a) is based on Luria's original work. In order to adapt the tasks in question both *Luria's Neuropsychological Investigation Text* (Christensen 1979a) and Luria's

English publications were studied. The main work consulted was Luria's *Higher Cortical Functions in Man* (1980). In some instances it was possible to substitute simpler examples of tasks cited by Luria for those given by Christensen. When this was not possible, suitable examples were selected from already established procedures such as *The Boston Diagnostic Aphasia Test* (Goodglass and Kaplan 1972), Government school syllabi, prescribed reading, spelling, grammar and mathematics text books and from ideas gained whilst administering the adult LNI to children.

Wherever possible a greater number of examples than was required for the final revision of the protocol were included in the preliminary version of the LNI for children. In addition, examples of different levels of difficulty were provided for children of different ages for many of the items.

5.3.3 Phase 3 : Administration of Luria's Neuropsychological Investigation adapted for children to a second age-graded sample of children with no known history of brain dysfunction

The proposed LNI for South African children was administered to a second sample of Durban school children in order to ascertain that the suggested adaptations were adequate.

5.3.3.1 Subjects

Subject selection

The second sample of children was comparable to the first in terms of subject selection (see Section 5.3.1.1 and Table 6), selection criteria (see Section 5.3.1.1) and sample composition in terms of size, age and sex (see Table 6). The composition of the two samples were very similar with respect to other variables except for the following differences:

- Socioeconomic status (see Table 6);
- Type of school attended (see Tables 6 and 7);
- Religious affiliation (see Table 6).

Comparison of both samples of children with available South African census and statistical data

Both samples of children were compared to available South African census and statistical information regarding socioeconomic status, schools attended and religious affiliation.

- *Socioeconomic status*

TABLE 10 : SOCIOECONOMIC STATUS : COMPARISON OF SAMPLES WITH 1970 AND 1980 CENSUS DATA (PERCENTAGES)

SOCIOECONOMIC STATUS	SAMPLE 1	SAMPLE 2	1970 CENSUS DATA (WATTS 1979)	1980 CENSUS DATA (RSA 1985a)
Upper white	47,1	35,7	17,5	32,8
Lower white	32,9	31,4	39,3	44,7
Upper blue	18,6	24,3	24,9	19,3
Lower blue	1,4	8,6	10,2	3,3

Notes:

1. The 1970 census data presented here was regrouped on a socioeconomic basis by H.L. Watts (1979).
2. The 1980 census data presented here was regrouped on a socioeconomic basis by H.L. Watts (pers. comm. 1985).
3. The white and blue collar groups presented in the table comprised 91,8% of economically active white South Africans. The remaining 8,2% of economically active white South Africans comprised independent and managerial agricultural workers (who are often in both white and blue collar (manual) aspects of work) and other occupations not readily classifiable or unspecified - neither of which categories were relevant for this study.

Comparison of the samples with the 1970 census data (see Table 10) indicated that a far higher proportion of children in Sample 1, as compared to the population, came from privileged backgrounds (i.e. upper white collar class). An attempt was therefore made to include a greater proportion of children whose fathers were blue collar workers into Sample 2. Although there remained a higher percentage of privileged children in this sample (2), the difference was less marked.

The more recently available 1980 census data suggested that a far greater proportion of white South Africans now belong to the upper white collar category. Sample 2 is more in keeping with this. H.L. Watts (pers.

comm. 1986) has nevertheless indicated that the great difference between the 1970 and 1980 census figures for the upper white collar category would seem to partially reflect the broad occupational categories used in the latter census. This prevented a detailed breakdown of the information in terms of socioeconomic groups. For example, the upper white collar category includes dental and related technical workers (RSA 1985a). The latter are actually upper blue collar workers and were classified as such in the 1970 census. In the 1980 census they were, however, incorporated into the upper white collar group. Furthermore, there were serious problems associated with the 1980 census which primarily relate to under enumeration. A special census was conducted in 1985 which collected information on an abbreviated range of questions (the South African census is usually dicennial) in an attempt to overcome these difficulties. The results of this abbreviated 1985 census are, however, not yet available.

- *School attended*

TABLE 11 : COMPARISON OF SAMPLES WITH 1980/1981 AND 1984/1985 EDUCATIONAL STATISTICS FOR PRIMARY AND SECONDARY SOUTH AFRICAN SCHOOLS (PERCENTAGES)

SCHOOL ATTENTED	SAMPLE 1	SAMPLE 2	1980/1981[1] EDUCATIONAL STATISTICS (RSA 1981)	1984/1985[2] EDUCATIONAL STATISTICS (RSA 1985b)
Government	47,1	80,0	93,0	94,3
Private	52,9	20,0	4,4	4,0

Notes:

1. The educational statistics cited are for *all* white scholars - not only for English-speaking children.
2. The remaining 2,6% of children in the 1980/1981 educational statistics data and 1,7% in the 1984/1985 data were children who attended provincial - (i.e. Government-aided) schools.

Table 11 indicates that the majority of children in Sample 1 attended private schools. The educational statistics reveal, however, that most white, South African children attend government schools. Sample 2 was therefore drawn predominantly from government schools in order to better reflect the actual situation. The second sample nevertheless still contained a somewhat smaller proportion of children attending government schools than the white, South African population.

- *Religious affiliation*

TABLE 12 : RELIGIOUS AFFILIATION : COMPARISON OF SAMPLES WITH 1980 CENSUS DATA (PERCENTAGES)

RELIGIOUS AFFILIATION	SAMPLE 1	SAMPLE 2	H.L. WATTS (1976)	1980 CENSUS DATA (RSA 1985a)
English Protestant	48,6	67,1	55,0	59,3
Roman Catholic	20,0	17,1	16,7	15,4
Jewish	31,4	15,7	8,3	6,76

Note:

The remaining 18,3% in Watts' study and 20% in the 1980 census data were Afrikaans Protestants, members of minor Christian sects and various types of Christian groups, and atheists or agnostics.

Table 12 reveals that the figures obtained by Watts (1976) and the 1980 census data (RSA 1985a) regarding the religious affiliations of white South Africans are very similar. Sample 1 comprised a far higher proportion of Jewish children than the South African population. These children had been selected from Jewish private schools. Fewer children in Sample 2 were therefore selected from such schools. Although there was still a higher percentage of Jewish children in this sample, it nevertheless more closely approximates the 1980 South African census data.

Overall, compared to the South African 1980 census and 1984/1985 statistical data, Sample 2 comprised more privileged children than the white South African population - as reflected by the higher proportion of children belonging to the upper white collar socioeconomic category and attending private, especially Jewish, schools.

5.3.3.2 Method

Administration of Luria's Neuropsychological Investigation adapted for children

The proposed LNI for South African children was administered by the author according to the format outlined by Christensen (1975). Both the tasks which were correctly completed by Sample 1 and therefore did not require adaptation, and the adapted tasks were administered to the children. The conditions under which each assessment was conducted were the same as those for Sample 1 (see Section 5.3.1.2).

Total assessment time for Sample 2	:	203 hours
Mean assessment time per child	:	2 hours 54 minutes

These assessment times were very similar to those for Sample 1 (see Section 5.3.1.2).

5.3.3.3 Data recording and processing

Recording charts were constructed on to which the responses and behaviour of each child during the assessment were entered. Chart 2 contains a specimen of these charts. For each section of the LNI, each age group was represented on a separate chart. Each child's verbal responses were audiotaped (as in Sample 1) to permit a more detailed analysis of the results and to provide a record of the adjustments needed to any instructions requiring clarification.

The author marked the responses of each child to each item on the charts as correct or incorrect and checked this marking at a later date. Any examples of items not correctly completed by all children were deleted so that of the items which remained, all children were able to complete those relating to their specific age group correctly. Completed copies of these charts have also been stored at the Neuropsychology Unit, University of Natal, Durban and are available from the Head of the Unit, Dr. Tollman, on request.

Record forms similar to those developed by the author for the adult LNI were drawn up. A copy of these forms is given in the LNI-C manual (see Part 2.3).

CHART 2 : SPECIMEN OF CHARTS USED FOR RECORDING THE RESPONSES OF INTACT CHILDREN (SAMPLE 2) ON TASKS COMPRISING THE PROPOSED LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN

LNI-C: SUGGESTED ITEMS	AGE AND STANDARD	EIGHT YEARS OLD; STANDARD 1										NUMBER OF INCORRECT RESPONSES
	SEX	MALE					FEMALE					
	SUBJECT NUMBER	71	72	73	74	75	76	77	78	79	80	
HIGHER VISUAL FUNCTIONS 1. VISUAL PERCEPTION OBJECTS AND PICTURES												
Naming objects:	pencil	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	key	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	rubber-band	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	coin	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
Naming pictures of objects:	watch	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	pair of scissors	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	handbag	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	clothes peg	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	measuring jug	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	transistor radio	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	egg box	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
Naming indistinct pictures:	blurred picture of book	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	focused picture of book	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
Naming masked outline drawings:	apple	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	clock	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	sailing boat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	hat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
Naming silhouette pictures:	dog	✓	✓	funny person	don't know	✓	pattern	moths	✓	cutting out	a tree	6
	man's face	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0
	boy's face	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0

5.4 RESULTS

The results of the three phases comprising the development of Luria's Neuropsychological Investigation for children (LNI-C) are presented first. Thereafter the performances of children (Sample 1) on the adult Luria's Neuropsychological Investigation (LNI) with respect to age, socioeconomic status and sex are detailed. Finally, the type of difficulty experienced by children on the adult battery and their apparent relationship to brain-behaviour development is delineated.

5.4.1 Development of Luria's Neuropsychological Investigation for Children

The results of the three phases comprising the development of the LNI for children are represented in Table 13. Only tasks from the adult LNI requiring adaptation are presented in this table. Adult LNI tasks correctly completed by all children in Sample 1 (the first group of eight to 14 year olds) and which therefore needed no alterations, are not included. As indicated in the table, the adult task was also retained for age groups in which the responses of all children were correct. Tasks to which children in younger age groups, as well as tasks to which children in all age groups, responded incorrectly, were adapted. For most of the tasks, examples of different levels of difficulty were provided for different age groups of children. A complete list of all tasks comprising the adapted LNI for white, English-speaking South African children aged eight to 14 years is presented in the separately bound manual accompanying this dissertation.

See Table 13 over.

Tasks comprising the LNI are multideterminational in nature. In other words, with complex tasks there are multiple pathways to the goal and failure may be due to a disturbance in any of these, and hence involve different functional systems. In children this is complicated by the qualitatively different role played by different functional systems at different stages of development (e.g. Luria 1963b, 1980) (see also p.166). Familiarity with Luria's work (notably Luria 1963b, 1980) is thus essential in order to determine what task performance should be viewed as deficient and the functional system considered to be implicated by the nature of the failure on a particular task. In the present thesis a model of brain-behaviour ontogeny, as per Luria, was devised in order to augment Luria's aforementioned writings, and hence facilitate the analysis and interpretation of children's responses to LNI tasks.

TABLE 13 : THE DEVELOPMENT OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR WHITE, ENGLISH-SPEAKING SOUTH AFRICAN CHILDREN AGED EIGHT TO FOURTEEN YEARS

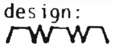
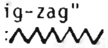
TABLE 13.1 : PRELIMINARY CONVERSATION

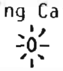
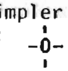
TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
16.* Date of birth	10-14	18,6	Able to give day and month, but not year of birth	8-9	Request only day and month of birth (1)	8-9	0	Include for 8-9 years
18. Time at present	9-14	8,6	Had not yet learnt to tell time	8	Delete for 8 years	-	-	-
Dates of well-known events:			Tasks 21-24: Did not know dates of events					
21. The Day of the Covenant	-	94,3		8-14	Delete task for 8-14 years	-	-	-
22. Christmas Day	13-14	31,4		8-12	Delete task for 8-12 years	-	-	-
23. Boxing Day	-	57,1		8-14	Delete task for 8-14 years	-	-	-
24. Republic Day	-	85,7		8-14	Delete task for 8-14 years	-	-	-
35. Date of arrival at institution	11-14	20,0	Did not know date of arrival	8-10	Age at arrival at institution (1)	8-10	0	Include for 8-10 years
36. Name of family doctor	9-14	1,4	Did not know name of doctor	8	Name of class teacher (1)	8	0	Include for 8 years
38. Ability to lose temper	10-14	11,4	Did not know meaning of word "temper"	8-9	Words "very angry or cross" substituted for word "temper" in question (1)	8-9	0	Include for 8-9 years
43. Anxiety	13-14	48,6	Did not know meaning of word "anxious"	8-12	Words "afraid or worried" substituted for word "anxious" in question (1)	8-12	0	Include for 8-12 years
50. Loss of initiative	13-14	55,7	Did not know meaning of word "initiative"	8-12	Original question replaced with "Do you find it hard to start or begin a job that you know you have to do, such as tidy your bedroom?" (1)	8-12	0	Include for 8-12 years
55. Fits	12-14	32,9	Did not know meaning of word "fits"	8-11	Original question replaced with "Have you ever fainted, lost consciousness, shaken a lot and/or been unable to move for a while?" (1)	8-11	0	Include for 8-11 years

* Numbers are those which were assigned to adult LNI tasks during data analysis. Missing numbers reflect tasks which were correctly completed by all children and thus required no adaptation.

1. A.D. Watts (Author)

TABLE 13.2 : MOTOR FUNCTIONS

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
70. Obeying instruction to place index finger over middle finger	14	50,0	Tasks 70 and 72: Unfamiliar with term "index finger"	8-13	Tasks 70 and 72: Substitution of words "pointing finger" for term "index finger" in instructions (1)	8-13	0	Tasks 70 and 72: Include for 8-13 years
72. Carrying out given movement on command	14	50,0		8-13		8-13	0	
Reproduction of examiner's hand positions:								
73. (i) one hand	-	24,3	Tasks 73 - 78:	8-14	Tasks 73-80, 84:	Tasks 73-80, 84:	Tasks 73-80, 84:	Tasks 73-80, 84:
74. (ii) two hands	-	80,0	Gave mirror-imaged reproduction of required pose	8-14	(i) If incorrect hand is used, examiner instructs subject to use same hand as he/she is using (3)	8-14	0	Include for 8-14 years
Placing pencil in:					(ii) Examiner sits next to subject (2)			
75. (i) horizontal plane	-	20,0		8-14				
76. (ii) frontal plane	-	20,0		8-14				
77. (iii) saggital plane	-	20,0		8-14				
Head's test:								
78. (i) Raising same hand as examiner	-	24,3		8-14				
79. (ii) Touching ipsilateral eye/ear	-	62,9	Tasks 79 and 80: (i) Gave mirror-imaged reproduction of required pose or (ii) Used dominant hand only	8-14				
80. (iii) Touching contralateral eye/ear	-	64,3		8-14				
84. Test of the dynamic organisation of movement involving one hand	-	30,0	Task 84: Gave mirror-imaged reproduction of required pose	8-14				
85. Learning sequential task: "fist-edge-palm" task	12-14	11,4	Did not know meaning of word "successively"	8-11	Substitution of words "one after another" for "successively" in instructions (1)	8-11	0	Include for 8-11 years
87. Copying design: Card D1 	9-14	2,9	Drew "zig-zag" pattern: 	8	Copying simpler design: Card D1  (4)	8	0	Include for 8 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
88. Drawing series of 2 circles, 1 cross and 3 triangles	14	18,6	(i) Did not know what triangle was (8 year olds) (ii) Not sure what type of cross required (iii) Recalled 2/3 triangles	8-13	Drawing: 2 circles, 1 square, 2 minus signs (1)	8-13	0	Include for 8 years
90. Complex, purposeful task: lacing shoes	9-14	1,4	Had not yet learnt to tie shoe laces	8	Undoing zipper (1)	8	0	Include for 8 years
94. Symbolic action: threatening	-	48,6	(i) Did not know what term meant (ii) Did not know how to represent term symbolically	8-14 8-14 9-14	Hitchhiking (1) Saluting (1) Beckon with a finger (5)	8-14 8-14 9-14	0 0 0	Include for 8-14 years Include for 8-14 years Include for 8-14 years
98. Frowning on command	-	25,7	Screwed the eyes up	8-14	Screwing the eyes tightly (6)	8-14	0	Include for 8-14 years
101. Rolling tongue	11-14	4,3	Did not understand instruction	8-10	Examiner demonstrates required tongue movement (7)	8-10	0	Include for 8-10 years
102. Tongue placed between teeth and upper lip	-	34,3	Did not understand instruction	8-14	Examiner demonstrates required tongue and lip movements (7)	8-14	0	Include for 8-14 years
103. Repetition of sequence of 3 oral movements	-	41,4	(i) Did not understand instruction (ii) Recalled 2/3 movements	8-14	Examiner demonstrates required sequence of 2 movements (bare teeth, then extrude tongue) (7)	8-14	0	Include for 8-14 years
105. Whistling on command	12-14	11,4	Unable to whistle	8-11	(i) Blow a kiss (7) (ii) Blow out a match (8) (iii) Suck on a straw (8)	Task 105 (i)-(iii): 8-11	Task 105 (i)-(iii) 0	Task 105 (i) - (iii): Include for 8-11 years
108. Drawing triangle	9-14	1,4	Did not know what triangle was	8	Drawing cross (9)	8	0	Include for 8 years
110. Copying Card D2a: 	9-14	4,3	Drew incorrect number of "rays" on "sun"	8	Copying simpler version of design:  (1)	8	0	Include for 8 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
112. Copying Card D3a:  (rectangle)	9-14	2,9	(i) Intersection of central lines misaligned (ii) Drew square instead of rectangle	8	Copying a simpler design  (10)	8	0	Include for 8 years
114. Reproducing series of 4 figures from memory Card D5: O□+Δ	10-14	5,7	Recalled 3/4 figures	8-9	Reproducing series of 3 figures from memory O□+ (1)	8-9	0	Include for 8-9 years

1. A.D. Watts (Author)
2. Luria, 1980, p.418
3. Luria, 1980, p.419
4. Luria, 1966b, p.185
5. Luria, 1980, p.424
6. Luria, 1980, p.425
7. Luria, 1980, p.427
8. Geshwind, 1975, p.190
9. Luria, 1980 p.343
10. Luria, 1966b, p.524

TABLE 13.3 : ACOUSTICO-MOTOR FUNCTIONS

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
126. Comparing pitch of two sounds and identifying higher and lower one	12-14	4,3	Unable to identify higher and lower sound	8-11	Comparing pitch of two sounds (1)	8-11	0	Include for 8-11 years
127. Making correct response to two different groups of sounds (𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥)	-	10,0	Raised hands alternatively irrespective of group of sounds played	8-14	Making correct response to two simpler groups of sounds (𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥) (1)	8-12 13-14	26,0 0	Delete for 8-12 years Include for 13-14 years
128. Comparing two groups of sounds (𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥)	14	14,3	Said groups were the same	8-13 8-13	Comparing two simpler groups of sounds: (i) 𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥 (1) (ii) 𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥 (1)	8-13 8-13	0 0	Include for 8-13 years Include for 8-13 years
129. Comparing two groups of sounds (𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥)	-	27,1	Said groups were the same	8-14 8-14	Comparing two simpler groups of sounds: (i) 𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥 (1) (ii) 𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥, 𝅗𝅥𝅗𝅥𝅗𝅥𝅗𝅥 (1)	8-14 8-14	4,3 15,7	Delete for 8-14 years Delete for 8-14 years
133. Singing melody: "My Bonnie lies over the ocean"	-	84,3	Did not know song	8-14 8-14	Singing melody: (i) "Happy Birthday" (1) (ii) "Jack and Jill" (1)	8-14 8-14	0 0	Include for 8-14 years Include for 8-14 years
Number of taps in series of groups:								
136. '' '' '' ''	14	17,1	Tasks 136-137: Counted number of taps incorrectly	8-13	Number of taps in shorter series of groups: '' '' ''	8-13	0	Include for 8-13 years
137. ''' ''' ''' '''	14	20,0		8-13	Number of taps in shorter series of groups: ''' ''' ''' Tasks 136-137: Simpler instruction: Subject told to count number of taps heard and to continue doing so until told to stop	8-13	0	Include for 8-13 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Number of taps of different strengths per group			Tasks 138-141:		Number of taps of different strengths per shorter group:			
138. UUU'	14	11,4	(i) Counted number of taps incorrectly	8-13	(i) 'U (1)	8-13	0	Include for 8-13 years
				8-13	(ii) 'UU (1)	8-13	0	Include for 8-13 years
139. UU'	14	15,7	(ii) Counted only loud taps	8-13	'''U (1)			
140. ''UUU	-	18,6		8-14	''UU (1)	8-14	0	Include for 8-14 years
141. UUU''	14	11,4		8-13	'''UUU (1)	8-13	0	Include for 8-13 years
					Additional instruction prior to administration of above tasks: Examiner demonstrates a loud and soft tap to subject			
Number of accentuated taps for group:			Tasks 142-143: Counted number of taps incorrectly		Number of accentuated taps per shorter group:			
142. UUU'''	9-14	1,4		8	(i) UU''	8	0	Include for 8 years
				8	(ii) ''U	8	10,0	Delete for 8 years
143. ''U'U''	-	82,9		8-14	(i) 'UU'	8-14	0	Include for 8-14 years
				8-14	(ii) ''UU'	8-12	8,0	Delete for 8-12 years
						13-14	0	Include for 13-14 years
Reproduction of acoustically presented rhythm:			Tasks 147, 148, 150		Reproduction of shorter acoustically presented rhythm:			
147. ''UUU''UUU''UUU''	-	55,7	Tapped incorrect number of loud and soft taps	8-12	''UU''UU'' (1)	8-12	0	Include for 8-12 years
				13-14	''UUU''UUU'' (2)	13-14	0	Include for 13-14 years
148. UU''UU'''UU''UU'''	-	95,7		8-12	'UU'UU (1)	8-12	0	Include for 8-12 years
				13-14	UU''UU'' (1)	13-14	0	Include for 13-14 years
150. 'U''U'U''U	-	8,6		8-12	UU'UU' (1)	8-12	0	Include for 8-12 years
				13-14	'U'U' (1)	13-14	0	Include for 13-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Reproduction of verbally presented rhythm:			Tasks 154-156:		Reproduction of simpler verbally presented rhythms:			
154. two strong and three weak taps	11-14	4,3	(i) Did not understand instructions	8-10	One soft and two loud taps (1)	8-10	0	Include for 8-10 years
155. three weak and two strong taps	13-14	10,0	(ii) Reproduced rhythm incorrectly	8-12	two loud and one soft tap (1)	8-12	0	Include 8-12 years
156. series of two and three taps	14	64,3		8-13	series of two taps (3)	8-13	0	Include for 8-13 years
					Prior to administration of above tasks, examiner illustrates instructions with an example.			
Reproduction of acoustically presented rhythm with verbal auto-reinforcement:			Tasks 160-163:		Reproduction of simpler rhythm with verbal auto-reinforcement:			
160. ''UUU''UUU''UUU''	-	50,0	(i) Unable to verbally describe rhythm	8-12 13-14	''UU''UU'' (1) ''UUU''UUU'' (2)	8-12 13-14	0 0	Include for 8-12 years Include for 13-14 years
161. UU''UU'''UU''UU'''	-	97,1		8-12 13-14	'UU'UU (1) UU''UU'' (1)	8-12 13-14	0 0	Include for 8-12 years Include for 13-14 years
163. 'U''U'U''U	-	100,0	(ii) Reproduced rhythm incorrectly	8-12 13-14	UU'UU' (1) 'U'U' (1)	8-12 13-14	0 0	Include for 8-12 years Include for 13-14 years
					Prior to administration of above tasks examiner illustrates instructions with an example.			
Reproduction of orally presented rhythm with verbal auto-reinforcement:			Tasks 167-169: Reproduced rhythm incorrectly		Reproduction of simpler orally presented rhythm with verbal auto-reinforcement:			
167. two strong and three weak taps	11-14	1,4		8-10	one soft and two loud taps (1)	8-10	0	Include for 8-10 years
168. three weak and two strong taps	13-14	2,9		8-12	two loud and one soft tap (1)	8-12	0	Include for 8-12 years
169. series of two and three taps	14	60,0		8-13	series of two taps (3)	8-13	0	Include for 8-13 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Changing from one rhythmic structure to another			Tasks 170 - 171: Reproduced rhythms incorrectly		Changing from one rhythmic structure to another:			
170. UUU', UU'	13-14	38,6		8-12	UU', U'	8-12	10,0	Delete for 8.12 years
171. ''UUU, ''UU	13-14	40,0		8-12	''UU, ''U	8-12	12,0	Delete for 8-12 years

1. A.D. Watts (author)
2. Luria, 1980, p.441
3. Luria, 1980, p.442

TABLE 13.4 : HIGHER CUTANEOUS AND KINESTHETIC FUNCTIONS

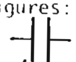
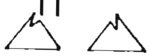
TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Number traced on skin:			Tasks 180-182:		Geometric shape traced on skin: (2)			
180. 1	13-14	11,4	Named number incorrectly	8-14	cross (2)	8-14	0	Include for 8-14 years
181. 5	-	15,7		8-14	circle (2)	8-14	0	Include for 8-14 years
182. 7	-	25,7		8-14	square (1)	8-14	0	Include for 8-14 years
				9-14	triangle (1)	9-14	0	Include for 9-14 years
					Additional instruction: Examiner informs subject that either a: 8 : cross, circle or square 9-14: cross, circle, square or triangle will be drawn on his/her hand			
Letter traced on skin:					Number traced on skin:			
183. D	-	25,7	Tasks 183-185:	13-14	1 (1)	13-14	0	Include for 13-14 years
184. T	14	25,7	Named letter incorrectly	13-14	4 (1)	13-14	0	Include for 13-14 years
185. S	-	41,4		13-14	8 (1)	13-14	0	Include for 13-14 years
					Additional instruction: Examiner informs subject that either a 1, 4 or 8 will be written on his/her hand			
					Letter traced on skin:			
				14	T (1)	14	10,0	Delete for 14 years
				14	O (1)	14	10,0	Delete for 14 years
				14	W (1)	14	10,0	Delete for 14 years
					Additional instruction: Examiner informs subject that either a T, O or W will be written on his/her hand			

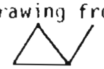
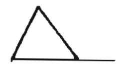
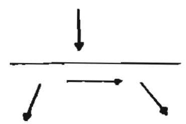
TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Tactile identification of object:					Tactile identification of object:			
192. india-rubber	9-14	1,4	Tasks 192-195:	8	pencil (1)	8	0	Include for 8 years
193. pencil-sharpener	-	2,9	(i) Misnamed object	8-14	coin (1)	8	1,4	Delete for 8 years
194. paper clip	-	24,3	(ii) Unable to name object			9-14	0	Include for 9-14 years
195. penknife	-	15,7		8-14	small comb (3)	8-14	0	Include for 8-14 years
				8-14	key (3)	8-14	0	Include for 8-14 years
				8-14	rubber band (1)	8-14	0	Include for 8-14 years

1. A.D. Watts (Author)
2. Luria, 1980, p.446
3. Luria, 1980, p.449

TABLE 13.5 : HIGHER VISUAL FUNCTIONS

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
202. Naming object: penknife	11-14	1,4	Unable to name object	8-10	Naming object: key (1)	8-10	0	Include for 8-10 years
Naming complicated pictures:					Naming complicated pictures:			
208. nutcracker	-	85,7	(i) Did not know what object was (ii) Named object incorrectly (e.g. "clippers")	8-14	clothes peg (1)	8-14	0	Include for 8-14 years
210. camera and lens	9-14	2,9	Named object incorrectly (e.g. "photograph")	8	transistor radio (1)	8	0	Include for 8 years
Naming indistinct pictures:			Tasks 214-215:					
214. very blurred sunglasses	-	50,0	(i) Did not know what object was	-	Delete for 8-14 years	-	-	-
215. blurred sunglasses	-	34,3	(ii) Named object incorrectly	8-14	blurred sunglasses	8-14	0	Include for 8-14 years
					Additional tasks:			
					Naming masked outline drawings: (2)			
				8-14	(i) apple (3)	8-14	0	Include for 8-14 years
				8-14	(ii) clock (4)	8-14	0	Include for 8-14 years
				8-14	(iii) sailing boat (5)	8-14	0	Include for 8-14 years
				8-14	(iv) hat (5)	8-14	0	Include for 8-14 years
Naming silhouette pictures:			Tasks 217-218:		Naming silhouette pictures:			
217. telephone	-	91,4	(i) Did not know what picture depicted	8-14	dog (6)	8-14	60,0	Delete for 8-14 years
218. man's face	-	48,6	(ii) Named picture incorrectly (e.g. "pattern", "bones")	8-14	man's face (7)	8-14	0	Include for 8-14 years
					boy's face (7)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Naming objects in superimposed outline drawings (Poppelreuter's Test):								
219. jug, knife, iron, hammer	-	62,9	(i) Did not name all the objects (ii) Named "iron" incorrectly	8-10	bottle, spoon, knife, plate (8)	8-10	23,3	Delete for 8-10 years
				11-14	jug, knife, hammer, cup and saucer (1)	11-14	0	Include for 11-14 years
220. bucket, axe, rake, paintbrush, pair of scissors	11-14	11,4	Tasks 220-221: Did not name all the objects	8-10	bed, table, chair (8)	8-10	0	Include for 8-10 years
221. kettle, glass, fork, dish, bottle	12-14	5,7		8-11	trousers, shirt, hat, shoe (8)	8-9	25,0	Delete for 8-9 years
						10-11	0	Include for 10-11 years
Identifying hidden figures (Gottschaldt):								
222. Dishinguishing number of simple figures imbedded in more complex one	-	71,4	(i) Could not see figure at all (ii) Identified small version of figure (iii) Miscounted	8-14	Patient asked to identify one simple figure, the same size as the sample, by tracing the outline of the figure with his/her finger (1)	8-14	48,6	Delete for 8-14 years
223. Distinguishing shapes on chessboard	-	81,4	Identified "strong" version of cross only (i.e. black cross with white centre)	8-14	Identifying a cross with a black center from a chessboard (9) Patient asked to trace outline of figure with his/her finger (10)	8-14	0	Include for 8-14 years
224. Raven's Matrices	-	24,3	(i) Said did not know (ii) Chose inset on basis of only one aspect of design (e.g. vertical or horizontal patterning)	8-14	Simpler examples of Raven's matrices: (i) See LNI-C Manual, Plate 1.5.2 (11)	8-14	0	Include for 8-14 years
225. Raven's Matrices	-	44,3		8-14	(ii) See LNI-C Manual, Plate 1.5.3 (12)	8-14	0	Include for 8-14 years
226. Raven's Matrices	-	87,1		8-14				
Determining difference between mirror-image figures:								
227. 	-	74,3	(i) Did not know (ii) Said one was longer	-	Delete for 8-14 years	-	-	-
228. 	-	47,1	(i) Did not know (ii) Said one indentation was longer	-	Delete for 8-14 years	-	-	-

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
229. Difference between mirror-image letters and numbers	-	38,6	(i) Did not know	8-14	Patient asked to state difference between 3 sets of mirror-image letters (1)	8-14	0	Include for 8-14 years
Drawing from memory:								
230. 	9-14	2,9	Positioned side "arm" of figure incorrectly (e.g. △)	8	 (1)	8	0	Include for 8 years
231. 	-	34,3	Tasks 231-232:	8-14	 (1)	8-14	0	Include for 8-14 years
232. 	-	87,1	Unable to correctly recall: (i) Number of arrows (ii) Spatial arrangement of arrows (iii) Direction of arrows	8-14	 (1)	8-14	55,7	Delete for 8-14 years
Evaluating position of hands of a clock:			Tasks 233-236:		Evaluating position of hands of a clock:			
233. 7,57	13-14	35,7	(i) Cannot tell time (8 years)	8-12 8-12	8,00 (1) 10,20 (1)	8-12 8-12	0 14,0	Include for 8-12 years Delete for 8-12 years
234. 5,09	14	17,1	(ii) Have only learnt hour, half-hour and quarter-hour positions (8 years)	8-13 8-13	4,45 (1) 5,10 (1)	8-13 8-10 11-13	0 6,7 0	Include for 8-13 years Delete for 8-10 years Include for 11-13 years
235. 1,25	13-14	24,3		8-12	10,30 (1)	8-12	0	Include for 8-12 years
236. 10,35	13-14	28,6	(iii) Confused hour and minute hands (iv) Incorrectly estimated the time					NOTE: This task is only administered to 8 year olds who have learnt to tell the time

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Drawing position of hands of a clock:			Tasks 237-239: (i) Cannot tell time (8 years) (ii) Incorrectly positioned hands of clock (iii) Confused hour and minute hands		Drawing position of hands of a clock:			
237. 12,50	13-14	18,6		8-12 8-12	11,00 (1) 11,15 (1)	8-12 8-12	0 6,0	Include for 8-12 years Delete for 8-12 years
238. 16,35	14	21,4		8-13 8-13	5,45 (1) 12,35 (1)	8-13 8-13	0 10,0	Include for 8-13 years Delete for 8-13 years
239. 11,10	12-14	15,7		8-11 8-11	9,30 (1) 8,50 (1)	8-11 8-11	0 10,0	Include for 8-11 years Delete for 8-11 years
								NOTE: This task is only administered to 8 year olds who have learnt to tell the time
Recognising compass directions:			Tasks 240-242: (i) Have not yet learnt directions (ii) Confused E and W, N and S					
240. North	13-14	12,9		-	Delete for 8-12 years	-	-	-
241. East	14	24,3		-	Delete for 8-13 years	-	-	-
242. West	14	29,7		-	Delete for 8-13 years	-	-	-
243. Completing honeycomb pattern (Rupp's Test):	-	30,0	Unable to correctly continue honeycomb pattern	-	Delete for 8-14 years	-	-	-
Evaluating number of blocks used to construct figures (Yerke's Test):			Tasks 249-252: (i) Counted only visible blocks (ii) Miscounted number of blocks					
249.	-	45,7		-	Delete for 8-14 years	-	-	-
250.	-	48,6		-	Delete for 8-14 years	-	-	-
251.	-	60,0		-	Delete for 8-14 years	-	-	-
252.	-	75,7		-	Delete for 8-14 years	-	-	-
253. Correct placement of circle in parallelogram	-	90,0	(i) Would not attempt task (ii) Placed circles in both parallelograms (iii) Placed circle in left or right-hand parallelogram only	-	Delete for 8-14 years	-	-	-

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
			(iv) Did not mentally rotate sample before placing circle in parallelogram					

1. A.D. Watts (Author)
2. Luria, 1980, p.456-457
3. Lezak, 1976, p.295
4. Adapted from Luria, 1973a, p.117 and Luria, 1980, p.162
5. Werner and Strauss, 1941, p.237
6. Vernon, 1961, p.58
7. Lezak, 1976, p.284
8. Teuber and Rudel, 1962, p.9
9. Luria, 1980, p.331
10. Luria, 1980, p.459, Christensen, 1979a, p.69
11. Anastasi, 1982, p.289
12. Anastasi, 1982, p.291

TABLE 13.6 : IMPRESSIVE SPEECH

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Correct response to given signal:			Tasks 268-269:		Tasks 268-269:			
268. Raising left and right hands in response to different signals	9-14	1,4	Raised left and right hand alternatively irrespective of signal given	-	Delete for 8 year olds	-	-	-
269. Raising left hand and leaving right hand where it is in response to different signals	9-14	1,4				-	-	-
284. Pointing to series of 5 body parts	-	4,3	Tasks 284-285: (i) Unable to reproduce series in correct order (ii) Failed to repeat all the words in the series	8-14	Pointing to series of 4 body parts	8-14	0	Include for 8-14 years
285. Pointing to series of 7 objects	-	72,9		8-14	Pointing to series of (i) 4 objects (ii) 5 objects	8-14 8-14	0 7,1	Include for 8-14 years Delete for 8-14 years
291. Pointing to cheekbone	-	34,3	Pointed to cheek	8-14	Pointing to: (i) cheek (1) (ii) fingernail (2)	8-14 8-14	0 0	Include for 8-14 years Include for 8-14 years
Definitions:			Tests 292-296: (i) Did not know meaning of word (ii) Gave incorrect meaning					
292. protea	-	17,1		8-14 8-14	(i) daisy (1) (ii) poppy (1)	8-14 8-14	0 5,7	Include for 8-14 years Delete for 8-14 years
293. centipede	-	31,4		8-14	butterfly (1)	8-14	0	Include for 8-14 years
294. caterpillar	10-14	7,1		8-9	locust (1)	8-9	0	Include for 8-9 years
295. calamity	-	74,3		8-14	annoy (1)	8-9 10-14	10,0 0	Delete for 8-9 years Include for 10-14 years
				8-14	understand (1)	8-14	0	Include for 8-14 years
296. audacious	-	98,6		8-14	nonsense (1)	8-14	0	Include for 8-14 years
				8-14	nuisance (1)	8-14	0	Include for 8-14 years
				8-14	courage (1)	8-14	5,7	Delete for 8-14 years
298. Defining "bat"	11-14	2,9	Gave incorrect meaning of word	8-10	Defining "hat" (1)	8-10	0	Include for 8-10 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDRLN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
305. Object used to light fire	11-14	5,7	Subjects pointed to logs of wood instead of box of matches	8-10	Modified instruction: Examiner asks subject to indicate which object is used to light the *flame* of a fire (1)	8-10	0	Include for 8-10 years
Pointing to one object with another object:			Tasks 310-311:					
310. With key towards pencil	11-14	2,9	Pointed separately to the two named objects	-	Tasks 310-311:	-	-	-
311. With pencil towards key	11-14	2,9		-	Delete for 8-10 years	-	-	-
Pointing with an object to another object:			Tasks 312-313:					
312. Pointing to pencil with key	13-14	5,7	Pointed to objects in the order in which they were named	-	Tasks 312-313:	-	-	-
313. Pointing to comb with pencil	13-14	5,7		-	Delete for 8-12 years	-	-	-
Attributive genetive case:								
314. Identification of daughter's mother in picture	9-14	1,4	Pointed to daughter	-	Delete for 8 years	-	-	-
315. Deciding if "the father's brother" and "the brother's father" are one or two people	-	20,0	Said they were same person		Deciding if the following people are men or women:			
				8-14	(i) my sister's father (3)	8-10 11-14	14,3 0	Delete for 8-10 years Include for 11-14 years
				8-14	(ii) my uncle's daughter (3)	8-10 11-14	12,9 0	Delete for 8-10 years Include for 11-14 years
Drawing spatially arranged figures:			Tasks 316-318:					
316. Cross beneath circle	-	5,7	Drew figures in the order in which they were named	8-14	Circle below square (4)	8-14	0	Include for 8-14 years
317. Circle to right of cross	-	15,7		8-14	Dot above circle (5)	8-14	0	Include for 8-14 years
318. Cross to right of circle but left of triangle	-	30,0		8-14	Minus sign above plus sign (5)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
319. Correct statement ("Spring comes before summer" or "Summer comes before spring")	13-14	32,9	Said summer came before spring		Ask for a "yes" - "no" response to the following:			Task 319 (i) - (iv): Include for 8-12 years
				8-12	(i) Do you put your shoes on *after* your socks? (6)	8-12	0	
				8-12	(ii) Do you put on your socks *before* your shoes? (6)	8-12	0	
				8-12	(iii) Do you eat lunch *after* supper? (6)	8-12	0	
				8-12	(iv) Do you eat supper *before* lunch? (6)	8-12	0	
Comparative constructions:								
320. "Which boy is shorter if John is taller than Peter?"	12-14	5,7	Said John was shorter	-	Delete for 8-10 years	-	-	-
321. Same meaning? "John is taller than Peter"; "Peter is taller than John"	12-14	14,3	Said the statements had same meaning	-	Delete for 8-10 years	-	-	-
324. Evaluation of colours: less light	-	47,1	Pointed to lighter colour	-	Delete for 8-14 years	-	-	-
326. Evaluation of colours: less dark	11-14	8,6	Pointed to darker colour	-	Delete for 8-10 years	-	-	-
327. Fairer girl if Olga is fairer than Kate but darker than Sonia?	-	52,9	Said Olga was fairer	-	Delete for 8-14 years	-	-	-
328. Darkest girl if Olga is fairer than Kate but darker than Sonia?	-	52,9	Said (i) Olga or (ii) Sonia was darkest	-	Delete for 8-14 years	-	-	-
Inverted grammatical constructions:								
329. Victim if "Peter struck John"	-	47,1	Did not know meaning of words "victim" and/or "struck"	8-14	Substitution of words "boy hurt" for "victim" and word "hit" for "struck" in task	8-14	0	Include for 8-14 years
330. Correct statement: "The sun illuminates the earth" or "the earth is illuminated by the sun"	-	70,0	(i) Did not know meaning of word "illuminates" (ii) Interpreted sentence on basis of active word order	8-14	Correct statement: "The sun lights up the earth" or "the earth is lit up by the sun" (1)	8-12	47,1	Delete for 8-12 years
						13-14	0	Include for 13-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
331. First activity if I had breakfast after I sawed wood?	-	30,0	Responded in accordance with order in which events were named in construction (i.e. said had breakfast first)	8-14	(i) First activity if I had breakfast after I had read the newspaper (7)	8-14	10,0	Delete for 8-14 years
				8-14	(ii) First activity if I washed the car after I had swept the yard (7)	8-12 13-14	8,0 0	Delete for 8-12 years Include for 13-14 years
332. Said by disciplined or undisciplined person? "I am unaccustomed to disobeying rules"	-	62,9	Said statement made by an undisciplined person	8-14	I am not in the habit of not obeying rules (7)	8-14	34,3	Delete for 8-14 years
Complex grammatical structure: "The woman who worked at the factory came to the school where Margaret studied to give a talk"								
333. Identification of speaker	-	45,7	Identified Margaret as speaker	-	Delete for 8-14 years	-	-	-
334. Description of Margaret's activities	-	51,4	Said Margaret gave talk	-	Delete for 8-14 years	-	-	-

1. A.D. Watts (Author)
2. Luria, 1980, P.494
3. Goodglass and Kaplan, 1972, p.42
4. Luria, 1966a, p.420
5. Luria, 1966a, p.440
6. Goodglass and Kaplan, 1972, p.41
7. Luria, 1976a, p.160

TABLE 13.7 : EXPRESSIVE SPEECH

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Repetition of unfamiliar words:			Tasks 353-354:		Repetition of unfamiliar words:			
353. streptomycin	9-14	2,9	Repeated word incorrectly	8	haematoma (1)	8	0	Include for 8 years
354. arachnoidendothelioma	-	55,7			hemiplegia (1) menengioma (1)	8-14 8-14	0 0	Include for 8-14 years Include for 8-14 years
Repeating series of 5 words:			Tasks 357, 360, 361:		Repeating series of 4 words:			
357. lamp - wood - pin - boy - bridge	-	40,0	(i) Recalled 4/5 words (ii) Most frequently omitted word: "wood"	8-14	lamp - pin - boy - bridge (1)	8-14	0	Include for 8-14 years
360. lamp - pin - bridge - wood - boy	-	21,4		8-14	lamp - pin - bridge - boy (1)	8-14	0	Include for 8-14 years
361. wood - bridge - boy - pin - lamp	14	5,7		8-14	bridge - boy - pin - lamp (1)	8-14	0	Include for 8-14 years
Repeating long sentences:			Tasks 364 - 365:		Repeating simpler long sentences:			
364. "The apple trees grew in the garden behind a high fence"	12-14	7,1	Omitted words in sentence	8-11	"The boy is writing in his exercise book" (2)	8-11	0	Include for 8-11 years
365. "On the edge of the forest the hunter killed the wolf"	10-14	2,9		8-9	"The thief ran away when he saw the police" (3)	8-9	0	Include for 8-9 years
Repeating series of 3 short sentences:			Tasks 366-367:		Repeating series of 2 short sentences:			
366. "The house is on fire, the moon is shining, the broom is sweeping"	10-14	5,7	(i) Recalled 2/3 sentences in series (ii) Recalled series incorrectly	8-9	"The house burns, the dog barks" (4)	8-9	0	Include for 8-9 years
367. "The broom is sweeping, the house is on fire, the moon is shining"	10-14	5,7		8-9	"The dog barks, the house burns" (4)	8-9	0	Include for 8-9 years
368. Repeating short story (The frog and the ox)	13-14	20,0	Did not know meaning of following words: (i) ox (ii) grazing (iii) bog	8-12	Substitution of "cow" for word "ox", "eating" for "grazing" and "swamp" for "bog" (1)	8-12	0	Include for 8-12 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
Naming objects in pictures			Tasks 372, 375, 376:		Naming objects in pictures:			
372. Card J14: ice-bucket	13-14	31,4	(i) Unable to name object	8-12	candle (1)	8-12	0	Include for 8-12 years
375. Card J17: paper punch	12-14	14,3	(ii) Misnamed object	8-11	pencil sharpener (1)	8-11	0	Include for 8-11 years
376. Card J18: egg tray in refridgerator	-	64,3		8-14	egg cup (1)	8-14	0	Include for 8-14 years
Naming body parts:					Naming body parts:			
378. Collarbone	-	-55,7	(i) Unable to name body part (ii) Incorrectly named it a shoulder	8-14	chin (5)	8-14	1,4	Delete for 8-14 years
Naming body parts in pictures:								
380. Card J20: elbow	-	10,0	(i) Unable to name body part in picture (ii) Incorrectly named it a leg	-	Delete for 8-14 years	-	-	-
Categorical names:			Tasks 385-387:		Categorical names:			
385. pencil - ruler - rubber	-	80,0	(i) Unable to give categorical name	8-14	apple - pineapple - banana (1)	8-14	0	Include for 8-14 years
386. plate - jug - cup and saucer (Cards J22-24)	-	78,6	(ii) Gave incorrect categorical name	8-14	cat - dog - budgie (1)	8-14	0	Include for 8-14 years
387. chair - table - cupboard (Cards J25-27)	-	68,6		8-14	sucker - sweet in wrapper - slab of chocolate (1)	8-14	0	Include for 8-14 years
				8-14	guitar - piano - violin (6)	8-12 13-14	12,0 0	Delete for 8-12 years Include for 13-14 years
388. Counting backwards from 20-1	9-14	1,4	Unable to correctly count backwards from 20-1	8	Counting to 21 (7)	8	0	Include for 8 years
390. Reciting months of the year	9-14	4,3	Unable to correctly recite the months of the year	8	Reciting the alphabet (7)	8	0	Include for 8 years
391. Reciting days of the week backwards	9-14	4,3	Order of days incorrect	8	Counting backwards from 10-1 (1)	8	0	Include for 8 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
392. Reciting months of the year backwards	13-14	32,9	(i) Omitted several months (ii) Order of months incorrect	-	Delete for 8-12 years	-	-	-
398. Repeating story: The Tortoise and the Hare	-	21,4	Did not know story	8-14	Repeating story: Little Red Riding Hood: (8)	8-14	0	Include for 8-14 years
400. Making speech: Conflict between generations	-	81,4	Did not know what topic meant	8-14	Making speech: Your Teacher (1)	8-14	0	Include for 8-14 years
Sentence completion:			Tasks 402-403: (i) Unable to give word to complete sentence (ii) Gave an incorrect word		Completion of simpler sentence:			
402. Card J33: I went to the ..... to buy some bread	9-14	2,9		8	I went out into the street to buy myself .... (9)	8	0	Include for 8 years
				8-14	I went to the ...... to buy some sweets (1)	8-14	0	Include for 8-14 years
403. Card J34: The airplane came down .... its engine was working properly	-	67,1		8-14	(i) Winter came and deep lay the ..... (9)	8-14	20,0	Delete for 8-14 years
				8-14	(ii) The autumn wind was like a wild ....(10)	8-14	10,0	Delete for 8-14 years
				8-14	(iii) I ..... tennis yesterday (1)	8-14	0	Include for 8-14 years
				8-14	(iv) She ..... her washing (1)	8-14	0	Include for 8-14 years
404. Sentence construction: Card J35: automobile - wood - garage	14	28,6	Unfamiliar with word "automobile"	8-13	Substitution of word "motor-car" for "automobile" (1)	8-13	0	Include for 8-13 years
Sentence formation:			Tasks 405-406: (i) All words not included in sentence (ii) Formed incorrect sentence		Formation of simpler sentence			
405. Card J36: teacher - my - asked - the - work - have to - I - paper	-	95,7		8-14	(i) he - river - sat - bank - on - the - of - the (11)	8-14	4,3	Delete for 8-14 years
406. Card J37: forest - went - and - into - woodcutter - the - got - a - wood	14	22,9		8-14	(ii) sit - the - cat - a to - loves - by - fire (11)	8-14	0	Include for 8-14 years
				8-13	(iii) nest - one - three - in - there - eggs - the (11)	8-13	0	Include for 8-13 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPON-SES: AGE RANGE	CHILDREN INCOR-RECTLY PERFORM-ING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	

1. A.D. Watts (Author)
2. Luria, 1976a, p.255
3. Redgrave and Nuttall, undated a
4. Adapted from Luria, 1976a, p.308
5. Luria, 1980, p.514
6. Adapted from Luria, 1976a, p.151
7. Goodglass and Kaplan, 1972, p.14
8. Galdone, 1974
9. Luria, 1976a, p.168
10. Luria, 1980, p.523
11. Redgrave and Nuttall, undated a, p.18

TABLE 13.8 : WRITING AND READING

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Number of letters:			Tasks 408-410: (i) Did not know (ii) Miscounted number of letters (iii) Unable to spell word - guessed answer		Number of letters:			
408. trap	11-14	5,7		8-10	jump (2)	8-10	0	Include for 8-10 years
409. banana	-	31,4		8-14	father (3)	8-12 13-14	8,3 0	Delete for 8-12 years Include for 13-14 years
				8-14	happy (4)	8-14	0	Include for 8-14 years
410. hedge	14	21,4		8-13	table (5)	8 9-13	10,0 0	Delete for 8 years Include for 8-13 years
				8-13	name (6)	8-13	0	Include for 8-13 years
413. Identification of sound: Third letter in "hedge"	14	18,6	(i) Did not know (ii) Named incorrect letter (iii) Unable to spell word - guessed answer		Identification of sound:			
				8-13	(i) Third letter in "most" (7)	8-13	0	Include for 8-13 years
				8-13	(ii) Third letter in "Wednesday" (7)	8-13	16,7	Delete for 8-13 years
Position of sounds:			Tasks 414-417: (i) Did not know (ii) Named incorrect letter (iii) Unable to spell word - guessed answer		Position of sounds:			
414. Letter in "stop" before "t"	10-14	2,9		8-9	Letter in "dog" after "o" (8)	8-9	0	Include for 8-9 years
415. Letter in "stop" after "o"	10-14	4,3		8-9	Letter in "dog" before "g" (8)	8-9	0	Include for 8-9 years
416. Letter in "bridges" before "g"	14	24,3		8-13	Letter in "light" before "h" (9)	8-9 10-13	20,0 0	Delete for 8-9 years Include for 10-13 years
417. Letter in "bridges" after "d"	14	25,7		8-13	Letter in "light" after "g" (9)	8-9 10-13	5,0 0	Delete for 8-9 years Include for 10-13 years
Synthesis of words:			Tasks 418 - 419: (i) Unable to synthesize letters into syllable (ii) Did not know what word "syllable" meant					
418. Syllable: g-r-o	14	11,4		8-13	Syllable: p-r-o (7)	8-9 10-13	0	Delete for 8-9 years Include for 10-13 years
419. Syllable: p-l-y	14	10,0		8-13	Syllable: o-p-t (1)	8-9 10-13	0	Delete for 8-9 years Include for 10-13 years
				8-13	Syllable: l-o-c (1)	8-9 10-13	0	Delete for 8-9 years Include for 10-13 years
					Substitution of word "sound" for "syllable" in instructions			

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
420. Word: s-t-o-n-e	10-14	7,1	Tasks 420-423: (i) Said did not know (ii) Gave incorrect word (e.g. "stop" for "stone")	8-9	Word: d-o-g (1)	8-9	0	Include for 8-9 years
				8-9	Word: s-t-o-p (7)	8-9	5,0	Delete for 8-9 years
421. Word: k-n-i-g-h-t	14	17,1		8-13	Word: b-o-n-e (1)	8-13	0	Include for 8-13 years
					Word: k-n-e-e	8-9	11,7	Delete for 8-9 years
						10-13	0	Include for 10-13 years
422. Word: o - then - p - then - e - then - r - then - a	-	37,1		8-14	Word: c - then - a - then - t (7)	8-14	0	Include for 8-14 years
423. Word: s - then - o - then - u - then - n - then - d	-	28,6		8-14	Word: f - then - r - then - o - then - g (10)	8-14	0	Include for 8-14 years
				8-14	Word: a - then - p - then - p - then - l - then - e (11)	8-9 10-14	5,7 0	Delete for 8-9 years Include for 10-14 years
Writing 3 words from memory:			Tasks 427-429: (i) Misspelt word (ii) Recalled 2/3 words		Writing 2 words from memory:			
427. match	14	14,3		8-13	bus (12)	8-13	0	Include for 8-13 years
428. district	13-14	31,4		8-13	cake (12)	8-13	0	Include for 8-13 years
429. antarctic	-	67,1		8-14	flower (12)	8-9 10-14	4,3 0	Delete for 8-9 years Include for 10-14 years
				8-14	island (13)	8-14	17,1	Delete for 8-14 years
431. Writing address	10-14	4,3	Did not know address	-	Delete for 8-9 years	-	-	-
Dictation:					Dictation:			
432. Letters: f	9-14	1,4	Did not know what "f" was	8	Letters: a, n (14)	8	0	Include for 8 years
Open syllables:			Tasks 433-434:		Closed syllables:			
433. ba	-	10,0	Misspelt syllable	8-14	(i) ot (14)	8-14	0	Include for 8-14 years
434. da	-	10,0		8-14	(ii) an (14)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Dictation - words:			Tasks 435-438, 440-442		Dictation - words:			
435. back	9-14	2,9	(i) Spelt word phonetically	8	ball (12)	8	0	Include for 8 years
436. pack	9-14	1,4		8	call (12)	8	0	Include for 8 years
437. wren	-	42,9	(ii) Had not yet learnt to spell word	8-14	knee (15)	8-12 13-14	16,0 0	Delete for 8-12 years Include for 13-14 years
438. knife	10-14	4,3		8-14	knock (15)	8-12 13-14	21,4 0	Delete for 8-12 years Include for 13-14 years
440 contemporary	-	88,6		8-9	play (11, 12)	8-9	0	Include for 8-9 years
				8-14	birthday (12)	8-9 10-14	2,9 0	Delete for 8-9 years Include for 10-14 years
				10-14	bicycle (16)	10-14	18,0	Delete for 10-14 years
				13-14	permanent (17)	13-14	20,0	Delete for 13-14 years
441. physiology	-	85,7		8-9	hand (12)	8-9	0	Include for 8-9 years
				10-12	sword (18)	10-12	20,0	Delete for 10-12 years
				10-14	caravan (19)	10-14	0	Include for 10-14 years
				13-14	guess (12)	13-14	15,0	Delete for 13-14 years
442. popocatepetl	- .	100,0		8-9	broom (19)	8-9	0	Include for 8-9 years
				10-12	special (20)	10-12	30,0	Delete for 10-12 years
				10-12	because (12)	10-12	0	Include for 10-12 years
				8-14	telephone (21)	8-12 13-14	17,1 0	Delete for 8-12 years Include for 13-14 years
				13-14	signature (1)	13-14	30,0	Delete for 13-14 years
				13-14	permanent (1)	13-14	20,0	Delete for 13-14 years
				13-14	microscope (1)	13-14	10,0	Delete for 13-14 years
Writing phrases:					Writing phrases:			
444. all of a sudden	10-14	11,4	Spelt "sudden" incorrectly	8-9	by the sea (22)	8-9	0	Include for 8-9 years
445. last year before Christmas	12-14	30,0	Spelt "Christmas" and/or "before" incorrectly	8-11	very happy (23)	8-11	0	Include for 8-11 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Writing names of objects:			Tasks 446-448:					
446. ashtray	10-14	12,9	(i) Spelt word phonetically	8-9	cup (24)	8-9	0	Include for 8-9 years
			(ii) Had not yet learnt to spell word	8-9	pen (1)	8-9	0	Include for 8-9 years
448. pair of scissors	13-14	40,0		8-12	spoon (24)	8-12	0	Include for 8-12 years
				8-12	pencil (24)	8	10,0	Delete for 8 years
						9-12	0	Include for 9-12 years
				10-12	sharpener (1)	10-12	6,7	Delete for 10-12 years
Reading open and closed syllables:			Tasks 456-460:		Reading closed syllables			
456. pro	9-14	4,3	(i) Did not know what word "syllable" meant	8	an (25)	8	0	Include for 8 years
457. cor	9-14	2,9		8	os (25)	8	0	Include for 8 years
458. cra	9-14	4,3	(ii) Unable to sound syllable	8	mon (1)	8	0	Include for 8 years
459. spro	9-14	4,3		8	prot (1)	8	0	Include for 8 years
460. prot	9-14	4,3			Substitute word "sound" for "syllable" in instructions			
Reading words:			Tasks 461-465:		Reading words:			
461. juice	10-14	7,1	(i) Had not yet learnt to read word	8-9	house (26)	8-9	0	Include for 8-9 years
463. bonfire	9-14	2,9		8	banana (27)	8	0	Include for 8 years
464. cloakroom	9-14	2,9	(ii) Sounded word incorrectly	8	bathroom (1)	8	0	Include for 8 years
465. fertilizer	10-14	11,4		8-9	umbrella (27)	8-9	0	Include for 8-9 years
Reading ideograms:			Tasks 466-468:		Reading ideograms:			
466. UN	12-14	28,6	Did not recognise ideogram and attempted to read it as word	8-11	SA (28)	8-11	0	Include for 8-11 years
467. USA	13-14	7,1		8-12	OFS (28)	8-12	0	Include for 8-12 years
468. USSR	13-14	15,7		8-12	SAP (28)	8-12	0	Include for 8-12 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Reading complex words:			Tasks 469 - 470:		Reading complex words:			
469. insubordination	14	35,7	(i) Could not "sound" word therefore pronounced it incorrectly	8-13	university (1)	8-9 10-13	10,0 0	Delete for 8-9 years Include for 10-13 years
				8-13	exchange (29)	8-9 10-13	1,7 0	Delete for 8-9 years Include for 10-13 years
470. indistinguishable	14	44,3	(ii) Said did not know	8-13	operation (30)	8-9 10-13	10,0 0	Delete for 8-9 years Include for 10-13 years
				8-13	hippopotamus (1)	8-9 10-13	3,3 0	Delete for 8-9 years Include for 10-13 years
				8-13	elephant (11)	8-13	0	Include for 8-13 years
Reading unfamiliar words:			Tasks 471-472:		Reading unfamiliar words:			
471. astrocytoma	14	55,7	(i) Said did not know	8-13	cortex (1)	8-13	0	Include for 8-13 years
472. hemopoeisis	-	61,4	(ii) Could not sound word therefore pronounced it incorrectly	8-14	praxis (1)	8-13	0	Include for 8-13 years
Reading a phrase:					Reading a phrase:			
474. My head aches very much	10-14	10,0	Could not read word "aches" correctly	8-9	Mother cooks the dinner (31)	8-9	0	Include for 8-9 years
Reading a text:					Reading text:			
478. Card K23	13-14	20,0	Could not read many of the words in the text correctly (eg "orchard", "especially")	8-12	The princess and the golden ball (32)	8-12	0	Include for 8-12 years

1. A D Watts (Author)
2. Prowse, undated, Box 5
3. Redgrave and Nuttall, undated a, p.21
4. Prowse, undated, Box 20
5. Prowse, undated, Box 10
6. Prowse, undated, Box 7
7. Luria, 1980, p.534
8. Author - word taken from Prowse, undated, Box 2

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	

9. Author - word taken from Prowse, undated, Box 21
10. Prowse, undated, Box 3,
11. Murray, undated, p.52
12. Stone, undated
13. Prowse, undated, Box 4
14. Luria, 1980, p.539
15. Freedman, Dorman and Descy, 1975, p.7
16. Redgrave and Nuttall, undated b, p.30
17. Redgrave and Nuttall undated b, p.30
18. Freedman, Dorman and Descy, 1975, p.8
19. Author - on basis of discussion with Std. 1 school teacher
20. Redgrave and Nuttall, undated b, p.21
21. Freedman, Dorman and Descy, 1975, p.60
22. Redgrave and Nuttall, undated a, p.18
23. Redgrave and Nuttall, undated a, p.54
24. Freedman, Dorman and Descy, 1975, p.24
25. Luria, 1980, p.545
26. Carr, undated, p.4
27. Freedman, Dorman and Descy, 1975, p.42
28. Author, on basis of examples given by Redgrave and Nuttall, undated b, p.113
29. Prowse, undated, Box 23
30. Prowse, undated, Box 7
31. Redgrave and Nuttall, undated a, p.41
32. Redgrave and Nuttall, undated a, p.33

TABLE 13.9 : ARITHMETIC SKILLS

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS: ALL CORRECT RESPONSES: AGE RANGE	PHASE 1: CHILDREN INCORRECTLY PERFORMING TASK (%)	PHASE 1: NATURE OF INCORRECT RESPONSE	PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1: AGE RANGE FOR ADAPTED TASK (YEARS)	PHASE 2: ADAPTED TASK	PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS: CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	PHASE 3: CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	PHASE 3: DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Reading and writing visually complementary Roman numerals :			Tasks 484-485: (i) 8-9 year olds - not yet learnt Roman numerals (ii) 10-12 years: a) Learnt Roman numerals up to IV b) Wrote numeral incorrectly c) Did not know how to write requested numeral					
484. IV and VI	13-14	34,3		-	Delete for 8-12 years	-	-	-
485. IX and XI	14	47,1		-	Delete for 8-13 years	-	-	-
Reading and writing simple multi-digit numbers :			Tasks 489-491 and 495-496: 8 years - taught only to write and read numbers up to 100. (e.g. thus wrote 396 as 30096)					
489. 158	9-14	4,3		8	58 (1)	8	0	Include for 8 years
490. 396	9-14	4,3		8	99 (1)	8	0	Include for 8 years
491. 9845	9-14	8,6		8	84 (1)	8	0	Include for 8 years
Reading and writing multi-digit numbers in which some digits are zero and therefore not spoken :								
495. 109	9-14	1,4		8	30 (1)	8	0	Include for 8 years
496. 1023	9-14	12,9		8	100 (1)	8	0	Include for 8 years
Identifying categories (numbers written vertically):			Tasks 497-500: (i) Identified categories incorrectly as confused by vertical presentation of numbers (ii) 8 years - not yet learnt thousands category	8-14	(i) Number written horizontally (2)			
				8	(ii) 8 years - delete thousands category: 158 (1)	8	0	Include for 8 years
				9-14	(iii) 9-14 years: 1023(1)	9-14	0	Include for 9-14 years
497. thousands	-	20,0						
498. hundreds	-	24,3						
499. tens	-	22,9						
500. units	-	22,9						

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Identifying larger numbers			Tasks 503-504: Said numerically smaller number comprising high-value subsidiary digits larger than number comprising low-value subsidiary digits					
503. Oral presentation: 189-201	9-14	1,4		8	189 - 211 (1)	8	0	Include for 8 years
504. Visual presentation: 1967 - 3002	11-14	5,7		8	489 - 632 (1)	8	0	Include for 8 years
				9-10	489 - 601 (3)	9-10	0	Include for 9-10 years
Simple, automatized calculations: Multiplication:			Tasks 505-507: (i) Gave incorrect answer (ii) Had not yet learnt multiplication table		Simple, automatized calculations: (i) Multiplication			
505. 3 x 3	10-14	8,6		8-9	2 x 3 (1)	8	20,0	Delete for 8 years
						9	0	Include for 9 years
506. 5 x 4	9-14	4,3		8	5 x 5 (1)	8	60,0	Delete for 8 years
507. 7 x 8	14	30,0		8-13	6 x 10 (1)	8	40,0	Delete for 8 years
						9-13	0	Include for 8-13 years
Complex arithmetic operations: (i) Addition			Tasks 512-515: Difficulty solving arithmetic calculations: (i) arranged horizontally (ii) requiring carrying over from different categorical units (8 years)					
512. 27 + 8	11-14	11,4		8	24 + 5 (1)	8	0	Include for 8 years
				9-10	24 + 8 (1)	9-10	0	Include for 9-10 years
513. 44 + 57	11-14	15,7		8-10	44 + 57 - vertical arrangement (3)	8-10	0	Include for 8-10 years
(ii) Subtraction								
514. 31 - 7	11-14	14,3		8	38 - 7 (1)	8	0	Include for 8 years
				9-10	31 - 7 - vertical arrangement (4)	9-10	0	Include for 9-10 years
515. 41 - 14	14	21,4		8	47 - 14 (1)	8	0	Include for 8 years
				9-13	41 - 14 - vertical Arrangement (4)	9-13	0	Include for 9-13 years
					Additional requirements for addition and subtraction calculations: (i) Vertical arrangement (4) (ii) Calculate with paper and pencil (4)			

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Arithmetic operations with unusually arranged numbers:					Arithmetic operations with unusually arranged numbers	-		
516. Addition - vertically arranged numbers: 5 + 9 + 7	14	11,4	Answer incorrect	8 - 13	Addition - vertically arranged numbers: 5 + 3 + 2 (1)	8-13	0	Include for 8-13 years
517. Complicated subtraction: 18 - 24	-	78,6	(i) Said calculation cannot be computed as presented (ii) Answer incorrect	-	Delete for 8-14 years	-	-	-
Determining arithmetical signs:								
518. 10 □ 2 = 20	9-14	11,4	Recognised that sum involved notion of "making bigger", but incorrectly expressed it with "+" sign	-	Delete for 8 years	-	-	-
521. 10 □ 2 = 5	10-14	15,7	Recognised that sum involved notion of "making less", but incorrectly expressed it with "-" sign (Not yet learnt ÷ sums)	-	Delete for 8 - 9 years	-	-	-
Determining missing number:			Tasks 522-523:		Determining missing number:			
522. 12 - □ = 8	10-14	7,1	Answer incorrect	8-9	9 - □ = 6 (1)	8-9	0	Include for 8-9 years
523. 12 + □ = 19	10-14	11,4		8-9	10 - □ = 15 (1)	8-9	0	Include for 8-9 years
Serial arithmetical operations:					Serial arithmetical operations:			
(i) Oral presentation:			Tasks 524-527:		(i) Oral presentation:			
524. 12 + 9 - 6	14	24,3	(i) Would not attempt calculation (ii) Answer incorrect	8-13	2 + 8 - 3 (1)	8 9-13	20,0 0	Delete for 8 years Include for 9-13 years
					8 + 4 - 5 (1)	8-9 10-13	15,0 0	Delete for 8-9 years Include for 10-13 years
525. 32 - 4 + 9	14	27,1		8-13	9 - 5 + 4 (1)	8 9-13	40,0 0	Delete for 8 years Include for 9-13 years
					12 - 3 + 4 (1)	8-9 10-13	35,0 0	Delete for 8-9 years Include for 10-13 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
(ii) Visual presentation:					(ii) Visual presentation:			
526. 27 + 34 + 14	14	21,4		8-13	11 + 2 + 3 (1)	8 9-13	20,0 0	Delete for 8 years Include for 9-13 years
				8-13	17 + 3 + 14 (1)	8-9 10-13	20,0 0	Delete for 8-9 years Include for 10-13 years
527. 158 + 396	14	27,1		8-13	20 + 32 (1)	8 9-13	10,0 0	Delete for 8 years Include for 9-13 years
				8-13	25 + 135 (1)	8-10 11-13	20,0 0	Delete for 8-10 years Include for 11-13 years
Series of consecutive arithmetical operations:			Tasks 528-529:					
528. Counting backwards from 100 in sevens	-	75,7	(i) Refused to attempt task	8-14	Counting backwards from 100 in tens (1)	8-14	0	Include for 8-14 years
529. Counting backwards from 100 in thirteens	-	81,4	(ii) Correctly completed first part of series but then a) made mistakes and/or b) refused to continue	8-14	Counting backwards from 100 in fives (1)	8-11 12-14	20,0 0	Delete for 8-11 years Include for 12-14 years

1. A.D. Watts (Author)
2. Luria, 1980, p.555
3. Luria, 1980, p.184
4. Luria, 1980, p.557

TABLE 13.10 : MNESTIC PROCESSES

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
530. Learning series of 10 unrelated words: house - forest - cat - night - table - needle - pie - bell - bridge - cross	-	78,6	Mean number of words recalled after 10 trials = 9 (last 2 words most frequently omitted)	8-14	Learning series of 8 unrelated words: house - forest - cat - night - table - needle - pie - bell (1)	8-14	0	Include for 8-14 years
531. Learning series of 9 unrelated numbers: 7 - 1 - 3 - 9 - 4 - 2 - 5 - 6 - 8	14	30,0	Mean number of digits recalled after 10 trials = 8 (last 2 numbers most frequently omitted)	8-13	Learning series of 7 unrelated numbers: 7 - 1 - 3 - 9 - 4 - 2 - 5 (1)	8-13	0	Include for 8-13 years
Form recognition (Kornorski's Test):					Form recognition (Kornorski's Test):			
532. (a) ■ (b) ■ Recall after "empty" pause	10-14	4,3	Said two stimuli were same	8-9	(a) ■ (b) ▲ (2) Recall after "empty" pause	8-9	0	Include for 8-9 years
533. (a) ▲ ■ ● (b) ▲ ■ ● Recall after filled pause	-	35,7	Said two sets of stimuli were the same	8-14	(i) (a) ▲ ● (b) ▲ ● Recall after filled pause (1)	8-14	42,9	Delete for 8-14 years
				8-14	(ii) (a) ⬢ (b) ▲ (3) Recall after filled pause	8-14	0	Include for 8-14 years
Multiplication:								
534. 9 x 3	13-14	12,9	Tasks 534-536: (i) Gave incorrect answer	8-12	Multiplication: 2 x 2 (1)	8-12	0	Include for 8-12 years
				8-12	9 x 3 (1)	8-9 10-12	35,0 0	Delete for 8-9 years Include for 10-12 years
535. 13 x 4	-	55,7	(ii) Had not yet learnt multiplication table	8-9	2 x 5 (1)	8-9	0	Include for 8-9 years
				8-9	3 x 10 (1)	8-9	15,0	Delete for 8-9 years
				10-14	6 x 5 (1)	10-14	0	Include for 10-14 years
536. 7 x 6	14	21,4		8-9	3 x 3 (1)	8-9	0	Include for 8-9 years
				10-13	7 x 4 (1)	10-13	0	Include for 10-13 years
Immediate recall of: 539. 5 geometric shapes □ ○ △ + ◇	-	32,9	Recalled 4 shapes (◇ most frequently omitted)	8-14	Immediate recall of 4 Geometric shapes: □ + ○ △ (4)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
540. Rhythmic taps ''UUU''UUU''	10-14	10,0	Tapped incorrect number of loud and soft taps	8-9	Rhythmic taps ''UU''UU	8-9	0	Include for 8-9 years
3 hand positions:  541 542 543	14	15,0	Tasks 541-543: Recalled 2 hand positions (543 most frequently omitted)	8-13	2 hand positions:  (1)	8-13	0	Include for 8-13 years
433. Series of 5 words house - moon - street - boy - water	-	14,3	Recalled 3 or 4 words ("street" most frequently omitted)	8-14	Series of 4 words: house - moon - boy - water (5)	8-14	0	Include for 8-14 years
545. Recall of 3-word series (heterogeneous interference): house - tree - cat	-	37,1	(i) Recalled 2 words ("tree" most frequently omitted) (ii) Substituted words (eg. "house - tree boy")	8-14	Recall of 2-word series (heterogeneous interference): house - cat (6)	8-14	0	Include for 8-14 years
Recall of 3-word series (homogeneous interference):			Tasks 547-548: (i) Omitted words from both series (ii) Substituted semantically similar words for words in both series (iii) Confused elements of 1st and 2nd series (iv) "Forgot" 2nd series		Recall of 2-word series (homogeneous interference):			
547. man - hat - door	-	22,9		8-14	man - hat	8-14	0	Include for 8-14 years
548. night - stove - cake	-	62,9		8-14	night - chair	8-14	0	Include for 8-14 years
Recall of sentences (homogeneous interference):			Tasks 549-550: (i) Recalled 2nd sentence incorrectly (ii) "Forgot" 2nd sentence (iii) Confused elements of 1st and 2nd sentence (iv) Recalled 1st sentence incorrectly		Recall of sentences (homogeneous interference):			
549. The sun rises in the East	13-14	8,6		8-12	Mother cooks the dinner (7)	8-12	0	Include for 8-12 years
550. In May the apple trees blossom	13-14	20,0		8-12	Father digs in the garden (7)	8-12	0	Include for 8-12 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)		PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS: ALL CORRECT RESPONSES: AGE RANGE	PHASE 1: CHILDREN INCORRECTLY PERFORMING TASK (%)	PHASE 1: NATURE OF INCORRECT RESPONSE	PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1: AGE RANGE FOR ADAPTED TASK (YEARS)	PHASE 2: ADAPTED TASK		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS: CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	PHASE 3: CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	PHASE 3: DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Recall of stories:				Tasks 551-552:		Recall of stories:				
551. The Hen and the Golden Eggs		10-14	2,9	(i) Recalled 1st part of story and "forgot" 2nd part (primacy factor)		The Lion and the Mouse (8)		8-9	0	Include for 8-9 years
552. The Crow and the Doves		10-14	15,7	(ii) Recalled 2nd part of story and "forgot" 1st part (recency factor)		The Lion and the Fox (8)		8-9	0	Include for 8-9 years
				(iii) Recalled characters involved in story, but unable to recall actions they performed						
				(iv) Asked for story to be repeated						
Indirect memorising of words with the aid of picture cards: (a) Picture corresponding to word given						Indirect memorising of words with the aid of picture cards:				
Word to be memorised	Auxiliary picture card			Tasks 553-572:		Word to be memorised	Auxiliary picture card			
553. energy	The sea	13-14	22,9	(i) Unable to form association between word and picture as:	8-14	rain	umbrella (9)	8-14	0	Include for 8-14 years
554. employment	Donkey rides on the beach	-	51,4		8-14	burglar	lock (9)	8-14	0	Include for 8-14 years
555. party	People sitting and standing around a motor car	-	21,4	a) Did not know meaning of word	8-14	small	elephant (1)	8-14	0	Include for 8-14 years
556. happy family	Ducks in a stream	-	20,0	b) Unfamiliar with content of picture	8-14	winter	people sunbathing on beach (1)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)		PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1			PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
		ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK		CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Word to be memorised	Auxiliary picture card					Word to be memorised	Auxiliary picture card			
557. project	Children in a paddling pool	-	40,0	(ii) Named picture instead of recalling word (iii) Unable to recall word	8-14	coffee	cup (10)	8-14	0	Include for 8-14 years
558. pollution	Science laboratory	-	34,3		8-14	tame	lion (1)	8-14	0	Include for 8-14 years
559. untidiness	Neat study	-	25,7		8-14	swim	sea (1)	8-14	8,6	Delete for 8-14 years
560. factory	Thatched buildings	-	11,4		8-14	wood	desk (1)	8-14	0	Include for 8-14 years
561. holiday	Female typing	-	30,0		8-14	stupid	boy in classroom raising hand (1)	8 9-14	10,0 0	Delete for 8 years Include for 9-14 years
562. wisdom	Shelves of books	-	58,6		8-14	morning	bed (10)	8-14	0	Include for 8-14 years
					8-14	boy	men running (1)	8-14	0	Include for 8-14 years
(b) Word corresponding to picture chosen by subject						(b) Word corresponding to picture chosen by subject				
Words to be memorised	Picture cards from which to choose					Words to be memorised	Picture cards from which to choose			
563. circles	marbles	-	12,9		8-14	round	marbles (1)	8-14	0	Include for 8-14 years
564. joy	horses galloping in field	-	81,4		8-14	cold	horsedrawn cart in snow (1)	8-12 13-14	8,3 0	Delete for 8-12 years Include for 13-14 years
565. pattern	wooden trellice	-	24,3		8-14	pattern	wooden trellice (1)	8-14	0	Include for 8-14 years
566. handicraft	fireplace	-	57,1		8-14	happy	smiling girl hugging dog (1)	8-14	0	Include for 8-14 years
567. peace	river scene	-	40,0		8-14	farm	cock (1)	8-14	0	Include for 8-14 years
568. ruin	broken roof	-	55,7		8-14	play	people playing swingball (1)	8-14	7,1	Delete for 8-14 years
569. friendship	lady helping man across stream	-	38,6		8-14	honey	bee (1)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)		PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1			PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
		ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK		CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
								AGE RANGE (YEARS)	%	
Words to be memorised	Picture cards from which to choose					Words to be memorised	Picture cards from which to choose			
570. curiosity	dog sniffing in snow	-	58,6		8-14	hungry	boy eating sandwich (1)	8-14	0	Include for 8-14 years
571. cold	factory buildings on banks of iced river	-	20,0		8-14	read	book-shelves (1)	8-14	11,4	Delete for 8-14 years
572. mannerism	riding horse-drawn cart in snow	-	67,1		8-14	music	piano (1)	8-14	0	Include for 8-14 years
					8-14	apple	orchard (1)	8-14	0	Include for 8-14 years
Recalling by the pictogram method:				Tasks 573-587:		Recalling by the pictogram method:				
573. a hungry boy		-	28,6	(i) Did not know meaning of word (ii) Recalled single word of phrase e.g. 'hungry' for "a hungry boy" (iii) Named drawing (iv) Unable to recall word	8-14	sad	(1)	8-14	0	Include for 8-14 years
574. a clear sky		-	30,0		8-14	sky	(1)	8-14	14,3	Delete for 8-14 years
575. cause		-	97,1		8-14	night	(1)	8-14	0	Include for 8-14 years
576. development		-	42,9		8-14	stormy	(1)	8-14	0	Include for 8-14 years
577. debts		-	55,7		8-14	teacher	(1)	8-14	0	Include for 8-14 years
578. stormy weather		-	31,4		8-14	games	(1)	8-9	10,0	Delete for 8-9 years
								10-14	0	Include for 10-14 years
579. guardian		14	52,9		8-14	pretty	(1)	8-14	0	Include for 8-14 years
580. abstraction		-	98,6		8-14	parent	(1)	8-14	0	Include for 8-14 years
581. happy event		-	47,1		8-14	rain	(1)	8-14	0	Include for 8-14 years
582. a dark night		-	27,1		8-14	sick	(1)	8-9 10-14	15,0 0	Delete for 8-9 years Include for 10-14 years
583. combination		-	98,6		8-14	winter	(1)	8-14	44,3	Delete for 8-14 years
584. tragedy		-	50,0		8-14	clever	(1)	8-14	5,7	Delete for 8-14 years
585. opponent		-	58,6							
586. omen		-	92,9							

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	

1. A.D. Watts (author)
2. Luria, 1976d, p.240
3. Luria, 1976d, p.264
4. Adapted from Luria, 1980, p.471
5. Adapted from Luria, 1980, p.472
6. Luria, 1976d, p.75
7. Redgrave and Nuttall, undated a, p.41
8. Luria, 1976d, p.110
9. Luria, 1980, p.483
10. Luria, 1976d, p.248

TABLE 13.11 : INTELLECTUAL FUNCTIONS

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Story conveyed by picture:			Tasks 589-590:		Story conveyed by picture:			
589. Card N2	12-14	5,7	Named individual elements in picture	8-11	The dolphinarium (1)	8-11	0	Include for 8-11 years
590. Card N3	14	42,9	Did not describe their relationships	8-13	A family braaivleis (1)	8-13	0	Include for 8-13 years
Picture arrangement:			Tasks 591-593:		Picture arrangement:			
591. Cards N4 - N8	-	35,7	(i) Described individual pictures. Did not synthesize these into general theme of pictures (ii) Arranged pictures in order which did not make coherent story	8-14	Examiner presents pictures in correct order and asks subject to explain the sequence of events depicted (2)	8-14	0	Include for 8-14 years
592. Cards N9 - N13	-	71,4				8-14	54,3	Delete for 8-14 years
593. Cards N14 - N18	-	54,3				8-14	0	Include for 8-14 years
Explanation of pictures:			Tasks 594-598:					
594. Card N19	-	75,7	Described individual pictures or elements in pictures. Did not synthesize those into general theme of picture(s)	-	Delete for 8-14 years	-	-	-
595-596. Cards N20 - N21	-	72,9		-	Delete for 8-14 years	-	-	-
597-598. Cards N22 - N23	-	78,6		-	Delete for 8-14 years	-	-	-
Explanation of texts:			Tasks 599, 600, 608		Explanation of texts:			
599. The Hen and the Golden Eggs	-	51,4	(i) Did not know (ii) Gave explanation based on literal interpretation of story	8-14	The Ant and the Pigeon (3)	8-9 10-14	25,0 0	Delete for 8-9 years Include for 10-14 years
600. The Crow and the Doves	-	55,7		8-14	The Lion and the Mouse (3)	8-14	21,4	Delete for 8-14 years
608. The Lion and the Fox	-	61,4		8-14	The Hare and the Tortoise (4)	8-14	0	Include for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPON-SES: AGE RANGE	CHILDREN INCOR-RECTLY PERFORM-ING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Evaluation of metaphors:			Tasks 601-603:		Explanation of metaphors:			
601. iron fist	-	88,6	(i) 8-9 years - had not yet learnt metaphors (ii) Did not know meaning (iii) Had not heard metaphor before (iv) Gave literal interpretation (v) Guessed meaning	10-14	(i) a short cut (5)	10-14	0	Include for 10-14 years
602. stony heart	-	57,1			(ii) a sweet tooth (5)	10-14	22,0	Delete for 10-14 years
603. green fingers	-	68,6			(iii) second hand (5)	10-14	14,0	Delete for 10-14 years
					(iv) a bad egg (5)	10-14	28,0	Delete for 10-14 years
Explanation of proverbs:			Tasks 604-607:		Explanation of proverbs:			
604. All that glitters is not gold	-	90,0	(i) 8-9 years - had not yet learnt proverbs (ii) Did not know meaning (iii) Gave literal meaning (iv) Guessed meaning	10-14	(i) Where there's a will there's a way (7)	10-14	28,0	Delete for 10-14 years
605. Don't count your chickens before they hatch	-	42,9			(ii) The more the merrier (6)	10-14	28,0	Delete for 10-14 years
606. Card N24: Strike while the iron is hot	13-14	32,9			(iii) Better late than never (7)	10-14	24,0	Delete for 10-14 years
607. Card N25: Still waters run deep	14	47,1			(iv) First come, first served (7)	10-12 13-14	6,0 0	Delete for 10-12 years Include for 13-14 years
					(v) More haste less speed (7)	10-14	24,0	Delete for 10-14 years
					(vi) A stitch in time saves nine (7)	10-14	38,0	Delete for 10-14 years
					(vii) It never rains but it pours (6)	10-14	78,0	Delete for 10-14 years
					(viii) Too many cooks spoil the broth (7)	10-12 13-14	8,0 0	Delete for 10-12 years Include for 13-14 years
Definition			Tasks 610-611:		Definition:			
610. tractor	11-14	4,3	Said did not know meaning of word	8-10	motorcar (8)	8-10	0	Include for 8-10 years
611. island	10-14	8,6		8-9	tree (8)	8-9	0	Include for 8-9 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Comparison:			Tasks 612-614:		Comparison			
612. table and sofa	-	64,3	(i) Said did not know	8-14	(i) dog and cat (1)	8-14	0	Include for 8-14 years
613. axe and saw	-	54,3	(ii) Said they were not alike		(ii) piano and guitar (1)	8-10 11-14	8,6 0	Delete for 8-10 years Include for 11-14 years
614. north and west	-	38,6			(iii) rose and daisy (1)	8-14	0	Include for 8-14 years
					(iv) tennis and cricket (1)	8-14	14,3	Delete for 8-14 years
					(v) apple and bananas (1)	8-14	0	Include for 8-14 years
					(vi) March and June (1)	8-9 10-14	4,3 0	Delete for 8-9 years Include for 10-14 years
Differentiation:			Tasks 615-617:		Differentiation:			
615. fox and dog	-	38,6	(i) Said did not know	8-14	(i) lion and cat (1)	8-9 10-14	10,0 0	Delete for 8-9 years Include for 10-14 years
			(ii) Said they were not the same, but unable to say in what way		(ii) carrot and banana (1)	8-14	0	Include for 8-14 years
616. stone and egg	13-14	18,6		8-12	(i) caterpillar and butterfly (1)	8-12	0	Include for 8-12 years
			(iii) Described physical difference (eg. "a stone is round, an egg is not")		(ii) trumpet and violin (1)	8-12	12,0	Delete for 8-12 years
617. plank and piece of glass	13-14	12,9			(iii) butterfly and fly (9)	8-12	22,0	Delete for 8-12 years
					(iv) potato and apple (1)	8-12	12,0	Delete for 8-12 years
General categories:			Tasks 618-619:		General categories:			
618. rose - flower	10-14	10,0	(i) Said did not know	8-9	daisy - flower (1)			
619. salmon - fish	11-14	10,0	(ii) Gave incorrect categorical name	8-10	(i) shark - fish (1)	8-9 10	26,7 0	Delete for 8.9 years Include for 10 years
				8-10	(ii) sheep - animals (1)	8-10	0	Include for 8-10 years
Parts of whole:								
622. knife	13-14	20,0	Said did not know	-	Delete for 8-12 years	-	-	-
Parts from whole:			Tasks 623-624:					
623. pages	-	31,4	(i) Said did not know	-	Delete for 8-14 years	-	-	-
624. trees	-	41,4	(ii) Gave incorrect answer	-	Delete for 8-14 years	-	-	-

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
Opposites:			Tasks 625-627		Opposites:			
625. high	9-14	4,3	(i) Said did not know	8	(i) big (10)	8	0	Include for 8 years
626. fat	9-14	1,4	(ii) Gave incorrect answer		(ii) bad (10)	8	10,0	Delete for 8 years
627. old	9-14	1,4			(iii) day (10)	8	0	Include for 8 years
					(iv) hot (10)	8	0	Include for 8 years
Analogous words:					Analogous words:			
628. good (bad): high-low	14	17,1	(i) Said did not know (ii) Guessed or gave incorrect answer (iii) Did not understand instructions	8-13	high-low:good [poor / bad / man] (11)	8-9 10-13	20,0 0	Delete for 8-9 years Include for 10-13 years
629. wide (narrow):fat-thin	14	31,4		8-13	fat-thin:wide [long / narrow / short] (1)	8-9 10-13	28,0 0	Delete for 8-9 years Include for 10-13 years
630. finger(glove):foot-shoe	-	51,4		8-13	foot-shoe:finger [finger / hand / glove] (1)	8-13	35,7	Delete for 8-13 years
631. bicycle(wheel): table-leg	-	31,7		8-14	table-leg: bicycle [wheel / road / seat] (1)	8-9 10-14	7,1 0	Delete for 8-9 years Include for 10-14 years
632. bicycle(wheel) (Card N28)	13-14	17,1		-	Delete for 8-12 years	-	-	-
633. library (books): regiment-soldiers	-	30,0		8-14	regiment - soldiers: library [reader / building / books] (11)	8-14	21,4	Delete for 8-14 years
634. street (pavement): river-banks	-	50,0		8-14	river-banks: street [pavement / road / motor car] (1)	8-14	25,7	Delete for 8-14 years
Object not belonging to group:			Tasks 636-639:		Object not belonging to group:			
636. spade-saw-axe-log	14	17,1	(i) Said did not know (ii) Gave incorrect answer	8-13	horse-cow-sheep-tractor (12)	8-13	0	Include for 8-13 years
637. spoon-table-glass-plate	14	25,7		8-13	coat-cupboard-dress-trousers (12)	8-13	0	Include for 8-13 years
638. ball-doll-rocking horse knife	14	5,7		8-13	peach-grass-apple-pear (12)	8-13	0	Include for 8-13 years
639. cigar-wine-cigarette-tobacco	14	11,4		8-13	chair-table-cup-bed (12)	8-13	0	Include for 8-13 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: AGE RANGE (YEARS)	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK: %	DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
Elementary arithmetical operations:			Tasks 642-648:		Addition:			
642. Intermediate addition: Mary had 4 apples and and Betty had 2 apples more than Mary. How many apples did they both have together?	11-14	5,7	(i) Said did not know (ii) Omitted intermediate operation when solving problem	8-10	Sue had 4 cents. Her mother gave her 2 cents for sweeping the floor. How much money did she have then? (13)	8-10	0	Include for 8-10 years
				8-14	Henry had 6 marbles. He won 8 in a competition. How many marbles did he have then? (13)	8-9 10-14	1,4 0	Delete for 8-9 years Include for 10-14 years
Complex arithmetical operations:				8-14	There were 3 birds sitting on a tree and 2 more arrived. How many birds in all were there on the tree? (15)	8-14	0	Include for 8-14 years
643. Consecutive serial problems: A farmer had 10 acres of land; from each acre he harvested 6 tons of grain; he sold one third to the government. How much did he have left?	-	88,6	(i) Said did not know (ii) Had not yet learnt fractions (iii) Did not carry out steps involved in solving problem		Intermediate addition:			
				8-14	In one pocket Peter had 2 pens and in the other 1 more than this. How many pens were in his 2 pockets? (14)	8-9 10-14	4,3 0	Delete for 8-9 years Include for 10-14 years
Intermediate operations by means of special mathematical procedures:					Subtraction:			
644. There were 18 books on 2 shelves; there were twice as many on one shelf as on the other. How many books were there on each shelf?	-	88,6	Tasks 644-645: (i) Said did not know (ii) Tried to solve problem by trial and error (iii) Tried to solve problem by dividing sum (18) into 2 parts	8-14	A newspaper seller had 12 newspapers. He sold 5 during the afternoon. How many did he have left? (13)	8-9 10-14	7,1 0	Delete for 8-9 years Include for 10-14 years
					Multiplication:			
645. There were 18 books on 2 shelves; there were 2 more on one shelf than on the other. How many books were there on each shelf? Card N35: 10 and 8	-	61,4		8-14	Jane had 3 oranges. Pam had twice as many. How many oranges did Pam have? (13)	8-12 13-14	14,3 0	Delete for 8-12 years Include for 13-14 years
				8-14	Jack had 6 times as many sweets as Peter. Peter had 7 sweets. How many sweets did Jack have? (13)	8-14	30,0	Delete for 8-14 years

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	
Complex problems involving intermediate operations:					Division:			
646. A son is 5 years old. In 15 years his father will be 3 times as old as he. How old is the father now?	-	77,1	(i) Recognised that problem involved concept "making bigger" but used addition instead of multiplication (ii) Said did not know	9-14	John had half as many sandwiches in his lunch-box as Paul, who had 6. How many sandwiches did Paul have? (13)	9-12 13-14	11,7 0	Delete for 9-12 years Include for 13-14 years
				9-14	Jill had 25 flowers in a vase. Mary had 1/5 of these. How many flowers were there in Mary's vase? (13)	9-12 13-14	15,0 0	Delete for 9-12 years Include for 13-14 years
Conflict problems:								
647. A pedestrian walked to the station in 15 minutes, and a cyclist rides there 5 times faster. How long does does the cyclist take to get to the station?	-	50,0	(i) Confused by word "faster" and therefore used multiplication instead of division to solve problem (ii) Said did not know					
648. A pencil is 6 inches long; the shadow of this pencil is 18 inches longer than the pencil. How many times longer than the pencil is the shadow?	-	88,6	(i) Omitted intermediate stage (18+6) and immediately divided 18 by 6 (ii) Did not know					

1. A.D. Watts (Author)
2. Luria, 1980, p.566
3. Luria, 1976d, p.109
4. Christensen, 1975, p.33
5. Best, 1963, p.35-62
6. Redgrave and Nuttall, undatedb, pp.80-83
7. Richards, 1960, pp.114-116
8. Luria, 1980, p.574

TASK (FOR ADULTS: AS PER CHRISTENSEN 1975)	PHASE 1: CHILDREN'S PERFORMANCE (SAMPLE 1) ON ADULT LNI TASKS			PHASE 2: ADAPTATIONS OF ADULT LNI TASKS ON BASIS OF PHASE 1		PHASE 3: CHILDREN'S PERFORMANCE (SAMPLE 2) ON ADAPTED LNI TASKS		
	ALL CORRECT RESPONSES: AGE RANGE	CHILDREN INCORRECTLY PERFORMING TASK (%)	NATURE OF INCORRECT RESPONSE	AGE RANGE FOR ADAPTED TASK (YEARS)	ADAPTED TASK	CHILDREN INCORRECTLY PERFORMING ADAPTED LNI TASK		DECISION CONCERNING USE OF ADAPTED TASK FOR CHILDREN'S LNI
						AGE RANGE (YEARS)	%	

9. Luria, 1963b, p.36
10. Redgrave and Nuttall, undated b, p.64
11. Luria, 1980, p.575
12. Adapted from Luria, 1980, p.576
13. Adapted from school arithmetic books
14. Adapted from Luria, 1963b, p.32
15. Luria, 1963b, p.38

5.4.2 Performance of children (Sample 1) on Luria's Neuropsychological Investigation with respect to age, socioeconomic status and sex

Information pertaining to the number of mistakes made by children comprising the first group of eight to 14 year olds (Sample 1) on each section of the LNI in terms of age, sex and socioeconomic status is detailed in Appendix 3.

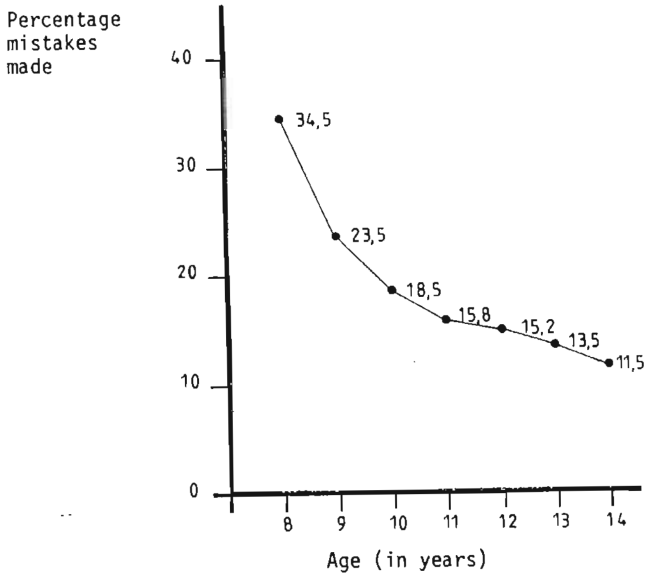
The performance of these children on the LNI in terms of age, sex, socio-economic status and LNI section has been visually represented in Graphs 1, 2, 3 and 4 respectively (see Appendix 4 for the tables on which these graphs were based).

Additional information concerning the number of mistakes made by the children in Sample 1 for each LNI section, sub-section and task requiring adaptation in terms of overall performance, age, sex, and socioeconomic status has been stored at the Neuropsychology Unit, Psychology Department, University of Natal, Durban and is available on request.

The interaction between age, sex, socioeconomic status and LNI sections with respect to number of errors was analysed according to a computerised analysis of variance. As there was no significant difference associated with sex, it was excluded (in consultation with a statistician). A second programme was run, the computation in this instance involving a three-way factorial analysis of variance (7 x 3 x 10 design) with age and socioeconomic status as the within subject variable. The findings have been summarised in Table 14. As indicated in this table, error frequency was significantly related to:

1. Age
2. LNI sections
3. The interaction of age and LNI sections
4. The interaction of socioeconomic status and LNI sections
5. The interaction between age, socioeconomic status and LNI sections.

Education was not included in the analysis as age was commensurate with level of education in this study (i.e. all eight year olds were in Standard one, and nine year olds in Standard two, and so on).

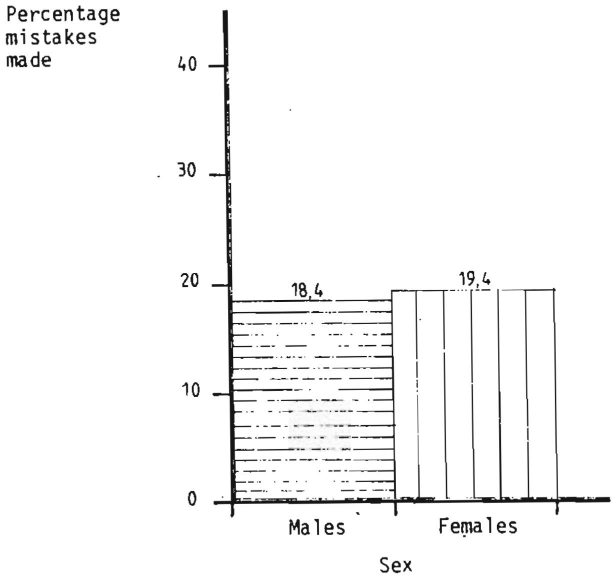


NOTE: An analysis of variance test was applied to the actual number of errors per age group.

Significantly fewer mistakes made on adult LNI tasks with increasing age ($F = 27{,}036$; $df_1 = 6$, $df_2 = 63$; $p<0{,}01$).

(See Appendix 4.1 for the table on which this graph was based.)

GRAPH 1 : PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) OF DIFFERENT AGES ON LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS

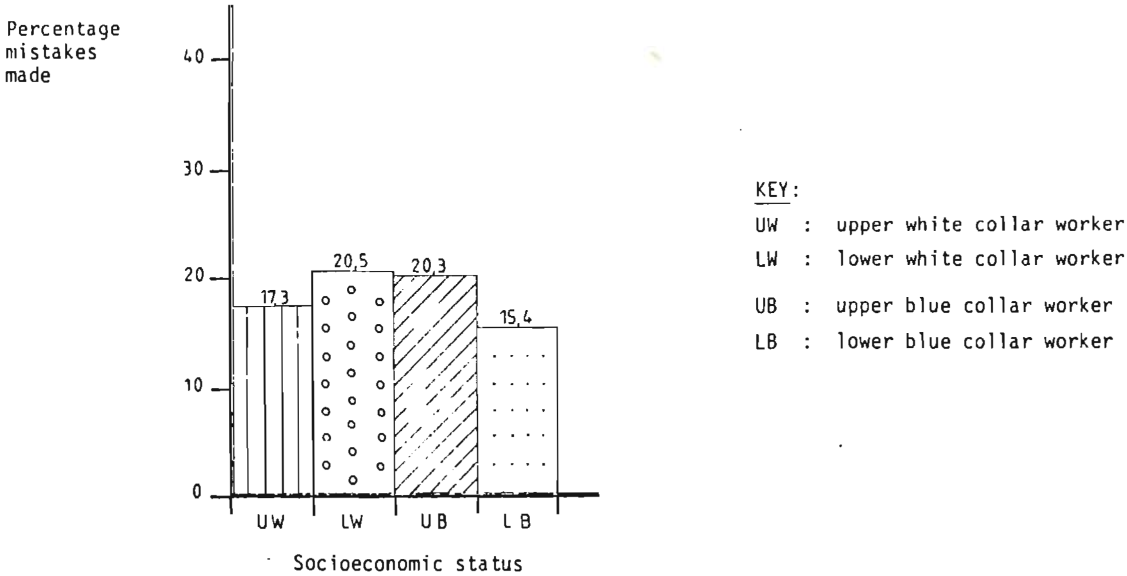


NOTE: An analysis of variance test was applied to the actual number of errors made by children of each sex.

No significant difference in the number of mistakes made on adult LNI tasks between the sexes. ($F = 0{,}188$; $df_1 = 1$, $df_2 = 68$; Not significant).

(See Appendix 4.2 for the table on which this graph was based.)

GRAPH 2 : PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) OF DIFFERENT SEX ON LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS

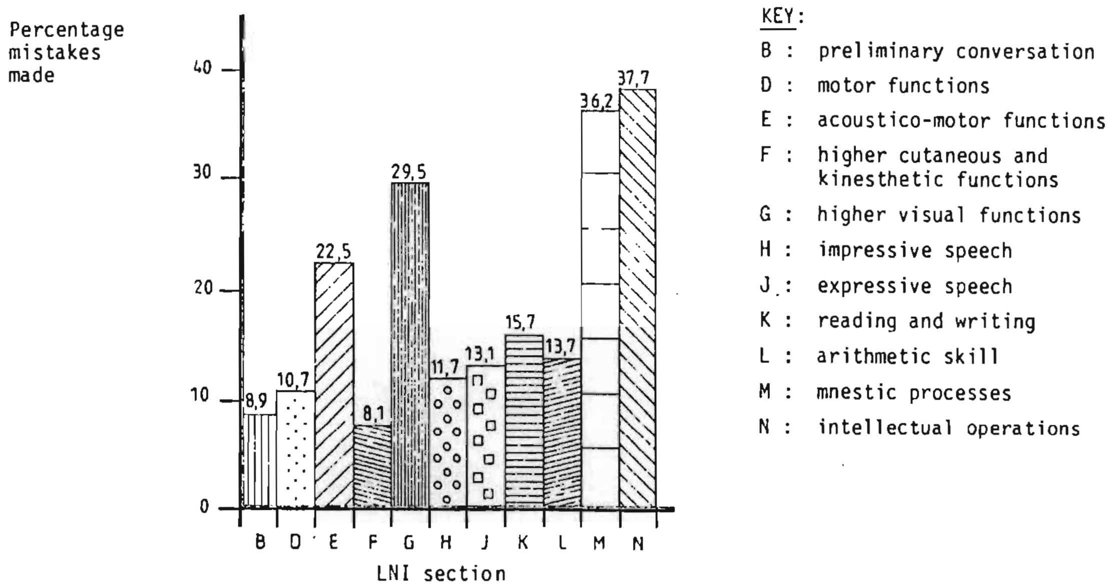


NOTE: An analysis of variance test was applied to the actual number of errors per socioeconomic group.

No significant difference in the number of mistakes made on adult LNI tasks by children of different socio-economic status. ($F = 3{,}340$; $df_1 = 2$, $df_2 = 67$; Not significant).

(See Appendix 4.3 for the table on which this graph was based.)

GRAPH 3 : PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) OF DIFFERENT SOCIOECONOMIC STATUS ON LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS



NOTE: An analysis of variance test was applied to the actual number of errors made by children on each adult LNI section.

Significantly greater number of mistakes made on adult LNI sections, comprising more complex tasks. ($F = 191{,}150$; $df_1 = 9$, $df_2 = 60$; $p<0{,}01$).

(See Appendix 4.4 for the table on which this graph was based.)

GRAPH 4 : PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) ON EACH SECTION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS

TABLE 14 : SUMMARY OF A THREE-WAY FACTORIAL ANALYSIS OF VARIANCE COMPUTED ON PHASE 1 RESULTS

SOURCE	DF	SUM OF SQUARES	MEAN SUM OF SQUARES	F-RATIO	SIGNIFICANCE LEVEL
Age	6	7 744,207	1 290,701	27,036	P<0,01
Socioeconomic status	2	318,883	159,441	3,340	Not Significant
Age x Socioeconomic Status	12	961,278	80,107	1,678	Not Significant
Error (1)	49	2 339,271	47,740		
LNI section	9	18 206,534	2 022,948	191,150	P<0,01
Age x LNI section	54	2 427,492	44,954	4,248	P<0,01
Socioeconomic status x LNI section	18	369,292	20,516	1,939	P<0,05
Age x Socioeconomic status x LNI section	108	1 882,744	16,877	1,595	P<0,01
Error (2)	441	4 667,128	10,583		

NOTE: See Appendix 5 for the table of means.

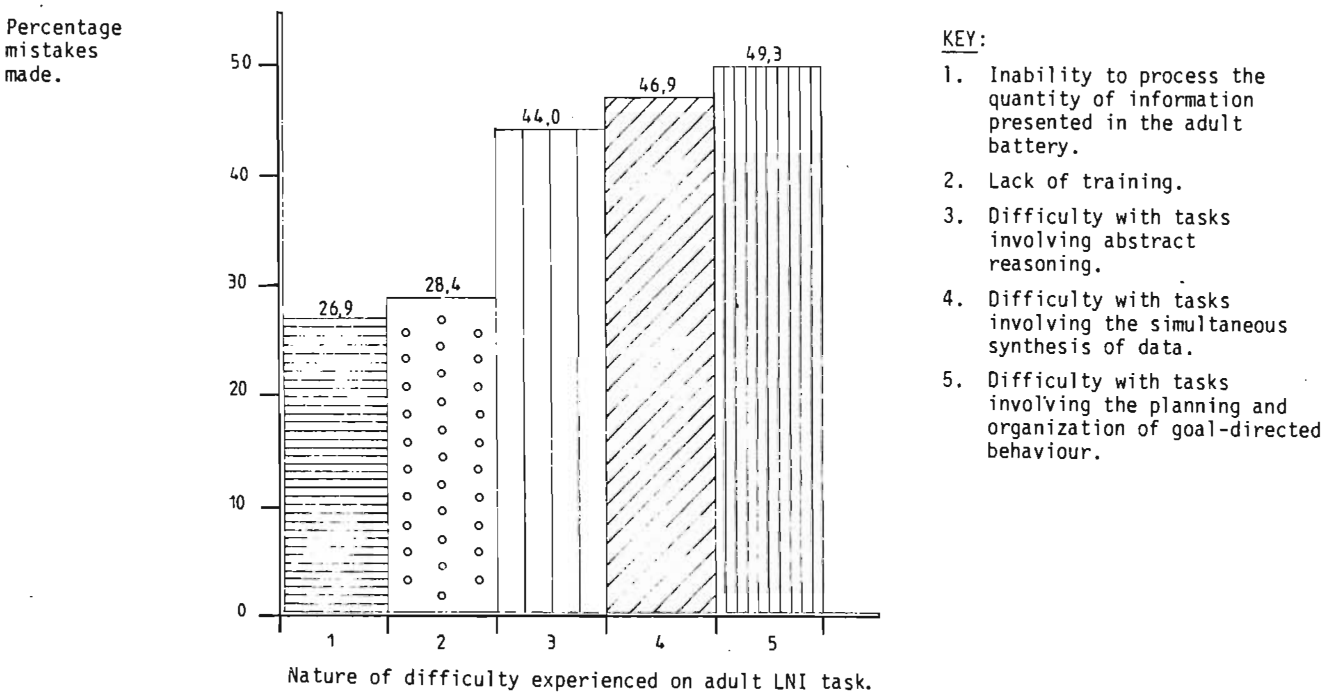
5.4.3 Type of difficulty experienced by children (Sample 1) on Luria's Neuropsychological Investigation and their apparent relationship to brain-behaviour development

The type of mistakes made by children on adult LNI tasks could be broadly defined as follows:

1. Inability to process the quantity of information presented in the adult battery;
2. Lack of training;
3. Difficulty with tasks involving abstract reasoning;
4. Difficulty with tasks involving the simultaneous synthesis of data; and
5. Difficulty with tasks involving the planning and organization of goal-directed behaviour.

The percentage of mistakes made by the children comprising the first sample of eight to 14 year old children (Sample 1) in each of these categories have been visually represented in Graph 5.

Inability of process and retain the same quantity of information as adults and age related increases in this respect were primarily evident on tasks involving the processing and retention of a series of stimuli. For instance, drawing a series of figures (e.g. two circles, a cross and three triangles (see Table 13.2)), learning a sequence of oral movements (see Table 13.2), reproducing an acoustically presented rhythm (e.g. ''UUU''UUU''UUU'' (see Table 13.3)), repetition of a series of words (e.g. "lamp - wood - pin - boy - bridge" (see Table 13.7)) and learning a series of ten unrelated words or numbers (see Table 13.10)). Children were able to correctly perform these tasks if the amount of information to be processed was reduced by shortening the length of the series.



NOTE: (1) Percentage mistakes made broadly grouped into those attributable to an inability to process the quantity of information presented in the adult battery and lack of training on the one hand, and difficulty with tasks involving abstract reasoning, the simultaneous synthesis of data and the planning and organization of goal-directed behaviour, on the other hand.

(2) Greater percentage mistakes attributable to the latter group described in (1) above.

(See Appendix 6 for the table on which this graph was based.)

GRAPH 5 : PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) FOR EACH TYPE OF DIFFICULTY EXPERIENCED ON TASKS COMPRISING LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS

Lack of training reflected as a lack of educational and language sophistication in all age groups studied. This was evident in failure on tasks involving concepts and skills children had not yet acquired or learnt. For instance, more complex words (see Table 13.6), arithmetic operations (e.g. fractions, Roman numerals (see Table 13.9)), and compass directions (see Table 13.5). In these cases, adaptation of tasks involved either the substitution of simpler instructions and items, or deletion of tasks beyond the children's capabilities.

Difficulty with tasks involving abstract reasoning skills was evident, for example, in the literal meaning frequently ascribed to words, thematic texts, proverbs and metaphors (e.g. defining the metaphor "iron fist" as "a very hard fist" (see Table 13.11)).

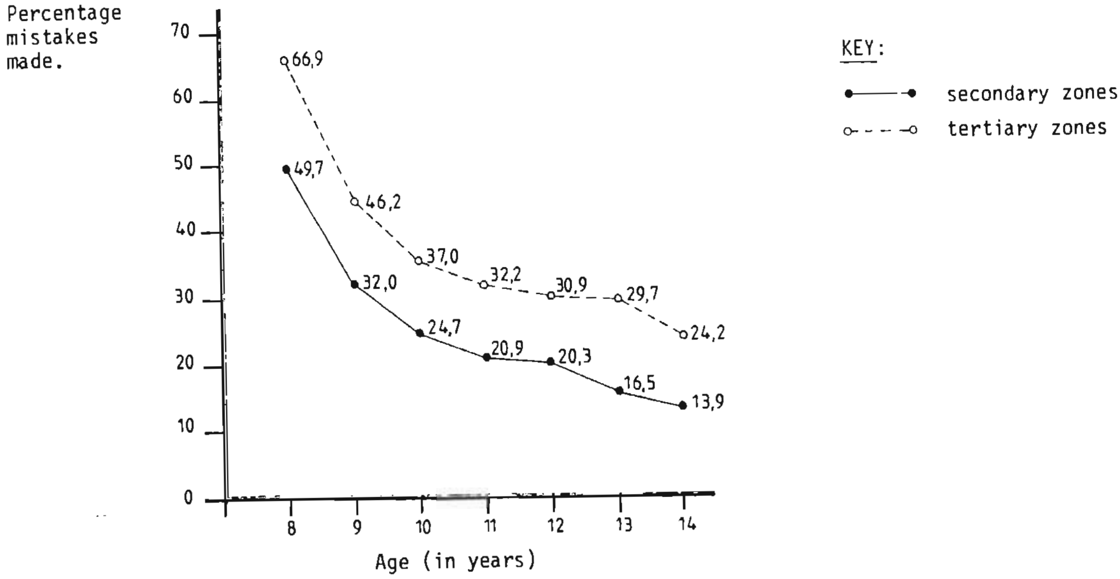
Difficulty with the simultaneous synthesis of data manifested during the performance of tasks which required the simultaneous integration of spatial data (e.g. completing a honeycomb pattern (Rupp's Test) and Block Designs (see Table 13.5)) and quasi-spatial synthesis (e.g. logico-grammatical constructions such as "Is the statement: I am unaccustomed to disobeying rules' said by a disciplined or undisciplined person" (see Table 13.6)).

Difficulty with tasks involving complex planned, goal-directed behaviour was evident, for instance, in a tendency to form direct impressions (e.g. thematic pictures and texts (see Table 13.11)).

In some instances where the mistakes children made on adult LNI tasks were apparently attributable to difficulties with abstract reasoning, the simultaneous synthesis of data and planned, goal-directed behaviour, they were able to perform a simplified version of the task (e.g. the block design pattern  (see Table 13.5)). In more complex items this was not, however, possible and the task was deleted during LNI-C development (e.g. the logico-grammatical construction: Which girl if fairer if Olga is fairer than Kate, but darker than Sonya". (See Table 13.6)).

The nature of the errors made by the children in Sample 1 were also categorised in terms of whether they appeared to reflect the functioning of the secondary or tertiary brain zones (none of the mistakes made appeared to reflect primary zone functioning). These results have been graphically presented in Graph 6.

Finally, tasks for cerebral dominance suggested that this was established in 60 (85,7%) of the children in Sample 1, and not established in ten (six eight year



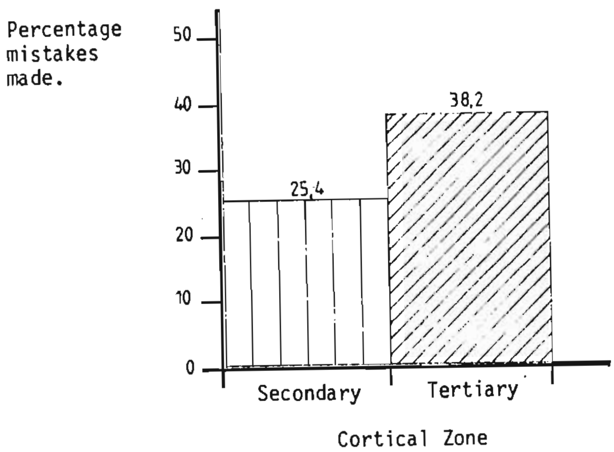
NOTE: (1) The differences are consistent in every age group assessed.

(2) Fewer mistakes made with increasing age on adult LNI tasks apparently reflecting the functioning of the secondary and tertiary zones.

(3) Greater percentage of mistakes made in all age groups on adult LNI tasks apparently reflecting the functions of the tertiary zones.

(4) An analysis of the nature of these difficulties is depicted in Graph 5.

GRAPH 6.1 : PERCENTAGE MISTAKES MADE BY CHILDREN OF DIFFERENT AGES ON ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS APPARENTLY REFLECTING SECONDARY AND TERTIARY ZONE FUNCTIONING



NOTE: (1) Greater percentage of mistakes made on adult LNI tasks apparently reflecting the functioning of the tertiary zones.

(2) This graph represents a synthesis of the results presented in Graph 6.1.

(See Appendix 7 for the tables on which these graphs were based.)

GRAPH 6.2 : COMPARISON OF PERCENTAGE MISTAKES MADE ON ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS APPARENTLY REFLECTING SECONDARY AND TERTIARY ZONE FUNCTIONING

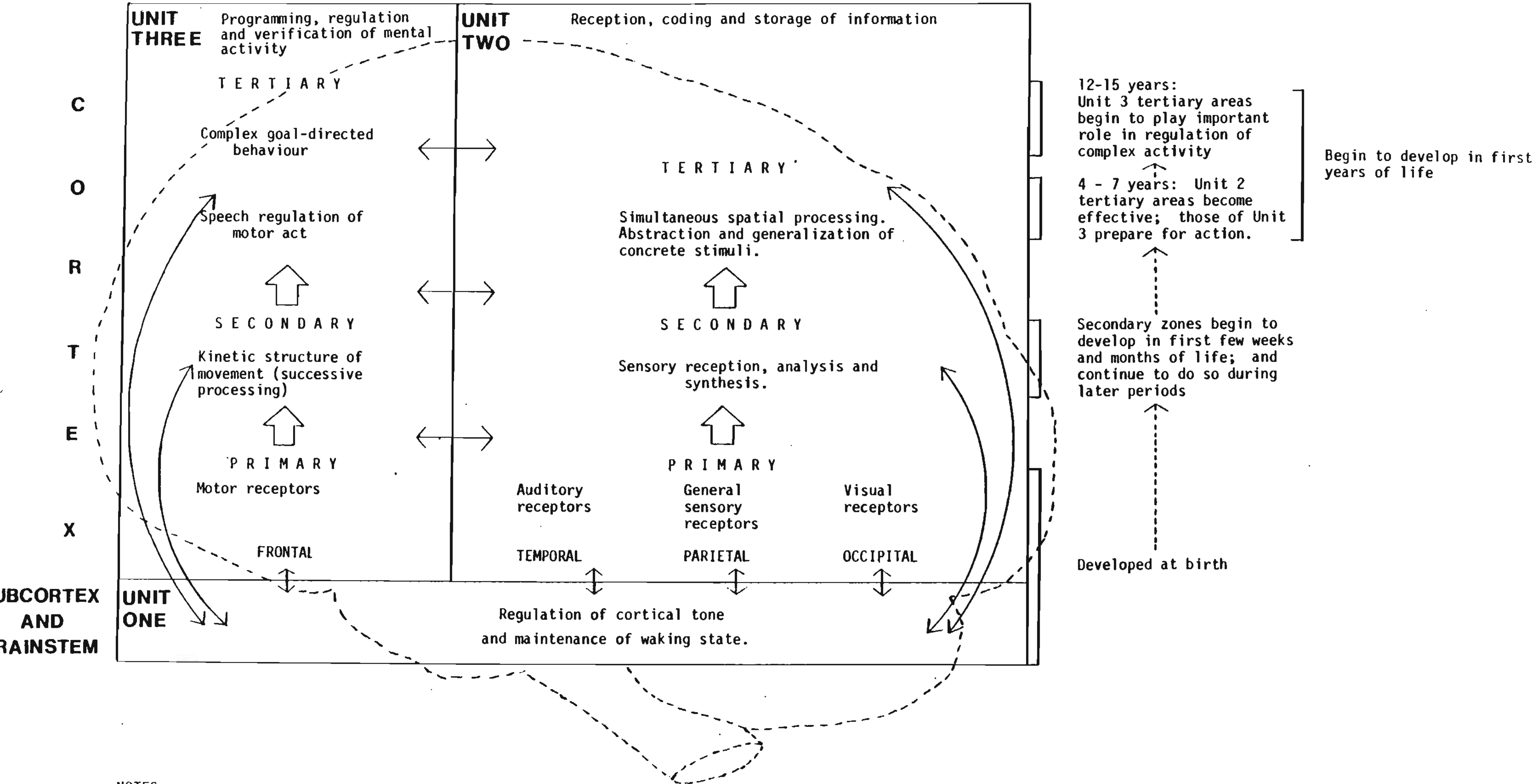
5.5 A CONCEPTUAL MODEL OF BRAIN-BEHAVIOUR ONTOGENY, BASED ON LURIA'S THEORIES, FOR LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN

The use of Luria's Neuropsychological Investigation for Children (LNI-C) necessitates a knowledge of the evolving functional organization of the developing brain. In order to provide a theoretical and explanatory developmental framework to the battery, a conceptual model of brain-behaviour ontogeny and interpretive protocol based on Luria's theories have been devised.

Luria's conception of the functional organization of the adult brain was described in Chapter 2 (see Section 2.4.1). The visual representation of Luria's model of brain-behaviour development which has been devised is presented in Figure 1.

Luria (e.g. 1973a, 1979, 1980) viewed development as a hierarchical process in which the development of lower cortical areas is essential for the adequate development of higher ones. He emphasized that elementary processes, which develop first, need to be intact in order to form the foundation on which complex processes develop.

According to Luria, Unit 1 is developed at birth. He indicated that the three cortical zones within the second and third units arise in definite order during ontogenetic development. As represented in Figure 1, the primary motor and sensory areas, together with the systems connecting them to the subcortical areas of the first unit, are the first to mature and become myelinated - a process which begins during the prenatal period. The secondary zones arise next, passing through an initial period of rapid myelinization during the first few weeks and months of life. Luria (1980 p.58) indicated that myelinization of these areas continues "during later periods" although he does not specify the time period involved. Finally, the tertiary fields develop during the first few years of life. The tempero-parieto-occipital tertiary zones become effective by four to seven years (Luria 1972b), whilst the frontal tertiary areas are the last to mature. They are prepared for action by four to seven years, but only begin to play a more important role in the regulation of complex activity at 12-15 years (Luria 1973a). The broad age ranges given by Luria, appear to reflect individual differences in the exact age at which a child attains



NOTES:

1. The different brain structures are interdependent.
2. There is constant feedback between cortical areas and the subcortex (⟷).
3. There is progressive functional lateralization with transition to secondary, and especially tertiary areas.
4. Development is continuous and proceeds in a hierarchical manner (⇧)
5. There are individual differences in the age at which each level of development is attained.
6. There is no direct correspondence between the brain-behaviour relationships depicted in this model and the stylized brain on which they are superimposed.

FIGURE 1 : STYLIZED MODEL OF THE SEQUENCE OF ONTOGENETIC DEVELOPMENT OF BRAIN-BEHAVIOUR RELATIONSHIPS AS PER LURIA.

each level within an invariant sequence of development. Biological and chronological age do thus not necessarily coincide.

Luria (1973a) indicated that the three cortical zones display progressive lateralization of function with the transition to secondary and especially tertiary areas during development. Luria (e.g. 1973a, 1980) also emphasized the interdependence of various areas during the development and activity of the brain. He additionally stressed the importance of constant feedback for regulating the activity of the brain. This feedback occurs vertically, between cortical and subcortical structures, and horizontally, between different cortical regions.

This model is discussed in relation to brain-behaviour developmental trends which emerged during the development of the LNI-C in Section 5.6.2.

5.6 DISCUSSION

This dissertation aimed to develop, within a Lurian framework, an integrated theoretical and assessment approach to the neuropsychological evaluation of children. Inherent in such an exercise are a myriad of difficulties (see Chapter 3) - wide variability in the rate at which children attain different levels of competency, together with the rapid changes occurring during development within different social environments, are but a few.

This discussion will first examine factors guiding the development of the protocol. Conceptual issues intrinsic to the task will be explored and these related to prominent approaches by other researchers. Thereafter, the age-related developmental trends which emerged in the course of this work will be discussed. These will be related to the visual representation of brain-behaviour ontogeny developed on the basis of Luria's work and prominent developmental theories. Methodology pertaining to sampling and data analysis, and areas for future research are addressed in Chapter 7 (see Sections 7.3 and 7.4 respectively).

5.6.1 Adaptation of the investigation and an evaluation of the protocol relative to prominent child neuropsychological procedures

Luria's Neuropsychological Investigation for Children (hereafter referred to as the LNI-C) has been designed for use with white, English-speaking South African children aged eight to 14 years. The protocol represents an adaptation of the adult battery of the same name in terms of Luria's view of the development of brain-behaviour relationships.

Luria (e.g. 1973a, 1980) has argued that higher mental processes are complex, functional systems which are based on the concerted working of different cortical areas. His mentor, Vygotsky, theorized that both the structure and cortical organization of higher cognitive functions varies at different developmental stages. A task may therefore be carried out by different groups of cortical zones at different ages (e.g. Vygotsky 1965).

Adaptation of the LNI for children thus proceeded on the premise that items should allow for qualitative differences in task performance at different ages. It was therefore not assumed that tasks would necessarily be performed by the same functional systems in children as in adults. In addition, Vygotsky's and Luria's concepts of brain-behaviour development have been incorporated into a conceptual framework for the protocol. This is discussed in Section 5.6.2.

The procedure used to adapt the LNI for children has been detailed in Section 5.3. To briefly reiterate, this involved administering the LNI adapted for adult, white South Africans (Watts and Tollman 1980b) to a sample of 70 eight to 14 year old children (ten per year) with no known history of brain dysfunction. Tasks that children were unable to complete correctly were deleted or adapted. The method for adapting tasks is described in Section 5.3.2. It involved:

- replacement of some stimulus material with that more appropriate for children (for example, as per educational syllabi);
- simplification of items by substitution of simpler words or examples, reduction of the length of sequential tasks, and simplification of the procedure and instructions;
- elaboration of tasks; and

- deletion of tasks beyond the capabilities of a particular age group.

Finally, the modified version of the protocol was administered to a second sample of children without brain dysfunction in order to ascertain that the proposed alterations were appropriate.

The LNI was modified for a lower age limit of eight as a major part of the instrument assesses educationally learnt skills such as language, reading, writing and arithmetic. By the age of eight a child has both acquired the basic concepts pertaining to these and entered the stage of concrete operations (e.g. Ginsberg and Opper 1969; Flavell 1963; Piaget and Inhelder 1969). The upper age limit of 14 was selected as it is the age at which Piaget considered most children to have attained the formal operational level (e.g. Ginsberg and Opper 1969; Flavell 1963; Piaget and Inhelder 1969). Whilst this age range is very similar to that of the Reitan-Indiana Battery (nine to 14 years), it is broader than the eight to 12 year age range of Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR).

Adaptation of tasks for the LNI-C was guided by the results of a statistical analysis performed on data collected when the adult LNI was administered to intact eight to 14 year old children (Sample 1). This revealed significant findings with respect to age and socioeconomic status, but not sex. Education was not included in the analysis as age was commensurate with educational level in this study. Each of these findings will be discussed in relation to LNI-C development.

The expected age-related improvement in performance on the adult battery was confirmed ($F = 27{,}036$, $p<0{,}01$) (see Graph 1). There was also a significant interaction between the performance of children of different ages and the sections of the LNI ($F = 4{,}248$, $p<0{,}01$). This reflected both an increase in the amount of information assimilated, and an increase in the complexity of material processed with age. In terms of the latter, progressively younger children made a significantly greater number of mistakes in LNI sections comprising more complex items (e.g. complex visual-spatial, mnemonic and intellectual tasks (see Table 13)). This is addressed further in relation to the development of brain and behaviour discussed in Section 5.6.2.

Age was thus central for the development of LNI-C items. When adapting tasks, care was always taken to modify them in terms of the literature's and educational view from a child's frame of reference - whilst at the same time adhering to the fundamental tenet underlying the LNI, that intact individuals should be able to correctly complete all, or nearly all, tasks with relative ease (Luria 1980; Luria and Majovski 1977). For purposes of constructing the battery, however, correct completion of *all* tasks was required. In order to differentiate the performance of children of different ages on the battery, both different tasks for different age levels and, at times, variations of the same task for different ages were developed in order to provide an appropriate range of difficulty (see Table 13 and LNI-C manual). This is consistent with Rourke's (1976) contention that the marked developmental changes occurring in the five to 15 year age span necessitate such a procedure. Age also appears to have been the major variable guiding the development of other neuropsychological batteries for children (e.g. Halstead-Reitan children's batteries, LNNB-CR).

The statistical analysis also revealed a significant interaction between socioeconomic status, and LNI section in terms of error frequency ($F = 1{,}939$, $p<0{,}05$). This supports both Vygotsky's (1962, 1965, 1978) and Luria's (e.g. 1973a, 1977/1978, 1979, 1980) emphasis on the importance of the sociocultural environment for development. This is further expanded in Section 5.6.2 in relation to the development of higher mental processes. The importance of taking socioeconomic status into account when developing the LNI-C nevertheless appears to have been highlighted. Socioeconomic status reflects differences in life opportunities, experiences and the cultural environment in which the child is reared. An attempt was thus made to adapt LNI-C tasks on the basis of samples of children which, socioeconomically, reflected the white, South African population.

Finally, the statistical analysis revealed no significant sex differences in the performance of children on the adult LNI. The same tasks have therefore been used for both males and females on the LNI-C. This would seem to be broadly in keeping with the experimental literature on sex differences. A male superiority for visuospatial skills and female for verbal abilities appears to be the most frequently and consistently cited sex difference in cognitive functioning (e.g. Maccoby and Jacklin 1974). This usually becomes evident during puberty (e.g. McGee 1979, Nyborg 1983). Despite these findings in the experimental literature, sex differences in performance on neuropsychological batteries has largely been neglected. Major instruments such as the Halstead-Reitan and Luria-Nebraska protocols have traditionally not reported any data on sex differences in performance (Filskov and Catanese 1986). Studies which have been conducted have generally focussed on isolated tests, mostly from the HRNB. This is especially true in adults where males have been shown to consistently perform better than females on tests of motor speed and grip strength (e.g. Dodrill 1979, Fromm-Auch and Yeudall 1983; Gordon and O'Dell 1983). Earlier studies involving the Halstead-Reitan children's batteries have generally found sex differences to be rare and to form no consistent or interpretable pattern (e.g. Klonoff and Low 1974; Klonoff, Robinson and Thompson 1969). A more recent study on the Reitan-Indiana Test Battery for Children by Townes *et al.* (1980), however, found superiority in primary school aged boys on a spatial memory task and combined score for grip strength and motor speed scores. Girls were superior on verbal reasoning, aphasia and serial perceptual matching tasks. This is inconsistent with both the experimental literature which suggests, as indicated earlier, that sex differences only become evident at puberty, and with the findings of this research project. As Spreen *et al.* (1984) have concluded, the findings regarding sex differences in the development of higher mental functions appear to be equivocal at present.

Luria (1973a, 1980) emphasized the importance of determining latent or partial left-handedness, and hence cerebral dominance, in order to evaluate the symptoms associated with brain damage. Christensen (1979a) suggested the use of the dichotic listening test (Kimura 1961; 1967) for this purpose in the adult LNI, as she argued that Luria's (1980) tests for determining latent or partial left-handedness were unsatisfactory. The dichotic listening test was retained for evaluating cerebral dominance in the LNI-C. It was, however, supplemented with several tasks for establishing hand, eye and foot dominance taken from the Halstead-Reitan children's batteries (Reitan undated), and selected items from Luria's (1980) tests for determining the presence of latent or partial left-handedness. These additional tasks were included in the LNI-C as findings concerning the development of a right ear advantage for speech and the validity of the dichotic listening technique as a measure of hemispheric asymmetry appear to be equivocal. In adults several studies have reported a fairly high incidence of classification errors (e.g. Bradshaw, Burden and Nettleton 1986; Springer 1986; Teng 1981) and hence raised questions about the validity of the dichotic listening procedure as a measure of speech hemispheric laterality (e.g. Wexler and Halwes 1983). In contrast, others (e.g. Geffen and Caudrey 1981) have found a high incidence of correct classification of speech hemispheric lateralization in subjects whose laterality was determined by other means, such as sodium amytal testing. In some instances, the discrepancies in these findings seem to be at least partially attributable to methodological differences in the nature and manner of presenting the dichotic listening material (see Clark 1986). Studies using the dichotic listening test in children appear divided in terms of whether right ear advantage (and hence left cerebral dominance for speech) is stable or increases during childhood (e.g. Satz *et al.* 1978; Springer 1986). Several studies have reported that right ear advantage is fairly stable after four years and comparable to that seen in adults (e.g. Berlin *et al.* 1975, Geffner and Hochberg 1971; Kimura 1963). Others have found an increase of right ear advantage between five to six years and 12 years (e.g. Bryden 1970; Simernitskaya, cited by Luria 1980). Luria (1980) has argued that the latter findings reflect increasing functional lateralization during development. He did, however, exphasize that the degree of hemispheric dominance ultimately present at maturity varies between individuals and for different functions. In the present study, tasks for cerebral dominance suggested that it was established in the majority of children evaluated (Sample 1). This seems to support Luria's view as it suggests that although hemispheric dominance for speech may be established in eight to 14 year olds, it appears to still be developing in some children of this age. Findings pertaining to the development of cerebral dominance for speech in brain-damaged children are discussed in Chapter 6 (see Section 6.7.1).

The LNI-C thus closely approximates the adult LNI from which it was adapted in terms of the areas of behavioural functioning investigated, the types of task used for this purpose, and the basic organization of the instrument. The qualitative nature of Luria's assessment approach has also been preserved. The LNI-C thus remains a process-orientated approach where the precise nature of information processing is explored.

The two most prominent batteries in child neuropsychology would seem to be the Halstead-Reitan tests and the Luria-Nebraska Neuropsychological Battery - Children's Revision (LNNB-CR) (see Chapter 3, Section 3.3). The LNI-C will therefore be discussed conceptually in relation to these.

There appear to be conceptual limitations associated with both the Halstead-Reitan Tests and LNNB-CR. The Halstead-Reitan does not seem to incorporate developmental aspects of child brain-behaviour processes (Majovski *et al.* 1979; see Chapter 3, Section 3.3). In developing the Halstead-Reitan tests for children, Reitan thus extended the adult battery downwards by administering it to progressively younger children in order to identify tasks with which they experienced difficulty. Items were then merely modified on the basis of the children's behavioural performance and norms developed (Reitan 1975). No conceptual framework appears to have guided this process.

Golden (e.g. 1981b) has argued that the LNNB-CR is based on a scheme of progressive neurobehavioural development generated by Luria. In relation to this, Golden has outlined five developmental stages (see Chapter 3, Section 3.3) which he implies Luria identified. At no point, however, do Golden and his co-workers seem to indicate the source of this information in their publications (e.g. Golden 1981b; Golden and Wilkening 1981). Perusal of Luria's literature via a literature search by this author - especially that relating to his work with children (reviewed in Chapter 3, Section 3.4) - has not elicited such a clear outline of any of these five developmental stages. Golden would therefore appear to have developed this scheme himself with reference to Luria's work and available developmental research. His sources of reference for these five stages do not appear to be acknowledged, however, nor do they seem to be stated in the available works of Luria. The battery thus appears to be based on a more general developmental scheme, and not on a purely Lurian framework, as seems to be implied by Golden. Furthermore, he does not seem to have attempted to verify this scheme or to demonstrate its diagnostic or interpretive use for the LNNB-CR in subsequent studies (see Chapter 3, Section 3.3).

The rationale used by Golden (e.g. 1981b) for LNNB-CR task selection, was to exclude tasks from the LNNB on the basis of the under-developed area of the brain they were supposedly designed to tap in the adult battery. More specifically he deleted items designed to evaluate frontal lobe functioning, as he argued that those areas are not functional in the eight to 12 year old child. The rationale behind this approach seems to be erroneous for the following reasons:

- In Chapter 1 it was pointed out that there is at present no known relationship between brain functional systems and behaviour in children of different ages as there is in adults. Furthermore, in children both the brain and psychological processes are still evolving. In adults behaviour patterns are established and the brain is developed (see Chapter 3, Sections 3.1 and 3.2). Exclusion of these tasks from an adult battery on the basis of the area of the brain they apparently evaluate implies that they examine the same region in both adults and children. As indicated earlier, Luria and Vygotsky have, however, argued that a task is carried out by different cortical zones at different stages in ontogenetic development.

- Luria (1979) has indicated that the frontal areas start to mature at three and a half to four years. In his work on the development of verbal self-regulation, he has related increased maturity of the frontal lobes to increasing verbal control over behaviour. This implies that the frontal lobes are, at least partially, functional in the eight to 12 year old child. As noted above, Golden (1981c) has, however, indicated that tasks to examine frontal lobe functioning - namely the "More complex items, involving frontal lobe control of behaviour" (Golden 1981c, p.295) - were excluded from the children's battery because these areas are not operational at eight to 12 years. Furthermore, this seems contradictory because perusal of the LNNB-CR (Golden, Hammeke and Purisch 1981) revealed that two items to measure the speech regulation of motor acts have been retained in the protocol (namely Items 33 and 34, p.4 of the battery). Additional confusion arises from a publication in which the authors were able to evaluate an 11 year old child with frontal lobe damage using the LNNB-CR (McKay *et al.* 1985). This issue is addressed further in Chapter 6 (see Section 6.7).

- Further, the rationale used by Golden to guide LNNB-CR item selection seems to ignore the multiple determinational nature of tasks comprising the LNI. In other words, with complex tasks, there are multiple pathways to the goal. Failure may be due to a disturbance of any of these, and hence to damage involving different functional systems. For instance, in complex arithmetic problems involving discursive thinking (e.g. "There were 18 books on two shelves; there were twice (or half) as many on one shelf as on the other. How many books were there on each shelf?" (Luria 1980 p.581)), failure may be due to a receptive language disturbance, a decline in general intellectual ability, numerical anomia, primary arithmetria, memory difficulties, an attentional problem, impulsivity and so on - each one of these involving different functional systems in the brain (Luria 1980).

- Finally, to exclude frontal lobe tasks on the basis of the underdevelopment of these areas means that the brain is not being viewed holistically. Luria (see Section 2.4.1) emphasized that the whole "working brain" is involved in any type of behaviour. At different stages of ontogenetic development, however, different areas play qualitatively different roles in the performance of a task (see Section 3.4).

The LNI-C which was developed in this dissertation, embodies a qualitative, process approach. In contrast, the Halstead-Reitan and Luria-Nebraska batteries involve the use of norms and patterns of scores, respectively, without an integration of a coherent developmental framework. As Milberg, Hebben and Kaplan (1986) have indicated, little emphasis is therefore given in these instruments to the cognitive functions summarized by these scores and the way in which the scores were attained. As a result, little information concerning the relationship of test findings to rehabilitation programmes and the child's everyday life, is generated. This problem is addressed in the present thesis (see Chapter 2, Section 2.4.3 and Chapter 6, Section 6.3).

A final issue that needs to be addressed is the appropriateness of using a downward extension of an adult battery for the neuropsychological evaluation of children. Telzrow (1983) has questioned this practice and argued that it implies that adults and children differ quantitatively. Whilst this would seem to be true of the Halstead-Reitan battery, both the LNNB-CR and LNI-C were developed on the assumption that adults and children differ qualitatively. The rationale on which the LNNB-CR evolved seems, however, to be erroneous in view of the difficulties highlighted above. As already indicated, in developing the present protocol an attempt was made to generate a developmental framework for the instrument on the basis of Luria's and Vygotsky's views and work on brain-behaviour development. In the absence of a children's model, the LNI which examines brain-behaviour relationships at maturity, seemed appropriate to use to guide the development of the children's battery within a Lurian/Vygotskian ontogenetic

5.6.2 A conceptual framework for the battery and its comparison with prominent developmental views

A conceptualization of the sequence of brain-behaviour ontogeny in the normal child would seem to be crucial for predicting the possible consequences of damage to the brain at different stages of development. The visually presented model of brain and behaviour depicted in Section 5.5 represents an attempt to facilitate this diagnostic and prognostic process.

As Parmelee and Sigman (1983 p.95) indicated: "The relation of brain maturation to behavioural development is .... a complex topic". There is not a direct one-to-one relationship between each stage of brain maturation and behavioural development. Neither do particular brain regions or behaviour patterns develop at the same rate in different individuals. The time-span of the stages in cognitive and behavioural maturation which have been identified, nevertheless do seem to parallel those of brain growth (Rose 1973).

There appears to be considerable information about prenatal and early postnatal brain development, in many cases by extrapolation from animal studies (e.g. Parmelee and Sigman 1983; Rose 1973). Dekaban (1970) has also outlined brain maturation in the child from birth to six years. In contrast, such detailed knowledge does not appear to be available for eight to 14 year olds. Comparison of brain growth and behavioural advancement during this period would therefore seem to be somewhat more difficult.

Luria's view of brain-behaviour ontogeny as depicted in the aforementioned model will be evaluated in relation to the developmental trends which emerged in the course of this study. In addition, the compatability of Luria and Vygotsky's views with prominent theories of brain growth and behavioural development will be illustrated. In doing so, parallels will be drawn with Maclean's conceptualization of a "triune" brain; the progressive sequences of brain myelination proposed by Flechsig, and Yakovlev and Lecours; Piaget and Bruner's theories of cognitive development; and Freud and Erikson's stages of emotional maturation. Brief mention will also be made of the postnatal structural changes in the growing brain and Gesell's developmental scales. Although this project focuses on the assessment of eight to 14 year olds, works relating to preceding ages is also dealt with, as a developmental model is needed which enables one to conceptualize the consequences of brain damage at an earlier developmental stage.

In the course of developing the LNI-C, certain developmental trends emerged in terms of the nature of the mistakes made by eight to 14 year old children on the adult LNI tasks. An attempt was made to relate the type of mistakes made by children to the area of the brain they appeared to be reflecting. It must, however, be borne in mind that brain-behaviour relationships in childhood do not appear to be clearly understood at the moment. There is therefore not at present, a known relationship between performance on Lurian tasks and brain functioning in children. Nevertheless, although the details of the trends in this thesis require further clarification (see Chapter 7, Section 7.4), they do seem to broadly reflect Luria's conceptualization of the hierarchical organization of the brain and the sequential development of successively more complex forms of information processing, despite variability in the age at which children attained each level of competency. Some children within each group were usually able to correctly complete more complex LNI tasks, whilst others of the same age were unable to do so. This individual variation in the rate at which a constant sequence of development occurs has been consistently reported in the developmental literature. As Fischer and Silvern (1985 p.636) wrote: "Uneveness in level or décalage is clearly the norm in development".

The trends were detailed in Section 5.4.3. To briefly reiterate, the following emerged in terms of the mistakes made by children on the adult LNI tasks:

- None of the mistakes appeared to reflect subcortical (Unit one) or primary cortical zone functioning.
- Children made progressively fewer mistakes on tasks reflecting secondary and tertiary cortical zone functioning with increasing age (see Graph 6).
- Children in all age groups made a greater number of mistakes on tasks which seemed to reflect tertiary as opposed to secondary zone functioning.
- The type of mistake made could be broadly grouped into two areas (see Graph 5). Errors attributable to a lack of training and inability to process the amount of information presented in the adult battery appeared to mainly reflect secondary zone functioning. The number of

mistakes made in these instances was considerably less than the number apparently due to difficulty with tasks involving abstract reasoning, the simultaneous synthesis of data and planned, goal-directed behaviour - all of which seemed to primarily reflect tertiary zone functioning.

A brief overview of Luria's theory of brain functioning and development is presented next. Thereafter Luria's view of development is compared with prominent work on brain maturation and behavioural development in order to illustrate the parallels between these views, and their compatability with Luria's work and the results of this research project.

Luria (e.g. 1965a, 1973a, 1980) perceived the brain as comprising three functional units, all of which play a particular role in the performance of any type of behaviour. These units have been described in Chapter 2 (see Section 2.4.1). To restate they are:

- Unit one which regulates the tone and energy level of the cortex and is situated in the upper and lower regions of the brain stem, especially the reticular formation and limbic system.
- Unit two which obtains, processes and stores incoming information and is located in the temporal, parietal and occipital areas of the cortex.
- Unit three which programmes, regulates and verifies voluntary behaviour and is located in the premotor and frontal cortical regions.

Units two and three are further divided into three cortical zones (Luria 1973a, 1980):

- Primary zones which receive sensory input from, or convey motor impulses to, the periphery;
- Secondary zones which process incoming sensory information and prepare motor programmes of action; and
- Tertiary zones which are responsible for cross-modal sensory integration and the formation of intentions.

Luria (e.g. 1973a; 1980) viewed development as a sequential process in which progressively more complex functions emerge on the basis of systems which evolved earlier. He indicated that Unit one (subcortical areas) and the primary cortical zones are largely functional at birth. Overlapping the development of these areas is the maturation of the secondary cortical regions, which continues into late childhood. The tertiary zones of Unit two become effective at four to seven years, whilst those of Unit three become prepared for action. The latter only become fully operational, however, at 12 to 15 years.

Maclean has also divided the brain into three hierarchically arranged systems which together form the "triune brain" (Maclean 1970; Spreen *et al.* 1974; van der Vlugt 1979). In contrast to Luria, his first two systems are sub-cortical and thus correspond to Luria's first unit. The protoreptilian brain consists of the upper spinal cord, midbrain, diencephalon and basal ganglia. Evolutionary the oldest, Maclean argued that it plays a vital role in many instinctive behaviours which are necessary for the survival of the individual and the species. The paleomammalian brain comprises the limbic system and, according to Maclean, functions to integrate emotional expression and self-awareness. It also has an inhibiting influence on the lower protoreptillian brain. The neomammalian brain forms the third system. It incorporates the cortex and is able to override the two more primitive systems. Maclean regarded its function as the nonemotional integration and fine grain analysis of the external world (Maclean 1970, Spreen *et al.* 1974; van der Vlugt 1979). Maclean thus emphasized the importance of emotion and hence the limbic system as a link between the protoreptilian and neomammalian systems. In contrast, Luria placed greater importance on the cortex (which comprises two of his three units) and its role in the formation and performance of higher mental processes. Despite his limited discussion of emotion, Luria regarded the medial cortical regions as a system which regulates and controls the emotions and inclinations associated with subcortical structures (e.g. Luria 1973a). Both authors nevertheless perceived development as a hierarchical, sequential process in which the maturation of earlier stages is a pre-requisite for the development of subsequent ones (e.g. Spreen *et al.* 1974). The views of Luria and Maclean do therefore not seem to be incompatible, but to reflect different emphases - Maclean emotion and Luria higher mental functions. Both perceptions are also in keeping with the developmental theories, still to be discussed, of, for example, Piaget, Bruner, Freud and Erikson, which view the child as progressing through a consecutive series of stages in which each developmental step is in some way dependent on the maturation of the previous one.

Luria's concept of development also appears to be consistent with the progressive postnatal anatomical and biochemical maturation of the brain, as well as the increasing myelination of different brain regions.

Literature on postnatal brain growth indicated that at birth the human brain appears to possess the full complement of neurons (e.g. Dekaban 1970; Keith Brown 1981; Nash 1978; Rose 1973). Nevertheless approximately 85 percent of human brain growth occurs postnatally (Dobbing and Sands 1970, 1973). This is largely the result of progressive growth in existing neuronal size (Dekaban 1970; Dobbing and Sands 1973; Rose 1973), axonal growth (e.g. Parmelee and Sigman 1983; Rose 1973), the development of dentritic processes (Dekaban 1970; Rose 1973), an increase in the number of synaptic connections (e.g. Cragg 1974), and glial cell development, which is closely linked to axonal myelination (Dobbing and Sands 1973; Grossman 1972; Rose 1973; Spreen *et al.* 1974). In addition, the type of neurotransmitters present and the strength of their deactivators also changes during maturation (Parmelee and Sigman 1983). Normal behavioural development appears to be dependent on this progressive anatomical and biochemical maturation of the brain.

Myelination may be regarded as an index of the maturity of various brain regions (Dekaban 1970; Himwich 1970; Kolb and Whishaw 1985). Although nerve cells can become functional prior to myelination, it is assumed that they reach adult functional levels as myelination is completed (Himwich 1970; Kolb and Whishaw 1985). In this regard, Flechsig (1901) has divided the cortex into three groups of sequentially developing "myelogenetic" fields. These are broadly in keeping with the progression of brain maturation proposed by Luria. Flechsig identified:

- Primordial fields which myelinate before birth and include the primary sensory and motor cortical zones;
- Intermediate fields which include the secondary cortical zones and myelinate during the first three postnatal months; and
- Terminal fields which are the last to myelinate and do so between the fourth postnatal month and 14 years.

Yakovlev and Lecours (1967) have also identified three areas of myelination which mature at different rates. In contrast to Flechsig, they have looked at both the cortex and subcortex. This difference in emphasis is reflected in the observation that, whilst not incompatible with Luria's work, the areas they delineate roughly correspond to Maclean's triune brain. The regions are:

- Median zones which myelinate during the first two to three decades;
- Paramedian zones which comprise the limbic system and myelinate during the first decade until puberty - and are thus the first regions to reach full structural growth; and
- Supralimbic region or cortex which myelinates into old age.

This seems to suggest that the orderly and sequential myelinization and organization of subcortical areas is a prerequisite to the subsequent proper organization at the cortical level. It is thus consistent with Luria's view of brain-behaviour development.

In terms of behavioural development, as indicated in Chapter 3 (see Section 3.4), Vygotsky proposed that higher mental processes pass through a series of five critical periods. He identified these as occurring at birth, one year, three years, seven years and 13 years (Zender and Zender 1974). They broadly follow Luria's ontogenetic progression and these periods do seem to roughly correspond to Epstein's (1974) periods of spurts in brain growth and the onset/end of Piaget's, Freud's and Erikson's developmental stages.

Each phase of Luria's developmental sequence - namely the development of Unit one and the primary cortical zones, the secondary cortical areas, the tertiary regions of Unit two and the tertiary zones of Unit three - will be discussed in turn, in relation to the views of Vygotsky, Piaget, Freud and Erikson, as well as the trends which emerged in the course of this study.

As indicated earlier, Luria (e.g. 1973a, 1980) conceptualized development as a sequential process in which successively more complex adaptive processes evolve on the basis of systems which emerged earlier. According to Luria, the subcortical structures comprising Unit one and the primary motor and sensory cortical regions are largely functional at birth. The finding that none of the mistakes made by eight to 14 year old children on the adult LNI seemed indicative of Unit one or primary cortical zone functioning was thus to be anticipated and in keeping with Luria's theory, as well as other developmental work.

Piaget has suggested that the child's cognitive development can be described in terms of four successive periods (e.g. Brown and Desforges 1979; Flavell 1963; Ginsberg and Opper 1969; Liebert, Poulos and Strauss 1974; Piaget and Inhelder 1969). Pertinent to the period of early childhood presently under discussion is the sensorimotor period which extends from birth to about two years. This stage is characterized by the extensive development of the motor and sensory systems (Sandström 1979; Rose 1973). This seems to generally parallel the functional and anatomical maturation of cortical motor and sensory regions which gradually inhibit and control the activity of lower regions. In keeping with Piaget's sensorimotor period of intelligence is Bruner's conceptualization of the enactive mode of representation - a stage in which the child represents the world through action (e.g. Liebert, Poulos and Strauss 1974). Gesell (1950) also described the increasing motor control and dexterity, and sensory refinement of the child from birth to two years. This is thus in keeping with the finding that Luria's Unit one and the primary cortical zones were functional in the eight to 14 year olds in this study.

In terms of emotional development, the time-span of the theories of Freud and Erikson are also broadly in keeping with those of Luria and Piaget. Freud (e.g. 1973) has described five stages of psychosexual development delimited by the erogeneous zone dominant at the time. The first two are relevant to the age period under review. The oral stage lasts from birth until approximately one year when the child is weaned. This is followed by the anal stage, from about one to three years of age, in which the focus is toilet training (e.g. Freud 1973; Liebert, Poulos and Strauss 1974; Liebert and Spiegler 1974). The first five of Erikson's eight stages of psychosocial development coincide with those of Freud. Each of Erikson's stages is designated by a conflict between two alternative ways of handling an encounter, one adaptive and the other maladaptive. In his first stage of basic trust versus mistrust this revolves around the extent to which the child's needs are satisfied which determines whether or not he/she learns to trust the environment. In the second stage of autonomy versus shame and doubt, as with Freud, toilet training reflects the essence of the conflict (e.g. Liebert, Poulos and Strauss 1974; Liebert and Spiegler 1974).

Overlapping the development of Luria's first Unit and the primary cortical areas, is the development of the secondary cortical zones of Units two and three. According to Luria (e.g. 1973a) these undergo an initial period of rapid myelination during the first few months of life and continue to myelinate into the later periods of childhood. In Luria's view progressive lateralization of function appears to be associated with the continuing maturation of these secondary areas. The finding in the present study that children made progressively fewer mistakes on adult LNI tasks reflecting secondary zone functioning would seem to reflect the increasing maturation of these regions with age.

The next stage in Luria's theory of brain-behaviour development is the development of the tertiary zones of Unit two. These apparently become effective at four to seven years, but do not become fully operational until the seventh year of life, an age which Vygotsky designated a critical period. During this period, the tertiary zones of Unit three also become prepared for action, although it is only at 12-15 years that they become fully functional. The tertiary zones of Unit two play a special role in the organization of complex (spatial) synthesis and cross-modal integration which is at the basis of the abstraction and generalization of concrete stimuli (Luria e.g. 1973a, 1980). As the secondary and then tertiary cortical regions develop, so the organization and integration of functional systems, and hence complex higher mental processes, becomes more refined.

The progressive maturation of the tertiary areas, especially of Unit two, as visualized by Luria, is supported by a consistently documented change in the way in which the child processes information (e.g. Dean 1985; van der Vlugt 1979). Luria (e.g. 1963a, 1977) indicated that at five to six years the child starts to use speech not only for communication, but to regulate his/her own behaviour. This coincides with the time at which the tertiary frontal zones become ready for action. Luria (e.g. 1973a, 1980) pointed out that a prerequisite to the development of planned, goal-directed activity, is the development of speech regulation of behaviour (see Figure 1). This was developed in all the eight to 14 year old children in this project (see Table 13.2) - a finding which supports Luria's work. This is also consistent with Vygotsky (1962) who wrote that thought is primarily internalized by seven to eight years, although it can still be externalized by any problem at this age.

From the perspective of cognitive development, Piaget also documented a change in the child's level of functioning during the period under discussion. At two to seven years Piaget identified a preoperational stage which is characterized by the evolving use of visual images and language as symbolic representations of real objects (e.g. Flavell 1963; Ginsberg and Opper 1969; Piaget and Inhelder 1969). Bruner's perception of an iconic mode which involves the use of images to represent the world, would seem to be generally in keeping with this. Towards the end of this stage, the child, according to Freud, enters the phallic stage (approximately fourth and fifth years) which involves resolution of the Oedipus complex (e.g. Freud 1973; Liebert, Poulos and Strauss 1974; Liebert and Spiegler 1974). Coinciding with this is Erikson's period of conflict between initiative and guilt (e.g. Liebert, Poulos and Strauss 1974; Liebert and Spiegler 1974).

At about six years the child enters school and starts to acquire the academic skills of reading, writing and arithmetic. This roughly corresponds with the child's entrance into Piaget's period of concrete operations which extends from about seven to 11 years. During this stage the child becomes capable of focussing simultaneously on several aspects of a situation, is sensitive to transformations and can reverse the direction of his thinking (e.g. Flavell 1963; Ginsberg and Opper 1969; Piaget and Inhelder 1969) - processes which Luria attributed largely to the functioning of the tertiary areas of Unit two (e.g. Luria 1980).

Freud (e.g. 1973) has argued that the child enters a period of latency at about five years which extends to adolescence. During this time the libido lies dormant and the child acquires many cultural skills. Erikson (e.g. Liebert, Poulos and Strauss 1974) also viewed this time as a period of sexual latency. He designated the stage one of industry versus inferiority as the child has entered school and has to master tasks in the face of feelings of inferiority.

To briefly summarize, by eight years of age, the lower age limit of this study, the subcortical regions (Unit one) and the primary and secondary zones of Units two and three are in advanced stages of myelination, and according to Luria, are functional. (Rose (1973) has however indicated that the reticular system continues to myelinate into the second decade of life.) The posterior tertiary zones are operational and complex integrative activities are possible (Luria 1973a). There has been, and continued to be, progressive lateralization of function, especially of speech, and the speech regulation of behaviour has developed (e.g. Luria 1973a, 1980). Thought is internalized (Vygotsky 1962) and the child is, according to Piaget, capable of concrete thinking (e.g. Piaget and Inhelder 1969). The child is in the third year of schooling and has begun to acquire the skills of reading, writing and arithmetic. Emotionally, a period of latency has been entered in which energies are chanelled towards the acquisition of these abilities (e.g. Freud 1973). Luria does not seem to precisely elaborate on the period between eight and 11 years, but suggested that the maturation of the tertiary zones continued and that there is progressive acquisition of skills in the mode already mentioned.

At 12-15 years, according to Luria (e.g. 1973a, 1980), the frontal tertiary zones of Unit three, which started their long process of development in the first few years of life, assume a supramodal role in the regulation of complex, goal-directed activity. At this age the frontal zones also begin to play a more complex role in higher forms of voluntary attention. Coinciding with this are the changes in evoked potentials in both the secondary cortical areas and frontal regions reported by Luria (1973a), and the emergence of an adult EEG pattern (Luria 1963b; Nash 1978; Rose 1973). Consistent with this is Vygotsky's proposal of a final critical period at 13 years (Zender and Zender 1974).

Cognitive developmental changes occuring at this age appear to parallel these developments. Piaget's stage of formal operations starts to emerge at around 12 years and the capacity to generalize across concrete situations so as to reason abstractly and construct hypothetical ideas, becomes possible (e.g. Fischer and Silvern 1985; Flavell 1963; Ginsberg and Opper 1969; Piaget and Inhelder 1969). Bruner's conceptualization of the symbolic mode of representation in which symbols represent things in a remote and arbitrary way (e.g. Liebert, Poulos and Strauss 1974) would seem to parallel this stage. Freud's (e.g. 1973) last stage of psychosexual development is also entered at adolescence. During this, the genital stage, the libido is reactivated and directed towards heterosexual objects. Parallel to this, Erikson (e.g. Liebert and Spiegler 1974) viewed the child as entering a period of identity versus role confusion. Thus all these theories appear to complement one another and to be in keeping with Luria's theory and the results of this project.

The developmental trends which emerged in terms of the nature of the mistakes children made on adult LNI tasks are also in keeping with the preceding description of the progressive development of secondary and tertiary brain areas and associated emergence of more complex modes of information processing. They additionally seem to reflect Luria's (1979) conceptualization of natural and cultural processes. He indicated that although there is a quantitative increase with age in the amount of information with which a child can deal, the information processing strategies used by the child also change during development. He referred to these as natural and cultural processes respectively. Luria (e.g. 1979) argued that in contrast to cultural processes, the basic principles governing the action of natural processes remain unchanged in the course of development. The inability to process and retain the same quantity of information as adults and age related changes in this respect thus seem to reflect Luria's view of natural processes. It is of interest that this difficulty seemed to reflect the functioning of the secondary cortical zones in the present survey. Luria has indicated that natural processes are dominant in the five to seven year period. The fact that difficulty with such tasks remained evident in the eight to 14 year age range would appear to reflect variability in the age at which children increase the capacity of such processes.

Difficulty due to a lack of training and with tasks involving abstract reasoning, the simultaneous synthesis of data and the planning and organization of stimuli seem to reflect the developmental changes in Luria's conceptualization of cultural processes. These he viewed as dominant in the 11-13 year period. A cornerstone of Luria's model is the interaction between neuropsychological development and environmental influences (e.g. Luria 1961a). Luria (1979) argued that changes occur in the way in which information is processed as a result of the increasing influence of the social environment during development. Culturally determined forms of information processing are consequently increasingly relied on as development progresses. The child's behaviour thus gradually becomes more organized and under voluntary control "through the use of the mental tools of his culture" (Luria 1979 p.83). Of interest in this respect is work which has shown that enriched or impoverished environments can increase or decrease the number of synapses respectively (e.g. Goldman-Rakic *et al.* 1983; Spinelli *et al.* 1980).

Luria (e.g. 1973, 1980) has indicated that simultaneous processing, abstract reasoning and goal-directed behaviour are based on the functioning of the tertiary cortical zones in adults. The difficulties noted in these processes appear to reflect a transition from secondary to tertiary modes of brain functioning during development in the eight to 14 year old child. It therefore appears that the tertiary zones have not yet fully assumed their supramodal role in brain activity at this age range. In keeping with this is work which has demonstrated that the association areas of the cortex apparently continue to increase in myelin content right into old age (Rose 1973). This perhaps reflects the continued evolution and refinement of complex behaviours such as planned, organized activity during adulthood. Furthermore, Arlin (1975) has proposed a fifth adult stage in Piaget's sequence of cognitive development and Erikson's final three stages of psychosocial maturation span the period of young adulthood through to maturity (e.g. Liebert, Poulos and Strauss 1974).

Activities associated with the secondary zones generally presented no difficulty for the eight to 14 year old children in this study, provided that tasks were in keeping with the quantity of information with which the children could cope and the educational and linguistic level of the children (e.g. retention and integration of sequences of stimuli). This appears to be broadly compatible with the visual representation of Luria's model of brain-behaviour development presented in Figure 1, and the literature reviewed in this discussion.

Finally, the broad trends emerging in this study suggest that eight to 14 year old children can cope with tasks involving sequential and simultaneous processing if the quantity and type of information is appropriate for their age and educational level. They nevertheless experienced difficulty with items involving both the sequential and simultaneous synthesis of more complex data. This contrasts with the findings of a study by Kaufman *et al.* (1982). These authors designed a factor analytic research project to measure simultaneous and successive modes of information processing in children aged three to $12\frac{1}{2}$ years based on the Luria-Das model (see Chapter 2, Section 2.4.1). They found developmental trends in these two factors which they related to Piagetian developmental stages. The authors suggested that the sequential mode of processing was predominant during the preoperational stage and the simultaneous during the concrete operational period (which the child enters at six to eight years). Sequential processing, they suggested, then re-emerges with the appearance of formal operational thought at 10-12 years.

The findings of this study suggest, however, that the situation is more complex than merely sequential and simultaneous modes of processing information. Education/social environment and age, for example, interact with the development of modes of information processing. Furthermore, it is possible that one mode of processing is more apparent than the other at different ages, effectively masking the other one. Finally Kaufman *et al.'s* (1982) work does not seem to be in keeping with Luria's conceptualization of natural and cultural processes.

In conclusion, there appears to be a parallel development of brain and behaviour during maturation as evidenced by the trends which emerged in terms of the type of mistake made by children on adult LNI tasks, and their apparent relationship to areas of brain functioning and the developmental theories outlined. This highlights the importance of a holistic approach to the neuropsychological evaluation and study of the developing individual. Focusing on only one aspect will prevent the illumination of the complex interaction of developmental factors which comprise the whole. Furthermore, it would seem that the varied rate at which children attain different levels of competency is superimposed on an invariant sequence of development.

5.7 CONCLUDING REMARKS

Adaptation of the adult Luria's Neuropsychological Investigation for use with children represented the first step in a research programme designed to develop, within a Lurian framework, an integrated theoretical and assessment approach to the neuropsychological evaluation of children.

Development of the children's protocol was guided by Luria's view of brain-behaviour development. Adult tasks which children were unable to perform correctly were either deleted or adapted by simplification and elaboration of items. A model of brain-behaviour development based on Luria's work was also devised. The model was discussed in terms of existing developmental theories and found to concur.

In the next chapter, the ability of Luria's Neuropsychological Investigation for children to delineate impaired and preserved functions in children with disturbed brain-behaviour relationships is examined. The effectiveness of the conceptual and interpretive schemes developed for facilitating interpretation of the data generated by the children's battery is also explored.

CHAPTER 6

THE APPLICATION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN TO BRAIN-INJURED CHILDREN

6.1 INTRODUCTION

The aim of this study is to develop a neuropsychological investigation for children which is integrated with a coherent theory of brain functioning, yet takes cognisance of the dynamic nature of the developing brain.

The complexity of this task was highlighted by a literature review which revealed that current knowledge of brain-behaviour relationships in the developing child is limited (e.g. Botes and Long 1986; Taylor 1984). Consequently, there is at present no well articulated framework to guide the neuropsychological investigation and interpretation of assessment data in children (e.g. Obrzut 1981; Rourke *et al.* 1983; Wilson 1986). Such a basis is important for the formulation of diagnoses, prognoses and rehabilitation programmes for children who have sustained brain damage at different stages of development.

The development of Luria's Neuropsychological Investigation for Children (LNI-C) was described in Chapter 5 and a visual representation of Luria's theory of brain-behaviour ontogeny outlined. It was argued that this model provides a conceptual framework for the children's protocol.

In this chapter the coherence of the thesis is explored by examining the fit between LNI-C data and the corresponding injury. A table has been devised which outlines the disturbances, as per Luria (1963b), associated with different kinds of childhood brain pathology and their developmental implications. It is contended that this table facilitates interpretation of LNI-C data.

The chapter commences with a statement of the research objectives of this aspect of the study. Conceptual issues intrinsic to the use of an instrument such as the LNI-C are then examined. The aforementioned table which delineates the behavioural disturbances, as per Luria (1963b), associated with different forms of brain damage in children is outlined next. Thereafter the procedure is described and results presented. Finally, research findings and syndromes associated with different types of brain injury or disease processes in children are discussed. It is argued that the information generated during an assessment with the LNI-C enhances our understanding of brain-behaviour relations in children. In addition, it highlights the "linchpins" (i.e. basic deficits) on which retraining programmes need to focus.

6.2 RESEARCH OBJECTIVES

This part of the research programme was designed to explore the application of Luria's Neuropsychological Investigation for Children (LNI-C). Knowledge of the syndromes associated with various types of damage at different stages of development is limited. The neuropsychological evaluation of children can therefore not proceed with the same assumptions regarding the behavioural consequences of different forms of brain injury as is the case with adults. Identification of the pattern of deficits associated with brain damage is, however, essential for designing rehabilitation programmes.

The aims of this phase of the study were therefore:

1. To apply the LNI-C to brain-damaged children:
   a) To examine its ease of application;
   b) To evaluate the extent to which the conceptual model of brain-behaviour ontogeny and the interpretive table based on Luria's theories, facilitate data interpretation; and
   c) To determine the battery's ability to delineate intact and impaired functions in children for rehabilitation purposes.

2. To examine the fit between:
   a) LNI-C assessment findings and the symptoms, as per Luria, associated with the brain pathology present;
   b) The locality of the lesion suggested by LNI-C data and the brain-damage as per CT scan reports and medical files; and
   c) Information provided by behavioural profiles and paramedical report findings.

3. To explore the pattern of deficits associated with different forms of brain pathology in children.

6.3 LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN: CONCEPTUAL ISSUES

Luria's Neuropsychological Investigation for Children (LNI-C) contrasts with prominent, psychometric neuropsychological assessment instruments for children (e.g. the Halstead-Reitan and Luria-Nebraska batteries) in that it is a qualitative, process-orientated, single case study approach, in which data are analysed using syndrome analysis and the concept of double dissociation. Conceptual issues intrinsic to such an approach will therefore be explored in this section. Issues pertaining to the qualitative, process-orientated nature of the LNI-C will be addressed first. Thereafter the use of a single case study methodology will be examined. Finally syndrome analysis and the concept of double dissociation will be discussed.

The importance of making a conceptual and practical distinction between a psychological test and the process of psychological assessment was highlighted by Maloney and Ward (1976). This distinction, the essence of which revolves around the difference between an assessment tool and process, would seem to be integral to the sphere of neuropsychological evaluation. As Maloney and Ward (1976 p.36) wrote:

> "the far too common equation of psychological assessment with administration of a test .... represents a gross misunderstanding of the nature of clinical assessment and indicates marked confusion between the tool and the process."

In this sense, a neuropsychological assessment in which the LNI-C is used may be regarded as an extremely complex process of identifying the basic factors underlying observed symptoms, as well as indicating which functions are intact — a process which is guided by a theory of brain-behaviour development. This necessitates expertise with both the assessment protocol and the underlying theoretical framework so that the clinician knows what kinds of disturbances can be expected with different types of brain damage sustained at different ages. The appropriate series of tasks can then be selected to elucidate the relevant information for formulating a diagnosis and prognosis, and planning a rehabilitation programme. In contrast, use of psychometric tests does not appear to necessitate the same level of clinical expertise. Interpretation is based on normative data and derived scores, and can thus be arrived at by a psychometrist trained in the administration and scoring of such devices.

In this respect, the use of scores for diagnostic purposes is appealing in that it is relatively easy to make decisions on the basis of normative data, in contrast to the extremely complex process of syndrome analysis needed for interpretation of LNI-C data. Scores are, however, problematic in that they result in a loss of information. Whilst they may indicate *what* a child attained, they do not reveal *how* the child performed the task — vital information for purposes of diagnosis and the development of intervention strategies. Scores also ignore the multideterminational nature of assessment tasks. They may thus mask impairment and hence give a misleading or spurious view of a child's level of functioning (e.g. Milberg, Hebben and Kaplan 1986; Wilson 1986). For instance, a summary IQ score on a language loaded test may reflect an aphasic disorder, rather than the child's overall cognitive abilities. Such a child may, in contrast, perform well on visually-mediated cognitive or visuo-constructive tasks. As Professor Smirnov (1957 p.189) wrote:

> "Tests are ... inadmissible ... because they are restricted to a mere statement of the result, without disclosing why or how it was achieved, or what prevented it from being better. When the process itself remains hidden, its significant and qualitative characteristics undisclosed, then it is impossible to judge of the child's activity. The essence of the phenomena is not discovered ...."

Wilson (1986) has additionally pointed out that most test instruments have been standardized on normal populations to which the performance of atypically developing brain-injured children are then compared. She argued that it is thus important to consider the pattern of functions, rather than the magnitude of the scores. It is misleading to state that an atypically developing five year old performs like a normal three year old. There are significant differences in performance between two such children — and different outcomes to be considered and teaching strategies to be devised. Wilson (1986 p.126) therefore cautioned that: "A handicapped five-year-old is not a tall, normally developing

3-year-old".

The single case study method is integral to the use of a Lurian approach to neuropsychological assessment and will now be discussed. The origin of this approach may be traced to Hippocrates (Sacks 1986). Its use reached a zenith in the nineteenth century when a variety of neuropsychological syndromes were identified on the basis of the approach (Kaplan 1986; Shallice 1979). Use of the single case study method thereafter appears to have declined as the brain-injured person began to be investigated on a psychological as well as neurological level (Shallice 1979). In keeping with the psychometric tradition prevalent in psychology at the time, the problems of generalizing from the results of a single case were highlighted (Bolgar 1965; Kazdin 1980; Shallice 1979). Furthermore, some of the syndromes, such as Gerstman's syndrome, derived via this method, were criticized (e.g. Frank Benson 1979; Walsh 1978). Despite these apparent problems, there has more recently been a revival of single case study methodology (e.g. Ellis 1985; Kaplan 1986; Lezak 1983; Patterson 1981; Saffran 1982; Shallice 1979; Walsh 1978, 1985). This has apparently been linked to recognition of the heterogeneity of the disorders exhibited by individuals with brain pathology (e.g. Lezak 1983; Lezak and Gray 1984) over which results have to be averaged (Shallice 1979) — a procedure which masks the individual differences crucial to diagnosis and rehabilitation planning. In addition, the importance of the method for extending knowledge of brain-behaviour relations has been acknowledged (e.g. Walsh 1978). As Kaplan (1986 p.xiii) wrote:

> "It is heartening to see single case studies ... again recognised for the contribution they can make to the better understanding of brain-behaviour relationships and individualized rehabilitation."

In view of this, the single case study method would seem to be uniquely suited to the use of a process-orientated approach to neuropsychological assessment, as well as for delineating syndromes associated with various forms of brain pathology in children (see Section 6.7.2).

The richness of the insights into the complexity of human behavioural disturbances and syndromes associated with brain pathology which the case study approach can generate has more recently been demonstrated by Oliver Sacks (1986). In his book *The Man who Mistook his Wife for a Hat*, Sacks presents a description of "the suffering, afflicted, fighting" (p.x) individuals as they struggle with their brain disorder. His reason for using such an approach is to gain an understanding of these individuals' pathology in order to effectively treat and manage them.

Luria (1979) equated the difference between the "romantic" or case study tradition and the "classical" or group approach with the ideographic versus nomothetic distinction with which he was concerned in the early stages of his career. He acknowledged that one of the factors which initially attracted him to Vygotsky was his emphasis on the necessity of resolving this crisis. Luria (1979) indicated that he attempted to reconcile the two approaches in his work by using scientific, instrumental laboratory techniques as aids to clinical analysis. He nevertheless lamented the virtual loss of the "art of observation and clinical description" (Luria 1979 p.177). Luria thus attempted to revive the nineteenth century tradition of a "romantic science" (Luria 1979, p.178), as exemplified by the neurological work of that time, in his two books *The Mind of a Mnemonist* (Luria 1968) and *The Man with a Shattered World* (Luria 1972b). In these studies Luria indicated that he attempted to do a "factor analysis" of his subjects by identifying the basic factor(s) underlying the phenomena under consideration and then describing the secondary consequences of these factors. He argued (Luria 1979 p.178):

> "When done properly, observation accomplishes the classical aim of explaining the facts, whilst not losing sight of the romantic aim of preserving the manifold richness of the subject."

This is the form of analysis at the basis of Luria's neuropsychological investigative process.

An important aspect of using a Lurian approach to neuropsychological assessment is thus interpretation of data using syndrome analysis and double dissociation of function. Each of these procedures will be discussed in turn.

Syndrome analysis involves a detailed, qualitative analysis of the symptoms revealed by the examination in accordance with the principle of double dissociation (i.e. that all functional systems which involve a disturbed factor will be disrupted, whilst those which do not include this factor will remain intact). Finally, a prediction of the lesion locality can be made on the basis of this information. Luria's theory of brain-behaviour functioning provides the framework for such an analysis (e.g. Luria 1973a, 1980. See also Chapter 2, Section 2.4.1).

The concept of a syndrome and its use in neuropsychology has received considerable criticism. Walsh (1978, 1985) has comprehensively reviewed the concept of the neuropsychological syndrome and highlighted the difficulties and controversies surrounding its use. He indicated that varying definitions have partially contributed to confusion regarding use of the term. An additional complication has been that the term refers to a common, but not invariant set of symptoms. In this respect, Patterson (1981) has pointed out that the uniqueness of each individual's performance casts doubt on the concept of distinct syndromes. She nevertheless argued that whilst two patients classified according to the same syndrome may differ from each other, these differences become inconsequential if these two are compared with a patient with a different syndrome.

Walsh (1978; 1985) also cited the objection raised by Kinsbourne (1971) — namely that the association between signs and symptoms is a probablistic, not invariant one. As a result "partial" syndromes occur frequently and it is often unclear how many symptoms have to be present in order for the diagnosis to be made. Walsh (1985) further identified two dangers associated with use of the syndrome method. It is the writer's opinion that these both seem to emphasize that use of such a technique necessitates skill and experience, together with a wide-ranging knowledge of brain-behaviour relationships and the type of responses which different tasks can elicit. The dangers highlighted by Walsh are:

1. The multiple determinational nature of most tasks. Task performance may therefore be impaired for a variety of reasons — and in each instance, the possible reasons for failure have to be carefully examined.

2. Insufficient knowledge or experience may lead an examiner to select an explanation that fits most, but not all observations of test performance, due to lack of awareness of an alternative explanation which may consider all facts.

Despite the aforementioned shortcomings, Walsh (1985) nevertheless concluded that clinically the syndrome is an important conceptual tool. He wrote that it is "a useful working fiction which allows us to create partial order out of the complexity of the patient's subjective complaints and the findings of our examinations" (Walsh 1985 p.21). In this respect, Walsh (1978, 1985) contended that because of the complexity of the brain, a variety of syndromes with different manifestations is to be expected. He argued that the term "syndrome" becomes meaningless when used in an extremely broad sense (e.g. "chronic brain syndrome"). Walsh further indicated that the differentation of broad syndromes into subtypes on the basis of characteristics identified by neuropsychological tests has refined differential diagnosis and hence prognostication and treatment planning. He cited as an example of such work the discovery of two distinct varieties of the general amnesic syndrome — an alcoholic-induced (mamillo-thalamic) variety in which recall improved with specific cuing, and a post-encephalic (hippocampal) form in which cuing did not improve recall (Walsh 1985).

The concept of a neuropsychological syndrome has also been criticized by researchers in the cognitive neuropsychology sphere (e.g. Coltheart 1984; Ellis 1985; Saffran 1982; Shallice 1979) who are investigating the structure of the information-processing systems involved in the performance of tasks such as reading. These workers have argued that as information-processing work progresses, an increasing number of syndromes are likely to be identified, some of which may fractionate into sub-types (i.e. where the same syndrome arises from different causes). This would become unwieldly. However, cognitive neuropsychologists are looking at the application of a syndrome to a single function such as reading/dyslexia or aphasia. Cognitive neuropsychologists thus focus on breakdown in one area of functioning (e.g. dyslexia) (Ellis 1985), rather than a holistic appraisal. Whilst this is appropriate for research purposes, it is not adequate clinically as the constellation of symptoms associated with the breakdown needs to be described for diagnostic, prognostic and hence management and treatment purposes. Furthermore, as indicated above, Walsh (1985) has argued that, clinically, the identification of syndrome sub-types, facilitates this process. The strength of Luria's theory of psychological functions lies in a holistic appraisal of all processes into a coherent theory. This would seem to be especially important in children where the disturbance in psychological functioning and its consequences must be viewed within the context of progressive development.

Integral to the use of syndrome analysis is the concept of double dissociation which Luria (e.g. 1979, 1980) argued ensures the reliability of results in such an approach. This paradigm is widely used in neuropsychology (Jones 1983; Walsh 1985) and its application requires considerable expertise and knowledge of brain-behaviour relations, as reflected in the warnings noted by the following neuropsychologists. Walsh (1985) cautioned against the equation of a dissociation in test performance with that of a function, especially when the dissociation was made on the basis of a single pair of tests. In this regard, Shallice (1979) warned, firstly, that an apparent dissociation may merely be a reflection of resource artefacts. In other words, the observable dissociation may not represent qualitative differences in the subsystems necessary for adequate performance on two tasks. It may instead result from quantitative differences in the resource requirements of the tasks —— good performance on one task may require more "resources" of a particular subsystem than the other task does. Secondly, an association may be caused by damage to anatomically proximal systems. If, however, it can be shown that the deficits the patient shows on different tasks have similar properties, there is an increasing likelihood that they are derived from the same functional source. Walsh (1985) emphasized, however, that such problems can be overcome by the use of syndrome analysis which evaluates an individual's performance on a range of tests in a particular area. As noted earlier, syndrome analysis is integral to the use of Luria's approach to neuropsychological evaluation.

The application of such an approach to children and syndromes associated with brain damage in childhood are discussed in the following sections.

6.4 AN INTERPRETIVE TABLE, BASED ON LURIA'S WORK, FOR LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN

Application of Luria's Neuropsychological Investigation for Children (LNI-C) to brain-damaged children requires a knowledge of the behavioural manifestations of various forms of childhood brain injury. A protocol which outlines the behavioural disturbances associated with different kinds of brain pathology in children as per Luria (1963b), has therefore been designed (see Table 15). This, together with the conceptual model of brain-behaviour ontogeny outlined in Chapter 5 (see Section 5.5 and Figure 1), is intended to facilitate interpretation of LNI-C data.

Luria (1963b) has argued that childhood brain injuries may seriously compromise future development as they destroy the basis on which it proceeds. According to Vygotsky (1965), brain damage to a particular zone in children prevents the development of the functional systems dependent on it, thus leading to mental underdevelopment and dysfunction. Determination of the possible consequences of damage to a particular region of the developing brain is therefore prognostically vitally important.

The efficacy of this table and the aforementioned model of brain-behaviour development for facilitating data interpretation is examined in Section 6.7.

TABLE 15 : LURIA'S (1963b) CONCEPTUALIZATION OF THE NATURE OF THE BRAIN DAMAGE AND SYMPTOMS ASSOCIATED WITH DIFFERENT TYPES OF BRAIN INJURY IN CHILDREN

TABLE 15.1 : ACQUIRED DISORDERS

NATURE OF DISORDER	SITE OF DAMAGE	ASSOCIATED SYMPTOMS
1.0 ACQUIRED MENTAL RETARDATION		
1.1 Viral infection (e.g. meningitis, encephalitis)	Diffuse cortical damage	- *Presentation:* Excitable, disinhibited, irrascible, unstable mood. - *Higher mental processes:* Combination of general underdevelopment of higher mental processes and specific localized disturbances (i.e. visual-spatial, speech, emotional-volitional) depending on developmental stage at which infection occurred.
1.2 Epilepsy	General cortical changes	- *Presentation:* Mood changes which include irritability, rudeness, greed, capriciousness. - *Higher mental processes:* Impaired ability to abstract and generalize. Slowness of information processing. Perseveration.
1.3 Traumatic childhood injury	May be diffuse or localized	- *Presentation:* Reduced work capacity and rapid fatigue. Headaches. Dizziness. - *Higher mental processes:* General disturbance in higher mental processes and/or disruption in functioning of particular analyzer (see 2.3 over).

TABLE 15.2 : CONGENITAL DISORDERS

NATURE OF DISORDER	SITE OF DAMAGE	ASSOCIATED SYMPTOMS
2.0 CONGENITAL MENTAL RETARDATION		
2.1 No behavioural defects	Diffuse cortical damage	- *Visual, auditory, kinesthetic and motor analyzers:* No specific disturbance. - *Higher mental processes:* No cognitive difficulty in situations child understands. Defective generalization and abstraction skills, which impair child's ability to learn to read, write and do arithmetic.
2.2 Behavioural defects	Diffuse cortical damage with residual hydrocephalus	
2.2.1 Excitable		- *Presentation:* Restless, irritable, capricious, distractible, impulsive, poor concentration, sleep disturbances, inability to play with peers. - *Motor:* Slight incoordination and impairment of muscle tonus. - *Higher mental processes:* Speech and visual-spatial functions intact. Generalization and abstraction ability and persistent goal-directed behaviour impaired.
2.2.2 Inhibited		- *Presentation:* Listless, rapid fatigue, passive insubordination, slow responses, disinterest in social interaction and play. - *Motor:* No marked defects, but poor fine-motor coordination and movements often slow and indecisive. - *Higher mental processes:* Speech and visual-spatial functions intact, although former may become slurred and incomprehensible with fatigue. Generalization and abstraction impaired. Perseveration may occur.
2.3 Disturbance in specific analyzer	Diffuse brain damage and more specific localized damage	- *General presentation:* Specific defects in higher mental processes superimposed on background of general mental underdevelopment, especially inability to abstract and generalize.
2.3.1 Visual-spatial	Visual-spatial (temporo-parieto-occipital) areas	- *Higher mental processes:* Impaired visual-spatial ability. Intact auditory-speech functions.
2.3.2 Auditory-speech	Speech (temporal) areas	- *Motor:* Undifferentiated, awkward movements. Apraxia of tongue and lips. - *Higher mental processes:* Auditory-speech functions disturbed. Visual-spatial ability intact.
2.3.3 Emotional-volitional	Frontal zones	- *Presentation:* Underdeveloped personality characterized by disinhibition and socially inappropriate behaviour. - *Motor:* Apraxia in walking. - *Higher mental processes:* Regulatory role of speech underdeveloped and resultant dissociation between "knowing" and "doing" (i.e. correctly carrying out command). This prevents development of goal-directed activity.

6.5 PROCEDURE

6.5.1 Subjects

The subjects comprized 18 white, English-speaking children aged eight to 14 years (mean age : 10,6 years) who had suffered some form of brain disease or injury.

Selection criteria

The brain-damaged children were selected for inclusion in this stage of the study on the basis of the following criteria:

- They were white, English-speaking and aged eight to 14 years;
- They had suffered some form of brain disease or injury; and
- They had had a brain scan.

Selection procedure

The sample of brain-damaged children was selected by the following people during the time period September 1980 - October 1981 on the basis of the aforementioned specifications supplied by the author:

- Dr. D. Saffer, Principal Neurologist, Baragwanath Hospital and University of Witwatersrand, and Consultant, Forest Town School for Cerebral Palsied Children, Johannesburg;
- Prof. J. van Dellen, Head, Department of Neurosurgery, Wentworth Hospital, Durban;
- Dr. H. Greiner, General Practitioner and Consultant, Open Air School, Durban;
- Ms A.Fraser and Mr C.Hallum, School Psychologists, Brown's School for Cerebral Palsied Children, Pinetown, Natal; and
- Mr Harding, the Principal, Sonskynhoekie Training Centre, Empangeni, Natal.

Sample characteristics

The characteristics of the sample are described in Table 16. Table 17 contains individual profiles of each subject's age, socio-economic status, schooling and medical information. Assessment dates and time taken to administer the LNI-C have also been included in this table.

TABLE 16 : CHARACTERISTICS OF THE SAMPLE OF BRAIN-DAMAGED CHILDREN

VARIABLE		n
SAMPLE SIZE		18
Age (years)	8	4
	9	2
	10	2
	11	4
	12	2
	13	3
	14	1
Sex	Male	11
	Female	7
Socioeconomic status[1.]	Upper white collar	7
	Lower white collar	7
	Upper blue collar	4
School attended[2.]	Forest Town	9
	Brown's	6
	Open Air	2
	Sonskynhoekie	1
Etiology	Acquired brain damage	9
	Congenital brain damage	9

NOTE: 1. Socioeconomic status was determined according to the procedure outlined in Section 5.3.1.1.

2. The schools that the brain-damaged children attended were:

- Forest Town School for Cerebral Palsied Children, Johannesburg;
- Brown's School for Cerebral Palsied Children, Pinetown, Natal;
- Open Air School, Durban; and
- Sonskynhoekie Training Centre, Empangeni.

TABLE 17 : INDIVIDUAL PROFILES OF EACH BRAIN-DAMAGED CHILD IN TERMS OF SOCIOECONOMIC STATUS, EDUCATION, MEDICAL AND ASSESSMENT INFORMATION

SUBJECT	SEX	AGE (YEARS)	SOCIOECONOMIC STATUS	SCHOOL ATTENDED	LEVEL OF EDUCATION	ETIOLOGY	AGE AT ONSET OF BRAIN DAMAGE	TIME SINCE ONSET	MEDICATION	DATE(S) OF BRAIN SCAN(S)	ASSESSMENT DATES	TOTAL TIME TAKEN TO ASSESS
1	Female	8	Lower white	Forest Town	Grade 2	CNS Malformation	Congenital	Congenital	None	23.03.1978	12.08.1981 13.08.1981 14.08.1981 17.08.1981	3 hours 16 minutes
2	Male	8	Lower white	Forest Town	Grade 2	von Recklinghausen's Disease	Congenital	Congenital	None	20.09.1980	13.08.1981 14.08.1981 18.08.1981 19.08.1981 20.08.1981	3 hours 14 minutes
3	Female	8	Upper white	Forest Town	Grade 2	Diffuse cortical atrophy	Congenital	Congenital	None	03.06.1980	18.08.1981 19.08.1981 20.08.1981	3 hours 1 minute
4	Female	8	Upper white	Open Air	Preprimary class	Cortical atrophy (left hemisphere)	Congenital	Congenital	None	17.04.1979 04.05.1981	14.10.1981 15.10.1981 16.10.1981	2 hours 30 minutes
5	Female	9	Lower white	Forest Town	Junior special class	Encephalitis	7 years	2 years	None	09.03.1981	18.08.1981 19.08.1981 20.08.1981	3 hours 6 minutes
6	Female	9	Lower white	Brown's	Std. 1	Encephalitis	4 years	5 years	Ritalin Epilim Tegretol	01.02.1980	20.05.1981 21.05.1981 22.05.1981 08.06.1981 10.06.1981	3 hours
7	Male	10	Upper blue	Brown's	Std. 1	Bilateral cortica-spinal damage	Congenital	Congenital	None	October 1979	16.09.1980 17.09.1980 19.09.1980	3 hours 34 minutes
8	Male	10	Upper white	Brown's	Std. 2	Head injury	10 years	6 months	None	12.03.1981	01.09.1981 02.09.1981 03.09.1981	3 hours 16 minutes
9	Male	11	Upper white	Brown's	Std. 4	Friedreich's Ataxia	Congenital	Congenital	None	19.10.1978	21.10.1980 22.10.1980 23.10.1980	2 hours 45 minutes
10	Male	11	Upper blue	Forest Town	Std. 2	Head injury	9 years	2½ years	None	February 1979	11.08.1981 12.08.1981 13.08.1981 17.08.1981	3 hours 50 minutes
11	Male	11	Upper blue	Forest Town	Std. 1	Head injury	6 years	5 years	Epineutum Phenobarbitol	14.03.1978	18.08.1981 20.08.1981 21.08.1981	3 hours 43 minutes
12	Female	11	Upper blue	Forest Town	Junior special class	Tumour : right frontal astro-cytoma (Grade III)	3 years	8 years	Epineutum Phenobarbitol	March 1973	17.08.1981 18.08.1981 19.08.1981 20.08.1981	3 hours 14 minutes
13	Male	12	Lower white	Forest Town	Senior special class	Head injury	5 years	7 years	None	15.02.1979	11.08.1981 12.08.1981 13.08.1981 14.08.1981	2 hours 55 minutes
14	Male	12	Lower white	Forest Town	Std. 2	von Recklinghausen's Disease	Congenital	Congenital	None	17.10.1979	13.08.1981 14.08.1981 17.08.1981 18.08.1981	3 hours 19 minutes
15	Female	13	Upper white	Brown's	Std. 4	Congenital hydrocephalus: arrested	Congenital	Congenital	None	06.02.1979	16.09.1980 17.09.1980 18.09.1980	3 hours 48 minutes
16	Male	13	Lower white	Brown's	Std. 4	Agenesis of occipital and parietal lobes and corpus callosum	Congenital	Congenital	Epilim Rivotril	13.12.1980	06.05.1981 07.05.1981 08.05.1981	3 hours 49 minutes
17	Male	13	Upper white	Sonskynnoekie	N.A. (Trained at Sonskynnoekie)	Meningitis	7-8 months	± 12 years	None	20.11.1980	15.06.1981	3 hours 5 minutes
18	Male	14	Upper white	Open Air	Std. 6	Head injury	13 years	1 year	None	16.02.1980	26.10.1981 27.10.1981 30.10.1981	3 hours

Information concerning the place, duration and number of assessment sessions is detailed in Table 18.

TABLE 18 : INFORMATION PERTAINING TO THE PLACE, DURATION AND NUMBER OF ASSESSMENT SESSIONS FOR BRAIN-DAMAGED CHILDREN

PLACE OF ASSESSMENT (TOWN : n)			TIME TAKEN TO ASSESS (HOURS)			MEAN NUMBER OF ASSESSMENT SESSIONS
DURBAN	JOHANNES-BURG	EMPANGENI	RANGE	MEAN	TOTAL	
8	9	1	2,5-3,8	3,3	58,4	3,3

A summary of the etiology of the brain damage is given in Table 19. The disorders are as given in each subject's medical file.

TABLE 19 : ETIOLOGY OF BRAIN DAMAGE IN SAMPLE OF CHILDREN

ETIOLOGY		n	ADDITIONAL INFORMATION ABOUT INJURY OR DISEASE PROCESS
Acquired:	Head injury (closed)	5	Motor vehicle accident: n = 4 Fall from lamp post : n = 1
	Viral infection	3	Encephalitis : n = 2 Meningitis : n = 1
	Cerebral tumour	1	Grade III (i.e. malignant) frontal astrocytoma: surgically removed prior to assessment
Congenital:	von Recklinghausen's disease	2	
	Friedreich's Ataxia	1	
	Hydrocephalus	1	Arrested hydrocephalus
	Agenesis occipital and parietal lobes, corpus callosum	1	
	Cortical atrophy	2	Diffuse: n = 1 Left cerebral hemisphere: n = 1
	CNS Malformation	1	
	Cortico-spinal atrophy (bilateral)	1	

6.5.2 Method

6.5.2.1 Administration of Luria's Neuropsychological Investigation for Children

The adapted LNI for South African children (see Chapter 5) was administered by the author according to the format outlined by Christensen (1975).

The procedure comprised the following three steps:

1. *Location of brain damage on the basis of LNI-C behavioural profile*
   Brain-damaged children were assessed "blind" — i.e. with no knowledge of medical or neurological findings. A suggestion as to the location of the lesion was then made on the basis of their behavioural profile using the LNI-C. Lesion sites were as suggested by Luria (1963b, 1980).

2. *Description of behaviour in terms of organic pathology*
   The medical files and CT scan reports were then consulted. On the basis of the locality of the damage as indicated by the CT scan and the nature of the injury or disease process, a description of the behavioural pathology, as per Luria, generally associated with the damage was formulated using the conceptual model presented in Chapter 5 (see Section 5.5) and the interpretive table outlined in the previous section.

3. *Comparison between information from Steps 1 and 2*
   The description of the behavioural disturbances usually accompanying the organic pathology, together with CT scan reports on lesion location (Step 2) was then compared with the LNI-C behavioural profile and the locality of the lesion it suggested (Step 1).

6.5.2.2 Data recording

Each subject's responses and behaviour during assessment were entered on to the recording sheets developed for this purpose (see LNI-C manual, Part 2.3, which contains a copy of these sheets). In addition, each subject's verbal responses were audiotaped in order to facilitate a later, more detailed analysis of the data. Copies of the completed LNI-C record forms, CT scan reports and transcriptions of the medical and paramedical (i.e.

speech, occupational and physio-therapists', and school teachers') files have been stored at the Neuropsychology Unit, Department of Psychology, University of Natal, Durban, and are available on request.

6.6 RESULTS

Luria's Neuropsychological Investigation for Children (LNI-C) was administered to brain-damaged children. In order to illustrate its application, an actual example of a detailed LNI-C report, as used for research purposes, is presented in Section 6.6.1 below. The purpose of this presentation is to demonstrate the hypothetico-deductive process whereby LNI-C assessment data were interpreted, and the factors underlying the observed symptoms identified, using Luria's concept of syndrome analysis and double dissociation. This case was chosen as the nature of the CT scan report and comprehensiveness of the medical and paramedical files — in particular the psychologist's report — seemed to be suitable for this task. The same format was followed for all LNI-C research reports, although only a summary of the findings has been presented for the remaining cases. The detailed reports for each subject have been lodged with Dr. S.G. Tollman, Head, Neuropsychology Unit, Psychology Department, University of Natal, Durban, and are available on request.

The format for presenting the findings for the illustrative case report is as follows:

1. Presentation of LNI-C assessment findings.

2. Prediction, as per Luria, of the behavioural consequences of the brain pathology indicated in CT scan and medical reports using Table 15 as a guide.

3. Comparison of LNI-C findings with 2. above and paramedical data.

These results are presented in tabular form to facilitate data assimilation.

The word "slight" will be used to denote difficulty with some of the tasks comprising a section, whilst "marked" will refer to difficulty with all or nearly all of the tasks.

This case presentation is followed by a description, in Section 6.6.2, of the findings which emerged from all 18 cases comprising the sample. The LNI-C findings for each of the nine different types of brain pathology present in the sample will first be compared with Luria's prediction of the symptoms and distribution of the brain damage associated with each disorder. Thereafter LNI-C and CT scan data regarding lesion locality is compared. This is followed by a comparison of LNI-C and EEG findings (when the latter were available). Finally, LNI-C and paramedical reports are contrasted.

6.6.1 Presentation of a detailed analysis of an illustrative case

Subject 8 was a ten year eight months old male who sustained a head injury at ten years two months of age. He was assessed six months posttrauma. At the time of the evaluation he was in Standard 2 at Brown's School for Cerebral Palsied Children. He was not on medication.

a. *A detailed analysis of LNI-C data from a selected illustrative case*

The assessment comprised three sessions and the total duration was three hours 16 minutes.

LNI-C ASSESSMENT FINDINGS	LESION SITE[1]. AS SUGGESTED BY LNI-C PERFORMANCE
Behaviour during assessment	
- This child was friendly, co-operative and talkative throughout the assessment. The content of this spontaneous chatter was, however, fairly immature and he tended to interject with inappropriate comments at various stages in the examination (e.g. "love is dot, dot, exclamation mark!")	Suggests frontal involvement.
- He had a scar on the left hand side of his face which extended from his hairline, through the inner corner of his eye to the outer corner of his mouth. His left eye watered continually	Suggests initial site of impact left frontal region.

1. Lesion site is as suggested by Luria (1963b; 1980).

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
and he reported that, since the accident, he has had diplopia in this eye. He therefore wears an eye patch.	
- He was a slow, neat worker who insisted on using a ruler whilst reproducing geometric shapes and designs. He was readily distractible and concentration was poor.	Suggests diffuse damage.
Note: The subject's initial behavioural presentation suggested the presence of both frontal and diffuse pathology.	
Preliminary conversation	
- Orientated for place and person.	
- Slight temporal disorientation (e.g. He inaccurately reported his involvement in an accident a "few weeks" previously and his attendance at Brown's School for approximately one week. His accident had, however, occurred six months earlier and he had attended Brown's School for approximately two months.)	Mediobasal frontal region.
- Limited insight into his condition. He listed his hobbies as soccer ("I play for Hillcrest"), cricket and tennis. However, in view of his physical condition, his discussion of his sporting activities was unrealistic.	Frontal.
- Complained of left frontal headaches, memory problems ("I forget my reading and reading study") and a lack of friends to play with at both home and school.	
Note: The subject's behaviour during the preliminary conversation confirmed the presence of frontal pathology, but additionally suggested that the frontal damage extended to	

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
Cerebral dominance	
- Left hemisphere speech dominant	Suggests laterality established.
Motor functions	
- Slight echopraxia (i.e. he tended to mirror image the examiner's hand movements)	Frontal.
- Difficulty forming new associations. e.g. He could perform the correct sequence of hand movements whilst "playing the piano", but during concurrent verbal counting he innertly counted "1-2-3-4-5-6-7", irrespective of the accompanying hand movements.	Frontal.
- Kinetic melody of movement intact.	Premotor intact.
Note: The subject's performance on motor tasks confirmed the presence of frontal pathology and further suggested that the premotor regions were intact.	
Acoustico-motor functions	
No disturbances observed	Right temporal intact.
Note: The subject's performance on acoustico-motor tasks suggested that the pathology did not extend to the right temporal region.	
Cutaneous and kinaesthetic functions	
No disturbances observed.	Premotor and postcentral intact.
Note: The subject's performance on tactile and	

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
kinaesthetic tasks confirmed that the premotor regions were intact and suggested that postcentral zones were also intact.	
Higher visual functions	
- No visuo-spatial disturbances noted.	Temporo-parieto-occipital zones intact.
- Difficulty with tasks requiring a preliminary analysis during which a correct choice between several possibilities had to be made. e.g. When asked to distinguish a white cross with a black centre from a homogeneous background of a chess-board, he was unable to do so and instead indicated the "stronger" structure — a black cross with a white centre.	Frontal.
Note: The subject's performance confirmed the presence of frontal pathology and additionally suggested that the damage did not involve the temporo-parieto-occipital zones.	
Impressive and expressive speech	
- Speech was at times indistinct and he occasionally had to be requested to repeat what he had said. Articulation, speech production and speech reception, however, appeared intact.	
- Anomia manifested as a difficulty in recalling the names of nouns. It was observed: (a) In situations involving the naming of objects where he attempted to describe objects in terms of their use (e.g. when shown a picture of a	Left hemisphere.

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
clothes peg and asked to name it, he responded with "I don't know ... I've forgotten.. you use it on the line... you hang clothes on the line to get dry"); (b) During the spontaneous production of phrases and sentences.	
- Slight literal paraphasia (instead of the necessary word similar sounds were uttered) and verbal paraphasia (the required word was replaced by another of similar sound).	Left temporal.
- Difficulty with tasks requiring a preliminary analysis during which a correct choice between several possibilities had to be made e.g. He was unable to rearrange words to form a sentence, innertly repeating the words in virtually the same order in which they had been presented.	Frontal.
- Difficulty completing tasks in which the answers required the formulation of new associations. e.g. When required to point to a black card if it was day and to a grey card if it was night, he insisted that the black card represented night and the grey card day — suggesting that he was only able to interprete this task in terms of well-formed associations.	Frontal.
- Difficulty recalling verbal material from long-term memory (e.g. information about his last holiday; the well-known story "Little Red Riding Hood"). Prompting did, however, sometimes elicit partial recall of the requested material, suggesting that lack of initiative to recall was perhaps a contributing factor to these disturbances.	Frontal.
Note: The subject's performance once more confirmed the presence of frontal damage and further suggested damage to the left temporal region	

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
Writing and Reading	
Difficulties experienced were isolated, involved phonetically complex words, and also seemed to reflect the aforementioned literal paraphasia. No difficulties were seen in tasks of a simpler nature.	Uncertain - suggests left temporo-parieto-occipital region possibly intact.
Note: The subject's performance appeared to confirm that the left temporo-parieto-occipital zones were intact.	
Arithmetic functions	
No disturbances observed.	Uncertain - suggests left temporo-parieto-occipital region intact.
Note: The subject's performance again seemed to confirm that the left temporo-parieto-occipital zones were intact.	
Mnestic functions	
- Impaired audioverbal memory. Difficulties were most marked when material was orally presented.	Left fronto-temporal.
- Distractability and erratic concentration, and resultant performance variability. (e.g. He was able to recall stories following interference during the final session. In contrast he had only been able to recall the first part of a story the previous day, tending to either forget the last part or confuse elements of the story).	Diffuse damage.
- Difficulty recalling material from long-term memory (e.g. information about his last holiday; the well-known story "Little Red Riding Hood").	

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
Prompting did, however, sometimes elicit partial recall of the requested material, suggesting that lack of initiative to recall was perhaps a contributing factor to these disturbances.	Frontal.
- Ability to learn new material impaired (e.g. He was unable to learn a series of unrelated words and his performance declined after the sixth trial suggesting fatigue. His evaluation of his performance was unrealistic and no learning strategy was apparent, words being repeated in random order with no attention to words not recalled on previous trials).	Frontal. Fatigue suggests diffuse damage.
- Impaired self monitoring as recall on learning tasks was marked by frequent repetitions and mistakes made initially were repeated on subsequent trials.	Frontal.
- Memory for visual, rhythmic and kinaesthetic stimuli intact. Note: The subject's performance on memory tasks confirmed the presence of diffuse pathology and frontal damage extending to the temporal region on the left. His performance suggested that the right temporal and parieto-occipital zones were intact.	Right temporal and parieto-occipital regions intact.
Intellectual processes	
- Difficulty in making a preliminary, planned approach to tasks, tending instead to make impulsive judgements on the basis of one aspect of the problem. (e.g. When asked to describe	Frontal.

LNI-C ASSESSMENT FINDINGS	LESION SITE AS SUGGESTED BY LNI-C PERFORMANCE
a thematic picture depicting a man and woman riding on horseback in the mountains, he said ".... a man and a woman .... they're getting involved").	
- Deficiencies in selectivity as evidenced by a tendency to form random associations (e.g. Analogies task).	Frontal.
- Perseveration (e.g. He attempted to solve an arithmetic problem by applying the same method of solution used in the previous one).	Frontal.
Note: The subject's performance further confirmed the presence of frontal pathology.	

SUMMARY AND CONCLUSIONS

Syndrome analysis of LNI-C data revealed several factors to be at the basis of the pattern of clinical symptoms observed during assessment. These factors suggested the lesion locality.

A disturbance in executive skills was implied by the following:

- Difficulty making a preliminary, planned and organized approach to tasks, tending instead to make impulsive judgements on the basis of one aspect of the problem. This impaired his ability to learn new material and was also evident in the intellectual sphere.

- Loss of selectivity in situations where a decision had to be made between competing hypotheses or response tendencies. This manifested as difficulty forming new associations in the motor and speech spheres, a tendency to make inappropriate comments whilst speaking, to form random associations in the area of intellectual functioning, difficulty with tasks requiring a preliminary analysis during which a correct choice between several possibilities had to be made in the perceptual and speech spheres, perseveration of previous response modes in the realm of intellect and slight echopraxia in the motor sphere.

- Loss of critical attitude and resultant poor insight into his condition and impaired self-monitoring on memory tasks.

- Slight loss of initiative which was evident on memory tasks.

- Slight temporal disorientation.

This disturbance in executive functions is related to frontal lobe pathology. The loss of selectivity and slight temporal disorientation suggested that the damage extended to the mediobasal regions of the frontal lobes.

The audioverbal memory impairment, anomia and slight literal paraphasia — the latter which appeared to account for the isolated difficulties noted whilst reading and writing — were indicative of damage to the left temporal zone.

Marked distractability and resultant erratic concentration were also evident. This impaired performance on memory tasks where behaviour was variable. This difficulty suggested the presence of diffuse damage.

In accordance with the principle of double dissociation no primary disturbances to motor, acoustico-motor, cutaneous and kinaesthetic, visuo-spatial and intellectual functions, reading, writing and arithmetic were evident. In this respect, no impairment was evident to the brain areas subserving these functions — namely the premotor, postcentral, parietal, occipital and right temporal regions.

b. *Prediction, as per Luria, of behavioural consequences of brain pathology as revealed by CT scan report on locality of lesion and medical files*

REPORT	FINDINGS	ASSOCIATED SYMPTOMS AS PER LURIA
Neurosurgeon	Traumatic head injury	Reduced work capacity and rapid fatigue. Headaches. Dizziness. Disturbance in higher mental processes and/or disruption of function of particular analyzer, depending on whether damage is diffuse of localized.
CT Scan	Diffuse decreased density in the left frontal lobe compatible with oedema.	Underdeveloped personality characterized by disinhibition and socially inappropriate behaviour. Apraxia in walking. Underdevelopment of regulatory role of speech, which prevents development of goal-directed activity.

c. *Comparison of LNI-C findings with Luria's prediction of lesion site and symptoms associated with type of brain damage and/or disease process present*

LNI-C findings were in keeping with Luria's prediction of the behavioural consequences of a traumatic childhood head injury which maximally involved the frontotemporal regions (see Table 15, Section 6.4). These findings may also be viewed within the context of the model of brain-behaviour presented in Figure 1 (see Chapter 5, Section 5.5). This subject sustained his brain damage at the age of ten years. Luria (e.g. 1980) argued that at this age the tertiary temporo-parieto-occipital zones have become effective, whilst the tertiary frontal regions are preparing for action. Damage to these regions will therefore disrupt their development and may prevent the frontal zones from assuming their supramodal and controlling role at 12 to 15 years.

d. *Comparison of LNI-C and CT scan findings*

LNI-C data were consistent with the left frontal lobe damage revealed by the CT scan. They additionally suggested more extensive focal damage involving both frontal lobes and the left temporal region superimposed on diffuse damage. This would seem to be a reflection of the fact that whilst the LNI-C provides information about the dynamics of brain-behaviour functioning, the CT scan does not.

e. *Comparison of LNI-C and EEG findings*

No EEG report available.

f. *Comparison of LNI-C findings with paramedical report findings*

PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARA-MEDICAL FINDINGS
Physiotherapist	No obvious physical disability.	LNI-C revealed slight echopraxia.
Occupational Therapist	Weakness of figure-ground perception.	LNI-C performance suggested that difficulty making a preliminary analysis during which a correct choice between several possibilities had to be made was at the basis of this weakness.
Speech Therapist	Psycholinguistic age below chronological age. Difficulties evident with linguistic reasoning, absurdities and associations. Word-finding difficulty evident.	LNI-C performance confirmed anomic difficulties and additionally revealed slight literal paraphasia. It suggested that impaired executive skills were at the basis of the linguistic difficulties noted in the speech therapy report.

PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARA-MEDICAL FINDINGS
School Psychologist	Intellect severely impaired. Auditory memory and abstract thought impaired. Word-finding difficulty and in-appropriate word usage evident. Impulsive approach to tasks. Readily distract-ible and poor concentration. Immature behaviour.	LNI-C performance confirmed anomia, impulsivity, poor con-centration, and auditory memory difficulties. It suggested that apparent inappropriate word usage was due to slight literal paraphasia. It ad-ditionally highlighted a learning problem and im-pairments in planning, selectivity, self-monitoring and perseveration as the underlying factors im-pairing his performance on ab-stract reasoning and other assessment tasks.

Note:

LNI-C findings suggested that impaired executive skills were at the basis of the difficulties noted by the school psychologist, occupational therapist, and speech therapist.

CONCLUSION:

LNI-C assessment findings were consistent with the difficulties reported by the paramedics. They additionally highlighted the factors underlying impaired performance on assessment tasks. These factors appeared to represent the linchpins on which retraining should focus. A similar conclusion was drawn in all cases evaluated (see Section 6.6.2).

6.6.2 Comparison of Luria's Neuropsychological Investigation for Children findings with Luria's prediction of lesion site and symptoms associated with the type of brain pathology present

A comparison of LNI-C findings with Luria's prediction of lesion site and clinical symptomatology, as per Table 15, associated with each of the nine different forms of brain pathology evident in the sample of 18 brain-damaged subjects is presented in Table 20. The findings pertaining to the acquired disorders of head injury, viral infections and tumour are presented first. Thereafter, the following cases of congenital disorders are dealt with: von Recklinghausen's Disease, Friedreich's Ataxia, bilateral cortico-spinal damage, congenital hydrocephalus (arrested), agenesis of the occipital and parietal lobes and corpus callosum, and congenital cortical atrophy and malformation.

TABLE 20 : COMPARISON OF LURIA'S PREDICTION OF LESION SITE AND SYMPTOMS ASSOCIATED WITH TYPE OF BRAIN PATHOLOGY PRESENT

TABLE 20.1 : HEAD INJURY

Number of subjects: 5 (Subjects 8, 10, 11, 13, 18)

Ages: 10, 11 (n = 2), 12 and 14 years

Ages at onset: 5, 6, 9, 10 and 13 years

Medication: Epineutum, Phenobarbitol n = [illegible]
None n = 4

Etiology: Closed head injury n = 5

CT Scans: Right frontal n = 1
Left frontal n = 1
Right parietal n = 1
No abnormalities n = 2

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS[1].		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
May be diffuse or localised	- Presentation: Reduced work capacity and rapid fatigue. Headaches. Dizziness. - Higher mental processes: General disturbance in higher mental processes and/or disruption in functioning of particular analyzer (i.e. visual-spatial, auditory-speech or emotional-volitional).	- Dominance established (n = 5)	Uncertain: suggests functional laterality developed.
		- Left hemiplegia (n = 3)	Right primary motor cortex.
		- Stereognosis (left side)	Right secondary parietal.
		- Marked distractability (n = 5) Manifestations: Erratic performance on memory and arithmetic tasks.	Diffuse.
		- Modality non-specific memory disturbance with marked interference effects and deterioration in performance with fatigue. (n = 3)	Diffuse.
		- Slow mental processing (n = 1).	Diffuse
		- Audioverbal memory disturbance together with anomia and literal paraphasia (n = 1).	Left temporal.
		- Visuo-spatial difficulties (n = 2). Manifestations: Spatial distortions on drawing tasks.	Right parietal.
		- Impaired executive skills (n = 5). Manifestations: Impaired selective, goal-directed behaviour (n = 5), irrelevant associations (n = 5), impulsivity (n = 5), perseveration (n = 5), difficulty forming new associations (n = 5); difficulty using speech to control behaviour (n = 1); echopraxia (n = 1);	Frontal lobes
		echolalia (n = 1); loss of critical attitude (n = 5): adynamia (n = 1); temporol disorientation (n = 2).	Mediobasal frontal regions.
		- No primary disturbance to motor (n = 2), acoustico-motor and visual analyzers, speech, reading, writing or arithmetic (n = 5).	Premotor, right temporal, primary occipital, left temporal and parietal zones intact.
		- No primary visual-spatial impairment (n = 3)	Right parietal intact.

COMMENTS:

1. Executive skills were impaired and marked distractability present in all five subjects. There were, however, individual variations in the manifestation of the disturbed executive skills.
2. Individuals varied in terms of the pattern of other disturbances associated with those noted in 1. above.
3. The earlier the onset of damage, the more marked and pervasive were the symptoms present.
4. LNI-C findings were generally in keeping with Luria's (1963b) prediction of disorders associated with head injury, but suggested that impaired executive skills may be at the basis of the general disturbance in higher

TABLE 20.2 : VIRAL INFECTIONS

Number of subjects: 3 (Subjects 5, 6, 17)

Ages: 8, 10 and 13 years

Ages at onset: 7 months, 4 years, 7 years

Medication: Ritalin, Epilim and Tegretol n = 1
None n = 2

Etiology: Encephalitis n = 2
Meningitis n = 1

CT Scans: Encephalitis - no abnormalities n = 2
Meningitis - diffuse pathology n = 1

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
Diffuse cortical atrophy.	- Presentation: excitable, disinhibited, mood unstable, irrascible. - Higher mental processes: Combination of general mental underdevelopment and specific, localized disturbances, depending on developmental stage at which infection occurred.	- Dominance not established (n = 2)	Uncertain. Suggests functional laterality failed to develop.
		- Distractible (n = 3)	Diffuse.
		- Rapid fatigue (n = 1)	Diffuse.
		- Slow mental processing (n = 1)	Diffuse.
		- Impaired kinetic melody of movement (n = 3). Manifestations: Motor sphere (n = 3); pathological inertia of speech processes (n = 2); telegraphic speech (n = 2)	Premotor zones.
		- Impaired simultaneous data synthesis (n = 3). Manifestations: Visual-spatial tasks (n = 3), quasi-spatial spheres (n = 3) which seemed to be at basis of speech, reading writing and arithmetic problems noted.	Tempero-parieto-occipital zones.
		- Impaired executive skills (n = 3). Manifestations: Selective, goal-directed behaviour-impulsivity; random and irrelevant associations; difficulty forming new associations; perseveration; echopraxia (n = 3); adynamia (n = 1); echolalia (n = 1).	Frontal. Mediobasal frontal zones
		- Disturbance of cortical tone (n = 3). Manifestations: Variable behaviour (n = 3); emotional lability (n = 2).	Subcortex (Unit 1).

COMMENTS:

1. General agreement between the three LNI-C profiles, but the earlier the onset of damage, the more severe and pervasive were the disturbances.
2. Pattern of LNI-C deficits in keeping with Luria's description of symptoms associated with viral infections. Profiles suggested, however, that impaired executive skills and simultaneous synthesis of data were at basis of general mental underdevelopment described by Luria.
3. Presentation of subject with meningitis more inhibited in nature than excitable behaviour Luria (1963b) attributed to such infections, and which was evident in the two subjects who had had encephalitis.
4. Variable behaviour and emotional lability were evident in the two subjects who were youngest at the time of contracting the infection. This author suggested that they were manifestations of disturbed cortical tone. This appeared to reflect a failure of the frontal lobes to assume their supramodal and controlling role during development due either to direct damage to these regions and/or to failure for them to develop.
5. Impairment to frontal and temporo-parieto-occipital zones evident in all three subjects.

TABLE 20.3 : TUMOUR

Number of subjects: 1 (Subject 12) Age: 10 years Age at onset: 3 years Medication: Epineutum, phenobarbitol		Etiology: Right frontal astrocytoma, Grade III. Surgically removed at 3 years and cranial irradition instituted. CT Scan: Right frontal	
LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
	No information regarding childhood tumours. Specifies clinical manifestations of disturbance to emotional-volitional analyzer and associated frontal lobe pathology.	- Dominance not established.	Uncertain. Suggest functional laterality failed to develop.
		- Rapid fatigue.	Diffuse.
		- Marked distractability.	Diffuse.
		- Modality non-specific memory difficulties.	Diffuse.
Frontal zones.	- Presentation: Underdeveloped personality characterized by disinhibition and socially inappropriate behaviour. - Motor: Apraxia in walking. - Higher mental processes: Regulatory role of speech underdeveloped and resultant dissociation between "knowing" and "doing" (i.e. correctly carrying out command). This prevents development of goal-directed activity.	- Impaired executive skills. Manifestations: Impaired use of language to regulate and control behaviour; impaired selective, goal-directed behaviour, perseveration, echopraxia, loss of critical attitude.	Frontal lobes.
		Disinhibition, marked adynamia, echolalia, poor perseverance.	Mediobasal frontal zones.
		- Impaired ability to abstract and generalize cross-modally. Manifestations: Unable to read. Able to write, compute and comprehend verbally at simple level only.	Temporo-parieto-occipital regions.

COMMENTS:

1. Manifestations of frontal pathology in keeping with Luria's (1963b, 1980) description of the disturbances associated with such damage in children.
2. Suggested posterior tertiary (temporo-parieto-occipital zone) dysfunction consistent with Luria's (e.g. 1980) contention that damage prior to the development of this region will result in impaired cross-modal abstraction and generalization. (Age at onset of damage in this subject was three years. Luria suggested these regions become operational at four to seven years as indicated in Figure 1).
3. Presence of more pervasive dysfunction than right frontal impairment suggested by CT scan may reflect effects of cranial irradiation.

TABLE 20.4 : VON RECKLINGHAUSEN'S DISEASE

Number of subjects: 2 (Subjects 2, 14)	Etiology: von Recklinghausen's Disease n = 2
Ages: 8 and 10 years	CT Scan: No abnormalities n = 2
Age at onset: Congenital	
Medication: None n = 2	

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LEGION SITE
	No information.	- Dominance not established (8 year old)	Uncertain: suggests functional laterality failed to develop.
		- Dominance established (10 year old)	Uncertain: Suggests functional laterality developed.
		- Mild right hemiplegia (n = 1)	
		- Modality non-specific memory problems (n = 2)	Diffuse.
		- Non-specific disturbances of narrative speech (n = 1)	Diffuse.
		- Disturbances in the kinetic melody of movement (n = 1). Manifestations: Motor sphere.	Premotor zone.
		- Difficulty with perception and reproduction of pitch relationships (n = 2)	Temporal lobes.
		- Optic agnosia (n = 1)	Occipital lobes.
		- Impaired simultaneous synthesis of data (n = 2). Manifestations: Visuospatial problems (n = 2); quasi-spatial sphere - impaired comprehension of logico-grammatical structures, spelling and reading.	Temporo-parieto-occipital zones.
		- Executive skills intact.	Frontal lobes intact.

COMMENTS:

1. Similarity between LNI-C profiles of the two subjects, but symptoms were more marked and numerous in the younger subject.
2. LNI-C findings suggested the presence of multi-focal damage - excluding the frontal lobes - superimposed on diffuse pathology.
3. Manifestations of the premotor, temporal, occipital, temporo-parieto-occipital and diffuse pathology present in keeping with Luria's (1963b, 1980) description of the disturbances associated with such damage in children.

TABLE 20.5 : FREIDREICH'S ATAXIA

Number of subjects: 1 (Subject 9)	Etiology: Freidreich's Ataxia
Age: 11 years	
Age at onset: Congenital	CT Scan: No abnormalities
Medication: None	

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
	No information	- Dominance established.	Uncertain: suggests functional laterality established.
		- Marked ataxic gait.	Cerebellum.
		- Extremely slow motor movements of the hands and mouth. Both accompanied by marked tremor. As a result ability to write severely impaired.	Cerebellum.
		- Slightly impaired simultaneous synthesis of data. Manifestations: Quasi-spatial sphere - comprehension of logico-grammatical structures.	Mild left temporo-parieto-occipital zones.
		- No primary disturbances evident in acoustico-motor, tactile, kinaesthetic, visual, visuo-spatial,reading, writing, arithmetic,memory or intellectual spheres. Executive skills intact.	No diffuse pathology. Frontal, premotor, postcentral, primary and secondary temporal, parietal and occipital zones, right temporo-parieto-occipital regions intact.

COMMENT:

Manifestations of cerebellar and left tempero-parieto-occipital damage in keeping with Luria's (1963b, 1980) description of the disturbances associated with such damage.

TABLE 20.6 : BILATERAL CORTICO-SPINAL DAMAGE

Number of subjects: 1 (Subject 7) Age: 10 years Age at onset: Congenital Medication: None	Etiology: Bilateral cortico-spinal (pyramidal tract) damage CT Scan: Left frontal atrophy

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
	No information.	- Dominance established.	Uncertain. Suggests functional laterality developed.
		- Impaired executive skills. Manifestations: Impaired selective, goal-directed behaviour and resultant pathological inertia of previously formed programmes of action, random associations, impulsivity. Echolalia	Frontal.
		Adynamia	Mediobasal frontal.
		No primary disturbances in following spheres: - acoustico-motor - tactile - stereognostic - visual-perceptual - visual-spatial - memory - reading - writing - arithmetic - intellect	Suggests premotor, postcentral, temporal, parietal, occipital and temporo-parieto-occipital regions intact.

COMMENT:

Manifestations of frontal pathology suggested by LNI-C in keeping with Luria's (1963b, 1980) description of the disturbances associated with such damage in children.

TABLE 20.7 : CONGENITAL HYDROCEPHALUS: ARRESTED

Number of subjects: 1 (Subject 15)	Etiology: Congenital hydrocephalus: arrested
Age: 13 years	CT Scan: Mildly enlarged ventricular system. Unusually elongated foramen magnum. Relatively large head circumference.
Age at onset: Congenital	
Medication: None	

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
Diffuse cortical damage with residual hydrocephalus.	*Excitable presentation* - Presentation: restless, irritable, capricious, distractible, impulsive, poor concentration, sleep disturbances, inability to play with peers. - Motor: slight incoordination and impairment of muscle tonus. - Higher mental processes: speech and visual-spatial functions intact. Generalization and abstraction ability and persistent goal-directed behaviour impaired. *Inhibited presentation* - Presentation: listless, rapid fatigue, passive insubordination, slow responses, disinterest in social interaction and play. - Motor: no marked defects, but poor fine-motor coordination and movements often slow and indecisive. - Higher mental processes: speech and visual-spatial functions intact, although former may become slurred and incomprehensible with fatigue. Generalization and abstraction impaired;perseveration may occur.	- Dominance not established.	Uncertain. Suggests functional laterality failed to develop.
		- Rapid fatigue.	Diffuse.
		- Modality non-specific memory problems.	Diffuse.
		- Non-specific disturbances in narrative speech.	Diffuse.
		- Ataxic gait.	Cerebellum.
		- Slow, jerky motor movements accompanied by fine tremor.	Cerebellum.
		- Difficulty with simultaneous synthesis of stimuli. Manifestations: Quasi-spatial spheres as speech, reading, writing and arithmetic problems; visuo-spatial difficulties.	Temporo-parieto-occipital zones.
		- Impaired executive skills. Manifestations: Speech regulation of behaviour impaired. Disturbed selective, goal-directed behaviour - echopraxia, perseveration, random associations, impulsivity.	Frontal.
		Marked adynamia.	Mediobasal frontal zones.

COMMENTS:

1. LNI-C profile in keeping with inhibited pattern of behaviour and presence of diffuse cortical damage described by Luria (1963b).
2. LNI-C findings suggested presence of more marked motor defects suggestive of cerebellar dysfunction, than indicated by Luria (1963b).

TABLE 20.8 : AGENESIS OF THE OCCIPITAL AND PARIETAL LOBES, AND CORPUS CALLOSUM

Number of subjects: 1 (Subject 16) Age: 13 years Age at onset: Congenital Medication: Epilim, Rivotril	Etiology: Agenesis of occipital and parietal lobes, and corpus callosum. Epilepsy present. CT Scan: Severe agenesis of both parietal and occipital lobes and probable associated agenesis of the corpus callosum

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
	No information regarding agenesis occipital and parietal lobes and corpus callosum. Symptoms associated with acquired damage to temporo-parieto-occipital regions and disturbance of *visual-spatial analyzer* described.	- Dominance established.	Uncertain. Suggests functional laterality developed.
		- Slow mental processing.	Diffuse.
		- Distractability.	Diffuse.
Temporo-parieto-occipital zones.	- Higher mental processes: Impairment visual-spatial ability. Intact auditory-speech functions	- Slight disturbance of kinetic melody of movement. Manifestations: Motor sphere and dysarthric speech.	Premotor zone.
	Epilepsy	- Slight disturbance in kinesthetic basis of movement.	Postcentral region.
General cortical changes.	- Presentation: Mood changes which include irritability, rudeness, greed, capriciousness.	- Optic agnosia.	Occipital lobes.
	- Higher mental processes: Impaired ability to abstract and generalize. Slowness of information processing. Perseveration.	- Difficulty with retention and recall of visual material. (No other memory problems evident.)	Occipital lobes.
		- Slight impairment of simultaneous synthesis of data. Manifestations: Slight quasi-spatial and visuo-spatial difficulties.	Temporo-parieto-occipital zones.
		- Executive functions intact.	Frontal regions intact.

COMMENTS:

1. Damage present appeared to be mild as many processes associated with the brain areas in question were intact.
2. LNI-C profile did not suggest the presence of corpus callosum pathology.
3. LNI-C profile was consistent with Luria's (1963b, 1980) description of symptoms associated with temporo-parieto-occipital zone pathology.
4. The slow mental processing and diffuse dysfunction suggested by LNI-C profile may reflect the epilepsy present and generalized cortical changes Luria (1963b) associated with this disorder. Mood changes, impaired ability to abstract and generalize, and perseveration which Luria also associated with epilepsy were not present - perhaps as the epilepsy was apparently secondary to the agenesis present.

TABLE 20.9 : CONGENITAL CORTICAL ATROPHY AND MALFORMATION

Number of subjects: 3 (Subjects 1, 3, 4) Ages: 8 years n = 3 Ages at onset: Congenital n = 3 Medication: None n = 3	Etiology: Cortical atrophy: Diffuse n = 1 Left sided n = 1 CNS malformation: n = 1 CT Scans: Left sided cortical atrophy n = 1 No abnormalities n = 2

LURIA'S PREDICTION OF LESION SITE AND ASSOCIATED SYMPTOMS		LNI-C ASSESSMENT FINDINGS	
LESION SITE	ASSOCIATED SYMPTOM	LNI-C PERFORMANCE	SUGGESTED LESION SITE
	No information.	- Dominance not established (n = 3)	Uncertain, suggests laterality failed to develop.
		- Executive skills impaired (n = 3) Manifestations: - Impaired goal-directed, selective behaviour and impulsivity, formation of random associations, disturbed verbal regulation of behaviour, perseveration (n = 3)	Frontal.
		- Echolalia (n = 1)	Frontal.
		- Adynamia (n = 1)	Mediobasal frontal.
		- Temporal disorientation (n = 1)	Mediobasal frontal.
		- Critical attitude impaired (n = 3)	Frontal.
		- Disturbance in kinetic melody of movement (n = 3). Manifestations: - Motor sphere (n = 3) - Speech sphere (n = 3); telegraphic speech (n = 1)	Premotor.
		- Disturbance in kinaesthetic basis of movement (n = 2)	Postcentral.
		- Impaired tactile sensation (n = 2)	Postcentral.
		- Stereognosis on right (n = 1)	Left parietal.
		- Visual agnosia (n = 3)	Occipital.
		- Difficulty with sequential synthesis (n = 3). Evident in speech (n = 3) and acoustico-motor (n = 3) spheres.	Temporal.
		- Simultaneous synthesis of data impaired (n = 3). Manifested: Visuo-spatial sphere (n = 3). Inability to abstract and generalize cross-modally (n = 3) and as result able to read, write, do arithmetic and comprehend verbally at very simple level only.	Temporo-parieto-occipital zones.

COMMENTS:

1. Overall pattern of functioning to emerge in keeping with Luria's (1963b, 1980) view that early pathology impairs the development of higher mental processes.
2. LNI-C performance suggested that damage was multifocal in all three subjects.
3. In all three cases dominance did not seem to be established and visual agnosia, difficulty with sequential synthesis, impaired simultaneous synthesis of data and disturbed executive skills were evident.

In summary, the following general trends emerged when LNI-C data were compared with Luria's prediction of the lesion site and symptoms associated with the type of pathology present in children:

- LNI-C findings were in keeping with the general pattern of symptoms Luria described for those forms of pathology for which he did provide information.

- In disorders for which Luria provided no information, the behavioural manifestations of the lesion site suggested by the LNI-C were consistent with Luria's description of the symptoms associated with such damage in children. (e.g. Table 20.3 indicates that, although Luria provided no information regarding childhood tumours, the manifestations of the frontal pathology present, as suggested by the LNI-C and CT scan, were consistent with Luria's description of the disturbances associated with such damage in children.)

- Age at onset was an important factor determining the severity and pattern of deficits present. The symptoms were more marked and numerous in children who were youngest at the onset of brain damage.

- The most frequent disturbances noted were an impairment to executive functions and/or the ability to process data simultaneously — both of which are, according to Luria (e.g. 1980), associated with the tertiary areas of the brain. These impairments frequently appeared to be factors underlying disturbances to, and/or impaired acquisition of, language and the educationally acquired skills of reading, writing and arithmetic.

- In most forms of pathology the LNI-C suggested that the damage present was multifocal and/or diffuse in nature.

6.6.3 Comparison of Luria's Neuropsychological Investigation for Children and CT scan findings regarding lesion locality

Comparison of the locality of the lesion suggested by LNI-C behavioural profiles and the lesion site recorded in CT scan reports indicated the following:

- The LNI-C behavioural profile suggested the presence of the brain damage denoted in the CT scan reports in eight of the 18 subjects.

- In all of these eight cases the LNI-C data additionally suggested that the damage was more pervasive than that delineated in the CT scan reports.

The LNI-C profile and suggested lesion site was, however, consistent with Luria's prediction of the clinical symptomatology and lesion locality for the types of brain pathology for which he did provide information.

- In one case the LNI-C correctly suggested the presence of damage to the parietal and occipital zones, but failed to identify agenesis of the corpus callosum.

- In the remaining nine subjects the LNI-C suggested the presence of brain-damage although the CT scan reports indicated no abnormalities. There were, however, neurological signs of brain damage recorded in the medical files and a history of brain trauma, disease or congenital disorder in all cases. Furthermore, the pattern of behaviour which emerged in these instances was consistent with the clinical symptoms Luria associated with the brain-damage suggested by the LNI-C. Finally, EEG reports were available for five of these subjects. In all of these cases the reports described pathology which was in keeping with the LNI-C findings.

6.6.4 Comparison of Luria's Neuropsychological Investigation for Children and EEG findings regarding lesion locality

EEG reports were available for ten of the 18 subjects. Comparison of LNI-C and EEG findings regarding the location of the lesion revealed the following:

- In all ten cases LNI-C data were in keeping with the locality of the damage detailed in the EEG reports.

- The LNI-C provided the following additional information regarding the distribution of the brain damage in all ten subjects:
  a) In five of the cases the LNI-C data suggested that focal damage was superimposed on the diffuse damage described in the EEG reports; and
  b) In the remaining five cases, the LNI-C suggested the presence of diffuse pathology in addition to the localized damage detailed in the EEG reports.

6.6.5 Comparison of Luria's Neuropsychological Investigation for Children findings and paramedical reports

Paramedical reports written by psychologists, speech therapists, occupational therapists, physiotherapists and class teachers were available for 16 subjects. The amount of information provided in each report varied. The only reports available for the remaining two subjects were those written by psychologists and school teachers. Both were extremely brief.

Comparison of all 18 LNI-C behavioural profiles and paramedical reports revealed the following:

- The LNI-C data identified the factors underlying the disturbances noted in the paramedical reports in all 18 cases. For example, in Subject 17, LNI-C data suggested that a disturbance in the kinetic melody was at the basis of the motor, speech and writing difficulties recorded in the paramedical reports.

- LNI-C findings were consistent with all the difficulties noted in the paramedical reports in 12 cases.

- The LNI-C did not reveal some of the disturbances recorded in the paramedical reports in the remaining six subjects. These were as follows:

  a) In three of these subjects the LNI-C did not identify emotional and interpersonal problems reported in the paramedical reports. For example, in Subject 16, the psychologist reported severe emotional problems (depression and a suicide attempt), which were not evident during the LNI-C evaluation one year later.

  b) Three cases involved acquired brain damage. The mean time period between the LNI-C evaluation and paramedical reports in these cases was 14 months. The absence, during the LNI-C examination, of some of the disturbances described in the earlier paramedical reports thus appeared attributable to recovery of function during the intervening time period. For example, the LNI-C was administered to Subject 18 approximately 20 months after he sustained a head injury. This neuropsychological evaluation did not reveal the following disturbances recorded in the paramedical reports dated one year earlier (i.e. eight months posttrauma):

     - slight hemiparesis, ataxic gait and poor balance (physiotherapist's report);

- perceptual visualization problems (occupational therapists's report);

- phonation difficulties and poor vertical tongue movements (speech therapist's report); and

- poor spelling, memory and short attention span (class teacher's report).

- In six subjects the LNI-C additionally revealed the presence of impairment not noted in any of the paramedical reports. For example, in Subject 7 the LNI-C identified a memory problem not recorded in the paramedical reports. The LNI-C also revealed that semantic organization of the material to be retained enabled the subject to compensate for this problem.

- Finally, in two subjects, the nature of the data provided by the LNI-C highlighted shortcomings associated with the use of scores in the paramedical reports.

  a) In Subject 5, scores appeared to provide misleading information. More specifically, LNI-C findings of a spatial problem initially seemed to contradict the psychologist's report which described the ability to solve problems in spatial relations as a "relative adequacy". Closer perusal of this report revealed, however, that the subject's score for the test evaluating this ability fell within the borderline-defective range.

  b) In Subject 11, scores seemed to mask areas of dysfunction. The psychologist's report initially appeared to have failed to identify several of the problems noted during LNI-C evaluation. This report merely comprised a list of scores for the Wechsler Intelligence Scale for Children - Revised (WISC-R). No reference to their implications in terms of the behavioural problems they denoted was made in the body of this report. Closer inspection of the pattern of these WISC-R scores nevertheless revealed that they were in keeping with the difficulties in the spheres of memory, goal-directed behaviour and spatial orientation identified by the LNI-C.

6.7 DISCUSSION

In 1985 Bolter and Long wrote that, in contrast to adults, current knowledge of brain-behaviour relationships in the developing child is limited. A review of the literature by the author indicated that this is still the case. As a result there is presently no well articulated framework to guide both the clinical interpretation of assessment data (e.g. Majovski 1984; Obrzut 1981; Wilson 1986), and formulation of a prognosis and treatment plan. As Bolter and Long (1985 p.55) have argued:

> "It is the clarification of this dynamic structural-functional organization associated with childhood that remains a task for future researchers."

Furthermore knowledge of the syndromes associated with various forms of damage to different brain areas in children is not well known (e.g. Benjamins 1984).

In Chapter 5, the development of an assessment approach, which is integrated with a conceptualization of brain-behaviour ontogeny, was described. In the present chapter, the application of this protocol to brain-damaged children is explored. This discussion will first consider the application of Luria's Neuropsychological Investigation for Children (LNI-C) to brain-injured children. In this respect, the procedure's ease of application and ability to delineate intact and impaired functions in children for rehabilitation purposes will be evaluated. The extent to which data interpretation was facilitated by the model of brain-behaviour ontogeny and the interpretive protocol devised will also be discussed. Thereafter LNI-C data will be compared with Luria's prediction of the symptoms and distribution of the lesion associated with the type of brain dysfunction present, CT scan and EEG (when available) reports regarding lesion locality, and paramedical reports. Finally syndromes associated with different forms of brain pathology in children will be explored. Methodology pertaining to sampling and data analysis, as well as areas for future research are addressed in Chapter 7 (see Sections 7.3 and 7.4 respectively).

6.7.1 The application of Luria's Neuropsychological Investigation for Children to brain-damaged children

The LNI-C is a qualitative, process-orientated approach to neuropsychological assessment which uses a single case study methodology. A detailed analysis of an illustrative case was presented in Section 6.6.1 in order to demonstrate the hypothetico-deductive process by which LNI-C data were interpreted, using Luria's concepts of syndrome analysis and double dissociation. Both the assessment and analysis of the findings were guided by the model of brain-behaviour development delineated in the previous chapter (see Section 5.5) and the interpreted protocol presented in Section 6.4 (see Table 15).

This case study illustrates that, by means of the process of assessment and data analysis embodied by the LNI-C, the factor(s) underlying the observed disturbances are identified, and an understanding and comprehensive description of impaired and preserved functions elicited, within a developmental framework. The LNI-C behavioural profile thus appears to highlight the areas on which retraining should focus. This case study further indicates that in order to conduct an assessment using the LNI-C, and analyse the data collected, the examiner needs to have expertise with the assessment protocol, as well as familiarity with the type of responses to tasks which may be made by children with various forms of brain dysfunction at different stages of development. In addition, the underlying theoretical structure of the battery needs to be understood and knowledge of the course of the brain pathology (e.g. progressive or recuperative) is needed.

The model of brain-behaviour ontogeny, together with the interpretive table, thus provides a conceptual framework within which to explain LNI-C assessment findings. This is particularly important in children, as developmental changes interact with changes in the behavioural disturbances of brain damage over time (e.g. Miller 1984). In formulating a prognosis for the brain-injured child, the effects of the damage must therefore be viewed within the context of development. The theoretical structure of the LNI-C does, however, provide a basis for predicting the behavioural consequences of brain damage sustained at different stages of development, and hence facilitates the formulation of a prognosis and rehabilitation plan. In this respect, Rourke, Fisk and Strang (1986) have indicated that the effects of early damage to the developing brain may only become apparent at later developmental stages. For instance, disturbances resulting from early damage to brain areas necessary for the subservance of more complex and mature neurodevelopmental systems will only become apparent when these structures are required for the mediation of more complex functions. Notable in this respect are executive functions which are, according to Luria (e.g. 1963b, 1980), subserved by the tertiary frontal regions. Disturbances to these functions may not manifest until late childhood and early adolescence (i.e. when the planning, direction, initiation and inhibition of complex behaviours become crucial developmental demands). Likewise, impairments in educationally acquired skills, which Luria suggested were largely associated with the tertiary tempero-parieto-occipital zones, may only become evident when the child enters school and the cross modal integration at the basis of these skills is required. The aforementioned model of brain-behaviour ontogeny would seem to provide the basis for anticipating the appearance of such difficulties as the child develops, and hence devising intervention plans that will take cognisance of these. In addition, the conceptual framework of the LNI-C provides a structure within which to generate hypotheses about syndromes associated with different forms of childhood brain pathology, on the basis of evidence derived during the LNI-C evaluation. This aspect of the battery is addressed in the next section.

The LNI-C thus appears to contrast with standardized batteries such as the Halstead-Reitan and Luria-Nebraska Neuropsychological Battery - Children's Revision (LNNB-CR). As contended in Section 6.3, the administration and interpretation of such protocols does not seem to require the same level of clinical expertise as is needed for a qualitative, process-orientated, theoretically based procedure such as the LNI-C. Interpretation of findings in standardized instruments is based on normative data and derived scores, and can thus be carried out by a psychometrist who has been trained to administer and score such protocols. Furthermore, as Taylor (1984) indicated, these batteries were initially developed for the purpose of diagnosing brain damage and hence provide only weak guidelines for therapeutic intervention. Evans *et al.* (1982) have, however, argued that the detection of brain damage *per se* in children is educationally meaningless, if not unethical. Several authors have consequently stressed the importance of understanding the reasons for the brain-damaged child's deficits in order to devise rehabilitation programmes (e.g. Evans *et al.* 1982; Feuerstein *et al.* 1981; Gaddes 1980; Taylor 1984, 1986). It has yet to be demonstrated by research that present standardized batteries are suitable for this purpose. Rourke, Strang and Fisk (1986) have more recently devised a treatment orientated approach to the neuropsychological assessment of children. The informal battery of standardized tasks they have assembled does not, however, appear to be linked to a theory of brain-behaviour development. Assessment and treatment planning are thus not guided by a conceptual framework. The process-orientated, theoretically based LNI-C would, however, seem able to provide such information.

LNI-C findings were compared with Luria's view of the manner in which clinical symptomalogy relates to brain damage in children (see Table 15). This was done as knowledge of the disturbances associated with different forms of childhood brain pathology is limited (e.g. Benjamins 1984). Furthermore, Luria's work with children is not as well developed as that with adults. Due to Vygotsky's death and the subsequent advent of World War II, the main focus of his neuropsychological investigations were adults. The comparison revealed the following:

- LNI-C findings were in keeping with the general pattern of symptoms associated with the different forms of brain disturbances described by Luria.

- In disorders for which Luria provided no information, the behavioural manifestations of the lesion site suggested by the LNI-C were consistent with Luria's description of the symptoms associated with such damage in children.

- Age at onset was an important factor determining the severity and pattern of deficits present.

- The most frequent disturbances noted were an impairment to executive functions and/or the ability to process data simultaneously — both of which are associated with the tertiary areas of the brain.

- In most forms of pathology the LNI-C suggested that the damage present was multifocal and/or diffuse in nature.

Each of these findings will be addressed in turn.

Comparison of LNI-C findings with Luria's prediction of the symptoms associated with the type of brain dysfunction present, indicated that the data were in keeping with the general pattern of disturbances associated with the different types of brain damage described by Luria (see Table 15). In several instances the LNI-C did, however, provide a more detailed description of the deficits present. For instance, Luria described the effects of viral infections on higher mental processes as a combination of general mental underdevelopment and specific, localized disturbances, depending on the developmental stage at which the infection occurred. The LNI-C behavioural profile indicated, however, that all three subjects who had had viral infections displayed an impairment in the kinetic melody of movement, simultaneous data synthesis, executive skills and a disturbance of cortical tone (see Table 20.2). This appears to reflect the fact noted earlier that Luria's work with children is not as well developed as that with adults. A further indication of this was that several children in the sample were diagnosed, in medical reports, as having disorders about which Luria (e.g. 1963b) provided no information — namely Friedreich's Ataxia, von Recklinghausen's Disease, agenesis of the corpus callosum and bilateral cortico-spinal damage. In these instances the behavioural manifestations of the lesion site(s) suggested by the LNI-C were nevertheless consistent with Luria's description of the symptoms associated with such damage (e.g. frontal zones) in children.

Age at onset of brain damage emerged as an important factor determining the severity and pattern of deficits evident. Damage in early childhood appeared to be associated with more marked deficits than later onset of damage. This is consistent with Luria's (e.g. 1980) and Vygotsky's (e.g. 1965) proposal that early brain damage prevents, limits or distorts future development. It also appears to be in keeping with the work of other researchers who have noted that developing neuropsychological functions appear to be more vulnerable to disruption by brain injury than fully developed skills (e.g. Ewing-Cobbs *et al.* 1987; Goethe and Levin 1986; Hebb 1942). The situation regarding age at onset and subsequent recovery of function does, however, appear to be more complex. As indicated in the literature reviewed in Chapter 3 (see Section 3.2.1), age at onset and the degree of recovery which ultimately occurs seems to interact with the extent of the lesion. Chelune and Edwards (1981) summarized this relationship as follows: younger children with diffuse damage tend to show poorer recovery of function than older children, whilst younger children with focal injuries show better functional recovery than their older counterparts. The findings of the present study suggest that additional complicating factors are the locality of the damage and the nature of the disease process present (i.e. whether the disorder is progressive, as in Freidreich's Ataxia, or one in which at least some recovery can be anticipated, as in a head injury). In terms of the locality of the lesion, the present study suggested, for instance, that early damage to the tertiary zones had more severe behavioural consequences than damage to other areas. This is addressed below. Luria (e.g. 1961, 1978a) also emphasized the importance of social and environmental factors on development, and these would seem to be further confounding factors pertaining to age at onset of damage and subsequent recovery of function.

Another finding which appeared to be age related was an apparent disruption in the development of functional laterality in the brain after early brain damage. According to Luria (e.g. 1980) there is progressive functional lateralization during normal ontogeny, which appears to be related to the development of the secondary cortical zones (see Chapter 5, Section 5.6.1). The nature and implications of a disruption in this process with brain damage need to be clarified. Certainly in work on learning disorders in children it has been suggested that the linguistic problems they display may be, at least in part, related to incomplete or atypical functional lateralization in the brain (e.g. Beaumont and Rugg 1978).

The most frequent disturbances to emerge were disturbances of executive skills, language and the educationally acquired skills of reading, writing and arithmetic. According to Luria (e.g. 1980) the acquisition of the latter skills is largely dependent on the tertiary tempero-parieto-occipital zones of the left hemisphere, whilst the adequate development of executive skills requires the integrity of the tertiary frontal regions. This finding is consistent with Luria's and Vygotsky's proposal that early brain damage prevents the development of the tertiary zones (e.g. Luria 1980). Rutter (1982) proposed that brain damage in childhood, unlike that in adults, tends to have its main effect on general intelligence, and that the cognitive sequelae of localized brain lesions in childhood are usually non-specific (see also Chapter 3, Section 3.2.2). It is the present author's contention that this perhaps reflects a failure of the tertiary zones to develop and/or a disturbance in the role played by these regions during the development of higher mental processes, as a result of early brain damage. This would also seem to be at the basis of a more recent proposal by Deysach (1986) that the most developmentally advanced and most cognitively complex tasks are the most vulnerable to the effects of brain damage in the preschool child.

Finally, in most forms of brain pathology present, the LNI-C suggested that the damage evident was multifocal and/or diffuse in distribution.

This was in keeping with the nature of the disease processes present. It was also consistent with the literature which reported that most forms of childhood brain pathology result in generalized rather than focal brain damage (e.g. Benjamins 1984; Bolter and Long 1985; Russell 1986).

It would seem opportune at this point to discuss two apparently contentious issues relating to the LNI-C — namely the ability of the protocol to identify diffuse pathology and frontal lobe damage. Furthermore, as Luria's approach to assessment has, by his own admission, focused primarily on the dominant (left) hemisphere, the ability of the LNI-C to identify non-dominant (right) hemisphere damage also needs to be explored (e.g. Luria, 1973a, 1980). Each of these topics will be addressed in turn.

Luria's work (namely Luria 1973a, 1980; Luria and Majovski 1977) has been criticized by Russell (1986) for failing to incorporate a conceptualization of diffuse brain damage. As indicated above, most forms of brain pathology in children result in diffuse rather than focal damage. A neuropsychological assessment procedure for children should therefore be sensitive to the effects of diffuse brain injury. Russell (1986) also critized Luria's approach to assessment for not using co-ordinated groups of tests to study the performance pattern of individuals with diffuse brain injury. Russell argued that as a result the applicability of Luria's work is limited as most patients seen by neuropsychologists today have some form of diffuse brain damage and in most forms of brain injury focal effects are superimposed on this more general impairment. He wrote: "It is inconceivable that Luria and other such neuropsychologists were unaware of these generalized effects" (p.62). In this respect at least, Russell is correct — it would have been inconceivable for a clinician of Luria's calibre to ignore these diffuse effects of brain injury. Luria (1980, p.105) specifically stated that "The presence of general cerebral components in practically every case of local brain lesion greatly complicates the evaluation of local symptomatology". Luria (1980 p.106) further indicated that, for didactic purposes, he "deliberately ignored" these "complicating factors" in his report of the changes in higher mental processes associated with focal brain damage. Luria acknowledged that as a result his account was "rather schematic". Luria did therefore, by his own admission, primarily focus on the effects of focal lesions which he evaluated with a comprehensive battery of tasks systematized with respect to his theory of brain functioning. This also seems to at least partially reflect the nature of the clinical material available to him at the time — namely patients with highly localized shrapnel wounds (e.g. Luria 1970), cerebral vascular accidents (e.g. Luria 1976) and tumours (e.g. Luria 1976). Both Luria (1980) and Christensen (1979a) do, however, include sections on the generalized effects of brain injury (see e.g. Christensen 1979a p.189-193; Luria 1980, p.104-106). Furthermore, Luria (1973a, 1980) has suggested that some of these so-called generalized effects of brain injury are the result of damage to subcortical areas such as the reticular formation, which are connected to all other regions. In addition, in his work with children, Luria (e.g. 1963b) described the effects of diffuse cortical damage arising from disorders such as viral infections, epilepsy and congenital retardation. This work is summarized in Table 15 (see Section 6.4).

Russell's (1986) criticisms thus appear to reflect a cursory reading of the writings of Luria and Christensen which he did consult, as well as a limited knowledge of Luria's work. In this respect, the case studies presented in this chapter indicated that the LNI-C does appear able to identify diffuse damage and the associated pattern of generalized effects in children. The presence of diffuse damage was suggested in children with traumatic head injury, viral infections and congenital conditions such as hydrocephalus (see Table 20). This damage primarily manifested as rapid fatigue, impaired concentration and slowness in responding — a pattern which is consistent with Luria's work as presented in Table 15.

In terms of frontal lobe pathology, Golden (e.g. 1981) argued that frontal damage cannot be evaluated in eight to 12 year olds as these areas are not yet developed. As reported in Chapter 5 (see Section 5.6.1) he therefore indicated that he had excluded all tasks designed to evaluate frontal pathology when developing the LNNB-CR. Shortcomings of his conceptualization were detailed in Chapter 5 (see Section 5.6.1). To briefly reiterate, these included a failure to take into consideration the multi-determinational nature of Lurian tasks, and an apparent contradiction in that a task designed to evaluate speech regulation of movement has not been excluded from the LNNB-CR. It was also pointed out that Luria (1979) has shown that the frontal lobes start to become operational at approximately three years of age. Thus, although executive skills may not be fully developed, they have begun to evolve by three years, but only assume their adult controlling role at 12 to 15 years. In this study it was possible to identify disturbances in executive skills and hence frontal lobe pathology, confirmed by the CT scan, in the eight to 14 year olds investigated. Furthermore, Mackay *et al.* (1985) found that the LNNB-CR was sensitive to frontal lobe dysfunction in children if a qualitative analysis of performance on individual items was used. They pointed out that there was, however, a dearth of items to evaluate executive skills on the LNNB-CR. As such, they appear to be unaware of the aforementioned rationale Golden used to develop the battery.

Finally, although Luria (e.g. 1973b, 1980) acknowledged that his assessment procedures primarily evaluated the dominant (left) hemisphere, he nevertheless did identify syndromes associated with non-dominant (right) hemisphere impairment in adults (e.g. see Luria 1980 p.374-384). It was not possible to fully explore the ability of the LNI-C to identify such impairment in children as most of the disturbances present in the subjects appeared to be bilateral. There were, however, isolated instances when the LNI-C did suggest that non-dominant (right) hemisphere impairment was present (see Table 20.1). The need to clarify the nature of disturbances associated with non-dominant (right) hemisphere lesions sustained at different development stages was highlighted by Luria (1980). He indicated that interhemispheric relationships change during development, with the non-dominant (right) hemisphere playing a far more important role in children than in adults. He cited as support for this, work by Simernitskaya and her colleagues, which indicated that the symptoms associated with non-dominant (right) hemisphere damage in early childhood are more marked and enduring than those associated with dominant (left) hemisphere impairment. Luria (1980) himself thus noted the need to more fully elucidate the nature of the changing interhemispheric relationships during ontogeny, as well as the type of impairment associated with damage to each hemisphere at different stages of development.

LNI-C and CT scan findings regarding lesion site will now be discussed.

Luria recognised the need to validate his adult neuropsychological assessment procedures in terms of modern neuroradiological techniques. Luria and Majovski (1977 p.962) wrote:

> "...it has become necessary to correlate the discoveries obtained by modern techniques of neuroradiology with the neuropsychological data concerning the nature of the disturbance observed in order to put the clinical neuropsychological method on a valid foundation."

In Chapter 4 of this dissertation a preliminary study was described in which adult LNI findings and CT scan reports as to the site of lesion were compared. A similar study was undertaken by Kagan (1982a, 1982b). Both studies found a significant positive correspondence between LNI and CT scan results as to lesion locality. Similar adult studies have also been undertaken using other assessment procedures such as the Halstead-Reitan Neuropsychological Battery (e.g. Bigler 1980; Snow 1981; Swiercinsky and Leigh 1979), the Wechsler Adult Intelligence Scale (e.g. Uzzel *et al.* 1979) and the Boston Diagnostic Aphasia Examination (e.g. Naeser and Hayward 1978). These studies have generally reported good agreement between assessment and CT scan results in terms of anatomical pathology.

In children, studies have either examined the ability of various neuropsychological measures, such as the Halstead-Reitan batteries, to detect brain pathology when the CT scan is used as the criterion for brain damage (e.g. Klesges and Fisher 1981), or looked at the type of structural brain abnormality evident on the CT scan in various types of dysfunction such as developmental neuropsychiatric disorders (e.g. Caparulo *et al.* 1982). As Klesges and Fisher (1981) pointed out, future research is still needed to examine the specific behavioural effects associated with structural brain damage in different areas of the brain in children.

In attempting to elucidate the nature of brain-behaviour relationships in children in the present study by comparing LNI-C and CT scan data, a simple, punctate relationship between the brain and behaviour of the type proposed by Gall and the phrenologists is not being advocated. The complexity and dynamic nature of evolving brain and behavioural functional systems negates this. Benton (1985) has, however, pointed out that to date, most work with children in the neuropsychological sphere has been purely behavioural. He argued that if brain-behaviour relationships in children are to be fully clarified, independent measures of cerebral functioning must now be incorporated into the structure of neuropsychological research, as has been done in this thesis.

The CT scan was chosen as the best available neuroradiological procedure for detecting structural brain damage at the time of conducting this phase of the research. The principals of CT scanning have been detailed in several publications and will not be described here (see e.g. Faerber 1986; Gawler *et al.* 1975). It is a non-invasive procedure (e.g. Baker *et al.* 1975; Christie *et al.* 1976; Faerber, 1986; Uzzel *et al.* 1979; Wedding and Gudeman 1980), which is rapid (e.g. Dublin, French and Rehrick 1977) in delineating neurological lesions *in vivo* (e.g. Gado, Hanaway and Frank 1979), with which behaviour can then be compared (e.g. Kertesz, Harlock and Coates 1979; Mazzochi and Vignolo 1978; Walsh 1978; Wedding and Gudeman 1980). Kertesz (1979 p.190) described the procedure as "a powerful tool to correlate structural abnormality in the nervous system with neuropsychological impairment".

The LNI-C behavioural profile suggested the presence of brain damage in those nine (i.e. half) of the subjects, where damage was evident on the CT scan. In all instances the LNI-C data additionally suggested that the damage was more pervasive than that indicated on the CT scan. The LNI-C behavioural profile and suggested lesion site was, however, consistent with Luria's prediction of the clinical symptomatology and lesion locality for the types of brain dysfunction in question. For Subject 16 the LNI-C correctly suggested the presence of cortical damage, but failed to identify agenesis of the corpus callosum. Firstly, the CT scan report described the presence of agenesis of the corpus callosum as "probable". Thus, whilst it was most likely present, there was not complete certainty in this respect. Secondly, research has indicated that such damage can be asymptomatic (e.g. Saul and Sperry 1968) or only demonstrable with the special tests devised in the study of split brain subjects (Walsh 1978). This is discussed further in the next section.

In the remaining nine subjects the LNI-C suggested the presence of brain damage although the CT scan revealed no abnormalities. This raises two issues. Firstly, whether the pattern of behavioural deficits evident on the LNI-C could have arisen from causes other than brain damage. Secondly, whether the CT scan is an effective procedure for identifying brain pathology in children. These issues will be discussed in turn.

In subjects with normal CT scans, the question arises as to whether mistakes made on the LNI-C were related to factors such as tasks comprising the battery being too difficult for children, psychogenic or emotional disturbances, socioeconomic deprivation and education. In all nine of the subjects with normal CT scans a history of brain trauma, disease or congenital disorder as well as neurological signs of brain damage were, however, described in the medical reports. All subjects also attended schools for brain-damaged children. In addition, in cases where an EEG report was available, it did indicate pathology which was consistent with the LNI-C findings. In terms of the LNI-C, the battery was developed so that *all* children comprising a sample of 70 eight to 14 year olds could correctly complete all tasks. Further when administering the battery to brain-damaged children, cognisance was taken not only of whether tasks were completed correctly or not, but of how they were performed (i.e. the process by which the goal was attained). In all instances a consistent pattern of difficulties became apparent during both the assessment and interpretation of LNI-C data using syndrome analysis and the principle of double dissociation of function. This pattern of behavioural disturbances and the nature of the brain damage it suggested was in keeping with both the neurological signs of brain injury and the pathological process reported in the medical files, as well as with the clinical symptoms Luria associated with the brain damage suggested by the LNI-C (see Table 15). In this respect, use of a syndrome approach to neuropsychological assessment would seem to be advantageous. If the pattern of symptoms is in keeping with a particular syndrome of brain damage, it is less likely that the behavioural deficits are attributable to non-organic factors. In contrast, in a psychometrically orientated approach, an abnormal score does not reveal the reason for the poor performance, and the possibility of misdiagnosis would seem to be greater. In this regard, Mensch and Woods (1986) have found that it was possible for subjects to fake impairment on the LNNB by, for example, responding slowly, as scores did not reflect the reasons for poor task performance. It was only possible to detect this when the responses to individual items were qualitatively analyzed and the nature and pattern of deficits to emerge compared with the disturbances usually associated with known syndromes of brain damage.

Finally, as mentioned earlier the behavioural impairment evident on the LNI-C could also have been related to factors such as psychogenic and emotional disturbances, socioeconomic deprivation and education. Certainly in adults, depression (e.g. Lezak 1983) and level of education (e.g. Parsons and Prigatano 1978) have been found to affect neuropsychological test performance. The above argument as to why LNI-C findings appeared to reflect brain pathology rather than factors other than brain damage would, however, seem to negate this in the present study. Parsons and Prigatano (1978) have also highlighted the importance of the socioeconomic variable as a confounding variable in the sphere of child neuropsychology. Children in the present sample fell into the upper and lower white collar categories of socioeconomic status. None belonged to the lower blue collar group (see Table 16). Possible social causation or exacerbation of neurological impairment did therefore not appear to be an issue in the present sample of more afluent children.

The second issue related to the effectiveness of the CT scan for diagnosing childhood brain pathology. Before discussing this, however, two complicating methodological factors need to be mentioned.

Firstly, the interval of time between the CT scan and LNI-C assessments was fairly lengthy (mean time period: one year six months). Subjects in which the CT scan did not reflect the dysfunction evident during LNI-C performance may thus represent children whose condition deteriorated during the intervening time period. As the CT scan is an expensive procedure it was not possible to have subjects scanned to coincide with the neuropsychological evaluation. Children were therefore chosen who had already had CT scans. The sample represents the only subjects available who fulfilled this criterion at the time the research was performed.

A second confounding factor is that each generation scanner represents an improvement in the resolution the machine is capable of achieving (Roberts 1984). No information was available regarding the model of CT scan used for each subject in this research project. It is thus possible that some of the instances in which the CT scan did not reveal abnormalities may reflect the use of earlier, less sophisticated machines.

To return to the issue of the diagnostic effectiveness of the CT scan, Roberts (1984) reported that the overall accuracy of the procedure is over 90 percent. Although valuable, the machine is nevertheless not perfect and is unable to identify many neurological abnormalities (Kolb and Whishaw 1985). As Wedding and Gudeman (1980 p.33) argued: "the

CAT scan ... is not a diagnostic panacea". Diagnostic shortcomings of the machine should therefore be borne in mind.

Brahme (1982) has pointed out that the sensitivity of the CT scan is greater than its specificity. For example, it is often not possible to determine whether a lesion represents an infarct, abscess, or primary or secondary tumour. Supplementary techniques such as angiography therefore have to be used at times to make a conclusive diagnosis.

Furthermore, several important anomalies may be missed by the CT scan (Brahme 1982). These include lesions that are isodense (e.g. Davis *et al.* 1976; Luzatti, Scotti and Gattoni 1979; Messina 1977), certain very small lesions (e.g. Davis *et al.* 1976; Luzatti, Scotti and Gattoni 1979), especially those which are diffuse in nature as in encephalitis (Messina 1977), acute cerebral infarcts (e.g. Kertesz, Harlock and Coates 1979; Wedding and Gudeman 1980), lesions in the posterior fossa (e.g. Christie *et al.* 1976; Roberts 1984), and other areas at the base of the brain (e.g. Roberts 1984), subdural haematomas (e.g. Davis *et al.* 1976; Dubin, French and Rennick 1977; Roberts 1984), small vascular structures and the detail of large vessels (e.g. Davis *et al.* 1976), and the brain changes secondary to slow growing or highly infiltrating tumours (e.g. Brahme 1982; Hawkes and Pusakulich 1982). In the present study the damage suggested by the LNI-C and most frequently not evident on the CT scan was diffuse pathology.

The diagnostic shortcomings of the CT scan have also been emphasized by other workers who have likewise reported abnormal neuropsychological profiles in the presence of normal CT scans, despite neurological evidence of cerebral dysfunction (e.g. Bigler 1980; Klesges and Fisher 1981; Klesges *et al.* 1984; Swiercinsky and Leigh 1979). None of these authors comment, however, as to whether the type of damage suspected, but not evident on the CT scan, was the type which usually proves to be diagnostically problematic for the scan.

It would thus appear that the CT scan is a fairly crude instrument and is consequently not particularly effective for identifying the type of brain lesions frequently found in children. Most brain lesions which affect the developing brain are diffuse and generalized in nature, although they may have focal emphasis (e.g. Benjamins 1984). In the present study, as noted above, diffuse damage was the most frequent type of pathology suggested by the LNI-C, but not evident on the CT scan. The more sophisticated, newly developed Nuclear Magnetic Resonance (NMR) Imaging, which has a higher resolution than the CT scan (e.g. Partain *et al.* 1983; Roberts 1984), would seem to be a more promising procedure in this respect.

The CT scan is further limited in that it produces a static picture of dynamic brain processes (Golden and Sawiki 1985; Roberts 1984). As such differential activity of the brain may be missed. The EGG (to be discussed next), cerebral blood flow (CBF) and positron emission tranaxial tomography (PETT) are examples of techniques in which differential brain activity can be observed (e.g. Buchsbaum 1986; Ingvar 1986; Hoyer 1986; Levene 1986; Madjirova 1986; Meyer 1986). Although the resolution of the PETT scan, for instance, is not as good as that of the CT scan, it has the unique advantage of providing information about metabolic activity of the brain (Kolb and Whishaw 1985; Roberts 1984).

When LNI-C data were compared with EEG reports in cases where they were available, they were in keeping with the locality of damage evident on the EEG in all instances. This is perhaps related to the fact that the EEG reflects ongoing activity of the brain, rather than records static anatomical changes as does the CT scan (e.g. Roberts 1984; Wiederhold 1982).

LNI-C profiles did, however, provide additional information regarding the distribution of the pathology in all cases. This suggested greater sensitivity and specificity of the LNI-C to the effects of cerebral dys- function. The question raised earlier as to whether behavioural deficits on the LNI-C could have arisen from factors other than brain damage and the argument given as to why this did not seem to be so, is nevertheless also applicable in this instance. In 50 percent of the subjects, LNI-C data suggested that focal damage was superimposed on the diffuse damage evident on the EEG. In the remaining 50 percent, LNI-C profiles suggested the presence of diffuse pathology in addition to the localized damage evident on the EEG. This perhaps reflects limitations in the diagnostic usefulness of the EEG. As Kolb and Whishaw (1985 p.105) pointed out, the EEG provides a "very crude measure of .... brain activity" as it only gives a measure of the summed activity of millions of dendrites. In addition, the surface scalp electrodes only record the surface activity of the brain. In abnormal states, disturbances in the deep structures may, however, secondarily affect the more superficially located cortical activity that can be recorded from the scalp (e.g. Wiederhold 1982). The barrier of bone and tissue which separates electrodes from the brain also interferes with the sensitivity of the EEG (Roberts 1984). In view of this barrier between the electrodes and the brain, and the fact that the EEG primarily reflects surface electrical activity of the brain, it does not seem surprising that EEG records can be normal in the presence of significant intracranial structural abnormality (e.g. Lishman 1978; Roberts 1984). Furthermore, a certain percentage of intact individuals have an abnormal EEG (e.g. Lishman 1978). The EEG would thus not seem to be a particularly useful external criterion measure of brain status against which to validate neuropsychological assessment procedures and findings.

Finally, LNI-C data was compared with paramedical reports in order to determine the nature of the information provided by the protocol. In general, this comparison seemed to highlight the value of a qualitative, process-orientated approach for providing a more dynamic explanation of the clinical symptoms present and identifying areas on which intervention can focus.

LNI-C findings were consistent with the difficulties noted in the paramedical reports in two thirds of the subjects. In the remaining third of the cases, the LNI-C did not reveal some of the disturbances reported by the paramedics. In half of these subjects this was due to the fact that the LNI-C does not evaluate emotional and interpersonal behaviour. In the other half, the discrepancy between paramedical reports and LNI-C data appeared attributable to the lengthy time period between the two. Subsequent recovery of function thus seemed to account for the absence, during LNI-C investigation, of some of the disturbances recorded in the paramedical reports. This nevertheless highlights a need, in future work, for paramedical reports written at the same time as the LNI-C assessment in order to clarify this finding.

In all subjects, the LNI-C data highlighted the factors underlying the disturbances noted in the paramedical reports — a process that was facilitated by the theory of brain-behaviour ontogeny which underlies the battery. These factors represented the linchpins on which retraining would focus. For instance, in Subject 17 a disturbance in the kinetic melody of movement was found to be at the basis of the motor, speech, and writing difficulties noted in the paramedical reports. Furthermore, in one third of the subjects the LNI-C revealed the presence of impairment not noted in any of the paramedical reports. The nature of this information was such that it would be important for retraining (e.g. a disturbance in executive skills)(see Section 6.6.1). Finally, the nature of the data provided by the LNI-C highlighted some of the shortcomings associated with the use of a psychometric approach to assessment which were identified in Section 6.3. These were the manner in which scores can mask areas of functioning and be misleading — both of which will hinder retraining efforts.

Therefore, in summary, application of the LNI-C and interpretation of findings using the process of syndrome analysis and the concept of double dissociation of function necessitates familiarity with Luria's writings and is facilitated by the interpretive protocol and model of brain-behaviour ontogeny devised during this research project. The battery is able to delineate impaired and preserved functions in children for rehabilitation purposes. Furthermore, LNI-C findings were consistent with the general pattern of symptoms Luria described for different forms of brain pathology in children. The LNI-C nevertheless provided additional insight into the nature of the deficits present in each instance. More specifically, age at onset of brain damage was found to be an important factor determining the severity and pattern of deficits to emerge. Impaired executive functions and/or a disturbance in the ability to process data simultaneously, both of which are associated with the functioning of the tertiary areas of the brain, emerged as the most frequent disturbances. These frequently appeared to be factors underlying disturbances to, and/or impaired acquisition of, language and the educationally acquired skills of reading, writing and arithmetic. A further result was that the CT scan was found to be limited in its use for identifying the type of diffuse and/or multifocal brain pathology frequently found in children. Finally the qualitative, process-orientated nature of the LNI-C proved effective for identifying factors at the basis of the disturbances recorded in the paramedical reports. These factors appeared to represent linchpins on which retraining could focus.

The syndromes associated with different forms of brain pathology which emerged during the application of the LNI-C to brain-injured children are discussed in the next section.

6.7.2 Syndromes associated with brain damage in children

limited knowledge of the syndromes associated with various types of brain pathology in children (e.g. Benjamins 1984). Dorman, Laarsch and Hurley (1985) have indicated that this is particularly true with respect to congenital childhood disorders which have been neglected in so far as the main body of neuropsychological research has been concerned. The neuropsychological evaluation of children can thus not proceed within the framework of a data base and set of assumptions concerning the symptoms associated with different types of childhood brain damage as is the case in adults (e.g. the writings of Lezak 1983; Luria 1980; and Walsh 1978, 1985). The model of brain-behaviour ontogeny and interpretive protocol devised in the present thesis nevertheless provided a basis for interpreting LNI-C assessment findings and generating hypotheses concerning the different types of brain pathology evident in the sample of brain-damaged children evaluated in this study. Findings pertaining to each type of pathological process will be explored in the present section. Brain damage acquired as a result of head injury, viral infections and tumours will be dealt with first. Thereafter the congenital disorders of hydrocephalus (arrested), Friedreich's Ataxia, bilateral corticospinal damage, von Recklinghausen's disease, agenesis of the occipital and parietal lobes and corpus callosum, and congenital atrophy and malformation of the brain will each be addressed in turn.

Five subjects (Numbers 8, 10, 11, 13 and 14) had sustained a closed head injury. Age at onset ranged from five to 13 years. No information was available concerning the severity of the head injury suffered by each child. All five subjects were male, which is consistent with the literature which has generally reported a higher incidence of boys in samples of head-injured children (e.g. Klonoff 1971; Klonoff, Crockett and Clark 1984; Klonoff and Paris 1974; Levin *et al.* 1982; Rutter, Chadwick and Shaffer 1984). Knowledge about the neuropsychological sequelae of childhood head injuries would seem to be important as they are one of the most common causes of brain damage in school-age children (Rutter, Chadwick and Shaffer 1984; Rutter *et al.* 1980). Furthermore, the mortality rates in children following severe head injury are lower than those in adults (e.g. Goethe and Levin 1986; Levin, Benton and Grossman 1982; Levin, Benton and Telzrow 1985; Lishman 1978). This appears to be related to differences in the neuropathology of head injury in adults and children described below (e.g. Bruce *et al.* 1978; Goethe and Levin 1986; Levin, Benton and Grossman 1982; Oddy 1984).

Head injury may be open, as in penetrating wounds, where the damage is usually focal and there is frequently no loss of consciousness or closed as when mechanical impact is transmitted to the brain (e.g. Becker *et al.* 1979; Grimm and Bleiberg 1986; Jellinger 1983; Levin, Benton and Grossman 1982; Lezak 1983; Rutter, Chadwick and Shaffer 1984). In the latter case damage results from acceleration and deceleration of the brain as it moves within the bony and fibrous skull. With the rapid change in momentum, the brain is subjected to rotational forces which create sheer stresses that cause diffuse axonal and microscopic lesions throughout the brain (e.g. Grimm and Bleiberg 1986; Levin, Benton and Grossman 1982; Lezak 1983; Oppenheimer 1968; Walsh 1978, 1985). Oppenheimer (1968) has demonstrated that these diffuse, microscopic lesions occur after both severe trauma and mild concussion. Contusions are formed at the initial point of impact (coup lesions) and directly opposite it (contre coup lesion). Regardless of the initial site of impact, frontotemporal contusions and lacerations also occur as the brain is thrown against the bony protrusions on the floor of the cranial cavity during rapid deceleration (e.g. Grimm and Bleiberg 1986; Jellinger 1983; Levin, Benton and Grossman 1982; Lezak 1983; Lishman 1978,; Walsh 1985). In addition to these primary sources of damage, secondary delayed pathophysiological processes also occur, which may be more damaging than the original injury (Grimm and Bleiberg 1986). These include anoxia, ischemia, oedema and distortion of the brain due to intracerebral bleeding (e.g. Grimm and Bleiberg 1986; Levin, Benton and Grossman 1982; Walsh 1985).

In young children, the greater flexibility of the cranial bones, the smoother interior of the skull and elastic properties of the less well myelinated young brain results in different types of traumatic damage pathologically to that sustained by adults (e.g. Goethe and Levin 1986; Hartlage 1985; Jellinger 1983; Levin, Benton and Grossman 1982; Lishman 1978; Oddy 1984). The greater pliability of the cranial bones enhances the capacity of the skull to absorb traumatic forces (e.g. Goethe and Levin 1986; Levin, Benton and Grossman 1982). This gives greater resistance to the effects of head injury (Lishman 1978; Oddy 1984) and reduces focal pathology (Levin, Benton and Grossman 1982) on the one hand. On the other hand, however, it results in greater deformation of the brain on impact and hence greater shearing effects (Goethe and Levin 1986; Oddy 1984). Diffuse white matter injury thus predominates in children (e.g. Bruce *et al.* 1978; Levin, Benton and Grossman 1982), in contrast to the contusions and haemorrhages seen in later life (e.g. Hartlage 1985; Levin, Benton and Grossman 1982). In this respect it should be noted that, as indicated in the previous section, diffuse insult to the brain of children appears to be more damaging than focal lesions (Chelune and Edwards 1981; Levin, Eisenberg and Miner 1983).

Goethe and Levin (1986) have pointed out that the methodological problems associated with many studies of childhood head injury make the comparison of results of different studies difficult. These include the diverse criteria which have been used to grade the severity of head injury and the wide range of procedures used to assess neuropsychological status. Despite this neurosurgical studies have generally supported the view that outcome of severe head injury in children is better than in adults (e.g. Goethe and Levin 1986; Jennett 1972; Levin *et al.* 1982). In contrast, neuropsychological studies have documented persistent cognitive and behavioural disturbances which are strongly related to the severity of the acute head injury (e.g. Brink *et al.* 1970; Chadwick, Rutter, Brown, Shaffer and Traub 1981; Colam 1986; Goethe and Levin 1986; Hemp, Cumpsty and Theron 1985; Levin and Eisenberg 1979a; Levin, Eisenberg and Miner 1983; Levin *et al.* 1982; Rutter, Chadwick and Shaffer 1984; Rutter *et al.* 1980), although residual impairment has also been found in children with relatively mild head injuries (e.g. Klonoff, Low and Clark 1977; Levin and Eisenberg 1979b). There is, however, as yet no clear indication of the typical pattern of neuropsychological deficits associated with closed head injury in childhood (e.g. Oddy 1984; Rutter *et al.* 1980; Telzrow 1985). Persistent disturbances have nevertheless been reported in intellect (e.g. Brink *et al.* 1970; Chadwick, Rutter, Brown, Shaffer and Traub 1981; Chadwick, Rutter, Thompson and Shaffer 1981; Flach and Malmros 1977; Field and Fisher 1977; Heiskanen and Kaste 1974; Heiskanen and Sipponen 1970; Hemp, Cumpsty and Theron 1985; Klonoff, Low and Clark 1977; Levin and Eisenberg 1979b; Richardson 1963; Telzrow 1985), scholastic performance (e.g. Field and Fisher 1977; Heiskanen and Kaste 1974; Richardson 1963; Rutter *et al.* 1980), and memory (e.g. Hemp, Cumpsty and Theron 1985; Levin and Eisenberg 1979a; Levin, Eisenberg and Miner 1983; Levin *et al.* 1982; Richardson 1963). Research has also suggested that the effects of childhood head injury are more marked with respect to speed of visuomotor and visuospatial functions than verbal skills (e.g. Chadwick, Rutter, Brown, Shaffer and Traub 1981; Chadwick, Rutter, Shaffer and Shrout 1981; Hemp, Cumpsty and Theron 1985; Levin, Benton and Grossman 1982; Levin, Eisenberg and Miner 1983; Rutter, Chadwick and Shaffer 1984). Furthermore posttraumatic linguistic difficulties appear to be non-specific in nature (e.g. Ewing-Cobbs *et al.* 1987; Levin, Grossman and Kelly 1976).

The onset of behavioural disturbances in head-injured children also appears to be related to the severity of the damage sustained (e.g. Brown *et al.* 1981; Goethe and Levin 1986; Rutter, Chadwick and Shaffer 1984) as well as to the child's premorbid behaviour, cognitive level and psycho-social circumstances (e.g. Brown *et al.* 1981). In terms of the latter, studies have found that children who sustain head injuries are not a random sample (e.g. Jennett 1972; Rutter, Chadwick and Shaffer 1984). They generally come from socially deprived and disturbed homes (e.g. Black *et al.* 1969, 1971, 1981; Klonoff 1971; Klonoff, Crockett and Clark 1984), and tend to have behavioural disturbances prior to the head injury (e.g. Black *et al.* 1969, 1971, 1981; Hemp, Cumpsty and Theron 1985; Fabian 1956; Jennett 1972).

No sex differences in the sequelae of childhood head injuries have been found (e.g. Klonoff 1971; Rutter, Chadwick and Shaffer 1984) despite the generally higher incidence of boys in such samples noted earlier.

Jennett (1972) has pointed out that recovery of function after childhood head injury is a protracted process. Although recovery is most rapid in the early months after injury (e.g. Chadwick, Rutter, Brown, Shaffer and Traub 1981; Rutter, Chadwick and Shaffer 1984), it continues into the second year (e.g. Chadwick, Rutter, Brown, Shaffer and Traub 1981), and a few studies have reported that recovery can still occur five to six years posttrauma (e.g. Colam 1986; Klonoff, Crockett and Clark 1984; Klonoff, Low and Clark 1977).

The findings of the present study were generally consistent with Luria's (1963b) description of the behavioural consequences of childhood head injury and the associated diffuse or focal brain damage. They did, however, suggest that impaired executive skills may be at the basis of the general disturbance in higher mental processes noted by Luria. This disturbance in executive skills was the most prominent symptom displaye by all subjects in the present study, although there were individual differences in how this manifested. This disturbance suggested the presence of frontal lobe impairment, which is consistent with the afore mentioned vulnerability of these regions to damage in head trauma. Ma distractability was also displayed by all children and seemed to be the most conspicuous reflection of the diffuse pathology usually associated with childhood head injuries. Individual differences were evident in t pattern of other symptoms present. These symptoms suggested the presen of focal pathology in areas other than the frontal lobes and hence seemec to possibly reflect the coup and/or contre coup effects in each subject. The difficulties revealed by the LNI-C, especially the disturbance in executive skills, appeared to be at the basis of the posttraumatic intellectual and scholastic problems reported in the aforementioned literature. These findings also suggest that a disruption in the controlling and modulating role of the frontal lobes as a result of brain damage may underly the behavioural disturbances which, as mentioned earlier, are frequently associated with childhood head injury.

The LNI-C behavioural profile suggested the presence of both focal and diffuse pathology, as well as the laterality of the impairment in some instances. This contrasts with the literature which has reported that laterality of damage does not have any significant effect on the pattern of cognitive deficit. Furthermore, other studies have found that diffuse damage tends to obscure focal effects in head-injured children (e.g. Chadwick, Rutter, Thompson and Shaffer 1981; Ewing-Cobbs *et al.* 1987; Hemp, Cumpsky and Theron 1985).

The present study also found that the earlier the onset of head injury, the more pervasive and marked were the sequelae. Findings regarding age at onset of childhood head injury and its subsequent effects on development appear to be equivocal. Several authors have reported that residual deficits are more marked in younger children (e.g. Brink *et al.* 1970; Levin *et al.* 1982; Woo-Sam *et al.* 1970) whilst others have found age differences in the nature of the residual sequelae (e.g. Ewing-Cobbs *et al.* 1987; Klonoff 1971; Klonoff, Crockett and Clark 1984). In contrast Chadwick, Rutter, Thompson and Shaffer (1981) indicated that age at injury did not affect the pattern of cognitive deficits. Further work would seem necessary to more fully elucidate the nature and consequences of childhood head injury within the context of the findings of the present study.

Three subjects presented with viral infections. Subjects 5 and 6 had had encephalitis and Subject 17 meningitis. According to Luria (e.g. 1963b), viral infections cause diffuse cortical atrophy, with associated behavioural and higher mental process impairment, which varies, depending on the developmental stage at which the infection was contracted.

Encephalitis is an inflammation of the brain (e.g. Dekabahn 1970; Kleiman and Carver 1981; Lishman 1978; Spreen *et al.* 1984). The clinical manifestations and diffuseness of gross and microscopic changes to the central nervous system vary slightly according to the specific etiology of the infective process (e.g. viral, postinfectious encephalitis) (e.g. Dekabahn 1970; Kleiman and Carver 1981; Lishman 1978; Magner, Kirzinger and Spector, 1986). In the present study no information was available as to the type of encephalitis which had been incurred. Sequelae described are those usually associated with viral encephalitis, as most information appears to be available for this form of the disease. The incidence of enduring sequelae appear to relate to the age at which the infection occurs. Young children seem to be especially at risk for sequelae which include mental retardation and behaviour change (e.g. Dekabahn 1970; Kleiman and Carver 1981). Lishman (1978) argued that the contribution of encephalitis to childhood behavioural disturbances has probably been under-estimated. Characteristic changes described include disinhibition, restlessness, impulsivity, extreme distractability, and emotional lability in which cheerful, affectionate behaviour can alternate with aggressive, destructive outbursts.

Meningitis is an inflammation of the meninges (e.g. Dekabahn 1970; Kleiman and Carver 1981; Lishman 1978; Spreen *et al.* 1984). It too may be caused by different infecting agents (e.g. Kleiman and Carver 1981). Sequelae include emotional, behavioural and learning problems (e.g. Graham 1984; Kleiman and Carver 1981). There are indications that contraction of the disease prior to one year results in greater intellectual impairment (e.g. Graham 1984).

In the present study there was general agreement between the LNI-C profiles of the three subjects, but the earlier the onset of the infection the more severe and pervasive were the disturbances. The pattern of LNI-C deficits was in keeping with both Luria's and the literature's description of the symptoms and diffuse pathology associated with childhood viral infections. The presentation of the subject who had had meningitis was, however, more inhibited in nature than the excitable behaviour Luria attributed to such infections, and which was evident in the two subjects who had had encephalitis.

Failure of the tertiary zones to develop adequately due either to the primary or secondary results of brain pathology, appeared to this author to be at the basis of the emotional, behavioural and learning problems cited as sequelae in the literature. The author suggested that the variable behaviour and emotional lability evident in the two subjects who were youngest at the time of contracting the viral infection were manifestations of disturbed cortical tone. This seemed to reflect a failure of the frontal lobes to assume their supramodal and controlling role during development due either to direct damage to these regions and/or to their failure to develop.

Cortical tone therefore did not appear to be under the modulating influence of the frontal lobes in these children. This may account for the emotional and behavioural problems frequently cited as sequelae to such infections in the literature. Likewise, in all three subjects, the simultaneous synthesis of data, which is associated with the functioning of the tertiary temporo-parieto-occipital regions, was impaired. In the present study it appeared to be at the basis of the speech, reading, writing and arithmetic difficulties noted. Furthermore, impairment to functions associated with the tertiary areas of the brain may explain the scholastic difficulties cited in the literature. These hypotheses nevertheless require clarification.

Subject 12 underwent a right frontal craniotomy for the removal of an astrocytoma, Grade III (i.e. malignant brain tumour) at the age of three years. She underwent radiation therapy following surgery and was ten years old when evaluated. This case is interesting for several reasons. There has been considerable work on the neuropsychological functioning of children surviving leukaemia, but comparatively little evaluating the survivors of malignant brain tumours (Mulhern, Crisco and Kun 1983). Brain tumours are, however, the second most frequent tumour after leukaemia in children (e.g. Becker and Yates 1986; Mulhern, Crisco and Kun 1983; Mulhern *et al.* 1986; Michael 1964; Richardson 1979). Further, the tumour in the present study was situated supratentorially. Approximately two thirds of all paediatric tumours occur infratentorially — the most common site being the posterior fossa (e.g. Becker and Yates 1986; Dekabahn 1970; Ganstorp 1985). In addition, malignant forms of astrocytomas (i.e. Grades III and IV) are rare in childhood and have a poor prognosis (e.g. Michael 1964; Spreen *et al.* 1984). The benign astrocytomas (Grades I and II) are, however, common among childhood neoplasms and are usually situated in the cerebellum (Spreen *et al.* 1984). Finally, as Mulhern, Crisco and Kun (1983) have indicated, the assessment of children surviving cerebral tumours has generally been restricted to fairly global measures of neurological and neuropsychological status on heterogeneous groups of subjects. Such studies have usually found a high incidence of intellectual impairment and clinical signs of behavioural/emotional disturbance in such children (Mulhern, Crisco and Kun 1983). In terms of tumour location, most work appears to have broadly differentiated tumours into supratentorial and infratentorial (e.g. Kun, Mulhern and Crisco 1983; Mulhern, Crisco and Kun 1983). There does not appear to be any data concerning the effects of supratentorial tumours in different localities.

Luria (e.g. 1963b) provided no specific information regarding childhood tumours. He nevertheless provided information about the effects of frontal lobe impairment in children. He has also argued that damage prior to the development of the tertiary zones impedes their future development (e.g. Luria 1980). In this study, the subject's performance on the LNI-C revealed disturbed executive skills. This manifestation of frontal pathology was in keeping with Luria's description of the disturbances associated with such damage. In addition, the ability to abstract and generalize cross-modally was impaired, which appeared to have hampered the ability of the subject to learn to read, write and do arithmetic. This seemed to be consistent with Luria's description of the consequences of damage to the temporo-parieto-occipital regions prior to their development. There were also behavioural indicators of underlying diffuse pathology. Furthermore, dominance was not established which suggested that laterality of function had not developed.

The presence of more pervasive dysfunction than the frontal impairment suggested by the tumour location and CT scan may be related to the secondary effects of raised intracranial pressure and surgical intervention, as well as to the effects of the cranial irradiation which the subject underwent. Studies of children with leukaemia who have undergone CNS irradiation and chemotherapy have found that the treatment does impair cognitive development (e.g. Fletcher and Copeland 1988; Mulhern, Crisco and Kun 1983). There are also indications of greater impairment in younger children and some suggestion of more frequent impairment of non-verbal skills relative to verbal ability (Fletcher and Copeland 1988). The treatment also causes structural changes in the brain which include cerebral atrophy, especially of subcortical white matter (Fletcher and Copeland 1988) and calcification. These changes are evident on CT scans and have been confirmed by autopsy (Fletcher and Copeland 1988; Mulhern, Crisco and Kun 1983). The diffuse pathology suggested by the LNI-C behavioural profile may reflect such damage. It remains, however, for future work to explore this further.

Subject 15 had arrested congenital hydrocephalus. This is a condition resulting from an obstruction along the cerebrospinal fluid pathways (Lishman 1978). The cause may be a congenital malformation of the brain (Dekabahn 1970; Lishman 1978), haemorrhage following birth trauma (Lishman 1978), or an inflammatory process of the brain (Dekabahn 1970;

Lishman 1978). If the condition manifests prior to closure of the cranial sutures there is progressive enlargement of the skull and dilation of the ventricles (Lishman 1978) which produces marked expansion and thinning of the cerebral wall (Brain 1977; Dekabahn 1970). In severe cases there is marked atrophy of white matter and loss of cortical ganglion cells (Brain 1977). Hydrocephalus is usually accompanied by varying degrees of spasticity (Brain 1977; Dekabahn 1970; Lishman 1978) and mental retardation (Dekabahn 1970; Duckett 1981; Lishman 1978). In some patients in which the hydrocephalus becomes arrested intellect may be surprisingly well preserved (Lishman 1978).

According to the literature, the visual and perceptual systems are particularly vulnerable to the effects of compression. The earlier the onset of the obstruction, the greater the dilation of the ventricular system, and the greater the relative compression of these areas (e.g. Hartlage 1985). The resultant neuropsychological profile in studies is one of relatively well preserved verbal abilities ("cocktail party" personality (Lishman 1978)) in the presence of visuospatial problems and varying degrees of mental retardation (e.g. Dennis *et al.* 1981; Grazion, Masson and Cracco 1981; Hartlage 1985).

In contrast, Luria (e.g. 1963b) described both excitable and inhibited forms of behavioural defects associated with congenital hydrocephalus and the accompanying diffuse cortical atrophy. He reported an absence of marked motor problems, intact speech and visual-spatial functions, but impaired abstraction and generalization, together with the presence of perseveration (see Table 15). The discrepancies between the aforementioned work and Luria's may represent subjects with different degrees of hydrocephalus. The so-called "cocktail party" personality at times associated with congenital hydrocephalus may be a reflection of the excitable behavioural defects Luria associated with the condition.

In terms of the present study, LNI-C findings appeared to be consistent with aspects of both Luria's work and the aforementioned studies. The LNI-C data did, however, seem to provide some additional insight into the manifestations of the condition. More specifically, the LNI-C profile was consistent with the inhibited behavioural presentation and presence of diffuse cortical atrophy described by Luria. It also suggested the presence of motor problems reminiscent of cerebellar dysfunction. Executive skills and the simultaneous synthesis of data were additionally impaired. The latter manifested in both the visuospatial and quasi-spatial spheres. As a result of this disturbance, the child had only learnt to read, write or do arithmetic at a simplistic level. In keeping with the literature, speech was, however, relatively well preserved, although slight difficulty with the comprehension of logicogrammatical structures, which involve quasi-spatial synthesis, was evident. Executive skills and the simultaneous synthesis of data are associated with the tertiary frontal and temporo-parieto-occipital zones respectively. The disturbances in these skills, together with the fact that dominance was not established, appears to reflect a failure of the tertiary zones and laterality to develop due to early onset of brain damage. The cerebral mechanisms at the basis of this require further work.

Subject 9 was a child with Freidreich's Ataxia, a disease process about which Luria provides no neuropsychological information. It is a common hereditary form of spinocerebellar ataxia (Lishman 1978) whose onset is usually during the first or second decade of life with death occuring approximately 15-20 years later (Dekabahn 1970; Lishman 1978). Freidreich's Ataxia involves the progressive degeneration of the posterior columns, spinocerebellar pyramidal tracts of the spinal cord and lesser changes in the lower region of the brain stem and cerebellum. The main clinical features of the disease are ataxia, loss of stretch reflexes, kyphoscoliosis (escessive backward curviture of the dorsal spine), pes cavus (claw feet), progressive paralysis of the legs, nystagmus and cardiac abnormalities. There is no specific treatment available (Dekabahn 1970; Ganstorp 1985; Lishman 1978; Tyrer 19,

According to the literature (e.g. Brain 1977; Dekabahn 1970; Lishman 1978; Tyrer 1975), intellectual development is usually initially normal, but a mild, and at times more severe, degree of mental impairment becomes evident as the disease progresses. Personality and psychotic states have also been reported in individuals with Freidreich's Ataxia (Lishman 1978). Davies (cited by Lishman 1978) has suggested that the personality disturbances may be reactive, rather than specific, to the disease. Lishman (1978) argued, however, that the high incidence of theta rhythms on the EEGs of such individuals suggests that the disease process may in some way prevent normal development of the central nervous system. The intellectual impairment and psychotic states which may accompany the disease would seem to further support this hypothesis.

The indications of cerebellar dysfunction observed during LNI-C assessment — namely ataxic gait, motor slowing and tremor — were thus in keeping with the disease process. Personality disturbances and psychosis were not evident in the subject. The only impairment of higher cognitive function evident on LNI-C evaluation was slight difficulty comprehending logico-grammatical structures. This suggested mild left temporo-parieto-occipital lobe impairment. This may represent the first signs of cognitive impairment and associated cortical involvement in this subject. It is possible that cortical damage initially manifests posteriorly and then spreads anteriorly as the disease advances. Of interest in this regard is a case study reported by Davies (cited by Lishman 1978) of a 15 year old Freidreich's Ataxia victim who had marked personality disturbances and psychotic episodes, although attention, concentration and memory were intact. The EEG was severely abnormal with a preponderance of theta waves in the right temporo-occipital region, which appears to be consistent with the findings of the present study. This nevertheless represents an area requiring future clarification.

One child (Subject 7) was diagnosed by the neurologist as having bilateral cortico-spinal (pyramidal tract) impairment. Luria (1963b) provided no information regarding this in children.

The pyramidal tract originates in the cerebral cortex — especially the primary motor cortex and descends to the spinal cord (Dimond 1980; Thompson 1967). Damage to the tract is characterized by paresis of volitional movement, spasticity, exaggerated tendon reflexes, depression of cutaneous reflexes and the Babinski reflex (Dimond 1980). The right-sided hemiplegia noted during LNI-C assessment would be in keeping with left pyramidal tract damage (the tracts are predominantly crossed (Dimond 1980; Thompson 1967)). Dimond (1980) reported that the degree of pyramidal tract damage frequently does not correlate with the extent of the paresis present. Furthermore, the LNI-C does not evaluate the reflexes usually used to determine the presence of pyramidal tract involvement. Right hemiplegia thus appeared to be the only symptom of pyramidal tract impairment evident during LNI-C assessment.

A disturbance in executive functions was also evident during LNI-C assessment. This suggested the presence of frontal lobe pathology, which was confirmed by the CT scan. A prominent manifestation of the disturbance in executive functions was pathological inertia of previously formed programmes of action and consequent difficulty in switching from one task to another. This is one of the two forms of pathological inertia of the motor processes which Luria (e.g. 1965d, 1980) has associated with frontal lobe pathology. It is usually associated with damage that does not extend to the subcortical motor ganglia (Luria 1965d) which forms part of the extrapyramidal tract (Dimond 1980). The other form of pathological inertia evident with frontal damage involves motor perseveration or compulsive repetition of a movement once initiated. As the intention for further action is unimpaired, switching from one task to another does not present a problem. In this case the frontal pathology usually extends to the subcortical motor ganglia, and if associated with deep seated damage to the posterior regions of the frontal lobes, appears against a background of extrapyramidal disturbance (e.g. Luria 1965d). In this respect, the findings of the present case study suggest that the pathological inertia of previously formed programmes of action may, in contrast, at times be associated with pyramidal tract signs, depending on the distribution of the lesion present.

Two children (Subjects 2 and 14) were diagnosed as having von Recklinghausen's Disease. Luria (e.g. 1963b) provided no information regarding the symptomatology associated with the disease.

von Recklinghausen's Disease, or Neurofibromatosis, is a congenital disorder characterized by cutaneous pigmentation (brownish or café au lait spots) and the formation of tumours in various tissues (Brain 1977). It is usually hereditary and the most frequent mode of transmission is dominant (Dekabahn 1970).

Peripheral and central forms of the disease can be distinguished. In the former, numerous cutaneous nodules are present. Lesions of the brain and spinal cord rarely occur. Most individuals develop normally although tumours may become malignant. In the central form, single or multiple tumours usually occur on the cranial and spinal nerve roots. Clinical manifestations may occur early and include progressive blindness due to optic nerve tumours, involvement of other cranial nerves and the presence of congenital defects such as spina bifida. Irreversible damage to the central nervous system may occur. The peripheral form of the disorder can be diagnosed readily in the presence of skin pigmentation and nodular skin lesions. In contrast, the central form may only be confirmed at operation or following histological study. In both, café au lait spots and other kinds of skin pigmentation may be the only manifestations of the disease (Dekabahn 1970).

In the present study, both subjects were diagnosed as having von Recklinghausen's disease on the basis of café au lait spots. No mention was made of the presence of peripheral skin nodules in the medical files. They, therefore, appear to have the central form of the disorder, although the CT scans revealed no abnormalities in both instances. LNI-C findings further supported this conclusion and suggested that clinical symptomatology of the disorder may precede detectable structural lesions. The assessment data revealed the presence of several functional disturbances, but intact executive functions. These difficulties included mild right hemiplegia (one subject), impairments in the simultaneous synthesis of data and kinetic melody of movement, optic agnosia and difficulty with the sequential processing of speech and rhythmic structures. This suggested the existence of multifocal lesions, which did not extend to the frontal lobes. Furthermore, memory problems, and a nonspecific disturbance of narrative speech (one subject) suggested that underlying diffuse pathology was possibly also present. This seems to be in keeping with the literature on the central form of the disorder.

Subject 16 was diagnosed as having agenesis of the occipital and parietal lobes and corpus callosum. Luria (1963b) provided no information about agenesis of these regions. He nevertheless outlined the disturbances usually associated with parietal and occipital lobe impairment in children. He also described the role played by the corpus callosum, in adults, in the interhemispheric integration of information and reciprocal co-ordination of the two hands (e.g. Luria 1973a, 1980).

Agenesis of the corpus callosum is a rare condition (e.g. Rourke *et al.* 1983; Spreen *et al.* 1984; Walsh 1978) characterized by complete or partial absence of the callosum (e.g. Dekabahn 1970; Duckett 1981; Faerber 1986; Williams and Caviness 1984) resulting from pathology (genetic or acquired) after fourteen weeks gestation (Williams and Caviness 1984). Although this anomaly may be an isolated finding, it is frequently associated with other malformations of the brain (e.g. Duckett 1981; Faerber 1986; Ganstorp 1985; Dekabahn 1970). When the defect is restricted to the corpus callosum, the anterior commissure may be abnormally large (Williams and Caviness 1984) and/or a thick bundle of fibres, which were to have formed the corpus callosum, may run longitudinally in each hemisphere (e.g. Dekabahn 1970; Spreen *et al.* 1984). In instances where other deficits are associated with the callosal agenesis these may at times be sufficient to obfuscate the significance of the defective corpus callosum (e.g. Kinsbourne and Hiscock 1983; Spreen *et al.* 1984). This, together with the small number of available cases, variability in the completeness of the agenesis in subjects (Kinsbourne and Hiscock 1983; Walsh 1978), and the fact that studies have generally not used sophisticated examination procedures which would have allowed disconnection effects to be demonstrated (Walsh 1978), appear to account for the equivocal findings of neuropsychological studies of individuals with agenesis of the corpus callosum.

Studies of children and adults with callosal agenesis have reported the presence of neuropsychological impairment, although there does not at present appear to be a common pattern of disturbance associated with the disorder. Difficulties have nevertheless been found with bimanual co-ordination (e.g. Field *et al.* 1978; Ferris and Dorsen 1975; Jeeves 1965b; Rourke *et al.* 1983; Sauerwein *et al.* 1981), integrating proprioceptive and tactile information across the midline (e.g. Dennis 1976; Jeeves 1965b; Russell and Reitan 1955; Solursh *et al.* 1965) identifying the locus of stimulation (e.g. Dennis 1976; Rourke *et al.* 1983) and visuo-motor co-ordination (Jeeves 1965a, 1965b, 1969; Russell and Reitan 1955). Low intelligence has also been associated with the disorder (e.g. Ferris and Dorsen 1975; Field *et al.* 1978; Jeeves 1965a, 1965b, 1969).

In contrast to these findings, several studies have reported an absence of impairment in such individuals (e.g. Bryden and Zurif 1970; Ettlinger *et al.* 1972, 1974; Saul and Sperry 1968), despite the use by Saul and Sperry of tasks to study split brain individuals. The results of Ettlinger *et al.* (1972, 1974) are, however, confounded by the inclusion of both complete and partial acallosal subjects in the sample. Pirozzolo, Pirozzolo and Ziman (1979) have nevertheless suggested that the absence of impairment in callosal agenesis subjects may be attributable to a rerouting of commissural fibres through the anterior commissure of other subcortical pathways.

In the present study, the LNI-C behavioural profile associated with the occipital and parietal lobe impairment was consistent with Luria's (1963b, 1980) description of the symptoms associated with such pathology in children. The LNI-C profile did not, however, suggest the presence of corpus callosum pathology. The slight impairment in the kinetic and kinesthetic basis of movement evident in this subject appeared to be related to premotor and postcentral region impairment, respectively, as the difficulties were not evident on tasks involving bimanual co-ordination and the transfer of information from the ipsilateral to contralateral hand. The cortical pathology thus seemed to extend anteriorly to involve these regions, although the damage present appeared to be mild as many processes associated with these brain areas were intact. The absence of behavioural disturbance related to callosal agenesis in this subject is thus consistent with the studies cited earlier which also reported an absence of impairment. Tests of cerebral dominance suggested that dominance, and hence functional laterality, was established in this subject. Thus contrasts with work that has suggested that the corpus callosum is developmentally important for the development of lateralized functions (e.g. Chiarello 1980; Teeter and Hynd 1981). It should, however, be noted that the CT scan report described the presence of callosal agenesis in this case as "probable". There thus seems to have been uncertainty as to whether it was in fact present.

Finally, it was argued that the slow mental processing and diffuse dysfunction suggested by the LNI-C profile may reflect the epilepsy reported in the medical file and generalized cortical changes Luria (1963b) associated with this disorder. The mood changes, impaired ability to abstract and generalize, and perseveration which Luria also associated with epilepsy were not, however, evident — perhaps as the epilepsy was apparently secondary to the agenesis present.

Three subjects (Numbers 1, 3 and 4) were diagnosed as having congenital atrophy and malformation of the brain. In two of these subjects the diagnosis was cortical atrophy — diffuse and left sided. The third case involved malformation of the central nervous system. No further information was available concerning the nature of the brain pathology present. These three cases were therefore grouped together.

Luria (1963b) provided no information concerning the clinical symptomatology associated with such disorders. He nevertheless proposed that early brain damage prevents the development of higher zones.

Although congenital malformations of the brain are a common occurrence (Williams and Caviness 1984), the etiology and pathogenesis are poorly understood (e.g. Dekabahn 1970; Spreen *et al.* 1984; Williams and

Caviness 1984). Maternal diseases during early gestation and faulty implants appear to be the most frequent causes (Dekabahn 1970). Timing of the insult to the developing brain determines the type of anomaly present at birth (Duckett 1981). The cerebral cortex appears to be particularly vulnerable to the pathological processes occurring during development. Cortical malformations are usually caused by pathological processes occurring during the cortical developmental stages of neurogenesis (i.e. the stage of neuronal growth and differentation which spans from six to 16 weeks gestation) and histogenesis (i.e. the process by which cells are assembled into individual tissue components which occurs between eight to 20 weeks gestation) (Williams and Caviness 1984). Cortical malformations include anencephaly (absence of cerebral hemispheres), microencephaly (a disproportionally small brain), megalencephaly (enlarged brain) and the disorders of commissuration, such as agenesis of the corpus callosum which was discussed earlier (e.g. Spreen *et al.* 1984; Williams and Caviness 1984). More than one form of congenital malformation can be present in the same individual (Dekabahn 1970).

Symptomatology is largely dependent on the severity of the malformation and the type of structures involved. Children with mild forms may only display a slight disturbance in their initial development, but mental retardation and epilepsy are usually present. Hemiplegia, diplegia, blindness, epilepsy, hearing and speech disturbances, as well as various degrees of intellectual impairment are most common features of the disturbance. Treatment is symptomatic and prognosis depends on the severity of the abnormalities and associated disturbances (e.g. Dekabahn 1970).

In the present study the LNI-C profiles of the three subjects were very similar despite the fact that one subject had left-sided cortical atrophy (confirmed by the CT scan) and the other two more diffuse pathology (not evident on the CT scan). In this respect all the subjects displayed visual agnosia and impairments in executive skills, as well as in both the simultaneous and sequential synthesis of data. Dominance was not established in any of the children which suggested that functional laterality had failed to develop. This profile suggested that the brain damage was multifocal in all subjects. These findings thus appear to be consistent with Luria's view that early brain damage impairs the subsequent development of higher mental processes. Furthermore, in contrast to available work, they suggested that a complex of symptoms is perhaps common to children with congenital atrophy and malformation of the brain. This requires confirmation in future work.

Therefore, in summary, the model of brain-behaviour ontogeny and interpretive protocol devised in the present thesis provided a basis for exploring the pattern of deficits associated with different types of childhood brain damage. In addition they formed a framework within which to generate hypotheses concerning the nine different forms of brain pathology evident in the sample of brain-damaged children evaluated in this study.

6.8 CONCLUDING REMARKS

The application of Luria's Neuropsychological Investigation for Children (LNI-C) to brain-damaged children revealed that the process-orientated battery, model of brain-behaviour ontogeny and interpretive protocol together provided a basis for formulating a diagnosis and prognosis, as well as for identifying the linchpins on which retraining should focus. They also provided a framework within which to understand the developmental implications of childhood brain pathology. This was demonstrated on the basis of nine brain disorders.

In the next chapter conceptual issues relating to the development of this approach to the neuropsychological assessment of children, and its aplication to brain-damaged children are evaluated. Methodology is also discussed and areas for future research highlighted.

CHAPTER 7

AN EVALUATION OF THE RESEARCH

> "We are far indeed from understanding the nature of links between the activity of neurons and the behaviour of children. There is a major need for the encouragement of research by teams with expertise in both the psychological and biological domains. Without this, clinical practice is likely to remain the prey of controversy and dogma."
>
> (Eric Taylor 1984 p.252.)

7.1 INTRODUCTION

Throughout this dissertation attention has been drawn to the comparative paucity of knowledge within the realm of child neuropsychology. In contrast to the adult sphere, syndromes associated with damage to different regions of the developing brain at different ages have not been clearly documented and the conceptual framework remains underdeveloped (see Chapter 3). This research project represents an attempt to deal with this problem by developing an integrated theoretical and assessment approach to the neuropsychological evaluation of children. Although conceptual issues have been detailed in the relevant chapters of the dissertation, they will be drawn together in the following section in order to evaluate the research project. Thereafter methodological issues pertaining to sampling and subjects, and data analyses will be examined. Finally, suggestions for future areas of research which emerged during this study will be made.

7.2 CONCEPTUAL ISSUES

In contrast to other procedures, Luria's Neuropsychological Investigation (LNI) is a qualitative, process-orientated approach which uses single case study methodology, and provides a comprehensive description of a wide range of behaviours which may have been disturbed as a result of brain damage.

In addition, the process of assessment is directed by Luria's theory of brain functioning. During Luria's early work with his mentor Vygotsky, he devised a scheme of brain-behaviour ontogeny. In view of the implicit developmental origin of Luria's theory, the LNI, which investigates brain-behaviour relationships in the adult, seemed particularly appropriate for guiding the development of a children's battery incorporating a conceptualization of Lurian ontogenetic development.

Luria's Neuropsychological Investigation for Children (LNI-C) is thus an adaptation of the adult LNI in terms of Luria's theory of brain-behaviour development. Adaptation of the adult protocol proceeded on the basis of Luria's and Vygotsky's view that assessment items should reflect qualitative differences in task performance by children of different ages. This is in apparent contrast to previous approaches. As pointed out in Chapter 5 (see Section 5.6.1), an inherent problem in this type of research is that unless such a downward extension of an adult battery is based on a developmental theoretical framework as used in the present study, it seems to imply that the researcher views children and adults as differing quantitatively.

Age was thus central to the adaptation. The procedure whereby the LNI was developed for children has been described in Chapter 5. As illustrated in this chapter, different tasks for different age levels and at times, different variations of the same task for different ages, have been devised. In doing so, care was taken to adhere to the Lurian premise that all, or nearly all, intact individuals should be able to complete the tasks comprising the battery (e.g. Christensen 1979a; Luria 1980). For research purposes, however, *all* intact children were required to correctly complete tasks appropriate for their age. This appears to contrast with the procedure whereby Golden developed a children's version of the Luria-Nebraska Neuropsychological Battery (LNNB). In Chapter 5 (see Section 5.6.1) he was criticized by the author for excluding items in the adult LNNB simply on the basis of the area of the brain whose functioning they supposedly reflected. Notable in this respect were items designed to tap frontal lobe functioning, as Golden argued that these areas are not developed in the eight to 12 year old child. The author pointed out that there is at present no apparently established relationship between brain functional systems and children's behaviour on the test items at different ages. Furthermore, Luria's work on the development of the verbal regulation of behaviour (e.g. Luria 1963b, 1973a, 1980) and myelogenic studies (e.g. Flechsig 1901; Yakovlev and Lecours 1967) suggest that the frontal lobes are, at least partially, operational by eight years. This seemed to be confirmed in the present study where it was demonstrated that the LNI-C can correctly identify frontal lobe damage and the associated pattern of symptoms in eight to 14 year old children (see Chapter 6, Section 6.7.1). Finally, it was argued that Golden's basis for modifying the LNNB ignores the multiple determinational nature of Lurian tasks.

In contrast to the Halstead-Reitan batteries and Luria-Nebraska Neuropsychological Battery - Chidren's Revision (LNNB-CR), this dissertation acknowledged the complexity of developing brain-behaviour relationships by devising a visual representation of Luria's view of brain-behaviour ontogeny in the course of developing the LNI-C (see Chapter 5, Section 5.5 and Figure 1). This presentation represents an attempt to facilitate comprehension of the intricate sequence of brain and behavioural development across the life span within a holistic framework. The model thus provides a theoretical structure to guide LNI-C assessment and data interpretation. It also aids prediction and comprehension of the consequences of brain injury at different stages of development, and hence the formulation of a prognosis and rehabilitation planning. Furthermore, this model provides a framework within which to generate research hypotheses about childhood brain damage and interpret the findings of such studies.

There does not to date appear to have been an attempt to relate task performance on prominent children's batteries to a model of brain functioning. The developmental trends manifest in this thesis (see Chapter 5, Sections 5.4.3 and 5.6.3), indicate that children made a greater number of mistakes on tasks which appeared to reflect tertiary as opposed to secondary zone brain functioning. The type of mistakes made in the former instance were those involving difficulty with abstract reasoning, the simultaneous synthesis of data, and complex goal-directed behaviour. In the latter instance, mistakes were attributable to a lack of training and an inability to process the same quantity of information as adults. None of the mistakes appeared to reflect the functioning of Luria's unit one (i.e. the subcortex) or the primary zones. This is consistent with Luria who has indicated that these areas are functional at an early age (see Figure 1). Furthermore, it was demonstrated in Chapter 5 (see Section 5.6.2) that the views of Luria and Vygotsky embodied in this model of brain-behaviour development are compatible with prominent theories of brain growth (e.g. the work of Dobbing and Sands (1973) and Fleschsig (1901)) and behavioural development (e.g. the writings of Bruner, Eriksen, Freud, Gesell and Piaget), as well as with McClean's conceptualization of a triune brain. The author pointed out that although there is not a direct one-to-one relationship between a particular region of the brain and the emergence of a behavioural pattern, the two processes occur in parallel. Whilst individuals appear to vary in terms of the rate at which they proceed through each developmental stage, this is superimposed on an invariant sequence of development. To the author's knowledge these issues do not appear to have been dealt with in the children's neuropsychological batteries developed thus far.

Kolb and Whishaw (1985 p.692) have cautioned against the use of neuro-psychological instruments which have been developed mainly to detect brain-damage:

> ".... the goal of the clinician is treatment as well as assessment. Labeling a person as brain damaged does little in the way of treatment and may actually deter treatment if the label is interpreted as meaning that nothing can be done."

In this respect, Christensen (1986) has argued that one of the main strengths of the LNI is that assessment and rehabilitation procedures are linked to Luria's theory. Assessment information regarding disturbed and preserved functions can therefore be directly utilized to plan an individualized rehabilitation programme within the framework of a holistic theory. Research with the Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR) and Halstead-Reitan children's batteries (see Chapter 3, Section 3.3) appears to have focused primarily on the ability of these batteries to detect brain damage. They therefore seem able to provide only weak guidelines for therapeutic intervention, which, it is argued, is an integral part of a neuropsychological evaluation. In Chapter 6 (see Section 6.4 and Table 15) the author presented an interpretive protocol which systematizes the behavioural disturbances associated with different kinds of childhood brain pathology, as per Luria. This, together with the aforementioned model of brain-behaviour development, thus facilitates interpretation of LNI-C data and formulation of a prognosis.

The detailed illustrative case study presented in Chapter 6 (see Section 6.6.1) demonstrated the hypothetico-deductive process by which LNI-C data were interpreted by means of syndrome analysis. This involves an evaluation of symptoms in accordance with the principle of double dissociation — a procedure which enabled the author to identify the factors at the basis of disturbances described in paramedical reports. These factors appeared to be linchpins on which retraining should focus.

Analysis of LNI-C data was not straight forward. Luria's work with children is not as well developed as his adult work. There was therefore no detailed description of the behavioural manifestations of different types of brain damage in children to guide the interpretive process, as is the case with adults (e.g. Luria's 1980 work). The changing state of brain-behaviour relationships during development was a further complicating factor. Further, the brain damage suggested by the LNI-C behavioural profile was usually multifocal or diffuse in nature. Consequently, several major behavioural problems were frequently evident and their relationship to the observed clinical symptoms was usually not clear.

The case studies of brain-injured children presented in Chapter 6 (see Section 6.6.2) nevertheless broadly supported Luria's view of the manner in which clinical symptoms relate to various forms of childhood brain pathology. Furthermore, age at onset of brain damage emerged as an important factor determining the severity and pattern of the deficits present. The findings also seemed to highlight the complex interaction between such factors as age at brain damage, the nature of the pathological process and locality of the brain injury in determining the consequences of childhood brain pathology. In childhood brain injury, a disturbance in the role played by executive functions, the ability to process data simultaneously and the associated tertiary areas of the brain emerged as an important factor underlying the observed sequelae and for determining a prognosis. The author suggested that these disturbances are perhaps at the basis of the cognitive sequelae in children reported by other workers (e.g. Rutter 1982). It was also pointed out that these findings are consistent with Luria's (e.g. 1963b, 1980) and Vygotsky's (1965) view that early brain injury prevents, limits or distorts subsequent development. They are also in keeping with reports that developing neuropsychological skills are more vulnerable to disruption by brain damage than fully developed skills (e.g. Hebb 1942).

A recurring theme throughout the dissertation has been the inappropriateness of a psychometric model for neuropsychological assessment. The LNI-C embodies a qualitative, process-orientated approach. The single case study methodology and concepts of syndrome analysis and double dissociation of function inherent in the use of this battery were discussed in Chapter 6 (see Section 6.3). It was argued that a flexible, clinical approach to neuropsychological assessment would seem more applicable in that each evaluation is unique and designed to elicit both an understanding and description of impaired and preserved functions for treatment and rehabilitation purposes. As discussed in Chapter 6, this type of single case study approach, which utilizes a flexible battery of tasks sensitive to subtle changes in task performance, would seem especially important for children where the changes occurring during development are themselves confounding factors. Syndrome analysis as used for the LNI-C necessitates considerable clinical expertise and a detailed knowledge of brain-behaviour development. In contrast, the use of scores seems to be somewhat seductive in that it is fairly easy, even for a psychometrician, to make a diagnosis on the basis of them. Scores nevertheless mask, and may even misrepresent, the idiosyncratic nature of the patterning of skills and process by which the goal is attained in each individual case, as they focus on the product (i.e. goal) and average out the differences. The psychometric approach is perhaps epitomized by the IQ score which Lezak (1988), in her paper titled *IQ: R.I.P.* argued has outlived its usefulness in neuropsychology for these reasons. In this respect Hynd, Hayes and Shaw (1982 p.448) highlighted the importance of clinical knowledge and expertise when they concluded that:

> "The use of assessment procedures designed to evaluate neuropsychological status by untrained clinicians presents more potential for their misuse than does their lack of application."

7.3 METHODOLOGY

The research comprised two stages. During the first a children's version of Luria's Neuropsychological Investigation (LNI-C) was developed, and in the second the children's battery was applied to brain-damaged children. Methodological issues pertaining to each of these stages will be discussed.

7.3.1 The development of a children's version of Luria's Neuropsychological Investigation

Development of a children's version of the LNI comprised three phases (see Chapter 5):

1. Administration of the adult LNI to a sample of children with no history of brain dysfunction in order to ascertain which tasks required adaptation.

2. Deletion or adaptation of tasks children were unable to complete correctly.

3. Administration of the adapted LNI to a second sample of intact children in order to determine that the suggested task modifications were age appropriate.

Subject selection and sample characteristics will be evaluated first. Thereafter the analysis of the data will be discussed. The procedure for adapting the LNI for children was described and discussed in Chapter 5 (see Sections 5.3 and 5.6.1 respectively).

The criterion used to choose children for inclusion in phases one and three of the development of the LNI-C were that they were white, English-speaking South Africans aged eight to 14 years who had not failed a standard and had no history of brain dysfunction — in other words, apparently "normal" children. The two sampling techniques used to select children for inclusion in these phases of the study were "snowball" sampling and selection by school principals on the basis of the above specifications supplied by the author (see Section 5.3.1). In both samples, the number of children selected by means of these two sampling procedures was very similar — the majority being chosen by school principals on the basis of the author's criteria (see Table 6). As the aim of this project was to identify the age at which all children could perform the different tasks, and not to establish norms, these non-probability sampling techniques were therefore deemed suitable for selecting both samples of children. An additional reason for employing these sampling procedures was that permission to use children attending government schools as subjects for the study was only granted by the Natal Education Department at the end of the first year of research. Hence although access to private schools was gained at the outset, the only way government school children could be included in the first sample was by means of snowball sampling.

An attempt was made to keep the samples as homogeneous as possible in terms of age, sex, socioeconomic status, religious affiliation, type of school attended, school performance, and the school term during which the child was assessed.

Each sample comprised 70 children, ten per age group from eight to 14 years. The main reason for adapting the LNI for the eight to 14 year old age range was that a major portion of the procedure evaluates the educationally acquired skills of language, reading, writing and arithmetic. By eight years the child has acquired the basic concepts pertaining to these. This is elaborated in Chapter 5 (see Section 5.6.1).

Age groups included equal numbers of males and females in order to enable an analysis of the children's performance with respect to sex to be conducted (see Chapter 5, Section 5.4.2).

An endeavour was made to obtain a sample of children whose composition reflected the white, English-speaking South African population when compared to the available census and statistical data. They were therefore selected from different socioeconomic groups, the main white, English-speaking religious denominations were represented (H.L. Watts 1976), and a wide range of government and private schools were attended (see Chapter 5, Tables 6 and 7). In this respect, Luria (e.g. 1979, 1980) emphasized the important influence of the sociocultural environment in the development of higher mental processes. This would seem to highlight the importance of considering socioeconomic, educational and religious backgrounds when modifying the LNI for use with children. These factors reflect differences in life opportunities, experiences and the cultural environments in which children are reared.

As both samples were selected exclusively from the metropolitan area of Durban, all children were urban. This does not, however, appear to be problematic because demographic studies have indicated that white, English-speaking South Africans are an almost entirely urban group (Malherbe 1966; Republic of South Africa 1977; H.L. Watts 1976).

The performance of both socioeconomically advantaged and disadvantaged children was considered in developing the LNI-C. As indicated in Table 10, however, comparison of the samples with census and statistical information revealed that the LNI-C has been developed with respect to a fairly privileged group of children, in contrast to the white, South African population. This was reflected in the somewhat higher proportion of children in the samples belonging to the upper white collar socioeconomic category. In addition, a greater percentage attended private, especially Jewish, schools — and there was consequently a higher proportion of Jewish children in the samples in comparison to the white South African population. As indicated earlier, this initial discrepancy was a function of the difficulty in obtaining permission to conduct research in Durban government schools. Access to private schools was therefore initially easier. In South Africa most private school pupils come from more advantaged backgrounds. The first sample, which comprised children to whom the adult LNI was administered in order to ascertain which tasks required adaptation, especially reflects this trend. An endeavour was thus made to include a greater proportion of less privileged, government school children into the second sample — a group of children to whom the adapted LNI-C was administered in order to determine that the modified tasks were age appropriate. This was made possible as the application had been debated by the many bureaucratic levels of the Natal Education Department and permission to use government school children for the research project had been granted.

Although the LNI-C evolved with respect to a group of generally more privileged children, those less advantaged were not entirely excluded. Both samples included a small proportion of children living in a Catholic institution for orphaned and underprivileged children (see Table 6). These children all belonged to less socioeconomically privileged groups (blue collar category).

It was deemed important to include children with different levels of academic ability in each sample in view of the qualitative nature of the LNI and underlying assumption that intact individuals can correctly perform all, or nearly all, the tasks, together with the emphasis in the battery on educationally learnt skills such as reading, writing and arithmetic. Children were therefore ranked according to whether they came in the top, middle or bottom third of their standard by school principals and by the parents of children selected by the snowball sampling technique. This system of classification provided a rough guide to each child's level of academic achievement at school relative to his/her peers in the same standard. The number of children falling into each category was very similar for both samples — the majority coming in the bottom third of their class (see Table 6).

The competence of children in the educational skills they acquire within each standard at school increases as the year progresses (e.g. arithmetic, spelling, reading). In this study, most children in the two samples were evaluated during the second school term. An indication as to the range of attainment of children within each age group as they progressed through the first three school terms was nevertheless obtained (see Table 9). Cognition of changes in educational proficiency over the school year was deemed necessary when developing the LNI-C because, as indicated earlier, many LNI items comprise educationally acquired abilities.

In sum, the composition of the two samples in this thesis were homogeneous in terms of age and sex, and similar in respect of academic ability and the school term during which children were assessed. The samples did, however, comprise a group of children who were more socioeconomically privileged and included a higher percentage of those who were Jewish and attended private schools in Durban than the South African white English-speaking population. Development of the LNI-C did not, however, involve establishing norms, but identifying the age at which all children could perform the different tasks comprising the battery. All children were able to correctly perform the tasks comprising the final LNI-C.

An inherent difficulty with this study was the organization of the large amount of qualitative information amassed. In order to impose order, data assembled when the adult battery was administered to the first sample of children were recorded onto the record forms developed during the preliminary study (see Chapter 4, Section 4.3.2.2 and Appendix 1). In addition two types of charts were designed. These have been described in the procedure. The charts facilitated comparison of the performance of children of different ages on the adult LNI (see Chart 1) and the proposed LNI-C (see Chart 2). Table 13, which details the results of the three phases comprising the development of LNI-C, was compiled largely on the basis of these charts.

In addition, the charts aided the detection of developmental trends. Finally, Chart 1 greatly assisted the quantification of the results of children's performance on the adult LNI for purposes of statistical analysis, by enabling the number of errors to be readily enumerated.

Once these results had been quantified, their analysis remained problematic insofar as choosing the most appropriate inferential statistic — parametric or non-parametric. A parametric test, in contrast to a non-parametric test, makes several assumptions about the population from which the research sample is drawn (see Siegel 1956 p.19). Wright (1976) has nevertheless indicated that such tests are fairly robust in their ability to deal with all, except very extreme, departures from these assumptions. After careful consideration of these requirements and assumptions, it was decided to analyse the data parametrically for the following reasons:

1. The data analysed seemed to conform to the standard requirements for a parametric analysis. Even Siegel (1956 p.33) who advocated the wider use of nonparametric statistics by researchers, acknowledged: "If all the assumptions of the parametric statistical model are in fact met by data, and if the measurement is of the required strength, then nonparametric statistical tests are wasteful of data. The degree of wastefulness is expressed by the power-efficiency of the nonparametric test".

2. A key factor in the decision to analyse the data parametrically was that, as Siegel (1956) indicated, there are at present no nonparametric methods for testing interactions in the three-way analysis of variance model. This was confirmed by Matthews (pers. comm. 1987[1].) The use of nonparametric statistics would thus mean that possible higher-ordered interactions would not be dealt with in the analysis.

In the present study the sample to which these statistical procedures were applied comprised a non-probability sample. The use of such samples, and application of statistics in these instances, do not seem to be generally discussed in the neuropsychological literature. The problem is nevertheless one which needs mentioning as the extent of sampling error for a non-probability sample remains unknown. In the present study parametric

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tests of significance were nevertheless applied to provide a rough indication as to the possible significance of the results.

7.3.2 The application of Luria's Neuropsychological Investigation for Children to brain-damaged children

Once the LNI-C had been developed, it was administered to a group of 18 white, English-speaking South African brain-damaged children in the eight to 14 year old age range in order to examine the fit between LNI-C data and the corresponding injury. The procedure whereby LNI-C data were analysed by means of syndrome analysis was also demonstrated.

The sample of brain-injured children in this study was drawn from Durban, Empangeni and Johannesburg. Numbers were, however, limited by the difficulty experienced in obtaining a sample of eight to 14 year olds who had had a brain scan, which was used to identify the locality of the brain damage present. An extensive search was conducted in the Natal area over a 22 month period during which Durban neurosurgeons, paediatricians, psychiatrists, psychologists, occupational and speech therapists, radiologists, the Dean of the Medical School, University of Natal, Durban, and schools and training centres for brain-damaged children were approached. Only nine suitable subjects were obtained during this period. A Johannesburg neurologist was therefore approached by the author and nine of his patients were assessed in Johannesburg.

The sample of brain-damaged children obtained was heterogeneous with respect to factors such as age, sex, socioeconomic status, educational level, age at onset of brain damage and nature of the pathological process present (see Table 17). In this respect, attention has been drawn in the literature to the problems of sampling, such as those experienced by this author (see also Chapter 4), which face researchers in the clinical neuropsychological sphere. As found in the present study, the number of individuals suited to a particular area of study are frequently limited. In addition brain-damaged individuals constitute a heterogeneous group, as noted above, in terms of locality and extent of the lesion, the nature of the disease process or insult to the brain, age at insult and time since onset, as well as such patient characteristics as age, sex, socioeconomic status, educational level and premorbid personality (e.g. Lezak 1983; Lezak and Gray 1984; Parsons and Prigatano 1978; Rourke, Fisk and Strang 1986; Walsh 1985).

Despite the heterogeneity of the sample, subjects in each age group of the eight to 14 year old range were found, although the number varied in each instance (see Table 16). Furthermore the children fell into the upper and lower white collar categories of socioeconomic status. None belonged to the lower blue collar group (see Table 16). The importance of the socio-economic variable in the sphere of child neuropsychology was highlighted by Parsons and Prigatano (1978). They cited a study by Amante *et al.* (1977) which found that levels of neurological integrity varied along a socioeconomic gradient. Relevant socially related causal factors included malnutrition, reduced environmental stimulation, and inadequate obstetrical and paediatric care. In view of the more affluent nature of the present sample, possible social deficits as causative or exacerbating factors of neurological impairment did not, however, appear to be an issue.

The single-case study approach used in the present study was especially suited to the wide range of brain injuries and disease processes displayed by this sample of children, as well as to the marked variability in the age at insult and time since onset of injury. The etiology of the brain pathology nevertheless broadly grouped into acquired and congenital disorders — half of the sample falling into each category (see Table 19).

Fatigue and medication are two potentially confounding factors in the sphere of neuropsychological assessment. Fatigue is a common sequela to brain injury (e.g. Luria 1980), and in the present study was noted in several subjects in the form of increasing sleepiness and excessive yawning as the evaluation session progressed. Furthermore, three subjects were on anticonvulsant medication, one of the side effects of which is drowsiness (e.g. Dekabahn 1970). Most children were therefore evaluated in three sessions, the duration of each session being determined by onset of fatigue and the attention span of each individual subject (see Table 18).

The CT scan was the instrument used to identify brain damage in this study. Its use for this purpose is addressed in the next section. A factor confounding interpretation of findings was, however, the lengthy time interval between CT scanning and the LNI-C assessment. As pointed out in Chapter 6 (see Section 6.7.1) the reason for this was that as the CT scan is an expensive procedure, it was not possible to have subjects scanned to coincide with the LNI-C evaluation. Children who had already had CT scans were therefore selected.

As a result of the qualitative nature of the LNI-C a large amount of information was collected during each assessment. In order to facilitate data collection, behavioural responses were recorded on to record sheets developed for this purpose (see LNI-C Manual, Part 2.3). These facilitated the subsequent identification of the factors at the basis of the observed symptoms by means of syndrome analysis and in terms of the principle of double dissociation of function — which were discussed in section 7.1.

7.4 SUGGESTIONS FOR FUTURE RESEARCH

The assessment procedure developed, together with the theoretical framework on which it is based, appear to represent useful adjuncts to present techniques for the neuropsychological evaluation of children (see Section 7.2 above). Many areas for further exploration were nevertheless highlighted and hypotheses for future research generated during this study. These broadly relate to further developments of the assessment protocol, and future work in the areas of brain-behaviour development and childhood brain pathology. These are addressed below.

In terms of the battery, the LNI-C has been adapted for white, English-speaking South African children aged eight to 14 years. Extension of the battery to age groups below eight years remains a major task for future workers. The need for this work is highlighted by the apparent dearth of neuropsychological procedures for this age range (e.g. Telzrow 1983). The appropriateness of the adult LNI for use with individuals of 15 to 18 years also needs exploration, as adaptations to more complex items may be found necessary.

South Africa is a multilingual society comprising diverse cultural groups. In order to extend the application of the LNI-C in this country the battery therefore needs to be translated into other languages, such as Zulu and Afrikaans. In addition, the protocol needs to be culturally adapted for use with different South African population groups, such as Africans, Indians and Coloureds.

Although an attempt was made to develop the LNI-C on the basis of a sample of children which was representative of the white, South African population, there were nevertheless a greater number of more privileged children in the sample, although less privileged children were not ignored (see Section 7.3). As indicated in Chapter 5 (see Section 5.4.2), a statistical analysis revealed a significant interaction between socioeconomic status and task performance. Furthermore, Luria (e.g. 1978a, 1980) emphasized the importance of the social environment during the development of higher mental processes. There is thus a need for further research to explore more fully the performance of less socio-economically privileged children on the instrument.

Research has indicated that cognisance should be taken of IQ levels in interpreting tests such as the Reitan-Indiana Neuropsychological Battery (e.g. Klonoff and Low 1974; Seidenberg *et al.* 1983). Many LNI-C tasks comprise educationally acquired skills (e.g. reading, writing and arithmetic) which improve as the school year progresses and whose acquisition is, at least partially, related to intellectual ability. As indicated in Chapter 5 (see Table 9), in the present study, intact children were evaluated during the first three school terms. Furthermore, they were grouped according to whether they came in the top, middle or bottom third of their class as a guide to their intellectual ability. Future research therefore perhaps needs to look more closely at the relationship between changes in educational proficiency over the entire school year and performance on LNI-C tasks in children of different intellectual ability, as measured more accurately by IQ scores.

A parallel form of the LNI-C also needs to be devised. Rourke, Fisk and Strang (1986) indicated that the development of parallel forms of neuropsychological tests has largely been neglected. The long-term follow-up of children and determination of the effectiveness of particular forms of intervention nevertheless necessitate parallel forms of assessment protocols.

Rutter (e.g. Rutter 1982; Rutter *et al.* 1970) has reported that brain damage greatly increases the risk of emotional disturbances in children.

An assessment of emotional behaviour should therefore be incorporated into the LNI-C.

Finally, the LNI-C has been compared with the Halstead-Reitan children's batteries and LNNB-CR on a conceptual level in Chapter 5 (see Section 5.6.2). Future research could therefore perhaps compare the nature of the information generated by each battery and clarify the contribution each has to make in the sphere of child neuropsychology.

The model of brain-behaviour ontogeny and interpretive table devised during this study together form a conceptual framework within which to explain LNI-C findings and conduct research.

Normal development in this model is viewed as a continuous process on which are superimposed individual differences in the rate at which development unfolds, and hence the ages at which each level is attained. This could be investigated within this structure in, for instance, different cultural and socioeconomic groups. The strategies used by intact children of different ages and cultural groups to perform LNI-C tasks could also be explored within the context of this model. In this regard, it was noted in Chapter 5 (see Section 5.6.1) that Spreen *et al.* (1984) concluded on the basis of a review of the literature on sex differences in development, that findings are equivocal. Although sex differences in task performance did not emerge as a significant factor in the present study, a detailed investigation of neuropsychological sex differences nevertheless represents an area for further exploration in order to clarify present research findings.

The conceptual framework also provides a structure within which to explore the effects of different types of brain damage sustained at different stages of development. As suggested in Chapter 6, there appears to be a complex interaction between the age at onset of brain damage, the locality and extent of the lesion, nature of the pathological process present, as well as the child's social and economic environment, and subsequent recovery of function. Future research could use the LNI-C to further explore this complex interaction.

Hypotheses were also generated during this study regarding nine different forms of brain damage in children. It was suggested that a disruption in the role played by the tertiary zones in development as a result of early brain damage, was at the basis of many of the symptoms observed. There nevertheless remains a paucity of information regarding syndromes associated with different forms of brain damage in children (e.g. see Chapter 6, Section 6.7.2). Further work is thus needed to examine these and more fully elucidate the pattern of symptoms associated with different types and localities of brain insult in children of different ages. A related issue is the effects of damage sustained at critical ontogenetic periods. In this respect, the consequences of hypoxic damage at different stages of development would seem to be of particular interest, as it is the most common form of cerebral damage in the fetus and newborn (e.g. Towbin 1981). More specifically, two basic patterns of perinatal hypoxic damage, related to the gestational age at which they occurred, have been identified. In the preterm (e.g. Dear 1986; Towbin 1981) and underweight (e.g. Rourke 1982) infant, deep periventricular cerebral damage (e.g. Dear 1986; Rourke 1982; Towbin 1981), and neuronal destruction in the deep grey nucleii and thalamus (Rourke 1982) predominate. At term, in the mature fetus and newborn, the cerebral cortex and subadjacent white matter is the main site of hypoxic damage (Deer 1986; Towbin 1981). The lesions in this case are similar to those seen in late infancy or childhood as a consequence of some hypoxic insult (Rourke 1982). Towbin (1981) has suggested that these two patterns of hypoxic damage correlate clinically with specific neuropsychological sequelae. The LNI-C would seem to be suited for elucidating these neuropsychological syndromes.

In the present study the CT scan was chosen as the best available procedure for detecting structural brain damage at the time of conducting the research. As noted in Chapter 6 (see Section 6.7.1), it appeared, however, to be a fairly ineffective instrument for identifying the type of diffuse brain damage frequently found in children. As a result the CT scan was at times normal in children in whom the LNI-C suggested the presence of brain damage. In these cases the behavioural manifestations and suggested locality of the brain pathology were nevertheless consistent with those to be expected from the nature of the pathological process present, as well as being in keeping with information recorded in the medical files. This does, however, represent an area for further work. Future studies which aim to describe the syndromes associated with different forms of brain injury in children should therefore identify its presence by utilizing the newer nuclear magnetic resonance scanner, which has a higher resolution than the CT scan, or positron emission tomographic scan, which records the metabollic activity of the brain. A related methodological problem in this study was that, as mentioned in the previous section, the time span between the CT scan and LNI-C assessment was fairly lengthy. The reason for this was given in the previous section. There is thus a need, in future studies, for the scanning to be specifically done as part of the research to coincide with the neuropsychological evaluation. This points to the need for well-funded research.

7.5 CONCLUDING REMARKS

The LNI-C, which is a qualitative, process-orientated approach to the neuropsychological assessment of children, was developed in the course of this research project. A model of brain-behaviour ontogeny and interpretive protocol were also devised to guide evaluation with this protocol. Application of the instrument to brain-damaged children indicated that the battery, model and interpretive protocol together provide a basis for formulating a diagnosis and prognosis and identifying the linchpins (i.e. basic factors underlying observed symptoms) for rehabilitation planning. Furthermore they appear to constitute a framework within which future studies can be conducted. As Kolb and Whishaw (1985 p.745) have argued:

> "The usefulness of any scientific endeavour is eventually measured by its technological applicability to the betterment of humankind."

CHAPTER 8

SUMMARY AND CONCLUSIONS

Despite an apparent increase of interest in the area of child neuropsychology, as evidenced by the growing number of publications in the field, knowledge of brain-behaviour relationships in the developing child, and of the syndromes associated with different forms of childhood brain damage, remains limited. Furthermore, no satisfactory child neuropsychological assessment approach linked to a coherent theory of brain functioning, seems to have emerged within the assessment sphere. A possible reason for this is that development is itself a complicating and confounding factor. In the present study, an assessment approach which was integrated with a conceptualization of the development of brain-behaviour processes, was devised. This process was guided by the neuropsychological model proposed by Alexandria Luria (e.g. 1973a, 1980).

Luria's Neuropsychological Investigation for Children (LNI-C) was developed by administering the adult battery to a sample of 70 children aged eight to 14 years (ten per age group) with no known history of brain dysfunction, in order to ascertain which items they were unable to complete correctly. Items incorrectly completed were deleted or adapted by simplification, elaboration or replacement of stimulus material with that more appropriate for children. Age was central to this process. In order to differentiate the performance of children of different ages on the battery, both different tasks for different age levels and, at times, variations of the same task, were developed in order to provide an appropriate range of difficulty. The rationale underlying this process was Luria's (e.g. 1980) tenet that intact individuals should be able to complete all, or nearly all, tasks because the quality of task performance will change with damage to different brain regions. For the purpose of constructing the battery, correct performance of all tasks was required. The adaptation of the tasks was guided by Luria's view of brain-behaviour ontogeny and other models of development (e.g. those of Piaget and Vygotsky). In addition cognisance was taken of the findings of a statistical analysis which revealed a significant interaction with respect to age, socioeconomic status and task performance. Finally, the suggested LNI-C was administered to a second sample of 70 intact children aged eight to 14 years in order to determine that the proposed adaptations were appropriate.

In order to provide a conceptual framework within which to interpret LNI-C findings, a model of brain-behaviour ontogeny was devised. Whilst developing the LNI-C, developmental trends emerged in terms of the nature of the difficulties experienced by children on adult LNI tasks and their apparent relationship to areas of brain functioning. These trends appeared to broadly reflect Luria's conceptualization of the hierarchical organization of the brain, and the sequential development of successively more complex forms of information processing, as depicted in the aforementioned model. They were also consistent with existing developmental theories, such as those of Piaget and Vygotsky. More specifically, the developmental trends manifest in this thesis indicated that intact children made the greatest number of mistakes on adult LNI tasks involving abstract reasoning, the simultaneous synthesis of data, and complex goal-directed behaviour — all of which appeared to reflect the functioning of the tertiary cortical zones. In contrast, fewer mistakes were attributable to a lack of training and inability to process the same quantity of information as adults — difficulties which seemed related to secondary zone functioning. None of the mistakes appeared to reflect the functioning of Luria's first brain unit (i.e. subcortical regions) or the primary cortical zones, which are areas that he has indicated are functional at birth.

The LNI-C was administered to a group of 18 brain-damaged children who had had CT scans in order to demonstrate the application of the battery and interpretation of findings using the process of syndrome analysis and concept of double dissociation of function. An interpretive protocol based on Luria's (1963b) work with children, was also devised in order to facilitate the process of data interpretation. As Luria's work with children is not as well developed as that with adults, an attempt was also made to evaluate his views of the manner in which clinical symptomatology relates to brain injury in children. This was done by examining the correspondence between the brain damage revealed by CT scans, the associated symptoms as per Luria, and LNI-C assessment data. In addition, LNI-C findings were compared with paramedical reports in order to determine the nature of the information provided by the battery. Despite the heterogeneity of the sample, broad trends were discernible.

The LNI-C findings were in keeping with the general pattern of symptoms Luria described for different brain disorders and lesion localities in children.

The LNI-C nevertheless provided additional insight into the nature of the deficits present in each instance. Age at onset of brain damage was found to be an important factor determining the severity and pattern of deficits to emerge. Impaired executive functions and/or a disturbance in the ability to process data simultaneously, both of which are associated with the functioning of the tertiary zones of the brain, emerged as the most frequent disturbances. These frequently appeared to be factors underlying disturbances to, and/or impaired acquisition of, language and the educationally acquired skills of reading, writing and arithmetic. It was argued that these findings highlighted the importance of a holistic approach to the neuropsychological evaluation and study of the developing child as cognisance needs to be taken of the complex interaction between development and the pathological brain process present when formulating a prognosis and treatment plan.

The CT scan was found to be limited in its use for identifying the type of diffuse and/or multifocal brain pathology frequently found in children. Furthermore, the qualitative, process-orientated nature of the LNI-C proved effective for identifying the factors at the basis of the disturbances recorded in the paramedical reports. These factors appeared to represent linchpins on which retraining could focus.

The usefulness of the model of brain-behaviour ontogeny and interpretive protocol for the diagnosis, understanding and prediction of the developmental implications of childhood brain pathology was demonstrated on the basis of nine brain disorders. This does not appear to have been done before.

Finally, pointers for further research emerged from the study.

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APPENDIX 1: LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION : RECORD FORM

Case No.: Name: Date: Time: Start: Finish:

B PRELIMINARY CONVERSATION

1. STATE OF CONSCIOUSNESS

ORIENTATION

Name:
Date of Birth:
Place of Birth:
Today's date:
Time:
Today's activities:
Yesterday's activities:
Christmas Day:
Boxing Day:
Republic Day:
Day of the Covenant:
Address:

Marital status:
Date of marriage:
Number of children:
Age of children:

PREMORBID LEVEL

School:
Level of education:
Present occupation:
Previous occupation:
Week-end activities:

Evening Activities

Interests:

ATTITUDE

Patient feels:

Patient's present residence:

Date of arrival:
Family doctor:
Examiner:
Ability to lose temper:
Ability to cope with normal work:
Family life:

2. PRINCIPAL COMPLAINTS

SUBJECTIVE

Patient feels:

Complaints:

Pain:
Anxiety:
Sleep:
Hunger:
Thirst:
Sexual behaviour:

GENERALISED

Headaches:

Eyesight:

Hearing:

Loss of initiative:

Fatigue:

Memory difficulties:

Speech problems:

Writing:

EPISODIC

Fits:

Visual hallucinations:

Auditory hallucinations:

Olfactory hallucinations:

Taste hallucinations:

Disturbance in body image:

PROGRESSING

Progressing symptoms:

COMPLEX DISTURBANCES

Difficulty finding way around:

Dressing/undressing:

Reading:

Writing:

Musical notation:

Comprehension :

Spontaneous speech:

Calculations:

C CEREBRAL DOMINANCE

Right hemisphere

Left hemisphere

Ambidexter

D MOTOR FUNCTIONS

1. MOTOR FUNCTIONS OF HANDS

SIMPLE MOVEMENT

Repeated touching and counting of fingers with thumb: Diff. btw. L/R

Repeated seperating of fingers:

Repeated clenching and stretching of fingers:

KINESTHETIC BASIS OF MOVEMENT

Reproduction of hand position while eyes are closed: left right

Copying hand positions of examiner:

Obeying instructions:

	left	right
Transference of pose assumed by one hand to the other:		
Carrying out given movement on command:		

OPTIC-SPATIAL ORGANISATION

Reproduction of hand positions using:
(i) one hand
(ii) two hands
Placement of pencil in:
(i) horizontal plane
(ii) frontal plane
(iii) saggital plane
Reproduction of hand positions of facing examiner (Head's Test):

	examiner opp.	examiner next.
Reproduction of examiner's hand position touching:		
(i) ipsilateral/contralateral ear		
(ii) ipsilateral/contralateral eye		

Reproduction of examiner's hand positions on verbal command:
(i) Indicating left eye with right hand.
(ii) Touching nose with right hand.
(iii) Touching right ear with left hand.

DYNAMIC ORGANISATION OF THE MOTOR ACT

Ozeretsnii Test: (note speed, smoothness)

Tapping rytnm with alternate hands:
r " " "
l ' '

Reproduction of examiner's movements:

Learning sequential task ("fist", "edge", palm"):

Sequential task ("piano playing"):

Drawing design (Card D1):

Drawing series of circles, crosses and triangles:

COMPLEX FORMS OF PRAXIS

Performance of complex, purposeful tasks:
eg. (i) fastening buttons
(ii) tying laces
Miming actions:
(i) pouring and stirring tea
(ii) threading needle
(iii) using scissors
Symbolic actions:
(i) threatening
(ii) waving good-bye

SUMMARY:

DISTURBANCE

	none	slight	severe
right			

2. INVESTIGATION OF ORAL PRAXIS

SIMPLE MOVEMENT

	repetition	maintenance	lip tremor	tongue deviance	salivation	paresis of facial muscles	other
Showing teeth							
Puffing cheeks							
Frowning							
Putting out tongue							

KINESTHETIC MOVEMENT

Flat extension of tongue:

Rolling tongue:

Placing tongue between teeth and upper lip:

DYNAMIC ORGANISATION

Repetition of sequence of movements:

INTEGRATIVE ORAL PRAXIS

	performance on command	natural performance
Chewing		
Whistling		

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			oral praxis

3. SPEECH REGULATION OF MOTOR ACT

SELECTIVITY

Drawing figures from memory: (i) circle (ii) square (iii) triangle

Copying cards: (i) card 02 (ii) card 02a (iii) card 03 (iv) card 03a (v) card 04

Reproduction of sequence of simple figures from memory (Card) 05)

Reproduction of figures on command:

single	series
(i) square	(i) circle & cross
(ii) triangle	(ii) two squares
	(iii) cross and circle

Performing motor act in response to "symbolic" signal to act:

effects of repetition	effects of correction
(i)	
(ii)	

SPEECH REGULATION

Appropriate response to given signal:

Correct response to given signal:

Establishment of motor-stereotype: (A-B-A-B-A-B etc.)

Ability to break down motor-stereotype: (A-B, A-B, A-A)

Conflict reactions: (i)

(ii)

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			speech regulation

E ACOUSTICO-MOTOR ORGANISATION

1. PERCEPTION AND REPRODUCTION OF PITCH RELATIONSHIPS

PERCEPTION OF PITCH

Pitch of sounds:

Group of sounds:

Comparison of groups of sounds: (i)
(ii)

SUMMARY: DISTURBANCE

no.	sl.	sev.	
			perception of pitch

REPRODUCTION OF PITCH RELATIONSHIPS AND MUSICAL MELODIES

Reproduction of tones by singing: (i)
(ii)
(iii)

Singing melody:

SUMMARY: DISTURBANCE

no.	sl.	sev.	
			reproduction of pitch (musical melodies)

2. PERCEPTION AND REPRODUCTION OF RHYTHMIC STRUCTURE

PERCEPTION AND EVALUATION OF ACOUSTIC SIGNALS

Number of taps per single group: (i) (ii)

Number of taps in a series of groups: (i) (ii)

Number of taps of differing strengths per single group: (i) (ii) (iii) (iv)

Number of accentuated taps comprising groups: (i) 3S 3W
(ii) 3S 5W

MOTOR PERFORMANCE OF RHYTHMIC GROUPS

Reproduction of rhythm from acoustically presented pattern: 1. 2. 3. 4. 5. 6. 7.

Reproduction of rhythm after verbal instruction: 1. 2. 3. 4. 5. 6.

Reproduction of rhythmic patterns with verbal auto-reinforcement: (a) 1. 2. 3. 4. 5. 6. 7.
(b) 1. 2. 3. 4. 5. 6.

Shifting from one rhythmic structure to another: (i) (ii)

SUMMARY: DISTURBANCE

no.	sl.	sev.	
			perception and reproduction of rhythmic structures

F HIGHER CUTANEOUS AND KINESTHETIC FUNCTIONS

1. CUTANEOUS SENSATION

TACTILE SENSATION

Tactile threshold (Frey's hair): weak medium strong

area touched

Tactile discrimination (i) straight pin | pin-head | pin-point

(ii) safety pin | weak | medium | strong

Tactile localisation: (i) area of body touched

(ii) area on opposite limb

Tactile spatial discrimination: (i) Weber compass | width

(ii) area touched

Tactile identification of: (i) direction of movement

(ii) number traced on skin

(iii) letter traced on skin

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			tactile sensation

2. MUSCLE AND JOINT SENSATION

KINESTHETIC SENSATION

Movement of limb: (i) upward

(ii) downward

(iii) sideways

Reproduction of given position of one limb by opposite limb:

Repetition of consecutive, passively induced movements with opposite arm:

Distinguish between two passively induced, consecutive positions of elbow:

SUMMARY:

DISTURBANCE

	no.	sl.	sev.	
left				muscle and joint sensation
right				

3. INVESTIGATION OF STEREOGNOSIS

Naming objects placed in palm: (i) rubber | (ii) pencil sharpener

(or actively handling objects if unsuccessful) (iii) paper clips | (iv) penknife

Naming of same objects placed in opposite hand: (i) rubber | (ii) pencil sharpener

(iii) paper clips | (iv) penknife

Selection of object in hand from objects on table:

SUMMARY:

DISTURBANCE

	no.	sl.	sev.	
left				stereognosis
right				

G HIGHER VISUAL FUNCTIONS

1. VISUAL PERCEPTION

OBJECTS AND PICTURES

Naming of objects (i) pencil | (ii) penknife

(iii) rubber band | (iv) coin

Naming of pictures: Card G1 | Card G2

Card G3 | Card G4

Card G5 | Card G6

Card G7 | Card G8a
Card G8b | Card G9a
Card G9b | Card G9c
Card G10 | Card G11

Distinguishing objects superimposed on one another (Poppelreuter's Test): (i) Card G12 (ii) Card G13 (iii) Card G14

Identifying figures in complex designs: (Gottschaldt): (i) Card G15 (ii) Card G16

Choosing portion of structure from series of given insets (Raven): (i) Card G17 (ii) Card G18 (iii) Card G19

SUMMARY:

DISTURBANCE no.	sl.	sev.	
			visual perception

2. SPATIAL ORIENTATION

Mirror images: (i) Card G20 Card G21 (iii) Card G22

Drawing from memory: (i) Card G23 (ii) Card G24 (iii) Card G25

Time: 7,53 5,09 1,25 10,35

Indicating positions of hands on clock: 12,50 16,35 11,10

Direction (Card G27): North East West

Plan of ward or home:

Drawing of special route:

Drawing from memory: (i) Card G27a (ii) Card G27b (iii) Card G27c

SUMMARY:

DISTURBANCE no.	sl.	sev.	
			spatial orientation

3. INTELLECTUAL OPERATIONS IN SPACE

Pattern construction (Koh's Test): Design 1, Design 2, Design 3

Completing honeycomb pattern (Rupp's Test): (Card G28)

Number of blocks per construction (Yerkes' Test): (i) Card G29 (ii) Card G30 (iii) Card G31

Correct placement of circle in parallelogram: (Card G33)

SUMMARY:

DISTURBANCE no.	sl.	sev.	
			intellectual operations

H INVESTIGATION OF IMPRESSIVE SPEECH

1. INVESTIGATION OF PHONEMIC HEARING

REPETITION

Simple, isolated sounds: b p m d k

Disjunctive phonemes: m-p b-n p-s

Correlating phonemes: b-p d-t k-g r-l

Series of disjunctive phonemes: a-o-e u-e-i b-r-k m-s-d

Series of correlating phonemes: b-p-b p-b-p d-t-d

Identical consonants, changing vowels: bi-ba-bo bi-bo-ba bo-bi-bo

WRITING

Sounds (Card H1): b - p - m - d - k

Letters: (Card H2): b-n m-p p-e

(Card H3): b-p d-t k-g r-l

(Card H4): a-o-e u-e-i b-r-k m-e-d

(Card H5): b-p-b p-b-p d-t-d

(Card H6): bi-be-bo bi-bo-be be-be-be

Sound differentiation: b-p

p-p

CONDITIONED REFLEX PRINCIPLE

Correct response to given signal: (i)

(different sound) (ii)

CHANGING STIMULATION

Sound differentiation: b - p (same pitch)

b - b (different pitches)

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
			phonemic hearing

2. WORD COMPREHENSION

DEFINITION

Individual words: (i) pencil (ii) ruler

(iii) rubber (iv) penknife

(Cards H7-9) (i) bottle (ii) oranges (iii) pencils

Indirectly visible objects: (i) eye (ii) nose (iii) ear

Series of words: (i) penknife - pencil- rubber

(ii) nose - ear - eye

EFFECTS OF REPETITION

Demonstration of: eye - nose - ear - eye - nose

Pointing at: rubber - pencil - knife - pencil - knife - rubber - pencil

IDENTIFICATION

Objects (Cards H10-16): (i) shoe (ii) egg carton (iii) stove

Complicated unfamiliar words (i) knee (ii) elbow (iii) cheekbone

Definitions: (i) prétse

(ii) centipede

(iii) caterpillar

(iv) calamity

(v) audacious

Meaning: (i) cat

(ii) bat

(iii) pat

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
			word comprehension

3. UNDERSTANDING OF SIMPLE SENTENCES

SIMPLE PHRASES

Picture illustrating: (i) typewriting
(Cards H17-18) (ii) mealtime

VERBAL INSTRUCTIONS

Maria's Test

SENTENCES IN WHICH THE MEANING IS NOT LIMITED TO THE OBJECTS MENTIONED

Identification of owner of watch:
Identification of patient's own possessions:
Object used to light a fire (Cards H23-25):

CONFLICTING INSTRUCTIONS

Pointing to grey or black cards: (i) black = day
(ii) grey = night

4. UNDERSTANDING OF LOGICAL GRAMMATICAL STRUCTURES

SIMPLE INFLECTIVE CONSTRUCTIONS

Pointing to objects: (i) pencil and key
(ii) key and comb
Pointing to one object with another object: (i) key towards pencil
(ii) pencil towards key
Pointing to object with another object: (i) point to pencil with key
(ii) point to comb with pencil

ATTRIBUTIVE GENETIVE CASE

Identification of the "girl's mother" (Card H28):
One or two persons: (i) the father's brother
(ii) the brother's father

SPATIAL RELATIONSHIPS

Drawing series of spatially arranged figures: (i) a cross beneath a circle
(ii) a circle to the right of a cross
(iii) a cross to the right of a circle but to the left of a triangle.

Same or different: (i) spring comes before summer
(ii) summer comes before spring

COMPARATIVE CONSTRUCTIONS

Shorter boy: (i) John (ii) Peter
Same or different: (i) John is taller than Peter
(ii) Peter is taller than John
Correct statement: (i) A fly is bigger than an elephant
(ii) An elephant is bigger than a fly
Evaluation of colours: (i) lighter (iii) darker
(Cards H26 - 27) (ii) less light (iv) less dark
Fairer girl: (i) Olga (ii) Kate (iii) Sonja
Darkest girl: (i) Olga (ii) Kate (iii) Sonja

INVERTED GRAMMATICAL CONSTRUCTIONS

Interpretation (victim) (i) Peter (ii) John
Correct statement: (i) The sun illuminates the earth
(ii) The earth is illuminated by the sun
First activity: (i) sawed wood (ii) ate breakfast
Interpretation of statement: (i) disciplined (ii) undisciplined

COMPLEX GRAMMATICAL STRUCTURE

(i) Talk given by: (a) woman (b) Margaret

(ii) Margaret's activities: (b) school (b) factory (c) talk

SUMMARY:

	DISTURBANCE			
	no.	sl.	Sev.	
				understanding

J EXPRESSIVE SPEECH

1. ARTICULATION OF SPEECH SOUNDS

REPETITION

Pronouncement:	s	i	m	b	sh
Repetition:	sp	th	pl	str	
Articulation:	(i)	see - seen			
	(ii)	tree - trick			

SUMMARY:

	DISTURBANCE			
	no.	sl.	sev.	
				articulation

2. REFLECTED (REPETITIVE) SPEECH

REPETITION OF SINGLE WORDS

Simple, single words:	(i)	cat	(ii)	dog	(iii)	man
Complex words:	(i)	house	(ii)	table	(iii)	apple
	(iv)	hairbrush	(v)	screwdriver	(vi)	laborious
	(vii)	rhinoceros	(viii)	surveillance	(ix)	hierarchy
Similar words:	(i)	cat	(ii)	hat	(iii)	bat
Unfamiliar words:	(i)	streptomycin	(ii)	arachnoidendothelioma		

REPETITION OF A SERIES OF WORDS

Series of words:	(i)	hat - sun - bell
	(ii)	house - ball - chair
	(iii)	lamp - wood - pin - boy - bridge
Different order:	(i)	hat - bell - sun
(same words)	(ii)	sun - hat - bell
	(iii)	lamp - pin - bridge - wood - boy
	(iv)	wood - bridge - boy - pin - lamp

REPETITION OF SENTENCES

Short sentences:	(i)	The weather is fine today
	(ii)	The sun shines and the sky is blue
Long sentences:	(i)	The apple trees grew in the garden behind a high fence
	(ii)	On the edge of the forest the hunter killed the wolf
Series of short sentences:	(i)	The house is on fire, the moon is shining, the broom is sweeping.
	(ii)	The moon is shining, the house is on fire, the broom is sweeping.

Story:

(i) An ox was grazing near a bog where some frogs were living.

(ii) One frog saw the ox and boasted to the other frogs that he could be just as big as the ox.

(iii) He tried to blow himself up.

(iv) He asked the other frogs if he was as big as the ox - they said he wasn't yet.

(v) He screamed that he'd show them.

(vi) He blew himself up so violently he burst

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
			repetitive speech

3. NOMINATIVE FUNCTION OF SPEECH

NAMING OBJECTS AND PICTURES

Objects: (i) pencil (ii) ruler (iii) watch

Objects in pictures: (i) Card J14 (ii) Card J15 (iii) Card J16
(iv) Card J17 (v) Card J18

Body parts: (i) elbow (ii) collarbone

Body parts in pictures: (i) Card J19 (ii) Card J20 (iii) Card J21

Objects: (i) watch (ii) pencil (iii) ruler

Pictures: (i) Card J14 (ii) Card J15
(iii) Card J16 (iv) Card J17
(v) Card J18

NAMING FROM DESCRIPTION

Questions: (i) Object used to tidy hair
(ii) Object which shows what time it is
(iii) Object which protects you against the rain

DETERMINATION OF CATEGORICAL NAMES

General names: (i) pencil - ruler - rubber
(ii) Cards J22 - J23 - J24
(iii) Cards J25 - J26 - J27

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
			nominative function of speech

4. NARRATIVE SPEECH

FLUENCY AND AUTOMATIZATION OF SPEECH

Counting backwards: 20 - 19 - 18 - 17 - 16 - 15 - 14 - 13 - 12 - 11 - 10 - 9 - 8 -
7 - 6 - 5 - 4 - 3 - 2 - 1

Days of the week: Sunday - Monday - Tuesday - Wednesday - Thursday - Friday - Saturday

Months of the year: January - February - March - April - May - June - July - August -
September - October - November - December

Days of the week backwards: Saturday - Friday - Thursday - Wednesday - Tuesday -
Monday - Sunday

Months of the year backwards: December - November - October - September - August - July -
June - May - April - March - February - January

PREDICATIVE SPEECH - REPRODUCTIVE FORMS

Questions: (i) breakfast / lunch
(ii) last holiday

Description of pictures: (i) Card J28
(ii) Card J29

Repetition of a short story: (i) 7 year old Peter went to the river to fish, yesterday
(ii) He took his dog Prince with him
(iii) The river had overflowed its banks during the rainy weather
(iv) Peter slipped and fell into deep water
(v) He would have drowned if his dog had not dived in and helped him reach the shore

PREDICATIVE SPEECH - PRODUCTIVE FORMS

Repetition of a story:

(i) A hare made fun of a tortoise because it was so slow
(ii) The tortoise challenged the hare to a race
(iii) Although the hare thought it was a silly idea, he agreed to the competition
(iv) The race began and the hare ran so fast he was soon far ahead
(v) He decided to take a nap until the stupid tortoise caught up with him
(vi) The tortoise crawled along very, very slowly
(vii) He passed the sleeping hare
(viii) The hare awoke when the tortoise had nearly reached the finishing post
(ix) The hare ran as fast as he could, but he didn't manage to get there first
(x) The tortoise had won the race

Speech:

(i) The weather
(ii) Conflict between generations

Sentence formation:

(i) Card J32
(ii) Card J33
(iii) Card J34
(iv) Card J35
(v) Card J36
(vi) Card J37

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			narrative speech

X WRITING AND READING

1. PHONETIC ANALYSIS AND SYNTHESIS OF WORDS

ANALYSIS

Number of letters: (i) cat (ii) trap (iii) banana (iv) hedge

Identification of sounds:

(i) 2nd letter in "cat"
(ii) 1st letter in "match"
(iii) 3rd letter in "hedge"

Position of sounds:

(i) letter in "stop" following "o"
(ii) letter in "stop" before "t"
(iii) letter in "bridges" before "g"
(iv) letter in "bridges" following "d"

SYNTHESIS

Syllable:

(i) g-r-e
(ii) p-l-y

Word:

(i) s-t-o-n-e
(ii) k-n-i-g-h-t
(iii) o "then" p "then" e "then" r "then" a
(iv) s "then" o "then" u "then" n "then" d

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			phonetic analysis and synthesis

2. WRITING

COPYING AND ORDINARY WRITING

Copying letters: (i) printed B L
(ii) written L D B

Copying syllables: (i) pa - an - pro - pre - ati
Writing from memory: (i) match (ii) district (iii) antarctic
Name:
Address:

COMPLEX FORMS

Dictation - letters: f t h l
Dictation - syllables: ba da back pack wren knife
Dictation - words: (i) hat (ii) contemporary
(iii) physiology (iv) popocatepetl
Writing series of words: hat - sun - bell
Writing phrases: (i) last year before Christmas
(ii) all of a sudden
Naming objects: (i) ashtray (ii) knife
(iii) book (iv) pair of scissors
Names of family: (i) brothers (ii) sisters
(iii) father (iv) mother
Writing a few words about how he / she feels:

Writing a few words about his / her ideas on bringing up children:

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			writing

3. READING

ANALYSIS AND PERCEPTION OF LETTERS

Isolated letters: K - S - W - R - T
Association of a letter with a word: (i) John B J S
(ii) Denmark D N R

READING SYLLABLES AND WORDS

Syllables: (i) pro (ii) car (iii) cre (iv) spro (v) prot
Words: (i) juice (ii) bread
(iii) bonfire (iv) cloakroom
(v) fertilizer
Ideograms: (i) UN (ii) USA (iii) USSR
Complex words: (i) insubordination (ii) indistinguishable
Unfamiliar words: (i) astrocytoma (ii) haemopoiesis

READING PHRASES AND WHOLE TEXTS

Phrases: (i) The man went out for a walk
(ii) My head aches very much
(iii) There are flowers in the garden
Sentences: (i) The sun rises in the West
(ii) The boy went to bed, because she was ill

Text:

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			reading

I. ARITHMETIC SKILL

1. COMPREHENSION OF NUMBER STRUCTURE

UNDERSTANDING, WRITING AND RECOGNISING FIGURES

Writing digits: (i) 7 - 9 - 3 (ii) 3 - 5 - 7

Reading digits: (i) 7 - 9 - 3 (ii) 3 - 5 - 7

Reading and writing visually complementary numbers:

(i) IV VI (ii) IX XI

(iii) 17 71 (iv) 69 96

Reading and writing multi-digit numbers:

(i) 27 - 34 - 158 - 396 - 9845

(ii) 14 - 17 - 19

(iii) 109 - 1023

Identification of categories: (i) thousands (ii) hundreds

(iii) tens (iv) units

NUMERICAL DIFFERENCES

Larger number: (i) 17 - 68 (ii) 23 - 56

(iii) 189 - 201 (iv) 1967 - 3002

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
☐	☐	☐	comprehension of figures

2. ARITHMETICAL OPERATIONS

SIMPLE AUTOMIZED CALCULATIONS

Multiplication: (i) 3 x 3 = 9 (ii) 5 x 4 = 20

(iii) 7 x 8 = 56

Addition: (i) 3 + 4 = 7 (ii) 6 + 7 = 13

Subtraction: (i) 7 - 4 = 3 (ii) 8 - 5 = 3

COMPLEX ARITHMETIC OPERATIONS

Addition: (i) 27 + 8 = 35 (ii) 44 + 57 = 101

Subtraction: (i) 31 - 7 = 24 (ii) 41 - 14 = 27

Addition - vertically arranged nos.: 5 + 9 + 7 = 21

Complicated subtraction: 18 - 24 = 6

ARITHMETICAL SIGNS

Missing sign: (i) x (ii) + (iii) - (iv) +

Missing number: (i) 4 (ii) 7

SERIAL ARITHMETIC OPERATIONS

Oral presentation: (i) 12 + 9 - 6 = 15 (ii) 32 - 4 + 9 = 37

Visual presentation: (i) 27 + 34 + 14 = 75 (ii) 158 + 396 = 554

SERIES OF CONSECUTIVE ARITHMETICAL OPERATIONS

Counting backwards from 100 in sevens: 100 - 93 - 86 - 79 - 72 - 65 - 58 - 51 - 44 - 37 - 30 - 23 - 16 - 9 - 2

Counting backwards from 100 in thirteens: 100 - 87 - 74 - 61 - 48 - 35 - 22 - 9

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
☐	☐	☐	arithmetical operations

M MNESTIC PROCESSES

1. LEARNING PROCESS

SERIES OF UNRELATED WORDS OR NUMBERS

TABLE 1

RESULTS OF LEARNING EXPERIMENT

Serial no.	Level of aspiration	Actual result	house	forest	cat	night	table	needle	pie	bell	bridge	cross
1.												
2.												
3.												
4.												
5.												
.												
.												
.												
.												

TABLE 2

RESULTS OF LEARNING EXPERIMENT

Serial no.	Level of aspiration	Actual result	7	1	3	9	4	2	5	6	8
1.											
2.											
3.											
4.											
5.											
.											
.											
.											
.											

SUMMARY:

DISTURBANCE			
no.	sl.	sev.	
			learning

2. RETENTION AND RETRIEVAL

FORM RECOGNITION

Same or different: (i) Card M1 and Card M2

(ii) Card M3 and Card M4 multiplication: (i) 9 x 3 = 27

(ii) 13 x 4 = 52

(iii) 7 x 6 = 42

SIZE CONTRAST EFFECT

Two balls of different sizes:

Two balls of the same size:

IMMEDIATE REPRODUCTION OF VISUAL, ACOUSTIC, KINESTHETIC AND VERBAL TRACES

Drawing from memory:

(Card M5)

Rhythmic tape: ''UUU''UUU''

Hand positions:

Series of words (Card M6): house - moon - street - boy - water

RETRIEVAL OF WORDS

Heterogenous interference: house - tree - cat

Card M8 - description

Homogenous interference: (i) man - hat - door (ii) night - stove - cake

RETRIEVAL OF SENTENCES AND PARAGRAPHS

Sentences
(i) The sun rises in the East
(ii) In May the apple trees blossom

Stories: Card M8
(i) A man had a hen which laid golden eggs
(ii) Wishing to obtain more gold without having to wait for it, he killed the hen
(iii) But, he found nothing inside, for it was just like any other hen

Card M9:
(i) A crow heard that doves had plenty to eat
(ii) He coloured himself white and flew to the dovecote
(iii) The doves thought that he was one of them and took him in
(iv) He could not help cawing like a crow
(v) The doves realized that he was a crow and threw him out
(vi) He went to rejoin the crows; they did not recognise him and would not accept him

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			retention and retrieval

3. LOGICAL MEMORIZING

RECALLING BY VISUAL AIDS

Words associated with pictures:
(i) Card M10 - energy
(ii) Card M11 - employment
(iii) Card M12 - party
(iv) Card M23 - happy family
(v) Card M14 - project
(vi) Card M15 - pollution
(vii) Card M16 - untidiness
(viii) Card M17 - factory
(ix) Card M18 - holiday
(x) Card M19 - wisdom

Words with pictures
(i) circles - Card M...
(ii) joy - Card M...
(iii) pattern - Card M...
(iv) handicraft - Card M...
(v) peace - Card M...
(vi) ruin - Card M...
(vii) friendship - Card M...
(viii) curiosity - Card M...
(ix) cold - Card M...
(x) mannerism - Card M...

RECALLING BY THE PICTOGRAM METHOD:

Pictogram method:
(i) a deaf old man
(ii) a hungry boy
(iii) a clear sky
(iv) cause
(v) development
(vi) debts
(vii) stormy weather
(viii) guardian
(ix) abstraction
(x) happy event
(xi) a dark night
(xii) combination
(xiii) tragedy
(xiv) opponent
(xv) omen

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			logical memorizing

III INTELLECTUAL PROCESSES

1. UNDERSTANDING OF THEMATIC PICTURES AND TEXTS

PICTURES

Story conveyed by picture:	(i)	Card N1
	(ii)	Card N2
	(iii)	Card N3
Rearrangement of pictures:	(i)	Card N4-8
	(ii)	Card N9-13
	(iii)	Card N14-18
Explanation of pictures:	(i)	Card N19
	(ii)	Card N20
	(iii)	Card N21
	(iv)	Card N22
	(v)	Card N23

TEXTS

Explanation of "The hen with the golden egg" (Card M8)

Explanation of "The crow and the doves" (Card M9)

Metaphors:	(i)	iron fist			
	(ii)	stony heart			
	(iii)	green fingers			
Proverbs:	(i)	all that glitters is not gold			
	(ii)	don't count your chickens before they hatch			
Proverbs:	(i)	Card N24	a	b	c
	(ii)	Card N25	a	b	c

EXPLANATION

Explanation of "The Lion and the Fox" (Card N26)

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			understanding

2. CONCEPT FORMATION

DEFINITION

Words:	(i)	table
	(ii)	tractor
	(iii)	island

COMPARISON AND DIFFERENTIATION

Comparison:	(i)	table and sofa
	(ii)	axe and saw
	(iii)	North and West
Difference:	(i)	fox and dog
	(ii)	stone and egg
	(iii)	plank and pane of glass

LOGICAL RELATIONSHIPS

General categories:	(i)	rose - flower
	(ii)	salmon - fish
Members of groups:	(i)	vehicles - car, etc.
	(ii)	tools - hammer, etc.
Parts of the whole:	(i)	knife - blade and handle

Whole from parts:	(i)	pages - book
	(ii)	trees - forest
Opposite values:	(i)	high - low
	(ii)	fat - thin
	(iii)	old - young

ANALOGIES

Analogous words:	(i)	good (bad) : high - low
	(ii)	wide (narrow) : fat - thin
	(iii)	finger (glove) : foot - shoe
	(iv)	bicycle (wheel) : table - leg
	(v)	bicycle - wheel (Card N28)
	(vi)	library (books) : regiment - soldiers
	(vii)	street (pavement) : river - banks

CATEGORICAL INTELLIGENCE

Object not belonging to group:	(i)	spade - saw - axe - log
	(ii)	spoon - table - glass - plate
	(iii)	ball - doll - rocking horse - knife
	(iv)	cigar - wine - cigarette - tobacco

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			concept formation

3. DISCURSIVE INTELLECTUAL ACTIVITY

ELEMENTARY ARITHMETICAL PROBLEMS

Addition:	Card N30:	answer =
Subtraction:	Card N31:	answer =
Intermediate addition:	Card N32:	answer =

COMPLEX ARITHMETICAL PROBLEMS

Consecutive serial problems:		Card N33:	answer =
Intermediate operations:	(i)	Card N34:	answer =
	(ii)	Card N35:	answer =
Complex problems:		Card N36:	answer =
Conflict problems:	(i)	Card N37:	answer =
	(ii)	Card N38:	answer =

SUMMARY:

DISTURBANCE

no.	sl.	sev.	
			discursive intellectual activity

APPENDIX 2

SUMMARY OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FINDINGS, CT SCAN REPORTS AND MEDICAL FILES FOR EACH ADULT BRAIN-DAMAGED SUBJECT

2.1 SUBJECT 1

LNI Findings

Tests for cerebral dominance suggested that the subject's left hemisphere was speech dominant. No primary disturbances were evident in the motor, acoustico-motor, visual-spatial, impressive speech, reading, writing, arithmetic or intellectual spheres. A marked disturbance of spontaneous speech was, however, evident. This manifested as a tendency to stutter, an inability to follow a train of thought once initiated, and a defect of verbal initiative such that spontaneous speech tended to be monosyllabic. This is characteristic of the syndrome of frontal dynamic aphasia, which is associated with damage to the left frontal lobe.

CT Scan Report

Left frontal damage.

Medical File

The patient sustained a self-inflicted missile wound on 12.03.1977. The entrance was in the left frontal region and the exit near the vertex on the opposite side. This wound was subject to debridement when it became evident that he was going to survive. He is now dysphasic. The patient had a history of alcoholism and a previous parasuicide prior to this shooting accident. He was discharged from hospital on 10.06.1977 and was still recuperating at home at the time of the assessment.

2.2 SUBJECT 2

LNI Findings

Dichotic tests for determining cerebral dominance were not administered as this subject was deaf in his left ear. No primary deficit in motor, acoustico-motor, visual-spatial functions, speech, reading, writing, arithmetic, memory, or intellect was evident. Damage to the peripheral innervation of articulatory apparatus was, however, suggested by salivation, indistinct, expressionless speech, and deviation of the tongue to the right. Paralysis to the right side of the face was also evident. This suggested damage to the nuclei of the nerves controlling salivation, facial movement and the sensitivity of the face and tongue. These nuclei are situated in the pons.

CT Scan Report

Haemorrhage in the pons.

Medical File

This patient was admitted to hospital on 27.02.1977 in a coma, following a motor-vehicle accident. He regained consciousness approximately eight days after the accident. Right cranial motor nerve VII damage was diagnosed. At the time of the assessment the patient was still hospitalised.

2.3 SUBJECT 3

LNI Findings

The subject was listless and frequently fell silent. She displayed little emotion, fatigued rapidly and tended to answer monosyllabically. She was very slow at completing tasks. Left-sided hemiparesis was evident in her arm and leg. Tests for cerebral dominance suggested that her left hemisphere was dominant for speech. Her writing was neat and no disturbances were evident. She read without difficulty and could do simple arithmetic calculations. She understood instructions and no speech defect was detectable. As she began to fatigue, however, signs of pathological innertia became noticeable. This manifested as perseveration of a previously formed programme of action and was evident in the motor, perceptual, speech, memory and intellectual spheres. This suggested that frontal lobe damage was present.

CT Scan Report

Right frontal lobe damage.

Medical File

The subject was admitted to hospital on 03.02.1977 with a history of severe headaches, which had begun at three years of age. Since onset of menstruation she had had one or two epileptic seizures per month. The neurosurgeon provisionally diagnosed these as frontal lobe epilepsy. A frontal burr-hole amygaloidectomy was performed on 11.02.1977. She was discharged from hospital approximately eight weeks after the operation, and had not yet been able to return to work when assessed.

2.4 SUBJECT 4

LNI Findings

The subject was readily distractible and she reacted to every side stimulus. Tests for determining cerebral dominance suggested that her left hemisphere was speech dominant. The main defect evident was a disturbance of spatial abilities. This manifested visuo-spatially as a disturbance in spatial orientation, the perception of spatial relations, and spatial distortions on drawings and construction tasks. It was also evident on tasks involving quasi-spatial synthesis - namely reading, writing, arithmetic and the comprehension of logico-grammatical speech structures. This suggested damage to the parieto-temporal regions, whilst the ready distractability suggested more diffuse pathology.

CT Scan

Lateral ventricles slightly dilated, but undisplaced. Considerable sulcal widening was evident on both sides which represented cortical atrophy.

Medical File

The subject's medical file was not available as she sustained a head injury in a motor vehicle accident in approximately 1959. Wentworth Hospital's medical files start from 1970. The only available medical information was the brief medical history cited on her CT Scan report (18.06.1976). According to this, a subdural haematoma was evacuated on the left side following the motor vehicle accident. There was a contusion on the right side. She made a slow recovery from the accident. In 1975 the neurosurgeon diagnosed cerebral atrophy.

2.5 SUBJECT 5

LNI Findings

The subject readily attempted all tasks set and appeared to be well-orientated in both time and place. Tests for cerebral dominance suggested that her left hemisphere was speech dominant. Right hemiplegia was evident in her arm and leg. Performance of motor tasks (taking her right hemiplegia into consideration) and spatial operations was unimpaired. The principle defect observed was a disturbance of phonemic hearing and an associated syndrome of sensory (acoustic) aphasia. As a result of this disturbance she had difficulty pronouncing words and analyzing the sound composition of speech and writing. She was unable to write from dictation or her own composition and could not read sentences or texts aloud. An impairment of word memory was also evident. The presence of this form of aphasia suggested damage involv'ng the left temporal lobe.

CT Scan Reports

Scan 1 : Left frontal tumour.
Scan 2 : (following surgical removal of tumour) Left frontal lobe.

Medical File

The subject was admitted to hospital on 12.04.1977 suffering from diplopia and nausea - symptoms which had become progressively more marked during the preceding three months. Examination revealed bilateral papilloedema, a transient speech defect and weakness to the right side of her body. The neurosurgeon diagnosed a tumour. A CT scan revealed a left frontal tumour. The results of a craniotomy biopsy were inconclusive. The tumour was then surgically removed from the left frontal lobe. Following the operation she developed right hemiplegia. She remained aphasic. She was discharged from hospital on 24.05.1977.

2.6 SUBJECT 6

LNI Findings

The subject was well orientated in both space and time. He was able to give a clear account of his life before his accident eight years ago, and his subsequent recovery. His legs were semi-paralysed and he walked with difficulty - using two walking sticks. Tests for cerebral dominance suggested that his left hemisphere was dominant for speech. No primary disturbance in motor, acoustico-motor, visual-spatial functions, speech, reading, writing, arithmetic, memory or intellect was evident. Higher mental processes thus appeared to be intact and there was consequently no evidence of brain damage.

CT Scan Report

No abnormalities.

Medical File

The medical file of this subject was not available as he sustained a head injury in a motor vehicle accident in approximately 1969. Wentworth Hospital's medical files date from 1970. A CT scan report dated 22.10.1975 was, however, available and this included a brief medical history. According to this, the subject was in a coma for about one week after the accident and his subsequent recovery was slow, but good.

2.6 SUBJECT 7

LNI Findings

The subject readily set about performing the tasks set him, but fatigued rapidly. He was disorientated in time and displayed gross insight into his condition. Tests for cerebral dominance suggested that his left hemisphere was speech dominent. Left hemiplegia was evident in his arm and leg. No primary disturbances of speech, reading or arithmetic were evident. The main defect to emerge during the evaluation was pathological inertia of motor processes. This manifested as motor perseveration during the performance of complex serial motor tasks. Writing deteriorated as he fatigued and was characterized by persevetory movements and micrographia. These disturbances suggested the presence of frontal lobe impairment. No speech defects were evident and his left hemisphere was found to be dominant for speech. Left hemiplegia was evident, which suggested right hemisphere impairment. It was therefore suggested that the main focus of the damage was the right frontal lobe.

CT Scan Report

Right frontal lobe.

Medical File

The subject was admitted to hospital on 17.05.1977. He had a history of focal epilepsy with no loss of consciousness. A radio-isotope scan on 20.05.1977 revealed an area of increased activity in the right frontal region which suggested a space-occupying lesion. The neurosurgeon provisionally diagnosed a tumour. An operation was performed on 30.05.1977. A tumour was found and right frontal lobectomy performed. The subject was discharged from hospital on 08.07.1977.

2.8 SUBJECT 8

LNI Findings

The subject displayed no insight into his condition and was disorientated for time. Tests for cerebral dominance suggested that his left hemisphere was speech dominant. He was able to perform spatial operations and displayed no primary disturbance in speech, reading, writing or arithmetic. Pathological inertia, which manifested as perseveration of a previously formed programme of action, was, however, evident in all areas assessed. Once initiated, a programme of action became inert and the subject, having performed a required task, was incapable of changing to any other task. He continued to perform the first task even when instructed otherwise.

CT Scan Report

Scan 1 : Extradural haematoma in left parietal region and considerable cerebral oedema.
Scan 2 : No abnormalities.
Scan 3 : Slight increase in size of third and fourth lateral ventricles, although they were within normal limits.

Medical File

The subject was admitted to hospital on 23.03.1977 in a deep coma following a motor vehicle accident. A contusion in the right hemisphere and subdural haematoma were provisionally diagnosed by the neurosurgeon. An extradural haematoma was drained on 08.04.1977. The subject gradually regained consciousness but complained of headaches and made an incomplete recovery. Both medical staff and the occupational therapist noted that his behaviour was characterized by perseveration. The neurosurgeon tentatively suggested chronic subdural hygromia, ventricular dilation or atrophy as the reason for his poor recovery. The subject was still hospitalized on 31.08.1977.

2.9 SUBJECT 9

LNI Findings

This subject was well orientated in time and place. He gave a clear account of his accident and subsequent recovery. Tests for cerebral dominance suggested that his left hemisphere was dominant for speech. No primary disturbance in motor, acoustico-motor, visual-spatial functions, speech, reading, writing, arithmetic, memory or intellect was evident. Higher mental processes thus appeared to be intact and there was consequently no evidence of brain damage.

CT Scan Report

No abnormalities.

Medical File

The subject was admitted to hospital on 30.05.1976 following a motor vehicle accident in which he sustained a head injury. He was reported to have had a lucid interval for several hours after the accident. He then lapsed once more into a coma in which he remained for approximately two weeks. He made a gradual recovery and was discharged on 28.07.1976. He returned to work at the beginning of 1977.

2.10 SUBJECT 10

LNI Findings

Tests for cerebral dominance suggested that the patient's left hemisphere was dominant for speech. He was well orientated in time and place. No primary disturbance of motor, acoustico-motor, visuo-spatial functions, speech, reading, writing, arithmetic or intellect were evident. As he began to fatigue, however, he began to display signs of pathological inertia, which were especially evident in tasks requiring memorizing. Pathological inertia manifested in the form of an inability to create a stable intention to remember, together with a failure to "shift" recall from one group of traces to another. This suggested damage involving the frontal lobes.

CT Scan Report

Damage to the left and right frontal lobes.

Medical File

The subject sustained a head injury in a motor vehicle accident on 26.06.1977. He was in a coma for approximately six weeks. At the time of assessment he was still hospitalized.

PERCENTAGE MISTAKES MADE IN EACH SECTION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS BY CHILDREN (SAMPLE 1) OF DIFFERENT AGE, SEX AND SOCIOECONOMIC STATUS

3.1 PERCENTAGE MISTAKES MADE IN EACH LNI SECTION BY CHILDREN IN EACH AGE GROUP

AGE (YEARS)	n	LNI SECTION*										
		B	D	E	F	G	H	J	K	L	M	N
8	10	18,20	25,08	32,39	11,38	45,09	19,26	22,50	39,31	38,24	56,14	66,83
9	10	15,00	13,44	26,09	8,62	32,26	13,83	17,50	21,94	19,02	43,16	45,83
10	10	9,00	8,69	24,35	7,93	30,75	11,36	13,19	14,31	10,39	31,05	42,00
11	10	5,60	8,03	20,22	11,72	27,92	10,00	10,56	9,86	6,47	34,05	31,67
12	10	5,60	5,90	22,61	6,21	26,04	10,00	11,53	9,72	9,41	30,88	29,67
13	10	4,00	7,87	16,09	4,14	21,70	8,89	8,33	8,89	8,04	31,58	27,83
14	10	3,40	5,74	15,65	6,55	22,83	8,77	7,92	5,56	3,53	26,67	21,00

Note: Significantly fewer mistakes made in each LNI section with increasing age ($F = 4,248$; $P < 0,01$)

3.2 PERCENTAGE MISTAKES MADE IN EACH LNI SECTION BY CHILDREN OF EACH SEX

AGE (YEARS)	n	LNI SECTION*										
		B	D	E	F	G	H	J	K	L	M	N
Males	35	8,80	9,88	22,05	7,29	27,44	12,03	12,94	15,87	12,49	36,64	17,88
Females	35	8,57	11,48	22,92	8,87	31,59	11,43	13,21	15,44	14,68	35,79	19,95

Note: There was no significant difference in error frequency between the sexes

3.3 PERCENTAGE MISTAKES MADE IN EACH LNI SECTION BY CHILDREN OF DIFFERENT SOCIOECONOMIC STATUS

SOCIO-ECONOMIC STATUS	n	LNI SECTION*										
		B	D	E	F	G	H	J	K	L	M	N
Upper white	32	8,75	9,27	20,58	7,65	28,89	11,38	11,41	13,45	12,38	33,00	33,75
Lower white	23	9,39	12,33	23,06	7,65	28,47	12,78	14,25	19,08	15,77	40,35	40,14
Upper blue	14	8,00	11,48	26,40	10,34	32,75	10,93	14,88	15,87	13,45	36,34	43,21
Lower blue	1	0,00	6,56	15,22	0,00	28,30	9,88	13,89	4,17	3,92	42,11	40,00

Note: Significant interaction between LNI section and socioeconomic status with respect to error frequency ($F = 1,939$; $P < 0,05$)

* KEY

B : Preliminary Conversation
D : Motor Functions
E : Acoustico-Motor Organization
F : Higher Cutaneous and Kinesthetic Functions
G : Higher Visual Functions
H : Impressive Speech
J : Expressive Speech
K : Writing and Reading
L : Arithmetic Skill
M : Mnestic Processes
N : Intellectual Operations

APPENDIX 4

PERCENTAGE MISTAKES MADE BY CHILDREN (SAMPLE 1) OF DIFFERENT AGE, SEX, SOCIOECONOMIC STATUS AND WITHIN EACH SECTION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR ADULTS

4.1 PERCENTAGE MISTAKES MADE BY CHILDREN IN EACH AGE GROUP

AGE (YEARS	n	%
8	10	34,5
9	10	23,5
10	10	18,5
11	10	15,8
12	10	15,2
13	10	13,5
14	10	11,5

4.2 PERCENTAGE MISTAKES MADE BY CHILDREN OF EACH SEX

SEX	n	%
Male	35	18,4
Female	35	19,4

4.3 PERCENTAGE MISTAKES MADE BY CHILDREN OF DIFFERENT SOCIOECONOMIC STATUS

SOCIO-ECONOMIC STATUS	n	%
Upper white	32	17,3
Lower white	23	20,5
Upper blue	14	20,3
Lower blue	1	15,4

4.4. PERCENTAGE MISTAKES MADE BY CHILDREN IN EACH SECTION OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION

LNI SECTION*	n	%
B	70	8,9
D	70	10,7
E	70	22,5
F	70	8,1
G	70	29,5
H	70	11,7
J	70	13,1
K	70	15,7
L	70	13,7
M	70	36,2
N	70	37,7

* KEY

B : Preliminary Conversation

D : Motor Functions

E : Acoustico-Motor Functions

F : Higher Cutaneous and Kinesthetic Functions

G : Higher Visual Functions

H : Impressive Speech

J : Expressive Speech

K : Writing and Reading

L : Arithmetic Skill

M : Mnestic Processes

N : Intellectual Operations

APPENDIX 5

THREE-WAY FACTORIAL ANALYSIS OF VARIANCE COMPUTED ON THE RESULTS OF THE ADMINISTRATION OF THE ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TO A SAMPLE OF CHILDREN (SAMPLE 1) : TABLE OF MEANS

AGE	SOCIOECONOMIC STATUS	n	LNI SECTION									
			D	E	F	G	H	J	K	L	M	N
8	Upper white collar	5	12,40	15,40	3,00	23,60	17,20	16,20	28,40	19,60	31,80	40,60
	Lower white collar	4	17,75	14,50	2,75	24,50	15,00	17,25	30,50	21,50	36,00	42,75
	Blue collar	1	20,00	14,00	7,00	23,00	10,00	12,00	19,00	11,00	17,00	27,00
9	Upper white collar	4	6,00	11,00	2,75	16,50	10,75	10,75	11,75	7,75	21,75	24,75
	Lower white collar	4	9,25	12,50	1,00	16,75	12,25	14,00	18,75	11,00	27,75	28,50
	Blue collar	2	10,50	13,00	5,00	19,00	10,00	13,50	18,00	11,00	24,00	31,00
10	Upper white collar	6	5,33	10,67	2,00	14,00	8,17	8,17	8,33	4,33	16,33	20,17
	Lower white collar	1	5,00	9,00	5,00	20,00	12,00	12,00	10,00	9,00	21,00	26,00
	Blue collar	3	5,33	13,00	2,00	19,67	10,33	11,33	14,33	6,00	19,33	35,00
11	Upper white collar	4	3,75	6,75	3,75	15,00	7,50	5,50	4,00	2,00	16,75	14,50
	Lower white collar	4	6,75	12,25	2,75	13,75	9,50	9,75	9,25	3,50	21,25	22,25
	Blue collar	2	3,50	8,50	4,00	16,50	6,50	7,50	9,00	5,50	21,00	21,50
12	Upper white collar	6	3,50	7,67	1,50	13,83	7,00	6,17	6,17	5,00	15,50	14,50
	Lower white collar	1	1,00	13,00	6,00	11,00	6,00	7,00	9,00	2,00	12,00	17,00
	Blue collar	3	4,67	15,00	1,00	14,67	11,00	0,00	8,00	5,33	23,67	34,67
13	Upper white collar	4	5,25	7,25	1,50	11,25	7,00	5,25	4,75	3,50	14,75	13,25
	Lower white collar	5	4,60	7,60	1,20	11,00	8,80	5,80	8,40	5,00	19,40	18,00
	Blue collar	1	4,00	7,00	0,00	15,00	0,00	10,00	3,00	2,00	24,00	24,00
14	Upper white collar	4	3,00	7,75	1,50	12,00	7,25	5,00	3,50	1,75	14,75	12,50
	Lower white collar	4	2,25	6,75	2,00	10,25	7,25	6,00	5,25	1,25	14,75	11,75
	Blue collar	2	7,00	7,00	2,50	16,00	6,50	6,50	2,50	3,00	17,00	14,50

APPENDIX 6

PERCENTAGE MISTAKES MADE BY CHILDREN FOR EACH TYPE OF DIFFICULTY EXPERIENCED ON ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS

TYPE OF DIFFICULTY EXPERIENCED ON ADULT LNI TASK*	n	%
1	70	26,9
2	70	28,4
3	70	44,0
4	70	46,9
5	70	49,3

* KEY

1. Inability to process the quantity of information presented in the adult battery.
2. Lack of training.
3. Difficulty with tasks involving abstract reasoning.
4. Difficulty with tasks involving the simultaneous synthesis of tasks.
5. Difficulty with tasks involving the planning and organisation of goal-directed behaviour.

APPENDIX 7

PERCENTAGE MISTAKES MADE ON ADULT LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION TASKS APPARENTLY REFLECTING THE FUNCTIONING OF THE SECONDARY AND TERTIARY ZONES OF THE BRAIN

7.1 PERCENTAGE MISTAKES MADE BY CHILDREN OF DIFFERENT AGES ON ADULT LNI TASKS APPARENTLY REFLECTING SECONDARY AND TERTIARY ZONE FUNCTIONING

AGE (YEARS)	n	CORTICAL ZONE	
		SECONDARY	TERTIARY
8	10	49,7	66,9
9	10	32,0	46,2
10	10	24,7	37,0
11	10	20,9	32,2
12	10	20,3	30,9
13	10	16,5	29,7
14	10	13,9	24,2

7.2 COMPARISON OF PERCENTAGE MISTAKES MADE ON ADULT LNI TASKS APPARENTLY REFLECTING SECONDARY AND TERTIARY ZONE FUNCTIONING

CORTICAL ZONE	n	%
Secondary	70	25,4
Tertiary	70	38,2

APPENDIX 8

COMPARISON OF LURIA'S NEUROPSYCHOLOGICAL INVESTIGATION FOR CHILDREN FINDINGS WITH PARAMEDICAL REPORT FINDINGS

SUBJECT	PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARAMEDICAL FINDINGS
1	Occupational therapist	Coordination problems (e.g. writing).	LNI-C findings consistent with paramedical reports. LNI-C suggested following: - Disturbance in kinetic melody of movement at basis of coordination problems. - Disturbance in simultaneous synthesis of data factor underlying 1) visuo-spatial difficulties; and 2) inability to abstract and generalize cross modally - and hence able to read, write, do arithmetic and comprehend at simple level only. - Impaired executive skills, together with above difficulties, at basis of subnormal intelligence. Emotional withdrawal not evident during LNI-C assessment.
	Speech therapist	Vocabulary 2-3 years below CA. Comprehension 2 years below CA.	
	Physiotherapist	Poor fine motor coordination.	
	School teacher	Marked visuospatial difficulties. Poor coordination. Written work and comprehension below class level.	
	School psychologist	Subnormal intelligence. Verbal abstract reasoning adequate. Below par in all other areas. Emotionally withdrawn.	
2	Occupational therapist	Coordination problems (e.g. writing). Visuospatial problems.	LNI-C findings consistent with paramedical reports. LNI-C nevertheless suggested: - Disturbance in kinetic melody of movement at basis of coordination problems. - Impaired simultaneous synthesis of data underlies 1) visuospatial difficulties; and 2) quasi-spatial problems of impaired comprehension of logico-grammatical structures, spelling and reading.
	Speech therapist	Auditory processing difficulties.	
	Physiotherapist	Poor fine motor coordination.	
	School teacher	Coordination problems. Poor memory. Reading and writing poor.	
	School psychologist	Low average intellect. Poor arithmetic and comprehension. Visual-motor perception poor.	
3	Occupational therapist	Co-ordination and visual-perceptual problems.	LNI-C findings consistent with paramedical reports, but LNI-C suggested following: - Disturbance in kinetic melody of movement at basis of coordination problems. - Disturbance in simultaneous synthesis of data factor underlying 1) visuospatial problems, and 2) inability to abstract and generalize cross modally - and hence only able to read, write, do arithmetic and comprehend at simple level. - Impaired executive skills, together with above difficulties, at basis of subnormal intelligence.
	Speech therapist	Speech immature. Socially immature.	
	Physiotherapist	Coordination problems. Lacks motivation.	
	School teacher	Performance in all areas retarded. Immature. Lacks motivation.	
	School psychologist	Subnormal intelligence. Learning problems. Immature. Lacks motivation.	
4	Occupational therapist	Poor concentration. Difficulty initiating words. Stutters. Visual-perceptual problems.	LNI-C findings consistent with paramedical reports, but LNI-C also suggested following: - Disturbance in kinetic melody of movement at basis of coordination and speech (including telegraphic speech) problems. - Disturbance in simultaneous synthesis of data factor underlying 1) visuospatial problems; and 2) inability to abstract and generalize cross modally, and hence able to read, write, do arithmetic and comprehend at simple level only. - Impaired executive skills, together with above difficulties at basis of subnormal intelligence.
	Speech therapist	Poor concentration. Speech - single words strung together. Difficulty initiating words (repeats first syllable before completing words). Poor receptive language.	
	Physiotherapist	Coordination problems. Poor concentration.	
	School teacher	Poor concentration. Below par in all subjects.	
	School psychologist	Subnormal intellect. Fine motor coordination problems. Expressive language staccato with single word sentences.	

SUBJECT	PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARAMEDICAL FINDINGS
5	Occupational therapist	Poor fine motor coordination. Letter and number reversals. Right-left concepts not fully established. Poor visual recall.	LNI-C findings confirmed most difficulties reported by paramedics. LNI-C additionally revealed following deficits: - echopraxia - slow mental processing. LNI-C also suggested: - Disturbance in kinetic melody of movement at basis of coordination problems. - Impaired simultaneous data synthesis at basis of 1) visual perceptual; and 2) quasi-spatial problems manifesting as comprehension, reading, writing and arithmetic problems. - Impaired executive skills, together with above, at basis of defective IQ score. LNI-C did not reveal: - word-finding problem - mild left hemiplegia. LNI-C findings of spatial problem initially appeared to contradict psychologist's report that ability to solve problems in spatial relations was a "relative" adequacy. However, scores for tests evaluating this fell in borderline - defective range (e.g. WISC-R, Object Assembly, score = 6).
	Speech therapist	Bilateral hearing loss. Vocabulary concrete. Articulatory defects. Good auditory memory. Language problems affecting all aspects of auditory processing and word finding.	
	Physiotherapist	Gross motor coordination problems. Mild left hemiplegia.	
	School teacher	Poor concentration. Work fluctuates daily. Arithmetic, spelling, reading and language weak. Unable to cope with basic Std. I work.	
	School psychologist	FSIQ 63. No significant difference between VIQ and PIQ. Wide inter-test scatter. Poor concentration. Ability to solve problems in spatial relations relative adequacy. Poor visual memory. Arithmetic, reading, spelling and comprehension subnormal.	
6	Occupational therapist	Aggressive, restless, uncooperative. Poor fine motor coordination. Perceptual problems.	LNI-C findings confirmed difficulties reported by paramedics. LNI-C however, suggested that: - Variable behaviour and emotional lability manifestations of disturbed cortical tone. - Impaired kinetic melody of movement at basis of coordination problems. - Impaired simultaneous data synthesis underlies 1) visuo-spatial; and 2) quasi-spatial problems. Latter appeared to be at basis of speech, reading, and arithmetic problems noted. - Impaired executive skills at basis of poor planning skills, impulsivity, perseveration and learning problems.
	Speech therapist	Language and speech poorly developed. Poor listening skills.	
	Physiotherapist	Dominance not established. Poor fine motor coordination. Adequate gross motor coordination and balance. Short attention span.	
	School teacher	Unable to manage Class i work. Behaviour fluctuates.	
	School psychologist	Emotionally labile, impulsive, distractible. Coordination problems. Visuo-spatial problems. Perseverates. Poor verbal comprehension. Unable to plan and organise work.	
7	Occupational therapist	Perseverates. Impulsive.	LNI-C findings consistent with paramedical reports but suggested that impaired executive skills were at basis of disturbances described. LNI-C additionally identified memory problem not recorded in paramedical reports and revealed that semantic organization of material to be retained enabled subject to compensate for this problem.
	Speech therapist	Perseverates. Repeats utterances made by others.	
	Physiotherapist	Walks with wide-based gait and body inclined forwards.	
	School teacher	Performance in all areas poor.	
	School psychologist	Intellect falls within educable mental retardate range.	
8	See Section 6.6.1		

SUBJECT	PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARAMEDICAL FINDINGS
9	Occupational therapist	Marked hand tremor: writing thus impaired and being taught to type.	LNI-C findings consistent with paramedical reports, but suggested that slightly impaired simultaneous synthesis of quasi-spatial data was at the basis of comprehension difficulties noted.
	Speech therapist	Oral movements influenced by uncontrolled tremor. Receptive ability borderline.	
	Physiotherapist	Marked ataxic gait.	
	School teacher	Comprehension below par.	
	School psychologist	Above average intelligence.	
10	Occupational therapist	Left hemiplegia. Visual-spatial problems. Writing: poor planning.	LNI-C findings consistent with paramedical reports, but suggested that impaired executive skills at basis of general disturbances in higher mental functions described. Further suggested that non-modality specific memory problem and distractability reflect diffuse impairment.
	Speech therapist	Slow rhythmic speech pattern with nasal overlay. Hearing normal. No articulatory errors.	
	Physiotherapist	Left hemiplegia.	
	School teacher	Distractible. Below par in all areas.	
	School psychologist	Below age level in all areas, especially visuo-spatial and short-term memory spheres. Distractible.	
11	Occupational therapist	Therapy aimed at improving use of hemiplegic left hand.	- LNI-C findings concurred with most of difficulties noted in paramedical reports, but LNI-C further suggested that impaired executive skills at basis of "poor thinking" skills, and visuo-spatial problems factor underlying reading and writing difficulties. - LNI-C identified difficulties in memory, goal-directed behaviour and spatial orientation not mentioned in psychologist's report. This report merely comprised list of WISC-R scores, with no reference to their implications in terms of the behavioural problems they denoted. Inspection of pattern of WISC-R scores nevertheless revealed them to be consistent with the aforementioned difficulties identified by the LNI-C. - LNI-C did not reveal the positive self image and indications of interpersonal familiar aggression noted in psychologist's report.
	Speech therapist	No primary speech disturbance.	
	Physiotherapist	Distractible. Left hemiplegia.	
	School teacher	Distractibility adversely affects performance in all areas. Reading and writing poor. Poor thinking skills.	
	School psychologist	WISC-R: VIQ 72; PIQ 75; FSIQ 72 Information 4 Digit Span 5 Arithmetic 5 Comprehension 6 Picture Completion 10 Picture Arrangement 3 Block Designs 6 Object Assembly 8 Coding 5 Reading and writing poor. Positive self image. Interpersonal familial aggression.	
12	Occupational Therapist	No report available.	LNI-C findings consistent with most of paramedical report findings. LNI-C nevertheless revealed additional disturbances: - adynamia; - disinhibition; - echolalia; - distractability; and - modality non-specific memory difficulties. LNI-C also suggested following: - Impaired kinetic melody of movement at basis of poor dexterity noted. - Difficulty with cross-modal abstraction and generalization underlies inability to read and spell. - Impaired executive skills at basis of defective IQ score.
	Speech therapist	No report available.	
	Physiotherapist	No report available.	
	School teacher	Does arithmetic to 10 with help of aids. Unable to read. Poor dexterity and acquired left hemiplegia. Moody, behaviourally inappropriate, and often sleeps in class.	
	School psychologist	FSIQ 64. Visual-motor perceptual age equivalent: 6 years. Unable to spell and read. Emotionally moody, and inappropriate.	

SUBJECT	PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARAMEDICAL FINDINGS
13	Occupational therapist	Poor letter formation. Poor memory. Distractible.	LNI-C findings concurred with paramedical report findings, but LNI-C additionally suggested: - Impaired executive skills at basis of intellectual and learning impairments. - Visuo-spatial difficulties underly poor letter formation. - Modality non-specific memory problem and distractibility reflect diffuse impairments.
	Speech therapist	Distractible. Poor memory.	
	Physiotherapist	No coordination problems.	
	School teacher	Unsatisfactory progress in all areas.	
	School psychologist	Intellectually borderline. Severely learning impaired.	
14	Occupational therapist	Poor writing, number work, spelling and reading. Mild visual-spatial problems.	LNI-C findings concurred with most paramedical report findings. LNI-C nevertheless revealed additional disturbances: - Slight difficulty comprehending logico-grammatical structures and a latent grammatical disturbance evident during spontaneous narrative speech. - Modality non-specific memory problem. - Difficulty with perception and reproduction of pitch relationships. LNI-C also suggested that impaired simultaneous synthesis of quasi-spatial data was at basis of reading, writing, spelling and arithmetic difficulties.
	Speech therapist	Slight articulatory problems.	
	Physiotherapist	No motor coordination problems.	
	School teacher	Reading, writing, spelling and arithmetic poor.	
	School psychologist	Average intelligence, but does not function at this level. Reading, writing, spelling and arithmetic poor.	
15	Occupational therapist	No report available.	LNI-C findings consistent with most paramedical report findings. LNI-C nevertheless revealed additional disturbances: - marked adynamia. - rapid fatigue - perseveration - modality non-specific memory problems. LNI-C also suggested that - Impaired simultaneous synthesis of quasi-spatial data at basis of comprehension, reading, writing and arithmetic problems. - Impaired executive skills, together with aforementioned problems, underly borderline intellect reported by psychologist.
	Speech therapist	Comprehension below chronological age.	
	Physiotherapist	Ataxic gait. Fine motor tremor accompanies all movements.	
	School teacher	Reading, writing and arithmetic poor.	
	School psychologist	Borderline intellect. Reading, writing and arithmetic 4 years below chronological age.	
16	Occupational therapist	Poor coordination. Slow worker. Visual perceptual problems. Poor visual memory.	LNI-C findings were consistent with most paramedical findings, but also suggested the following: - Disturbance in kinetic melody and kinesthetic basis of movement factors underlying coordination problems. - Perceptual problems reflect optic agnosia and visuo-spatial problems revealed by LNI-C. LNI-C did not reveal the severe emotional problems described by the psychologist.
	Speech therapist	Poor coordination. Distractible. Articulation intact. No primary speech difficulty.	
	Physiotherapist	Fine motor coordination problems.	
	School teacher	No report available.	
	School psychologist	Intellectually low average range. Orientated for place and time. Fine motor coordination problems. Visual perceptual difficulties. Severe emotional problems (depression and parasuicide).	

SUBJECT	PARAMEDIC	PARAMEDICAL REPORT FINDINGS	COMPARISON OF LNI-C AND PARAMEDICAL FINDINGS
17	Occupational therapist	No report available.	LNI-C in keeping with available paramedical report findings. LNI-C nevertheless revealed additional disturbances: - Distractible - Rapid fatigue - Marked mental slowing - Impaired executive skills - Variable behaviour reflecting disturbance of cortical tone. LNI-C also suggested following: - Disturbance in kinetic melody of movement at basis of coordination problems. - Disturbance in simultaneous synthesis of visuo-spatial data as basis of reading, writing, arithmetic and speech problems. - Mental retardation reflects combination of aforementioned primary factors.
	Speech therapist	No report available.	
	Physiotherapist	No report available.	
	School teacher	Cooperative. Marked speech, reading, writing and arithmetic problems.	
	School psychologist	Severe mental retardation. Poor motor coordination. Cooperative.	
18	Occupational therapist	Poor motor coordination. Perceptual visualization problems.	LNI-C findings concurred with most paramedical report findings. LNI-C further suggested: - Disturbance in kinetic melody of movement at basis of coordination problems. - Impaired executive skills underly poor planning skills. LNI-C did not reveal the following disturbances: - Slight hemiparesis, ataxic gait and poor balance; - perceptual visualization problems; - phonation difficulties and poor vertical tongue movements; and - poor spelling, memory and short attention span.
	Speech therapist	Poor motor coordination. Phonation difficulties and poor vertical tongue movements. Intact expressive and impressive speech.	
	Physiotherapist	Motor coordination problems. Mild left hemiparesis. Ataxic gait. Poor balance.	
	School teacher	Slow worker. Tires rapidly. Short attention span. Poor spelling. Poor memory. Reading, writing and arithmetic age appropriate.	
	School psychologist	Intact cognition. Poor coordination. Poor planning.	

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