

LEARNING AND DEVELOPMENT : AN  
INVESTIGATION OF A NEO-PIAGETIAN  
THEORY OF COGNITIVE GROWTH

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ABSTRACT

Within the framework of Pascual-Leone's Theory of Constructive Operators (TCO), 252 Zulu-speaking children in the 7-8, 9-10 and 11-12 age-groups were tested four times on the FIT RAC 794, a measure of mental capacity or M-power.

Two hypotheses were investigated: (i) A "local" hypothesis (related to the fact that many black South African schoolchildren appear to struggle at school) was that all children have the same M-power. Performance differences are explained in terms of different learning experiences, which give rise to different repertoires of executive structures responsible for allocating M-power. It was predicted that on Trial 1 of the FIT children would underperform, but that with repeated exposure to the task they would develop the executives necessary for success. (ii) A "general" hypothesis sought to test the TCO's theoretical prediction that there is an age-linked developmental ceiling on performance, and that in spite of over-learning children will not perform beyond their age-determined M-power.

As predicted the children underperformed on Trial 1. They reached criterion on Trial 2 and then overperformed on Trial 3 where performance reached a ceiling with no further significant improvement on Trial 4. The fact that children achieved scores above those predicted by the TCO on Trials 3 and 4 was explained in terms of non-M facilitating factors, developed as the result of over-exposure to the test.

CONTENTS

CHAPTER		<u>PAGE NUMBER</u>
	INTRODUCTION	1
	<u>REVIEW OF THEORETICAL ISSUES:</u>	8
1.	A THEORY-METHOD FOR CROSS-CULTURAL PSYCHOLOGY: EXPERIMENTAL OR DEVELOPMENTAL?	9
2.	TOWARDS A THEORY-METHOD OF CHANGE: PIAGET AND VYGOTSKY	21
3.	PASCUAL-LEONE'S THEORY OF CONSTRUCTIVE OPERATORS: A THEORY-METHOD OF CHANGE	39
	<u>EMPIRICAL RESEARCH</u>	65
4.	METHODOLOGY	66
5.	RESULTS	76
6.	DISCUSSION	98
	BIBLIOGRAPHY	125
	APPENDICES	134

APPENDICES

	<u>PAGE NUMBER</u>
<u>APPENDIX A</u>	
THE FIT RAC 794: EXAMPLES OF EACH ITEM CLASS	134
<u>APPENDIX B</u>	
FIT SCORES: Y-SCALING	137

LIST OF TABLES

	<u>PAGE</u>	
3.1	Predicted maximum <u>M</u> -power values as a function of age, and their correspondence to the Piagetian substage sequence.	52
4.3	Age distribution of subjects.	74
4.4	Age-group distribution of subjects	74
5.1	Goodman's data on the percentage of correct FIT responses as a function of age and stimulus class.	77
5.2	Means and standard deviations for the three age groups on each trial for the seven item classes.	80
5.3	Summary of analyses of variance for item classes 2 to 8.	82
5.4.1	Results of Tukey's tests investigating differences in mean performance on trials 1 to 4 for each age group.	83
5.4.2	Results of Tukey's tests investigating age-group differences in performance for each trial.	84
5.4.3.1	Results of Tukey's tests investigating differences in age-group performance meaned across the four trials.	85
5.4.3.2	Results of Tukey's tests investigating differences in performance on each trial meaned across the three age-groups.	85

LIST OF FIGURES

		<u>PAGE</u>
1.1	Bhaskar's transformational model of the society/person connection	16
4.1	FIT RAC 794 : Class 4 Item	69
4.2	FIT RAC 794 : Class 4 + 1 Item	69
5.1	7 to 8 year olds : Percentage of correct responses per item class for Trials 1 to 4.	87
5.2	9 to 10 year olds : Percentage of correct responses per item class for Trials 1 to 4.	89
5.3	11 to 12 year olds : Percentage of correct responses per item class for Trials 1 to 4.	90
5.4	Trial 1 : Percentage of responses correct per stimulus class for 7 - 8's, 9 - 10's and 11 - 12's.	92
5.5	Trial 2 : Percentage of responses correct per stimulus class for 7 - 8's, 9 - 10's and 11 - 12's.	93
5.6	Trial 3 : Percentage of responses correct per stimulus class for 7 - 8's, 9 - 10's and 11 - 12's.	94
5.7	Trial 4 : Percentage of responses correct per stimulus class for 7 - 8's, 9 - 10's and 11 - 12's.	95

## INTRODUCTION

Many black South African children appear to struggle at school, especially during the first few years. This is manifest in a high rate of failure in grade one.

Various sorts of explanation have been offered for poor school performance. One sort of explanation holds that there are culturally determined variations in basic cognitive structures, and hence in performance. This view - cultural relativism - is based on the assumption that cognitive development can be explained as a function of learning alone - with no recourse to the notion of a universal aspect of human development common to all people regardless of variations in culture. Different cultures are said to provide different learning experiences, with consequent different cognitive structures and performance differences. Such an assumption informs the view of Cole and his co-workers at the Laboratory of Human Cognition (LCHC), for example, who claim there are "... cultural differences in the events out of which people can create schemata", and for this reason "... intelligence will be different across cultures insofar as there are differences in the kinds of problems that different cultural milieus pose their initiates." (1982, p. 710).

The LCHC operate within the basic experimental paradigm that guides research in cross-cultural psychology. The essence of this approach is expressed in formula  $M = f(C)$ , where M stands for mind (or cognition or intelligence) and C for a particular culture. In these terms mind is regarded as the dependent variable, and culture as the independent variable. Thus culture is relevant to cognitive development because cognition or mind is a function of culture.<sup>1</sup>



The present research uses the theoretical framework provided by Piaget, Vygotsky and Pascual-Leone to show the limitations of this view on the grounds that it is based on an inadequate notion of the respective roles of learning or culture and cognitive development in intellectual performance.

This inadequacy may be traced to the experimental method's approach to the relation between mind and culture:

- 1) they are treated as two *separate* entities rather than as two interacting phenomena locked into an ongoing process of mutual transformation
- 2) they are treated as *static* systems, failing to appreciate their essentially socio-historic nature.

As a result of these notions the experimental method is unable to account for change either in the individual's life-span or in the life-span of a society. Miller (1984) points to the dangers of such a theory, particularly in South Africa. A theory that emphasises racial differences at the expense of a focus on universal human characteristics fits well with the prevailing repressive political ideology of apartheid which seeks to maintain "white" and "western"<sup>2</sup> supremacy in the face of a "black" and "african" majority (Craig and Miller, 1984).

"In its benign form cultural relativity is an injunction not to allow prejudice to influence comparisons between cultures. But in a malignant form it becomes separate development in which the so-called cultural relativity of various groups provides a basis for a social system that at best encourages, and, at worst forces people to remain locked into their own cultural past." (Miller, 1984, p. 5).

Wexler (1982) warns that the experimental approach,

"... is a system of collective representations that make us content with the present, portraying it as

natural and inevitable. It systematically excludes consideration of structured incipient changes, and thus performs the role of affirmation and legitimation of the status quo." (p. 2).

This study looks to the developmental method (outlined by Vygotsky, and practiced by Piaget and Pascual-Leone) as a more fruitful and appropriate approach to the intellectual performance of children in a rapidly changing society. Rather than viewing children as immobile prisoners of static cultural constraints, this method focusses on child's ability to overcome the constraints of his/her cultural context. It does so by focussing on the generative mechanisms<sup>3</sup> that produce change in the interaction between learning and development which propels the developing child to adulthood.

As opposed to the LCHC and other theorists within the experimental paradigm, who claim that development occurs BY learning, exponents of the developmental method argue that development occurs THROUGH learning. Pascual-Leone's theory of cognitive development acknowledges the importance of *context-specific* achievements which are the backbone of the LCHC's theory. However, he poses another equally important level in the cognitive organisation of the developing child: that of *context-free* operators, in dynamic interaction with context-specific operations.

His most important context-free operator is M: a quantitative factor which determines the number of operations or schemes a child can simultaneously consider in solving a particular task. Progress from one Piagetian development stage to another is possible because with development the child acquires the ability to conjointly apply more and more schemes in task-solving. Allocation of M-power is determined by context-specific executive schemes, which are a direct function of learning/experience.

This study investigates the implication of Pascual-Leone's theory that all children - regardless of culture or learning experience - are endowed with the same amount of M-power which develops at a constant rate from age to age, that is that all children have the same basic mental capacity. In a study conducted by Globerson (1981) gifted, normal and disadvantaged children were found to have the same M-power despite very different performance.

The present study has two objectives. One is more local, referring specifically to black South African schoolchildren. The other objective seeks to test an aspect of Pascual-Leone's theory at a more general level.

The "local" objective concerns itself with Pascual-Leone's contention that performance differences are the result of different learning experiences which result in different repertoires of executive structures. As opposed to the cultural relativists who seek to generalise from performance differences to culturally determined differences in basic cognitive ability (Jahoda, 1980), Pascual-Leone argues that all children have the same basic cognitive ability of M-power. Poor school performance is thus due to the fact that children who grow up in a culture in which formal schooling is not predominant may not have the opportunities to develop the kinds of executives that classroom learning requires, although they have the same M-power as all other children.

Pascual-Leone has devised a number of tests for M-power. In most of these tests learning is controlled. Before the test is administered, children are trained to perform the elements that make up the test. One test is the CSVI where children are trained to make nine associations and only those who are perfectly trained are used as subjects. In this way Pascual-Leone's tests control for learning.

can you find  
evidence

This study will use the Figural Intersection Test (FIT), a pencil-and-paper test with embedded geometrical figures. It is usually assumed that schoolchildren are already familiar with the elements making up the FIT. However in this study this assumption may not be warranted because of the kinds of experience black South African schoolchildren have had before school. Most come from poor backgrounds and so do not have the variety of toys such as puzzles, drawing books, etc, that are part of western-industrialised-technological pre-school experience.

A pilot study suggests these children perform erratically on the FIT. The present study investigates this phenomenon. Unlike the CSVI, learning is not controlled and the present study attempts to understand the learning process as it relates to M-capacity. Instead of teaching children the necessary executives for performing the test in advance as in the CSVI, thereby eliminating the effects of learning on performance, the children are required to repeat the FIT several times. By repeated exposure to the task it is hypothesised the children will develop the necessary executives.

It is expected that not all the children will perform to criterion the first time they do the test. However, once they are provided with the necessary experience they will perform to criterion. Such an outcome would serve to demonstrate empirically that poor performance is a function of inappropriate learning and experience to develop the kinds of executives necessary for adequate task performance.

The more general objective of the study is to test Pascual-Leone's hypotheses that there is a developmental restriction on performance at each stage, and that in spite of over-learning children will not be able to perform beyond their M-power. This hypothesis will be examined by

continuing the testing procedure after the criterion is reached.

It must be stressed that because M-power is independent of learning or experience, repeated testing does not invalidate a test designed to measure M-power. On the contrary, improvement in performance as a result of practice must be attributed to learning factors.

A possible outcome of the research is that children will perform the FIT test correctly on first application. However the pilot study suggests this is unlikely, and it is expected that performance will improve with learning. This would enable us to conclude that once children have the necessary experience they perform to criterion.

The finding that performance improved with learning would also point towards the conclusion that all performance tests, including IQ, are affected by experience. Thus the practice in South Africa of rating tests differently for different populations would be shown to be unfortunate insofar as it wrongly suggests some kind of inherent difference in intellectual ability. Furthermore, it would indicate that the effort expended on this kind of work would be better used in trying to understand which kinds of learning experience best promote school achievement.

The finding that children have the same mental capabilities and that the situation-bound executives controlling these capacities are a function of learning and experience would point towards social, political and economic explanations for under-performance at school. All these conclusions would point towards the need for a learning environment that facilitates the acquisition of executive repertoires that are necessary for successful school performance.

NOTES: INTRODUCTION

1. This project uses the terms "mind" and "culture" as defined by Craig (1985, p. 25). Mind, which will be used interchangeably with cognition, refers to "the totality of the organism's psychological power or ability to adapt to a milieu". Culture refers to "the totality of a group's power to institute tried and tested guidelines for adaptation. 'Culture' may therefore be seen as the term for the 'recipes' for living embodied in the institutions of society". Thus "learning" and "experience" fall within the definition of "culture".
2. The word "western" is used to refer to what Miller (1984) calls "western-industrialised-urban-technological-schooled society" (p. 21).
3. Generative mechanisms are discussed in more detail in Chapter 2. They refer to the "deep structures" of a phenomenon that give rise to its manifest behaviour. "In terms of change and development, 'generative mechanisms' refer to the ability to adapt. 'Change' and 'development' are used interchangeably to indicate the process of unfolding greater degrees of complexity or maturity" (Craig, 1985, p. 25).

REVIEW OF THEORETICAL ISSUES

1. A THEORY-METHOD FOR CROSS-CULTURAL PSYCHOLOGY: EXPERIMENTAL OR DEVELOPMENTAL?



This section critically examines the presuppositions of cultural relativism in order to argue that it does not come to grips with the crucial relevance of development in the mind-culture issue. This will be traced to its roots in the experimental approach, with its attendant assumptions about the relation between mind and culture.

A prominent contemporary expression of cultural relativism is the work of the Laboratory of Comparative Human Cognition or LCHC (1982), and one of its chief researchers, Michael Cole (Cole, 1975, Cole and Scribner, 1974, Cole *et al* 1971, Griffin and Cole, 1984). They assume that all children, regardless of culture, begin their lives with uniform cognitive ability. Thereafter their cognitive development is determined predominantly by the learning experiences provided by their particular culture.

"Cultural differences are merely the expressions of the many products that a universal human mind can manufacture, given the wide variations in conditions of life, and culturally valued activities" (Cole and Scribner, 1974, p. 172).

This domain-specific theory of learning is similar to the old-fashioned behaviourist S-R approach to cognition, although the LCHC re-phrase it in E-T terms. According to them, the task of the cross-cultural psychologist is to explain differences in the manifest performance of children in various tasks (T) by linking the tasks to the experiences that gave rise to them (E) with no recourse to any universal, maturational factor in development. This approach qualifies Cole and the LCHC as psychologists in the experimental mould as outlined by Vygotsky (1978).

The LCHC argue that the extent to which learning in one context controls performance in another depends on three factors alone:

- 1) what the individual learns on the basis of experience in the first

context;

- 2) the similarity between the two performance tasks; and
- 3) the activity of other people in the second context (LCHC, 1982, p. 674).

Generalised response tendencies derive *not* from "central processor" cognitive structures such as those postulated by Piaget, but from common features shared by the current task and the previous contexts.

"We are adopting a position championed 75 years ago by Thorndike when he insisted that the extent to which learning in one situation transfers to learning and performance in others depends on the similarity between settings." (*Ibid*, p. 674).

Thus context-specific intellectual achievements become the basis for cognitive development. Development is seen as the acquisition of increasingly generalised rules that apply to a progressively larger set of specific domains of experience.

"Development in this view is virtually never general .... The concept of stage is secondary." (LCHC, 1982, p. 698).

Depending upon how long it takes for the world to provide the child with appropriately informative experiences, the child will respond to problems in a given domain in a characteristic way. Insofar as it takes time to undergo the needed experiences, children growing up in similar circumstances are likely to reach the same stages at about the same ages.

"Development is the acquisition of ever-wider ranges of contexts to which a constant set of cognitive capacities and more powerful (general) rules for interpreting the phenomena of the environment are applied." (LCHC, 1982, p. 700).

Culture organises for the progressive "stages" of development to occur by:

1) arranging for the raw occurrence or non-occurrence of specific basic problem-solving environments; 2) organising the frequency of the same kinds of events in these learning environments; 3) shaping the patterning or co-occurrence of events; and 4) regulating the level of difficulty of the task at hand. Cultural relativism is the logical conclusion of this approach. Since cognitive development is a function of learning, cognition is seen to differ across cultures because different cultural conditions pose different kinds of problems.

The foundation stone of such a cross-cultural theory of intelligence is the necessity of exploring cultural differences in the events out of which people create cognitive "schemata".

"Intelligence will be different across cultures insofar as there are differences in the kinds of problems that different cultural milieus pose their initiates .... No universal notion of a single general ability, called intelligence, can be abstracted from the behavior of people whose experiences in the world have systematically been different from birth in response to different life predicaments handed down to them in their ecocultural niche." (LCHC, 1982, p. 710).

This heavy emphasis on the situational determinants of behaviour commits the cultural relativists to the search for a "theory of situations". Research should aim at establishing culturally determined experimental factors that give rise to various behaviours.

"Our situation-dependent theory will have to specify the rules underlying the patterns of behaviour that are seen in different situations." (Cole and Scribner, 1974, p. 194).

Situation, the independent variable, is manipulated in order to measure its effect on behaviour/performance.

This view of development as the accumulation of learning experiences is based on three fundamental implications about the relationship of mind and culture which are embedded in the  $M = f(C)$  view of the world.

- i) The relation between mind and culture is static and can be examined ahistorically in terms of manifest performances at a given time.
- ii) Mind and culture can be conceived of as separate and independent phenomena. *You could not write this sentence if you reject the claim*
- iii) There is a unidirectional, causal relationship between mind and culture, mind being a product of culture.

These assumptions are examined with a view to providing an alternative account of this relation, which emphasises that in order to fully understand any phenomenon, be it mind, culture or the relationship between them, one must examine it in the process of change. Cultural relativists such as Cole and the LCHC not only ignore this insight, but their method actually excludes the possibility of accommodating it.

Vygotsky stresses that any change in the theoretical assumptions informing a theory necessarily goes hand in hand with a change in method, since method is a reflection of the way a researcher approaches and seeks to solve a problem. In this way "... the method is simultaneously prerequisite and product, the tool and the result of the study." (1978, p. p. 65). His term "theory-method" embodies his view of the ultimate inseparability of the two domains.

Implicit in the  $M = f(C)$  equation is the assumption that mind and culture can be regarded as separate systems. This assumption is reflected in the methodology of the LCHC and Cole, which examines the mind-culture relation by varying culture (the independent variable) and looking at the

effect this has on cognition (the dependent variable). This equation is upheld by the related assumptions that the two phenomena are causally related in a unidirectional way (E → T or culture → mind) and that they can be operationalised as states rather than processes since human behaviour is essentially reactive.

According to Vygotsky, to view psychological processes as states misconceives their essential nature. Human behaviour is not reactive as it has a "transforming effect on nature", and the interaction of the two phenomena should be seen as "... a process undergoing changes right before one's eyes." (Vygotsky, 1978). He rejects the experimental paradigm on the grounds of its failure to comprehend that to discover the nature or essence of the development of a phenomenon is to "... encompass (it) ... in all its phases and changes ... for 'it is only in movement that a body shows what it is'." (Ibid, p. 65). *~ is what it is*

Miller (1984) too claims that human activity is not reactive, but should be seen as "both responsive to and generative of the world in which it occurs". (p. 6). This view forms the foundation-stone for a new conception of the mind-culture relationship which locates the two phenomena within a unitary system. According to this view it is meaningless to separate them as causally interrelated independent variable and dependent variable forming two separate systems that can be "experimentally" manipulated.

This means that neither culture nor mind can be treated as static entities or as "pure" concepts, functioning or existing independently of each other, neither can one be defined without referring to the other. The dialectic view (Georgoudi, 1983) which places mind and culture within a

*in one sense  
the dual - unity  
not - whole  
problem  
repeated*

*what is 'nature', 'human' 'phen' 'tools'*

*① The whole is more than the sum of its parts  
or as we know.*

unitary system accommodates this insight.

"From the dialectic perspective the study of independent entities and their interaction is replaced by a concern with concrete *relations* in a continuous process of creation, change and transformation." (*Ibid*, p. 84).

However, Bhaskar (1979) warns against the conception of individuals and society as a *dialectical* unity, which views them as "fixed in an ongoing process of created and recreated relations." (Georgoudi, 1983, p. 84). He argues that it is wrong to view the two phenomena as two moments of the same process, when in fact there is an "ontological hiatus" between them. Rather than say that persons *create* society and *vice versa*, he prefers to see them *reproducing* and *transforming* each other. The dialectical model "... seems to involve continuous recreation, with genuine novelty, seemingly entailing incomplete social formation, something of a mystery." (Bhaskar, 1979, p. 47). He replaces the dialectic model with his own 'transformational' model, in which society provides the necessary conditions for human action, and human action is the necessary condition for society, yet both are recognised as radically different in ontological status.

"The model of the society/person connection I am proposing could be summarised as follows: People do not create society. For it *always* pre-exists them and is a necessary condition for their activity. Rather, society must be regarded as an ensemble of structures, practices and conventions which individuals reproduce or transform, but which would not exist unless they did so. Society does not exist independently of human activity (the error of reification). But it is not the product of it (the error of voluntarism). Now the process whereby the stocks of skills, competencies and habits appropriate to given social contexts, and necessary for the reproduction and/or transformation of society, are acquired and maintained could be generically referred to as '*socialisation*'. It is important to stress that the reproduction and/or transformation of society, though for the most part unconsciously achieved, is nevertheless still an *achievement*, a skilled accomplishment of active

subjects, not a mechanical consequent of antecedent conditions." (*Ibid*, pp. 45 - 46).

Bhaskar's model of the society-person connection is presented in Figure 1.1 :

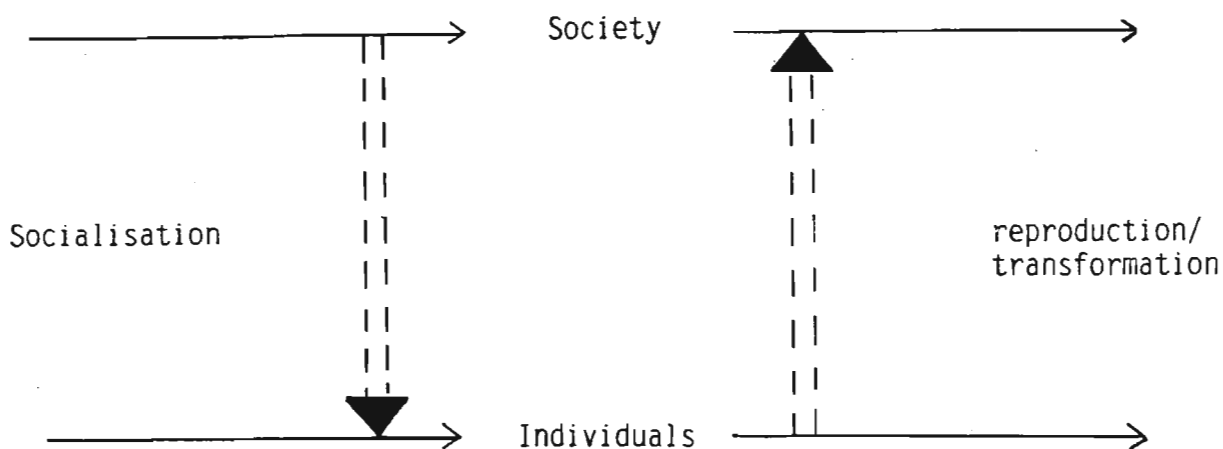


Figure 1 : Bhaskar's transformational model of the society/person connection (*Ibid*, p. 45).

Bhaskar claims that by attributing to society an independent ontological status, his model emphasises "material continuity" compared to the dialectical model which regards society as eternally incomplete in the sense that it is constantly being recreated. The transformational model "... as a result of its emphasis on material continuity, can sustain a genuine concept of *change*, and hence of *history*." (*Ibid*, p. 47).

Miller (1984) adapts Bhaskar's model "... to serve as a foundation for a human science specifically directed to an understanding of change." (p. 12). He does so by expanding the arrows of "socialisation" and "reproduction/transformation" into a "... third dimension ... generated by, or abstracted from, the primary datum of the social and individual domains", which serves to explicate further the relationship between the two domains or dimensions (*Ibid*, p. 12). From the social domain he abstracts a set of *roles* prescribed by the existing social forms. (These

abstracted roles are called "actors"). From the individual domain he abstracts the concept of a *group* from the plurality of individuals.

"It is at this (third) level that Bhaskar's insistence that people and society should not be regarded as forming a dialectical unity becomes significant. Theories about social forms and individual agents cannot be related directly .... It is only in the context of action that the four analytical categories of social, actor, individual and group acquire a functional quality that animates the model .... The dialectic resides in the process whereby an individual engages in a role prescribed by a social form, or alternatively, a social form is expressed in a group of individuals. The two unitary processes may be understood as mind and culture. What this model asserts is that the terms 'mind' and 'culture' should be understood as mind-in-action and culture-in-action." (*Ibid*, p.14).

It is this *action* link between the ontologically distinct social and individual domains which qualifies Miller's expansion of Bhaskar's model as a conceptualisation of the mind-culture relationship that takes account of change.

Not only does the experimental approach's view of mind and culture as independent entities preclude the investigation of change. Its ahistorical perspective does this too. Luria stresses that it is important to situate the mind-culture relationship historically.

"It seems surprising that the science of psychology has avoided the idea that mental processes are social and *historical* in origin." (Luria, 1976, p. 3).

The cultural relativist viewpoint which looks at differences *between* cultures, at *any one given time* is unable to accommodate the ever-changing nature of mind and society. The problematic nature of this position is evident in the LCHC's contention that all cultures are "... equally effective in producing ways of dealing with the problems of survival under unique patterns of constraint." (LCHC, 1982, p. 710).



Miller (1984) points to the flaw in this claim.

"If ways of 'dealing with the problems of survival' are 'equally effective' then the question as to why culture or mind would bother to change remains an enigma." (P. 3).

So, it does!  
Why is an engine a flaw?

Not only do the LCHC and Cole fail to accommodate the possibility of change within a society, they also lack insight into the essence of change/development in an individual's life-span. In a later section it will be argued that the essence of development is the child's confrontation with contradictions - between the familiar and the unfamiliar, and the old and the new. Their method of making comparisons between children of different cultures on familiar tasks can at most tell us about the specific performance of particular children, and nothing about the longitudinal development of generalised competencies in the life-span of the individual child.

This stress on the importance of change points to the inadequacy of Cole's focus on *manifest* performance. In the establishment of his theory of the mind-culture relation, Vygotsky argues that cognitive processes are often the product of a long history of social transformations which may have become "fossilised" or mechanised over time. "Their outer appearance tells us nothing about their internal nature." (1978, p. 64). Based on the assumption that the development of cognitive processes in one individual's life follows the same course as the historical development of these processes from generation to generation within a culture over long periods of time, he argues that the best mode of access to behaviours that have become fossilised in the history of a culture is to return to their source in the development of the individual and reconstruct them as they are manifested in her/his performance.

"The fossilised form is the end of the thread that ties the present to the past, the higher stages of development to the primary ones." (*Ibid*, p. 64).

The study of the evolution of the structures underlying performance becomes a better mode of access to the problem of the mind-culture issue: development becomes the arena for insight into the "inner nature" of the mind-culture relationship embedded in a particular behaviour.

The focus away from manifest performance towards a historically situated view of the generative processes underlying performance entails a shift of emphasis from analysis of psychological process as fixed, stable objects to "... analysis of processes, which requires a dynamic display of the main points making up the processes' history." (*Ibid*, p. 61). The basic task of research becomes a reconstruction of each stage in the development of the process: the process must be turned back to its initial stages.

In the developmental paradigm each manifest performance is seen as a moment in the developmental history of the individual.

"The significance of these states lies not in their manifest form but in the comparison of successive states as they become transformed within a unitary developmental sequence." (Miller and Craig, 1984, p. 6).

Having excluded the possibility of viewing mind and culture as separate systems and then systematically varying culture to observe the effect on cognition, the developmental method prefers to look at particular examples of the unitary mind-culture system in action within a particular culture. The research problem then becomes not how mind varies as a function of culture, but how the two phenomena simultaneously react to and generate each other in the process of their mutual transformation.

In this new frame of reference cross-cultural psychology becomes *not* the comparison of how people in other cultures do *their* tricks - as advocated by the exponents of cultural relativity. Within the developmental paradigm the issue is to understand how we do *our* tricks (Miller, 1984). We look to other cultures simply because we may be so enmeshed in our own frame of reference that we are unable to see the way in which mind and culture interact in every aspect of our experience.

"There is only one way of seeing one's own spectacles clearly: that is to take them off. It is impossible to focus both on them and through them at the same time." (Toulmin, quoted in Miller and Craig, 1984, p. 14).

Thus whereas the experimental paradigm is predominantly cross-cultural, development being of secondary interest, the developmental paradigm focusses predominantly on development, its cross-cultural aspect being a methodological strategy to "take off one's spectacles."

2. TOWARDS A THEORY-METHOD OF CHANGE: PIAGET AND VYGOTSKY

Two problems with the experimental method are particularly relevant to this study: the problem of task equivalence, a methodological issue, and the learning paradox, a conceptual issue. The work of Piaget - probably the greatest exponent of the developmental method - takes the first steps towards an approach that avoids these pitfalls. In a later section it will be argued that, with regard to the learning paradox, Piaget fails to take his insights far enough, and we turn to Pascual-Leone for a theory-method which better accommodates Piaget's seminal insights.

### 2.1 The problem of task equivalence

The problem of task equivalence arises as a direct result of traditional cross-cultural psychology's assigning of mind and culture to different sides of the  $M = f(C)$  equation as dependent variable and independent variable respectively. If the independent variable, culture, is systematically varied, the nature of the task must remain constant in order to draw conclusions about mind. If the variation in the independent variable consists of subjects from different cultures, the task must be equally familiar to each group of subjects in order to draw conclusions about the performance across these different groups of subjects. For example, if one compares the performance of children from the Namib desert to Eskimo children on snow-survival techniques, the fact that Eskimos perform better doesn't point to the fact that Eskimos have superior abilities to Namibians, but simply that the Namibians are less familiar and less experienced at snow-survival.

The problem of establishing tasks that are equally familiar in the cultures to be compared is widely acknowledged (Cole and Means, 1981; Brislin *et al.*, 1975). The LCHC refers to this problem as "... the conundrum blocking cross-cultural comparisons", and one which is "... at

the heart of methodological disputes in cross-cultural research." (1982, p. 687).

This problem is not an issue for a methodology that looks at change *within* a culture rather variation *between* cultures (Miller, 1984). Piaget, instead of regarding mind and culture as separate systems, and then looking at variation in performance *between* cultures, looks at mind and culture as two aspects of a unitary system, locked in an ongoing process of mutual transformation.

One of Piaget's most important contributions to developmental psychology is his insight that this transformation process consists of overcoming constraints which take the form of old familiar ways of looking at the world - in favour of increasingly sophisticated and unfamiliar ways.

"Non-balance ... produces the driving force of development. Without this, knowledge remains static .... It is therefore evident that the real source of progress is to be sought in both the insufficiency responsible for the conflict and the improvement expressed in the equilibration." (Piaget, 1977, p. 13).

Piaget's insight in developmental psychology is similar to the Marxist insight that contradiction or conflict and its resolution, is the fundamental mechanism at work in the process of history or change. "The given state of affairs is negative, and can be rendered positive only by liberating the possibilities immanent in it" (Marcuse, 1973, p. 315). The essence of transformation or change is the resolution of contradictions (Georgoudi, 1983).

In order to examine the overcoming of constraints - or how children proceed to master the unfamiliar - it is necessary to use unfamiliar tasks as the process of development consists of the child's successful

confrontation of increasingly complex unfamiliar tasks: unavoidable milestones along the journey to competent adulthood.

Not only must the tasks be unfamiliar, they should also be misleading, according to Miller.

"The key to Piaget's method lies in his extraordinary insight ... that young children consistently give wrong answers to certain kinds of questions. The young child's understanding of the world is constrained by a reliance on familiar but misleading perceptual cues. When children are able to overcome the compelling nature of these cues, change or development occurs." (Miller, 1984, pp. 17 - 18).

Thus the problem of establishing task equivalence is a non-issue for the developmental approach. In the light of these observations, the experimental method of testing how well children can do the things they know how to do is shown up as an ineffective tool for investigating development.

## 2.2 The learning paradox

"The subject's production of a given acquired behaviour is frequently attributed to previous learning even though (i) the behaviour in question has never before been produced by the subject, (ii) such a behaviour is complex and improbable enough not to have been produced by 'chance'." (Pascual-Leone, 1976c, p. 94).

Explaining cognitive development or mind in terms of culture or learning as Cole and the LCHC do leads to the learning paradox: It is not possible to explain a child's spontaneous solution of a problem for the first time in terms of learning - for the child cannot *know* how to solve the problem unless she/he has *learned* how to do it already.

To avoid this paradox, some factor other than learning must be posited to

account for what Pascual-Leone calls the truly novel performances, that is

"... behaviour which is neither mere transfer of learning or novel integration of pre-existent learned units, nor innately determined." (*Ibid*, p. 94).

Truly novel performance entails the child's overcoming and compelling nature of familiar but misleading cues, in favour of more complex and unfamiliar cues more appropriate to the task at hand - and this process constitutes development.

In the following sections the views of Piaget and Vygotsky are discussed. Both posit a maturational developmental factor in dynamic interaction with learning. They refer to this factor as "development".

### 2.3 Piaget on Learning and Development

At the outset it must be emphasised that Piaget was an epistemologist rather than a child psychologist. His primary concern was the development of logico-mathematical thought, and not the development of children - he was interested in children only insofar as they threw light on the problem of the genesis of knowledge. Piaget sees the development of knowledge as the evolution of increasingly complex psychological structures: the emergence of which coincides with developmental stages in the child's life. At each stage there is an extension, reconstruction and surpassing of the structures of the preceding one.

The integration of successive structures, each of which leads to the emergence of the subsequent one, makes it possible to divide the child's development into stages and sub-stages which can be characterised as follows: (1) Their order of succession is constant, although the average ages at which they occur may vary with the individual according to his/her



degree of intelligence or with the social milieu. (2) Each stage is characterised by an overall structure in terms of which the main behaviour patterns can be explained. (3) These overall structures are "integrative and non-interchangeable". Each stage results from the preceding one, integrating it as a subordinate structure, and prepares for the subsequent one, into which it is sooner or later itself integrated (Piaget and Inhelder, 1969, p. 72).

Pascual-Leone characterises Piaget's method as the search for genetic-epistemological sequences. Such a sequence is defined as "the congruent pairing of a psychogenetic and psycho-logical sequence", where:

- i) a psychogenetic sequence is a sequence of tasks obtained by ordering the tasks in terms of the developmental trace shown by the performance score they elicit from different age-group samples; and
- ii) a psycho-logical sequence of tasks is obtained by ordering the tasks according to psycho-logical inclusion relations, that is, task B is ordered after task A whenever its underlying constructive process presupposes the constructive process of A (Pascual-Leone *et al.* 1980, p. 266).

Progress from stage to stage involves the child's acquisition of increasingly complex psycho-logical structures. The regulatory process which is responsible for the child's transition from stage to stage, constituting cognitive growth, involves the two processes of learning and development, and their integrating principle - the internal regulatory principle which Piaget calls equilibration.

According to Piaget, development is a spontaneous process linked to embryogenesis, and learning is provoked by external situations. Piaget

outlines four general factors involved in mental development: The first three factors are organic growth, experience and social transmission.

Organic growth is the biological maturational component of development, internal to the individual, which opens up possibilities for development. These possibilities are "reinforced" through experience and social transmission - the "learning" components of development external to the individual. The effect of these three factors are integrated by a fourth factor: equilibration, a dynamic force that serves to produce successive states of equilibrium within the cognitive system.

Piaget described equilibration as

"A process of equilibrium, in the sense of self-regulation; that is, a series of active compensations on the part of the subject in response to external disturbances and an adjustment that is both retroactive (loop systems or feedbacks) and anticipatory, constituting a permanent system of compensations." (Piaget and Inhelder, 1969, p. 74).

Central to the notion of equilibration are the processes of accommodation (the adaptation of internal cognitive structures to incorporate external elements or events) and assimilation (the incorporation of external elements or events into already existing internal cognitive schemes). Equilibrium maintains an organised balance of reciprocal assimilation and accommodation and compensates for internal and external imbalances, and in so doing reaches ever more advanced stages of organisation; in other words bringing about progress from one developmental stage to another.

Piaget (1977) details three different forms of equilibration. The first is the fundamental interaction of subject and objects, of the subject's intrinsic generative structures and the external world. This is "... the equilibration between the assimilation of schemes of action and the

accommodation of these objects." (p. 9). The second form involves the interaction of the resulting sub-systems, and the third involves the establishment of a hierarchy of these sub-systems in relation to the totality of the subject's knowledge about the world.

Piaget outlines the interaction of development and learning thus:

"Maturation, as regards the cognitive functions, simply determines the range of possibilities at a specific age. It does not cause the actualisation of structure. Maturation simply indicates whether or not the construction of a specific structure is possible at a specific age. It does not itself contain a preformed structure, but simply opens up possibilities - the new reality still has to be constructed." (Piaget, 1970, p. 193).

It is the equilibration processes, mediating between maturation on the one hand, and experience and social transmission on the other hand, that engineer this construction of reality.

The concept of equilibration points to the mental structures and functions that generate intelligent behaviour, through the successive stages that constitute the development of logico-mathematical thought. For this reason Piaget's theory of equilibration can be interpreted in terms of intrinsic generative mechanisms (Craig, 1985).

The focus on generative mechanisms is the first requirement for an adequate theory of change. The second requirement is also accommodated by the theory of equilibration: the necessity of viewing change in terms of the ongoing resolution of successive contradictions.

"The internal reinforcements we call equilibration or self-regulation are what enable the subject to eliminate contradictions, incompatibilities and conflicts. All development is composed of momentary conflicts and incompatibilities which must be overcome

to reach a higher level of equilibrium." (Piaget and Inhelder, 1969, p. 78).

Pascual-Leone (1980) provides a concrete example of the cognitive conflict present in Piaget's substance conservation task<sup>1</sup> - an example of a misleading situation containing potential error factors which must be overcome by the developing child in order to correctly solve the task. The two error factors that operate here are:

- 1) an overlearned habitual structure that equates the size of the perceptual surface with amount of substance.
- 2) the tendency of the child to respond to the dominant perceptual features of a situation rather than tackling it on a conceptual level.

"These error factors turn conservation tasks (and many other problem-solving situations) into mental teasers or (unconscious) cognitive conflicts where the correct solution (strategy X) to the problem must assert itself, if it can, against the strong interference provided by error-factor-facilitated wrong solutions (strategies Y)." (*Ibid.*, p. 273)

It is the equilibration process that enables the variety of X strategies mastered by the developing organism to prevail over the Y strategies.

However, although Piaget's method seems to offer the possibility of a theory of development that adequately accommodates the notion of change, two criticisms have been levelled at him which are of particular relevance to this study. The first criticism often levelled against Piaget's notion of equilibration is its limited "explanatory scope" (Moessinger, 1978, p. 264). Rowell (1983) described equilibration, the hard core of Piaget's programme, as an "article of faith", simply accepted by Piagetians as a necessary foundation for their formulations, and never adequately explicated. The next chapter will examine Pascual-Leone's critique of the

notion of equilibration as an incomplete explanation of the process of change in the developing child. He argues that although Piaget takes important steps towards solving the learning paradox, and the problem of truly novel performance, he does not effect such a solution. Pascual-Leone seeks to "stand on Piaget's shoulders", using his insights as guidelines for a neo-Piagetian programme better equipped to deal with change. It is this programme that guides the present research.

The second criticism of Piaget deals with the fact that although he acknowledges the importance of social and cultural factors (Piaget, 1966), his theory does not attempt to explain *how* these factors influence development. He looks at the *intrinsic* psychological processes that generate performance, simply taking as given that it occurs in a social context (Craig, 1985). This review now turns to Vygotsky's notion of the interaction between learning and development, with a view to examining his focus on the constraints *external* to the individual which govern cognitive development - a focus which complements Piaget's focus on internal generative mechanisms (*Ibid*).

#### 2.4 Vygotsky on Learning and Development

Like Piaget, Vygotsky sees development as the integration of learning and maturational elements. However, his emphasis is different from Piaget's. Piaget focuses on the individual constraints on development. His interest lies in the epistemic subject, which Craig (1985) defines as "... the description or explanation of the human potential to construct logico-mathematical knowledge, and the development of the necessary structures and the functions for this." (*Ibid*, p. 27). In spite of his acknowledgement that learning plays an important role in development, Piaget's main focus is on the "processing organismic constraints" of the

subject and his methods "... minimise learning and maximise conceptual problem solving, while generating a large family of often interrelated genetic-epistemological sequences." (Pascual-Leone, 1980, p. 267). Thus Piaget is interested in the universal capacities of individuals to acquire the structures of logico-mathematical thought. These are conditions internal to the individual, "... those characteristics that the structures of all subjects of the same developmental level have in common." (Vuyk, 1980, p. 52).

Vygotsky's focus, by contrast, is on "Mind in Society", the title of his important work (1978). He looks at development not in the context of the epistemic subject, but of the social actor, defined by Craig as follows :

"The social actor is an individual who acts, and is socialised to act, in a particular socio-historical context ... who must meet the demands of a reality which already exists in some form before that individual life can take its course." (Craig, 1985, p. 13).

For Vygotsky psychological functions appear first *inter-psychologically* or between people - initially the child is regulated from outside by some informed other person, usually the mother. Only later are these functions internalised as *intra-psychological* functions. Thus whereas in Piaget's theory equilibration plays the central role in cognitive growth, mediating between learning and development, and steering the child from one stage to the next, in Vygotsky's theory culture becomes the steering principle of regulation. For Piaget the process of regulation is an internal, biological process. For Vygotsky it is a social process, involving an external mediator.

According to Vygotsky, the interaction between learning and development, or between child and adult, takes place in the "Zone of Proximal

Development". This is the distance between the "actual developmental level" or functions which have already matured (end products of development) and the "level of potential development" or functions which are currently in a state of formation and can be exercised under adult guidance. Thus this Zone defines those functions which "... are in the process of maturation; functions that will mature tomorrow but are currently in an embryonic state ... the 'buds' or 'flowers' of development rather than the 'fruits' of development." (Vygotsky, 1978, p. 86).

Thus in reconstructing the origin and course of development, Vygotsky's theory points towards the notion of instruction, or cultural transmission, as the interface between mind and culture. Learning awakens a variety of internal developmental processes which operate only when a child is interacting with other persons in his/her environment. These processes are internalised and thus does development occur.

"Properly organised learning results in mental development, and sets in motion a variety of developmental processes that would be impossible apart from learning ... developmental processes do not coincide with learning processes. Rather, the developmental process lags behind the learning process; this sequence then results in zones of proximal development." (*Ibid*, p. 90).

The zone of proximal development is thus the interface between mind and culture, in the sense that it is here that mind and culture interact. Vygotsky regards it as "... the fundamental unit of a psychology that is essentially human and intrinsically social." (Miller and Craig, 1985, p. 3). Vygotsky's mode of access to this interface is what he calls his experimental-developmental method, which "... artificially provokes or creates a process of psychological development." (1978, p. 61). This method aims to expose the processes that generate development or change by reconstructing the processes that regulate the mind-culture transactions

within the zone.

Vygotsky discusses the zone of proximal development in the context of school learning, pointing to the idea that "schooling is a social institution that artificially provokes and creates psychological development; artificial in the sense that it is not a natural phenomenon, but a human or cultural artifact." (Miller and Craig, 1985, pp 6 - 7).

## 2.5 The Theory-Method of Rational Reconstruction

Vygotsky's focus on the external ("learning" or "culture") constraints on the social actor, Piaget's focus on the internal ("mind" or "development") constraints of the epistemic subject may be regarded as parallel to Bhaskar's social and psychological dimensions respectively. In this light they are the two moments of his "linking science of socio-psychology" unfolding in the transformational (Bhasker, 1979) or transactional (Miller, 1984) interaction between the cultural and cognitive systems.

The means of access to these transformations or transactions is already implicit in the respective theory-methods of Piaget and Vygotsky. This section spells out more explicitly the notion of generative mechanisms or enabling conditions. These are the "deep structures" of the unitary mind-culture system at the heart of these transformations or transactions which are responsible for the manifest performance of the developing child. It is these generative mechanisms that constitute change, and which are elaborated by Pascual-Leone in his explication of Piaget's notion of equilibration in terms of generative and psychogenetic constructivity (Pascual-Leone and Goodman, 1979) which together constitute the ability of the psychological organism to undergo change.



Chomsky coined the term "generative" to describe the structures of his "transformational grammar", the system of deep structures underlying language.

"Though the surface structures of languages differ Noam Chomsky and others claim that the 'deep structure' underlying them is to a large extent common. Transformational grammar has as its task the uncovering of the deep structure of language, and the rules according to which this structure is transformed into the surface structures of various languages." (De Georges and De Georges, 1972, p. xx).

Harre and Secord (1972) outline a methodology to investigate the deep structures of human behaviour in a social context. Their aim is to provide "a methodology out of a general theory of social action and its genesis", as an alternative to the experimental or positivist approach which is still adhered to in many circles "long after the theoretical justification for it, in naive behaviorism, has been repudiated." (p. 1).

Harre and Secord look to the methodology of the advanced sciences and find two pointers which guide them in their search for a more appropriate methodology for the social sciences. The first pointer is the notion that the scientist's task is the rational explanation of non-random patterns through the discovery of the mechanisms that generate such patterns.

"There is no simple route to discovering such mechanisms. Some may be simply inspected; others are only quasi-accessible. But in the first instance, our ideas of most generative mechanisms come from a disciplined use of the imagination. The use of analogy through the key concept of model is important here, for it is analogies which control the imagination so that models are plausible analogies of the unknown, causal mechanisms that produce the known non-random patterns of phenomena," (Harre and Secord, 1972, p. 6).

The second pointer is the perception that modern physics is increasingly based on the conceptions of power and potentialities, which can also be

applied to humans. The ascription of a power to a person or thing involves the notion of *enabling conditions* which produce a state of "readiness" for the exercise of the power or potentiality. Intrinsic enabling conditions are marked off from other circumstances surrounding the possession and exercise of powers because of their "... connection criteria of identity of the individuals who have the powers - thus, powers are related to the essential nature of things and people." (*Ibid*, p. 6).

The ascription of powers is characterised in the following formula:

If  $C_1, C_2, C_3, \dots, C_n$ , then B, if N.

C refers to circumstances in the environment which make a behaviour possible, B represents the behaviour, and N the intrinsic enabling conditions (*Ibid*, p. 18).

For the purposes of this review, these intrinsic enabling conditions (N) may be interpreted as the internal constraints of Piaget's epistemic subject. C then becomes the extrinsic constraints on Vygotsky's social actor, or the extrinsic enabling conditions. In this framework the task of the psychologist becomes the identification of the intrinsic and extrinsic generative mechanisms that are united in the process of development, and which are the vehicles of change.

According to Harre and Secord, the search for generative mechanisms should lead the researcher "... in social life to find a 'deep structure' something like the deep structure Chomsky finds in language." (*Ibid*, p. 12). It is in the deep structures of mind and culture locked in a process of generative constructions (in Bhaskar's transformational dimension, or Miller's transactional dimension), which must be explicated in order to comprehend development. Pascual-Leone's work is an attempt at a "rational

reconstruction" (1976c, p. 90) of the intrinsic generative mechanisms.

Bhaskar (1979) suggests that the most fruitful way to investigate the generative mechanisms responsible for change is to look at societies involved in rapid social change, because "... in period of transition or crisis generative structures, previously opaque, become more visible." Such an approach provides "... a partial analogue to the role played by experimentation in natural science." (p. 61).

It is this rationale that informs the present research's choice of Zulu-speaking schoolchildren, performing an unfamiliar and western-orientated task (the FIT), as a means of access to the generative mechanisms of mind and culture interlocked in the process of development. Along the lines of Vygotsky's experimental-developmental method it attempts to artificially provoke or create a miniscule process of psychological development - the acquisition, through experience, of the executives necessary for successful performance on the FIT, and in so doing support Pascual-Leone's hypothesis about the interaction of learning/culture (in this case the acquisition of the particular executives necessary for success on the FIT) and development/mind (a developmental, maturational M-factor). This hypothesis is dealt with in detail in the next chapter.

Craig and Miller (1984) refer to the encounter of Zulu-speaking African children with the requirements of a "western-industrialised-urban-technological-schooled society" as part of the process of resolution of African and western forms, through socialisation and transformation (terms from Bhaskar's model discussed earlier).

"Formal schooling is an example of a western social form that is valued throughout Africa. A major highway to western technology is through the school system and those that travel this route have the

option to select those aspects of western culture that are useful and to reject what may be inappropriate in other situations. But many children throughout the world become 'victims' of this historically recent and unique system of transmitting information. Psychology is painfully aware of its limited contribution to understanding the enabling conditions that ease the way for children to adapt to this foreign agency." (Craig and Miller, 1984).

The present research is an investigation of these enabling conditions, motivated by the notion that insight into their structure and functions must inform any attempt to transform the learning environment of children and the school system, to better facilitate school performance.

NOTES: CHAPTER 2

1. In the substance conservation problem two balls of plasticine of identical shape and size (A and B) are shown to the child. Then ball B is rolled on the table into a sausage-like shape  $B_1$ . The child is asked whether or not the amounts of substance found in A and  $B_1$  are equal. This problem is generally solved at about 7 years of age. (Pascual-Leone, 1980).

3. PASCUAL-LEONE'S THEORY OF CONSTRUCTIVE OPERATORS: A THEORY-METHOD OF CHANGE

Pascual-Leone uses the ideas of Piaget as the foundation stone for his Theory of Constructive Operators (Pascual-Leone, 1970, 1976a, 1976b, 1976c, 1976d, 1976e, 1978, 1980, Pascual-Leone and Goodman 1979, Pascual-Leone *et al* 1978, Pascual-Leone and Smith 1969, Pascual-Leone and Sparkman, 1980). He speaks of two aspects of Piaget's theory (1978):

- 1) his *explicit psychological theory*, encompassing his characterisation of the stages and equilibration, and
- 2) his *genetic-epistemological theory*, which is "... an *empirically based* constructive rationalist *methodology*, ie, a set of guidelines along which different psychological theories of cognitive and personality development could be built." (2. 244).

He claims that Piaget fails to provide an adequate psychological theory. His account of the stages and equilibration are valid only at the level of *descriptive structural* theory, that is insofar as they refer to empirical invariants in the data base. However, they fail at the *process structural* level, in other words they are incapable of accounting for the step-by-step temporal unfolding of the subject's behaviour (1976c). This means they are incapable of accounting for change, or the developing child's ability for truly novel performance.

For this reason he prefers to include the concepts of equilibration and the stages as part of Piaget's "heuristic" metatheory (Pascual-Leone *et al*, 1978, p. 244) which he adopts as a foundation for his Theory of Constructive Operators (TCO). Considering Piaget's genetic epistemology, his stages and equilibration as a metatheory, allows Pascual-Leone to remain within Piaget's framework while elaborating a new psychological approach. The TCO, his neoPiagetian theory of cognitive development, formulates explicit constructs to account for the step-by-step cognitive

growth which is described by Piaget's logico-mathematical stages and equilibration in very general terms.

"A constructive theory functions as a conceptual gadget capable of simulating the genesis in the subject of his performances, ie capable of deriving these data by means of a 'rational reconstruction' ... which explains the data by way of exhibiting the genesis of their construction." (Pascual-Leone, 1976c, p. 90).

The TCO attacks the problems of truly novel performance by explicating cognitive development in terms of two sorts of constructivity:

- i) psychogenetic constructivity: the developmental capacity to permanently modify the internal organisation of cognitive structures to increase adaptation.
- ii) generative constructivity: the capacity to produce moment-to-moment performances which are truly novel.

Thus the TCO is intended as an expansion of Piaget's structuralist framework into a working model of cognitive development which adequately accounts for change, or "human constructivity" (the organism's ability to synthesise or create truly novel performances using and recombining aspects of past experience, and its ability to permanently modify itself as a result of the new experiences thus achieved). It has been described as "... a model of the psychological organisms which is at work inside Piaget's 'epistemic subject' for each age group" (Pascual-Leone *et al.*, 1978, p. 271).

Pascual-Leone pinpoints two deficiencies in Piaget's system. The first is the attempt to make one descriptive-structural model, equilibration, the cause (ie the generative *and* psychogenetic constructive model) of the



other descriptive structural mode, the stages, when in fact "both co-exist as structural aspects of the data base" (1980, p. 275). The second is "... the attempt to make the stage models (ie the abstract categorical descriptions of molar empirical invariances) into causal determinants of performance" (*Ibid*, p. 275). Symptomatic of these deficiencies is Piaget's failure to differentiate between learned habitual cognitive structures and those structures that result from the equilibration processes - truly novel performances, and the spontaneous construction of correct performances for logical-structural tasks such as conservations when they are solved for the first time. On this first time performance cannot be explained in terms of a learned habitual structure without falling into the snares of the learning paradox.

To resolve this paradox, Pascual-Leone posits situation-free organismic factors or "constructive operators", which he calls silent operators. These factors are process-structurally different to Piaget's cognitive structures or schemes. Through their dynamic effect on schemes, these organismic factors, in interaction, account for the developing child's constructivity.

In the light of Piaget's description of cognitive growth, novel performance is seen as an integration or co-ordination of existing learned or innate structures or schemes. Pascual-Leone, on the other hand, speaks of *truly* novel performance which transcends already learned knowledge, and represents a qualitative break from already learned schemes in the sense that the integration is the result of a higher form of abstraction than the integration underlying novel performances (Craig, 1985). A truly novel performance is neither the result of applying a habitual (ie learned or innate) structure or scheme nor the result of a novel integration of habitual learned structures by means of a habitual integration-rule

structure which is situation-specific.

"In a truly novel performance the integration of habitual schemes occurs serendipitously, without a habitual rule-integration scheme, as a result of hidden interactions among situation-free organismic processes - the silent operators and basic principles." (Pascual-Leone and Goodman, 1979, p. 308).

Craig ascribed the possibility of this serendipitous achievement of truly novel performance to the power of the metasubject's intrinsic generative mechanisms "... to achieve greater levels of abstraction than are available in the immediate data from action performed on objects and the integration from knowledge thus gained." (1985, p. 77).

Pascual-Leone's theory of the functional structure of a metasubject - which adequately explicates the metasubject's ability to overcome the constraints of learning from past and present contexts to achieve truly novel performance - qualifies as an adequate model for a general psychological theory of change (Craig and Miller, 1984).

The most important situation-free organismic process, which plays a pivotal role in truly novel performance is the M-operator, the reserve of mental energy which increases quantitatively in power with age. The M-operator originated as a deductive/inductive inference stemming from analyses of the informational complexity of Piagetian tasks (Goodman, 1979, p. 2). These analyses revealed a quantitative pattern in the transition from one qualitative Piagetian stage to another. Tasks typically solved at a particular substage of development were found to be of the same "dimensionality", that is they involved the consideration and co-ordination of the same minimum number of schemes. This suggested the M-operator to Pascual-Leone: a mental energy mechanism that determines the

attending to and integration of task-relevant information. As the power of M increases the number of schemes the child can apply increases and hence more complex problems can be solved. Thus with suitable experience/learning quantitative growth leads to qualitative change from one developmental stage to the next. M imposes limits to learning, and increases in M make structural cognitive growth possible. However M alone does not *cause* this growth as suitable experience is also necessary.

Pascual-Leone offers the silent operators as a solution to the stage transition problem in Piaget's theory which is inadequately explicated by the notion of equilibration. They are posited as the quantitative element underlying the equilibration process which carry the child from one stage to the next. The developmental growth of M is the "transition rule" for passing from one Piagetian cognitive stage to the next" (Pascual-Leone and Goodman, 1979, p. 319).

"The ability to cope with increasing informational complexity is for Piaget a by-product of the main developmental factor - the structural stage level attained by the child. Pascual-Leone, by contrast, proposes that quantitative increases in the ability to cope with informational complexity are primary and these increases (together with experience) *generate* structural growth" (Goodman, 1979, p. 4).

The growth of M is seen as a maturational process, working in intimate interaction with experience. It must be stressed that M is simply a store of energy. M does *not* constitute the structure in itself. Its quantitative increase simply opens up the possibility of the development of a more complex structure as the child progresses from one stage to the next. This possibility is actualised by the interaction of the other silent operators and schemes which are boosted by M. This process will be the subject of a later section.

### 3.1 The Three Principles of the TCO

Pascual-Leone's view of the developing individual on which the TCO is based can be formulated in three principles:

- (1) the Principle of Assimilatory Praxis;
- (2) the Principle of Equilibration; and
- (3) the Principle of Bilevel Psychological Organisation.

He refers to the psychological organisation of the developing child as the *metasubject* or "... the silent (unconscious) organisation of functional structures or 'psychological machinery' underlying the subject's activity" (Pascual-Leone and Goodman, 1979, p. 303).

#### 3.1.1 Principle of Assimilatory Praxis

The metasubject is a highly active organism which engages in praxis, or goal-directed activity, addressed at the subject's external world. Situation-specific activities have an external referent and are manifestations of *schemes* or *subjective operators* stored in the metasubject. The notion of schemes is taken from Piaget and refers to an organised set of actions which can be transferred from one situation to another, by assimilation of the second to the first. Assimilation refers to the "rushing-to-apply" tendency of schemes: unless prevented by some incompatible and dominant scheme, they will rush to apply in accordance with their rules under minimal conditions of satisfaction (Pascual-Leone *et al.*, 1978, p. 269).

Pascual-Leone's extension of Piaget's notion of schemes concerns the problem of how choice among schemes is possible. How does it come about that a dynamic choice takes place within the metasubject, leading some

schemes to apply and stopping many others from doing so, rather than the metasubject simply "jamming" up with a multiplicity of schemes rushing to apply under minimal conditions of satisfaction? The choice between schemes is determined by *silent operators*, the set of organismic factors hidden (ie silent) inside the organism. These silent operators determine which of a potentially applicable range of schemes should apply by boosting or weighting relevant schemes, and inhibiting or de-boosting the application of others.

"The subjective operators and silent operators which comprise the metasubject together construct (ie cause) the praxis of the subject" (Pascual-Leone and Goodman, 1979, p. 304).

### 3.1.2 Principle of Equilibration

Pascual-Leone (Pascual-Leone and Goodman, 1979, p. 304) reformulates Piaget's principle of equilibration as the metasubject's tendency, as a result of its activity, to spontaneously undergo enduring structural changes that pursue three goals:

"(a) *maximise the internal consistency* among its functional parts, (b) *maximise adaptation* (functional payoff) in its dealings with the environment, ie maximise the number of different *types of* situations with which the organism can successfully interact without having to learn (ie to change its internal structures), and (c) *minimise internal complexity* (organic structural cost) in its organisations, ie organise its psychogenetic and generative constructive processes in such a manner that (a) and (b) are satisfied with a minimum of learned and innate resources" (*Ibid*, p. 304).

In the Piagetian tradition, (a) is a substantive organismic disposition that increases with development. Sub-principles (b) and (c) account for i) the generative constructivity of the metasubject in its "here and how" adaptation - its ability to produce generative constructions or truly

novel performances from its constituents; and ii) the psychogenetic constructivity demonstrated by the metasubject in its learning and development - its engagement in structural growth (differentiation and coordination of structures) which cannot be predicted by its generative constructive capability alone, nor by maturation alone, but as a result of the dialectical interactions between them (*Ibid*).

It is to explain sub-principles (b) and (c) that the TCO posits the silent operators. These are discussed in the next section.

### 3.1.3 Principle of Bilevel Psychological Organisation

The schemes or subjective operators and the silent operators form two levels of the metasubject. These levels are strongly hierarchically organised in two, functionally and structurally different interacting systems.

"The first level or *subjective system* is constituted by situation-specific constructs (organismic *schemes*) which apply on the input to categorise and/or modify it: the second-level or *silent system* is constructed by situation free *metaconstructs* (basic *factors* and basic *principles*) which apply on the first-level constructs (not on the input) to modify their activation weights (ie assimilatory strength) in accordance with organismic requirements" (Pascual-Leone and Goodman, 1979, p. 306).

Whereas the metasubject's repertoire of schemes form a "situation-specific semantic-pragmatic automation", silent operators form a higher-order system organised according to "little-known dialectic or context-sensitive laws" (Pascual-Leone, 1976c, p. 97). Pascual-Leone mentions Freud's principle of unconscious overdetermination of behaviour as a possible analogy for the as yet unexplicated functioning of this system.

### 3.2 The Theory of Constructive Operators

The Theory of Constructive Operators will now be discussed in more detail under the following three headings: 1) Schemes, 2) The field of activation, 3) Silent operators.

#### 3.2.1 Schemes

Through learning the metasubject comes to have a large and ever-changing repertoire of schemes which reflect all sorts of invariances it has encountered in its interaction with the environment. This constitutes the subject's repertoire of permanently stored knowledge units. Pascual-Leone characterises schemes as "semantic-pragmatic" insofar as each one consists of a bundle of pragmatically relevant blueprints corresponding to expectations, actions, percepts, beliefs, plans or affects. For any scheme "... these blueprints can be elicited by features which confirm the scheme as a semantic truth-function would" (1976c, p. 96). Structurally all schemes have the same form: if a set of *conditions* is minimally satisfied by the input from the environment or the subject's internal state, the scheme will tend to apply (unless another more dominant scheme prevents its application). When it applies, the set of *effects* (blueprints) which it carries are used by the metasubject to further or modify its ongoing activities.

There are three different kinds of schemes, distinguished mainly by their effects:

- i) Affective schemes: These generate two sorts of effects : physiological reactions (eg blushing, sweating) and motivational effects (eg fear, ambition). The latter in turn generate affective goals which in turn bring about the activation of corresponding

schemes.

- ii) Cognitive schemes: These include both figurative and operative schemes, which are action schemes which can implement into performance the plan of an executive scheme. Figurative schemes are predicates that have the effect of representing objects and events. Operative schemes have the effect of changing the mental or physical objects they represent.
- iii) Executive schemes: These are epistemologically complex and general operative schemes which specify general-purpose plans of action for procedures to accomplish a given task. These procedures are then implemented through the application of specific task relevant figurative and operative schemes which satisfy their plan.

Executive schemes mediate between motives (affect-defined goals) and other cognitive schemes, co-ordinating their combination and temporal sequence to produce a complex goal-directed performance.

### 3.2.2 The Field of Activation

Regardless of their functional type, from a structural point of view, Pascual-Leone suggests that all schemes are of the same form: they have a releasing component (rc), an effecting component (ec) and a terminal component (tc). The releasing component consists of a set of potential cues or conditions which govern the scheme's activation. When features of an input match at least one condition of the scheme, they *cue* or *release* the scheme. Each condition of the rc causes a "content activation weight" determined in part on the basis of innate saliency factors (ie how salient in a psychophysical sense is the feature matching the condition) and in part on the basis of "learned" saliency factors (ie how important is the



condition to the scheme). The local degree of activation of the scheme is given by the sum of a set of weights of satisfied (ie activated) conditions. This is the TCO's "local cue function rule" for scheme activation (Pascual-Leone and Goodman, 1979, p. 308). The effecting component causes the effect or consequence of the scheme, and the terminal component specifies its outcome, should it be realised.

Any performance produced by a subject results from the metasubjective application of schemes. At any particular moment, a set of schemes from the total repertoire of schemes is active, by virtue of the local cue function. This set of schemes is called the initial field of activation. A distinction needs to be made between the activation and application of a scheme. Not all activated schemes actually produce performance - only those which are compatible and dominant in activation strength come to apply. Each one of these dominant schemes shares in the shaping of performance, while other schemes which are weaker and incompatible will be prevented from applying. This law is called the Principle of Schematic Over-determination of Performance or SOP.

The SOP criterion of dominance is organismically defined. The local cue function rule explains how silent choices are made between potentially applicable schemes in a limited number of cases only. However this rule is obviously not an adequate explanation of truly novel performance which cannot be explained in terms of learned schemes. The initial degree of activation of schemes is modified by the silent operators, and it is the terminal activation weight of schemes, after silent operators have applied, that determines dominance. Silent operators apply on schemes and, via this application, construct the subject's performance.

### 3.2.3 Silent Operators

The TCO proposes seven silent operators in its account of human constructivity: C, L, M, F, I, B, A. The first four will be discussed in this section. They are the most important for the present research as they determine performance on the FIT (Johnson, 1982).

#### The learning operators: C and L

The TCO posits two types of learning: C (content) learning, which corresponds to Piaget's notion of empirical experience, and L (logical or structural) learning that corresponds to Piaget's notion of logico-mathematical experience (Pascual-Leone *et al*, 1978). C and L learning account for the differentiation of schemes through experience, and the corresponding C and L operators formalise the increase in assimilatory power that a scheme derives as a result of its differentiation. C learning takes place whenever a single scheme differentiates by expanding its set of conditions and/or effects, thereby increasing its activation weight, or effectiveness as a scheme booster.

This expansion may take place by means of i) incorporating previously non-schematised figurative or operative properties into the scheme's rc or ec, or ii) the main scheme assimilating some functionally related scheme of a lower assimilatory strength (ie the main scheme incorporating the rc's and/or ec's of a subordinate scheme).

Compared to C learning which involves no change in epistemological level, L learning creates "super-schemes" which reflect structural relations among constituent schemes. It does not replace the constituents, but rather carries information about their interrelationship - which no particular constituent could contain.

There are two types of L learning: L structuring by overlearning (LC learning) and L structuring via M boosting (LM learning). LC learning occurs through repeated exposure to a situational invariant, ie a set of schemes standing in a particular structural relationship to one another. This exposure leads to repeated co-activation of the functionally related schemes. All the schemes involved come to acquire equally high assimilatory strength, and slowly come to assimilate each other, forming an LC structure. LC learning is slow, and results in structures that are functionally interlocked with the schemes that led to their formation. As a result they usually are not used independently of context.

LC structures constitute the subject's repertoire of experiential knowledge or empirical experience, and weighting of LC structures will facilitate performance where previous learning is relevant to the task solution. However, they may hinder the solution of a task requiring a novel approach. LC learning is continuous and cumulative. The LC repertoire will expand slowly with the subject's increased and repeated exposure to a variety of contexts. Thus the developmental course of the LC factor is smooth and gradually incremental within a stage (Goodman, 1979).

LC learning is often tacit, taking place latently and without mental effort (that is, without the application of M boosting to the schemes involved). Pascual-Leone and Goodman (1979) cite instances of LC learning where the "invariant" to be learned is too complicated to be consciously analysed - such as Bruckner's Music Style, for example. The activation weights of the schemes constituting the invariant are initially not equal because their interrelationship is too complex to be worked out by executives, and boosted by M. However with repeated exposure to these schemes they gradually come to be equally strongly boosted, and an LC structure is formed. "By repeated exposure to the same situation the

network of C schemes should become denser and denser until, after some time, a conglomerate of LC structures would start developing" (*Ibid.*, p. 343).

In contrast, LM learning takes place when the subject is mentally aroused. A set of schemes is simultaneously and repeatedly boosted by M, and a superscheme is formed which reflects them all. This learning is rapid, and detached from context, resulting in very generalised structures reflecting trans-situational invariances. The superscheme is functionally equivalent to the schemes comprising it, and may replace them in subsequent mental processes with a reduction in required mental energy. Executive schemes are formed by way of LM learning.

LM learning is recursive (ie the LM learning process may apply on the superschemes themselves to create superschemes of superschemes, and so on). Its recursive nature, and the combinability of LM and LC structures may lead to the formation of overlearned LM structures called LM/LC structures - automatised mental operations that can be carried out without the intervention of M. These LM/LC processes have the effect of lowering the M-demand of a task.

"They are of major significance for development and learning, and make accessible to the M-power of children (and adults) previously inaccessible solutions" (Pascual-Leone and Goodman, 1979, p. 347).

There is a developmental ceiling to the quantitative complexity of structures which may be abstracted and schematised via LM learning. This learning is limited by the M power available to the subject at his/her particular developmental stage (Goodman, 1979).

### The F operator

The F operator is the content-free subjective cognitive field factor which corresponds to the tendency to structure performance so as to create a cohesive (holistic) and subjectively salient representation of a situation. It applies both early and late in any processing step. In its initial application it provides the cues of schemes in the field of activation with their innate sensorial saliency, and is known as F<sub>s</sub> (sensorial F). Later, after all the other silent operators have applied on the field of activation, F serves to boost schemes which generate the most economical and structurally cohesive representation of a situation. Here it is known as F<sub>p</sub> (processing F).

F will tend to correct performance in situations where perceptually salient aspects are relevant for task solutions. Such situations are called F-facilitating. It will tend to hinder correct performance when F boosts perceptually salient aspects which are irrelevant of task solution and which hinder the application of relevant schemes. (F-misleading situations). In task situations that are misleading because of F (or L) boosting of irrelevant schemes, the application of M energy to boost schemes relevant to task solution is essential for correct performance.

The F factor works in close association with the LC structures. "LC structures present the structural form of compactness, consistency and information minimisation" and will thus tend to be weighted by F operators. As these F-facilitated LC structures develop, the absolute weight of F will tend to increase in practice. Thus the developmental course of F should follow the course of expansion of the LC repertoire of schemes (Goodman, 1979, p. 57).

### The M operator

M is a limited amount of mental attentional energy that can be used to boost task-relevant schemes that are not sufficiently boosted by other silent operators. The mobilisation and allocation of M are carried out by executive schemes which carry the subject's representation of the task instructions and the corresponding plans for solving the task.

In every task situation, M serves to boost task-relevant aspects which are not physically present (and, thus, must be "kept in mind"). In task situations where habitual (ie L-boosted) structures and/or highly salient (ie F boosted) schemes are inadequate for task solution, M energy is allocated to boost the activation of task-relevance schemes, leading to correct performance, M also serves to boost task-relevant schemes in misleading task situations where inappropriate schemes have been boosted by silent operators such as F and L.

The maximum number of schemes that an individual can simultaneously M boost is called M power (M<sub>p</sub>). Maximum M<sub>p</sub> grows throughout childhood, one unit every other year, from e + 1 at 3 and 4 years of age to e + 7 at 15 years of age. "e" represents a constant amount of M energy which is developed during the first two years of life, and later used to boost the task executive. Table 1 lists the predicted maximum M power values as a function of age, and their correspondence to the Piagetian sub-stage sequence.

The components of M<sub>p</sub>, e and k (k = 1, 2, 3, ..., 7), do not refer to structural constituents of M, but simply to the measure of energy which goes respectively to the executive (e) and to other relevant k schemes. "k" refers to the measure of M energy that increases developmentally,

measured in terms of the number of schemes the child can simultaneously activate in solving a task.

However the prediction of a subject's performance on an M-test cannot be deduced from the subject's age alone. The lack of a rich repertoire of executive structures to guide the efficient application of the available M energy (perhaps due to a poor learning environment) may lead to an allocation of less than the maximum available M capacity in situations requiring sophisticated executives (Miller and Pascual-Leone, 1980). This means that functional M (the amount of M energy being used to produce the performance) may not always reflect the true M reserve power. This may lead to individual differences in performance on a task by children at a particular stage.

The number of schemes the subject will actually activate will also depend on the characteristics of the tasks. If the task is too easy or well-learned, there is no need to M-activate so many schemes. If the task is too difficult, more schemes may be required than the maximum number available to the subject via M-activation, causing the subject to fail. However in such a case there may be a way out via learning (LM or LC). Schemes may be "chunked" in such a way that fewer are required to solve a well-known problem than when the problem was first encountered. In addition, it has already been mentioned that LM learning is limited by maturational development, whereas LC learning is not. Thus in the case of tasks where LC learning is involved, it is possible to bypass developmental constraints for the acquisition of particular structures.

Considering all these complications it is clear that an explanation of a

Table 3.1

Predicted maximum M power values as a function of age, and their correspondence to the Piagetian substage sequence.

<u>M power (e+k)</u>	<u>Piagetian substage</u>	<u>average chronological age (in year pairs)</u>
<u>e+1</u>	low preoperations	3 - 4
<u>e+2</u>	high preoperations	5 - 6
<u>e+3</u>	low concrete operations	7 - 8
<u>e+4</u>	high concrete operations	9 - 10
<u>e+5</u>	substage introductory to formal operations	11 - 12
<u>e+6</u>	low formal operations	13 - 14
<u>e+7</u>	high formal operations	15 - adults

(Pascual-Leone and Goodman, 1979, p. 324)



subject's performance requires a detailed task analysis, showing the minimum number of schemes which a subject should hold simultaneously for the task to be solved. A task analysis evaluating the M-demand of a task and analysing the mental strategies used to solve it is called a "metasubjective task analysis" (Pascual-Leone and Goodman, 1979, p. 329).

Detailed task analyses show that horizontal decalages - never adequately explicated by Piaget (Vuyk, 1981) - such as those between the conservation of substance, weight and volume, can often be explained by the increasing M-demand of the tasks. In other cases they can be explained in terms of facilitation or interference effects which other silent operations (C, L, F etc) may have on the task solution.

#### AN ALTERNATIVE APPROACH TO M: CASE'S NEO-PIAGETIAN APPROACH TO COGNITIVE DEVELOPMENT

Case (1974, 1978, 1980; Case and Sandlos, 1980) modifies Pascual-Leone's theory by rejecting its developmental assumption: he claims that there is no real growth in M, only a reduction, with age, in the amount of M energy required to boost executive schemes.

This section examines Case's formulation of M which he calls the CPC (central processing capacity) and rejects it as a possible framework for studying cognitive development and the respective roles of learning and maturational development in this process.

Like Pascual-Leone, Case recognises Piaget's stages and postulates the CPC as a maturational factor or "general organismic factor" that controls the child's rate of progression from one stage to the next. He explains the CPC as the maximum number of schemes the subject can attend to at any one

moment without losing track of his/her overall objective. The size of the child's current CPC limits the complexity of the executive control structures she/he can acquire and utilise.

What causes growth of the CPC? Case rejects the TCO's claim that the subject's total processing capacity increases as a result of a developmental increase with age in the amount of mental energy available to the subject, arguing instead that the measured increase in capacity within each stage is due to a decrease in the capacity required to execute the operations characteristic of that stage.

Case claims that the subject's CPC does not change after she/he has reached 2 years of age. From this age onwards a constant amount of energy is involved in any mental operations. What changes with development is the ratio of energy required to carry out the two aspects of a mental operation: functional operational capacity (o) and functional storage capacity (s). This idea can be symbolised thus:  $o + s = k$ , where k is a constant, equal to the system's total processing capacity.

As the child progresses through a developmental stage, less and less energy or "attentional control" is required to perform the basic operations associated with that stage. This frees energy to be used for storage of the results of previous operations particularly relevant to the task at hand. As o decreases, s increases, and the subject is able to store an extra "loop" or mental operation thus progressing to a more advanced sub-stage.

The decrease in required "attentional control" for o is due to the fact that with practice basic operations become automatic, requiring less energy or processing space, freeing it for the acquisition of new loops.

(Case uses the concepts of an amount of energy and an amount of space interchangeably in his account of the growth of the CPC). His transition rule from one stage to another is a certain minimum level of operational automaticity. Automaticity is explained in terms of both general experience and maturational factors.

Not only is there no increase in the size of the CPC after two years, but also no change in the child's capacity for learning across the stages of development. All that changes are the types of learning. Case (1978) says that this conclusion follows from two assumptions:

- i) that learning occurs very rapidly when the elements to be learned can be placed in the working memory simultaneously.
- ii) that the capability for learning certain content varies radically as a function of the strategies that are available and the size of the functional storage space in the domain in question.

From the age of two years the child has the capacity for complex learning in terms of "raw" energy, but that at this early age the distribution of this energy (with a large amount being used for operations and therefore a small amount for storage) limits the complexity of his/her mental operations. Thus all that changes with time is the gradual redistribution of this energy rather than its quantity.

Case argues that many tasks a child encounters in his/her day-to-day existence are familiar (repeatedly exposed to the child) and facilitating (have no features that suggest an incorrect strategy). In such a task the child need not bring a complex knowledge gathering strategy to the situation. Its only requirement is that the child has sufficient function storage space to attend to two task elements at the same time (the one

presumably being the recently-automatised executive control structure of the immediately preceding stage, and the other the about-to-be-incorporated new loop) as well as sufficient motivation to persist until these elements form one chunk.

Case's version of Pascual-Leone's thought is simplified to the extent that it is unable to deal with the complexity of cognitive development. At best it is a description of one very particular form of learning - Pascual-Leone's LC learning. Ironically, he simplifies Pascual-Leone's thought to such an extent that he falls into the very trap that Pascual-Leone developed his theory to overcome, and the most central issue for a theory of cognitive development - the learning paradox.

Case's theory does not tackle the issue of the learning paradox. He briefly mentions it once in his 1980 paper, saying the notion of the CPC is necessary because task related experience is inadequate to explain the infant's success in "genuinely novel problems" (p. 11). However in the remainder of the paper he fails to provide any indication of the relevance of the CPC to this problem. In his 1978 paper he expressly dismisses the need to consider unfamiliar tasks, saying that this was only necessary for Piaget because he was considering "the structure of the child's knowledge-gathering activity" rather than "childrens' knowledge *per se* (p. 61). (The implication here is that Case is concerned with the latter - a betrayal of his avowed intent to produce a "functional" theory, "to describe the mechanisms whereby knowledge is acquired and utilised" (1974, p. 542).)

Not only does he fail to tackle the issue of the learning paradox directly but he fails to make any sort of convincing case for the existence of factors other than learning in cognitive development, and his theory thus

precludes its solution. One important reason for this failure is his exclusive focus on familiar and facilitating tasks, and his definition of his developmental stages and sub-stages in terms of the child's ability to perform such tasks.

His account of the acquisition of knowledge akin to Pascual-Leone's LC learning is limited: the child learns by repeatedly chunking his/her newly-acquired automatised basic operation with a new loop, the two requirements for this being:

- i) sufficient repeated exposure to the task, and
- ii) sufficient motivation to persist in holding the elements in working memory for long enough to enable them to become chunked.

(One way he might have introduced a situation-free factor into this learning process could have been to link maturation and motivation).

He sees development in terms of progress up a hierarchy of tasks, each task composed of a rigidly fossilised lower order task plus one extra mental operation. This view severely limits the child's potential for novelty seen as a new combination of elements, since the most Case's developing child can do is to add one more loop to a rigid pre-existing scheme.

Although Case claims that the growth of the working memory/CPC is determined by organismic factors, he explains this process totally in terms of learning.

- i) He insists that the size of the working memory remains unchanged after two years of age, and that all that changes is the ratio of energy devoted to o (operations) and s (storage).

- ii) Then he explains this changing ratio in terms of operational automaticity which frees energy previously required by operations to be used for storage.
- iii) Then he explains operational automaticity in terms of repeated practice/exposure to the particular learned task in question. Thus while paying lip-service to the notion of a maturationally developing CPC, he fails to explain what this maturational element could be and how it would interact with learning in cognitive development.

This involves the following circular argument:

1. Case holds that cognitive development cannot be explained in terms of learning alone, and introduces an organismic factor, the CPC.
2. The CPC does not change in size. Its growth is explained in terms of a shifting ratio of energy/space allocation.
3. This shifting ratio is explained in terms of increasing operational automaticity of basic operations.
4. This operational automaticity is explained in terms of practice/repeated exposure to the task in question ie learning.

To avoid this predicament he should:

- a) not have argued that the CPC remained a constant size after 2 years of age (point 2), or else
- b) explained operational automaticity in organismic terms.

Because Case fails to make an adequate case for the existence of factors other than learning, his theory is of no use for the purpose of the

present research. Applied in this context, Case's theory would commit him to the cultural relativist position, explaining cognitive development in terms of learning, and falling prey to the criticism of cultural relativism discussed earlier, namely its inability to deal with truly novel performance or change. Case has simply turned Pascual-Leone's theory into yet another learning theory.

Success of the present research in its objective to show that there are developmental restrictions on the rate of growth of M or CPC (and that even with overlearning a child can only reach certain levels of performance at two-yearly intervals) will discredit Case's hypothesis that CPC has a constant amount of energy. One could no longer explain the developmental stages in terms of the reallocation of this energy as a result of learning.

"If M stages of two-year duration can be demonstrated empirically, there is no possibility of explaining effective M growth in terms of executive changes (learning), for there is no possible and plausible learning explanation that can predict an absence of learning during a two year period" (Goodman, 1979, p. 48).

EMPIRICAL RESEARCH



#### 4. METHODOLOGY

#### 4.1 THE FIGURAL INTERSECTIONS TEST

The FIT (Pascual-Leone no date; Johnson, 1982; Goodman, 1979) is a group administered paper and pencil test designed by Pascual-Leone to measure M-power. M-measurement tasks are constructed by the double procedure of theory-guided metasubjective task analysis and quantitative structural analysis. The former procedure assigns M-demands to tasks (the M-demand being the minimum number of schemes which must be simultaneously M-boosted in order to solve a task). Quantitative structural analysis is used to select task items that best reflect M-variance. This involves the study of the developmental patterns of performance on a task and the patterns of correlations of the task with other already-established M-measures.

Using these methods a test is constructed with a variety of items representative of the range of M-power of interest. Because a subject should not be able to pass a task before his/her M-power is equal to the task's M-demand, the passing rates of subjects on the graded M items provide estimates of their M-power. A pure M task should attempt to minimise the role of silent operators (eg L or F) other than M, so that their influence does not confound the M-measure yielded by the test.

##### Description of the FIT

The task consists of a booklet of items in which each item consists of two sets of figures, one "presentation set" on the right side of a page, and one "intersecting set" on the left. In the presentation set a number of single geometric figures are arranged separately. In the intersecting set the same figures are presented in an overlapping way such that there is one area of common intersection. The subject's task is to find this area of intersection and mark it with a dot. Figures 4.1 and 4.2 illustrate sample FIT items.

Items vary with regard to the number of shapes in the presentation and test sets. In some items there is also a misleading irrelevant shape in the test set, which is not present in the presentation set and which does not form a common area of intersection with all the other shapes. Figure 2 illustrates an item with an irrelevant shape. It is a matter of controversy as to whether or not an irrelevant shape adds to an item's M-demand (Johnson, 1982). As a result there are two ways of scoring the test (see next section). In the RAC794 version of the FIT used in this research, the class of a FIT item *without* an irrelevant shape is designated by the number of shapes in the presentation set. The class of an item *with* an irrelevant shape is designated by the number of shapes in the presentation set "+1". Thus Figure 4.1 depicts a class 4 item, and Figure 4.2 a class 4+1 item.

The FIT RAC794 includes 36 items distributed in the following classes:

Class 2	:	5 items
Class 3	:	4 items
Class 3+1	:	1 item
Class 4	:	4 items
Class 4+1	:	2 items
Class 5	:	4 items
Class 5+1	:	1 item
Class 6	:	4 items
Class 6+1	:	1 item
Class 7	:	4 items
Class 7+1	:	1 item
Class 8	:	4 items
Class 8+1	:	1 item

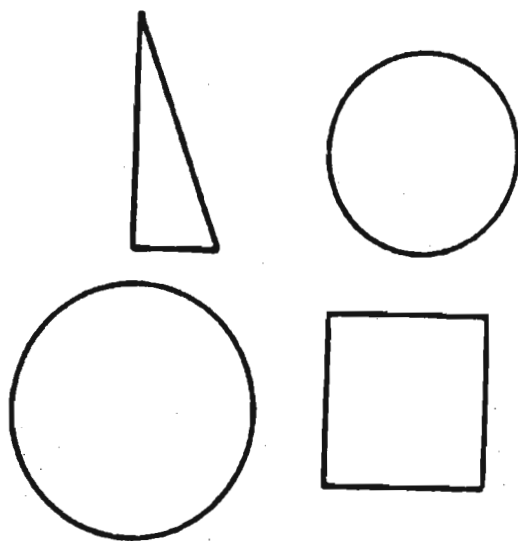
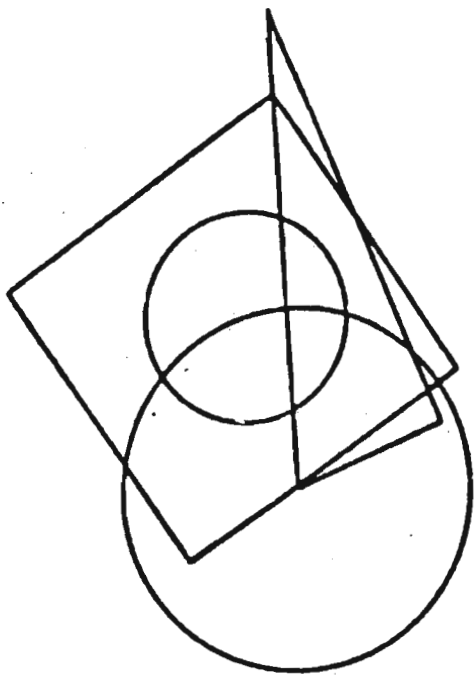


FIGURE 4.1

FIT RAC 794 : CLASS 4 ITEM

*CPIT*

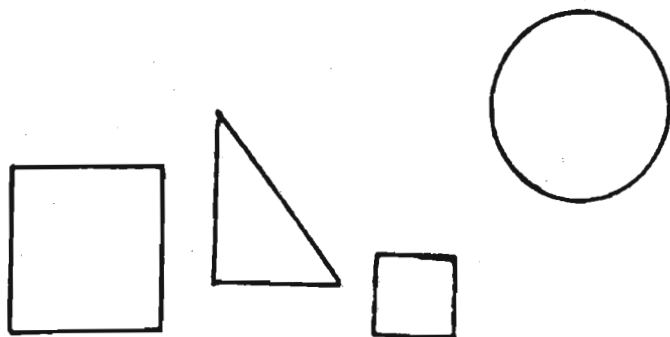
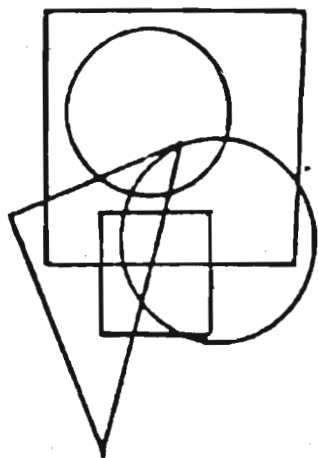


FIGURE 4.2

FIT RAC 794 : CLASS 4+1 ITEM

Items are randomly ordered with respect to class (Appendix A includes examples of each item class).

#### Administration of the FIT

Each child is given a FIT booklet and a red pen. In an elaborate instruction period, using class 2 items, subjects are familiarised with features of the task.

- a) The subjects are told that the items are arranged in paired sets. They should first attend to the separate figures on the right, marking each with a dot before attending to the intersecting shapes on the left. This ensures that the subject has attended to each individual figure.
- b) The subjects are shown the correspondence between the items in the intersecting set and the presentation set. It is stressed that this correspondence need only be one of shape, and that the size and orientation of items can vary from the presentation to the intersecting set.
- c) The subjects are told about the possibility of encountering irrelevant figures in the intersecting set which are not found in the presentation set. These figures should be disregarded.
- d) Subjects are familiarised with the notion of the intersection of all the relevant figures, to be marked by placing a dot in the area of intersection.

Detailed instructions are presented in Pascual-Leone's FIT Manual (no date).

The children are warned that they cannot rub out marks made by the red

pen. Therefore they must think very carefully since more than one dot on the left will be counted as wrong.

The tester circulates among the children, watching for certain errors which should be prevented. No more information is given about how to solve the task, but children who are struggling may be encouraged by repeating the instructions again.

Common errors which must be guarded against are:

- 1) Marks on the set of shapes other than the necessary dots. Some subjects lightly place their pen inside each shape as they find it, leaving faint marks. Some subjects try and correct errors, and place two or more dots on the intersecting figure. Some forget the instructions and put a dot in every shape on the left.
- 2) Dots on the line, or large dots that cover more than one area.
- 3) Missed items. Subjects should try every item, even if they have to guess.

The test is untimed. Subjects usually finished it within 30 minutes. Initially the teaching of instructions took 20 - 30 minutes, but on the third and fourth attempts this period diminished as children became familiar with what had to be done.

### Scoring

A FIT item is passed if there is a mark in the area of common intersection in the test set which does not also extend into another area, and there are no other marks on the test set. The reason for this last requirement is that the tendency of some subjects to mark each shape in the

intersecting set as they identify it, reduces the M-demand of the test. The M-demand is given precisely by the need to *mentally* keep track of all the figures which are located in the intersecting pattern.

Parkinson (1975) found that estimates of M-power could be generated from the FIT by determining k as the highest FIT class in which a subject could pass at least 75% of the class items. She found that the central tendency of the frequency distribution of k estimates tended to match the theoretically predicted M-power values, although the range of variation was considerable, and the distributions tended to be skewed towards k values higher than those theoretically predicted.

Previous research has shown that the FIT on average yields k-scores consistent with the TCO's age-determined values.

"However the range of k estimates tends to be too large, presumably because, as the test stands, FIT performance reflects individual differences in strategies, susceptibility to field effects, chance performance, and other factors as well as the individual's k value." (Pascual-Leone, no date, p. 9).

In view of the controversy as to whether the presence of an irrelevant non-intersecting figure increases the M-demand of an item, two methods of scoring the FIT were applied in the present research. The first method, called X-scaling, assumes that the presence of an irrelevant figure does not increase the M-demand of a task, and thus includes items of the  $x+1$  variety in class  $x$  when scoring. Thus in Figure 4.2, for example, an item of the  $4+1$  variety, would be included in class 4. The second method, called Y-scaling, includes items of the  $x+1$  variety in the class higher than  $x$ . Thus Figure 4.2 would be included in class 5 for scoring purposes.

In the present research the difference between X-scaling and Y-scaling was negligible, with the X-scores tending to be slightly lower than the Y-scores. In other words X-scaling proved to be a very slightly stricter measure. This study chose to use X-scaling, the more conservative measure. Thus the X-scores are written up in the results sections (Table 5.2 and Figures 5.1 to 5.7). The Y-scores are included in Appendix B.

#### 4.2 SUBJECTS

Subjects were working-class Zulu-speaking schoolchildren drawn from the Dukemini Primary School. E Section, Kwa Mashu. Kwa Mashu is a sprawling urban township on the outskirts of Durban, inhabited predominantly by Zulu-speaking people who work in Durban and the surrounding areas.

The sample was drawn from children who had performed to criterion on the pre-test of the Compound Stimulus Visual Information task (CSVI), another M-test, derived by Pascual-Leone. The reason for this choice of subjects was that this study is part of a larger research project which will eventually, amongst other things, compare subjects' performance across the CSVI and the FIT.

Altogether 252 children tested were in the age groups 7 - 8, 9 - 10 and 11 - 12. Table 4.3 shows the age distribution of the children at the time of testing.



Table 4.3Age Distribution of Subjects

<u>Age</u>	7	8	9	10	11	12
<u>Number</u>	16	51	72	42	50	21

Total = 252

The research aimed to investigate children in the 7 - 8, 9 - 10, 11 - 12 age groups because each group comprises a TCO sub-stage. The number of children in each sub-stage is shown in Table 4.4.

Table 4.4Age Group Distribution of Subjects

<u>Age</u>	7 - 8	9 - 10	11 - 12
<u>Number</u>	67	114	71

Total = 252

From the above distributions it will be clear that the 7 - 8 year olds consisted of a higher proportion of 8 year olds than 7's, the 9 - 10 year olds of a higher proportion of 9's than 10's and the 11 - 12 year olds of a higher proportion of 11's than 12's. This was due to delays in testing as a result of disruption in the schools. This meant that the FIT tests were conducted four months after the CSVI tests, with the result that many of the subjects then fell into a different age group.

#### 4.3 PROCEDURE

The research planned to test the children four times at weekly intervals. However due to school unrest there was a two-week interval between the third and the fourth trials. They were tested in groups of 20. For each new trial the intersecting set of shapes was rotated 45 degrees. This was to ensure that children did not become familiar with the test items. The four trials are referred to as trials 1, 2, 3 and 4.

## 5. RESULTS

Two performance criteria were considered in approaching the analysis of results. The first was the criterion established by Pascual-Leone and Burtis (1975) (used by Goodman (1979) in her analysis of FIT data). This specifies that the highest item class succeeded at a probability level of 0.75 by subjects of  $\underline{M}$ -power  $\underline{e} + \underline{k}$  is class  $\underline{k}$ . For example the highest class passed by the majority of 7-year-olds ( $\underline{M} = \underline{e} + 3$ ) is class 3, by 9 year olds ( $\underline{M} = \underline{e} + 4$ ) is class 4, and by 11 year olds ( $\underline{M} = \underline{e} + 5$ ) is class 5. This criterion (which will be referred to as the Pascual-Leone and Burtis criterion) specifies further that performance drops off from 0.75 to 0.60 or less in classes with an  $\underline{M}$ -demand one or more  $\underline{k}$  units higher than the particular subject's age-determined  $\underline{M}$ -level.

The second criterion against which performance in the present research will be considered is the set of results found by Goodman (1979) who tested children in the 7 - 12 age range on the FIT. According to Goodman, these results "... show basically the structure ... empirically found by Pascual-Leone and Burtis (1975)", (Goodman, 1979, p. 281) and she presents these data as the passing probabilities for each age at each stimulus class. These results are presented in Table 5.1.

TABLE 5.1

Goodman's (1979) Data on the Percentage of Correct FIT Responses as a Function of Age and Stimulus Class

	<u>STIMULUS CLASS</u>							
	2	3	4	5	6	7	8	
AGE								
	7 - 8	95	88	50	43	27	8	10
	9 - 10	98	92	76	57	42	15	15
	11 - 12	100	98	90	71	51	27	20

Looking at Table 5.1 in terms of the Pascual-Leone and Burtis criterion, the 7 - 8 year olds are well above the 75 percent passing level on class 3, and well below the 60 percent level on all higher classes. The 9 - 10 year olds pass class 4 at the 75 percent level, and drop below 60 percent on the subsequent classes. Although the 11 - 12 year olds pass class 5 at 71 percent, below Pascual-Leone and Burtis' specification of 75 percent, Goodman points out that even this level serves to distinguish this age group from the others, and points to class 5 as the highest class before which performance drops to 60% or below.

The Goodman (1979) data will be used as an approximate guide to criterion performance by middle-class schoolchildren from a westernised-industrialised-technological schooled society.

Two issues are at stake in analysing the present results. The first is the prediction that the first time the children do the test they will not all perform to criterion. However, once they have been provided with the experience necessary to acquire the relevant executives, they will perform to criterion. The second issue is that there is a developmental "ceiling" on a child's M-power at each stage, and that in spite of over-learning children will not be able to perform beyond their M-power. In statistical form these issues may be translated into the following predictions:

- a) On Trial 1 the children will not perform to criterion. This means that less than 75% of the responses of the 7 - 8, 9 - 10 and 11 - 12 year olds will be correct on item classes 3, 4 and 5 respectively. These scores will be lower than those of the Goodman data.
- b) On successive trials performance will reach criterion. This means that perhaps as early as Trial 2, but definitely by Trials 3 and 4,

75% of the subjects' responses will be correct on their age-appropriate item class.

- c) Once the children have reached their age-appropriate criterion there will be no significant improvement on successive trials. This means that there will be an age-determined "ceiling" to their performance.

For analyses, the responses of each test were grouped according to their item class. Then the sums of correct responses for each item class were calculated, yielding seven scores per test. (All items classes except class 4 consisted of 5 response items and thus the highest possible score for these items was 5. There were 6 response items belonging to class 4, and thus the highest possible score for this class was 6). The item class means were then calculated for each age group on each trial. The means and standard deviations are presented in Table 5.2. The data are also presented graphically in Figures 5.1 to 5.7. (The results presented in this section are those derived from the X-scaling scoring method, with the Y-scaling included in Appendix B).

TABLE 5.2

Means and Standard Deviations for the Three Age Groups on Each Trial for

The Seven Item Classes

(Means above, Standard deviations below)

Item Class	2	3	4	5	6	7	8
A1 T1	4.507 0.959	3.746 1.259	3.851 1.777	2.358 1.367	1.269 1.175	0.463 0.826	0.254 0.472
A1 T2	4.761 0.605	4.269 1.250	3.507 1.330	3.149 1.559	2.000 1.255	1.119 1.023	0.373 0.573
A1 T3	4.925 0.317	4.537 0.983	4.731 1.388	3.836 1.238	2.672 1.655	1.687 1.062	0.821 0.903
A1 T4	4.970 0.602	4.731 0.592	4.477 1.521	3.567 1.131	2.493 1.284	1.582 1.143	0.612 0.673
A2 T1	4.579 1.136	3.965 1.499	3.359 1.887	2.561 1.494	1.693 1.440	0.675 0.936	0.228 0.498
A2 T2	4.868 0.388	4.465 0.942	3.859 1.296	3.588 1.368	2.281 1.340	1.430 1.152	0.675 0.991
A2 T3	4.930 0.289	4.658 0.702	5.070 1.195	4.088 1.125	2.772 1.396	1.904 1.136	0.912 1.130
A2 T4	4.982 0.132	4.789 0.556	5.122 1.183	4.105 1.285	2.974 1.333	1.833 1.004	0.983 0.922
A3 T1	4.789 0.411	4.493 0.924	3.648 1.733	3.324 1.350	1.901 1.333	0.873 1.027	0.380 0.763
A3 T2	4.944 0.232	4.620 0.663	4.183 1.073	3.859 1.112	2.535 1.510	1.549 1.169	0.831 0.894
A3 T3	4.972 0.167	4.8592 0.389	5.352 1.016	4.296 1.020	3.225 1.375	2.014 1.189	1.042 0.917
A3 T4	5.000 0.521	4.8028 0.401	5.282 0.988	4.324 1.039	3.105 1.211	2.014 1.102	1.141 1.138

A1 : 7 - 8 years                      T1 : Trial 1

A2 : 9 - 10 years                    T2 : Trial 2

A3 : 11 - 12 years                  T3 : Trial 3

T4 : Trial 4

Figures 5.1 to 5.3 present the item class means, expressed as percentages, for the 7 - 8, 9 - 10 and 11 - 12 age groups respectively over each of the four trials. In Figures 5.4 to 5.7 the same data are represented for each trial across the different age groups.

The data were analysed further by a 3 x 4 (age x trials) analysis of variance with repeated measures (trials). Table 5.3 represents the annova summary table for item classes 2 to 8. With the exception of class 3, there was no significant interaction between the age (A) and trials (B) variables, but the main effects were significant at the 0.01 level for all item classes. For item class 3 there was a significant interaction between the age and trials variables ( $p < 0.01$ ).

These effects were analysed further by means of the Tukey's HSD statistic to establish which levels of each respective variable were significantly different from each other. The results of the Tukey's tests are summarised in Tables 5.4.1, 5.4.2 and 5.4.3.



TABLE 5.3  
 Summary of Analyses of Variance for Item Classes 2 to 8

Item Class	Source	SS	DF	MS	F-ratio
2	A	27.765	2	8.883	6.390 **
	S/A	346.118	249	1.390	
	B	64.789	3	21.596	40.383 **
	A x B	5.549	6	0.925	1.729
	B x S/A	399.486	747	0.535	
3	A	22.372	2	11.186	7.122 **
	S/A	391.072	249	1.571	
	B	71.078	3	23.693	39.353 **
	A x B	20.373	6	1.729	2.872 **
	B x S/A	449.734	747	0.602	
4	A	85.415	2	42.708	9.703 **
	A/A	1095.933	249	4.401	
	B	531.355	3	177.118	155.234 **
	A x B	2.732	6	0.455	0.399
	B x S/A	852.310	747	1.141	
5	A	83.037	2	41.519	11.634 **
	S/A	888.590	249	3.569	
	B	265.141	3	88.380	89.580 **
	A x B	11.020	6	1.837	1.863
	B x S/A	736.994	747	0.987	
6	A	55.886	2	27.943	7.284 **
	S/A	955.176	249	3.836	
	B	257.808	3	85.936	70.797 **
	A x B	3.823	6	0.637	0.525
	B x S/A	906.731	747	1.214	
7	A	25.892	2	12.946	5.550 **
	S/A	580.811	249	2.332	
	B	218.472	3	72.824	97.891 **
	A x B	0.505	6	0.084	0.113
	B x S/A	555.717	747	0.744	
8	A	17.765	2	8.883	6.390 **
	S/A	346.118	249	1.390	
	B	64.790	3	21.597	40.383 **
	A x B	5.550	6	0.925	1.729
	B x S/A	399.486	747	0.535	

\*\* p 0.01

A = AGE

B = TRIAL

TABLE 5.4.1  
Results of Tukey's Tests Investigating Differences in Mean Performance  
on Trials 1 to 4 for Each Age Group

<u>ITEM CLASS 3</u>					<u>ITEM CLASS 4</u>					
<u>Trials</u>	1	2	3	4	1	2	3	4		
<u>7 - 8 years</u>	1	-	s **	s **	s **	1	-	s **	s **	s **
	2		-	ns	s **	2		-	s **	s **
	3			-	ns	3			-	s **
	4				-	4				-
<u>9 - 10 years</u>	1	-	s **	s **	s **	1	-	s **	s **	s **
	2		-	ns	s *	2		-	s **	s **
	3			-	ns	3			-	ns
	4				-	4				-
<u>11 - 12 years</u>	1	-	ns	s *	ns	1	-	s **	s **	s **
	2		-	ns	ns	2		-	s **	s **
	3			-	ns	3			-	ns
	4				-	4				-

<u>ITEM CLASS 5</u>					<u>ITEM CLASS 6</u>					
<u>Trials</u>	1	2	3	4	1	2	3	4		
<u>7 - 8 years</u>	1	-	s **	s **	s **	1	-	s **	s **	s **
	2		-	s **	s **	2		-	s **	s **
	3			-	s *	3			-	ns
	4				-	4				-
<u>9 - 10 years</u>	1	-	s **	s **	s **	1	-	s **	s **	s **
	2		-	s **	s **	2		-	s **	s **
	3			-	ns	3			-	ns
	4				-	4				-
<u>11 - 12 years</u>	1	-	s **	s **	s **	1	-	s **	s **	s **
	2		-	s **	s **	2		-	s **	s **
	3			-	ns	3			-	ns
	4				-	4				-

s = significant  
 ns = non-significant

\*\* = p 0.01  
 \* = p 0.05

TABLE 5.4.2  
Results of Tukey's Tests Investigating Age-Group  
Differences in Performance for Each Trial

ITEM CLASS 3					ITEM CLASS 4				
		7 - 8	9 - 10	11 - 12		7 - 8	9 - 10	11 - 12	
TRIAL 1	7 - 8	-	ns	s **	7 - 8	-	s **	s **	
	9 - 10		-	s **	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 2	7 - 8	-	ns	s *	7 - 8	-	ns	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 3	7 - 8	-	ns	ns	7 - 8	-	ns	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 3	7 - 8	-	ns	ns	7 - 8	-	ns	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 4	7 - 8	-	ns	ns	7 - 8	-	s **	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	

ITEM CLASS 5					ITEM CLASS 6				
		7 - 8	9 - 10	11 - 12		7 - 8	9 - 10	11 - 12	
TRIAL 1	7 - 8	-	ns	s **	7 - 8	-	s **	s **	
	9 - 10		-	s **	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 2	7 - 8	-	s **	s **	7 - 8	-	ns	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 3	7 - 8	-	ns	s **	7 - 8	-	ns	s *	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	
TRIAL 4	7 - 8	-	s **	s **	7 - 8	-	s **	s **	
	9 - 10		-	ns	9 - 10		-	ns	
	11 - 12			-	11 - 12			-	

s = significant  
ns = non-significant

\*\* = p 0.01  
\* = p 0.05

TABLE 5.4.3

5.4.3.1

Results of Tukey's Tests Investigating Differences in Age-GroupPerformance Meaned Across the Four Trials

		7 - 8	9 - 10	11 - 12
<u>ITEM</u>	7 - 8	-	ns	s **
<u>CLASS</u>	9 - 10		-	ns
<u>3</u>	11 - 12			-
<u>ITEM</u>	7 - 8	-	s *	s **
<u>CLASS</u>	9 - 10		-	ns
<u>4</u>	11 - 12			-
<u>ITEM</u>	7 - 8	-	s *	s **
<u>CLASS</u>	9 - 10		-	s *
<u>5</u>	11 - 12			-
<u>ITEM</u>	7 - 8	-	ns	s **
<u>CLASS</u>	9 - 10		-	ns
<u>6</u>	11 - 12			-

5.4.3.2

Results of Tukey's Tests Investigating Differences in Performanceon Each Trial Meaned Across the Three Age Groups

		1	2	3	4
<u>ITEM</u>	1	-	s **	s **	s **
<u>CLASS</u>	2		-	ns	s **
<u>3</u>	3			-	ns
	4				-
<u>ITEM</u>	1	-	s **	s **	s **
<u>CLASS</u>	2		-	s **	s **
<u>4</u>	3			-	ns
	4				-
<u>ITEM</u>	1	-	s **	s **	s **
<u>CLASS</u>	2		-	s **	s **
<u>5</u>	3			-	ns
	4				-
<u>ITEM</u>	1	-	s **	s **	s **
<u>CLASS</u>	2		-	s **	s **
<u>6</u>	3			-	ns
	4				-

s = significant  
 ns = non-significant

\*\* = p 0.01  
 \* = p 0.05

In Figures 5.1 to 5.3 the data are presented separately for each age group. In each of the figures the results for each of the four trials are plotted across the item classes. In addition, the results obtained by Goodman are plotted and provide a sense of comparison. On each figure the 75% and 60% criterion levels are indicated as well as the age-appropriate item class.

#### 7 -8 year olds (Figure 5.1)

Figure 5.1 shows that for item class 3 (the TCO's criterion level for this age group) the 7 - 8 year olds succeeded on 74% of the item responses. Although this is near the Pascual-Leone and Burtis 75% criterion level, it is well below Goodman's passing probability of 88 percent for 7 - 8's on this class. This age group also perform below 88 percent on Trial 2, reaching this level on Trial 3.

Table 5.4.1 shows that on item class 3 performance improved significantly from Trial 1 to Trial 2 ( $p < 0.01$ ). Thereafter there was a gradual increase in success, with no significant improvement from Trials 2 to 3, and 3 to 4. However there was a significant improvement from Trial 2 to Trial 4 ( $p < 0.01$ ).

On class 4 items these children performed below the 60% level on Trial 1, as predicted by the Pascual-Leone and Burtis criterion (although their performance did not differ from Goodman's 7 - 8 passing probability of 50 percent). Similarly on class 5 items on Trial 1 they performed below the 60% level (although performance reached Goodman's passing probability of 43 percent). However on subsequent trials in both class 4 and 5 items the 7 - 8's performed above the 60 percent level, and surpassed Goodman's result by a wide margin. By Trial 3 they had passed the 75 percent level

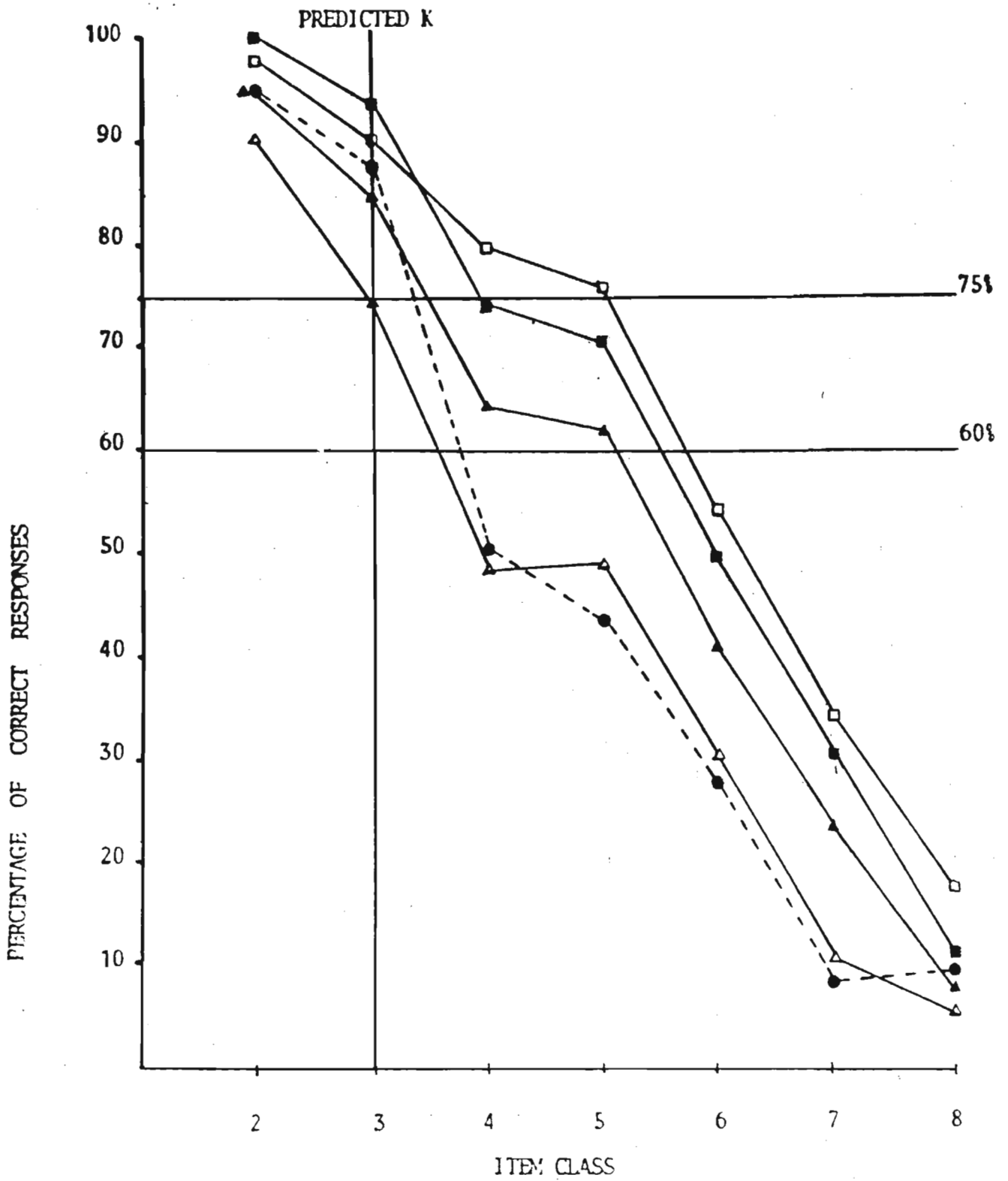


FIGURE 5.1

7 to 8 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N= 67 ).

TRIAL

- 1 —
- 2 —
- 3 —
- 4 —
- GOODMAN DATA - -

on these items - thus reaching the level expected of 11 - 12 year olds. On Trial 4 their performance level dropped slightly but did not differ significantly from their Trial 3 performance (see Table 5.4.1).

On item class 6 and 7 the children performed at the same level as the Goodman data on Trial 1, and surpassed it on the succeeding trials.

Table 5.4.3.2 shows that on all four item classes under consideration, performance seemed to reach a "ceiling" on Trial 3, with no significant improvement on Trial 4.

#### 9 - 10 year olds (Figure 5.2)

For item class 4 (the age-appropriate item class for this age group) the 9 - 10's performed well below the 75 percent level and below the level of the Goodman subjects on Trial 1. By Trial 2 their performance had improved significantly ( $p < 0.01$ ), reaching both these levels. Their performance continued to improve significantly on Trial 3 ( $p < 0.01$ ), where it stabilised, with no significant improvement on Trial 4, (see Table 5.4.1).

On item class 5 the 9 - 10's under-performed on Trial 1, with performance well below that of the Goodman subjects. However their performance improved dramatically on Trials 2, 3 and 4, amply surpassing the Goodman data. On Trials 3 and 4 their performance exceeded the 75 percent mark - reaching the level expected of 11 - 12 year olds. Performance once again reached a "ceiling" on Trial 3 (see Table 5.4.1).

On item class 6 performance was below the 60% level as predicted by the Pascual-Leone criterion on all four trials. Performance fell below

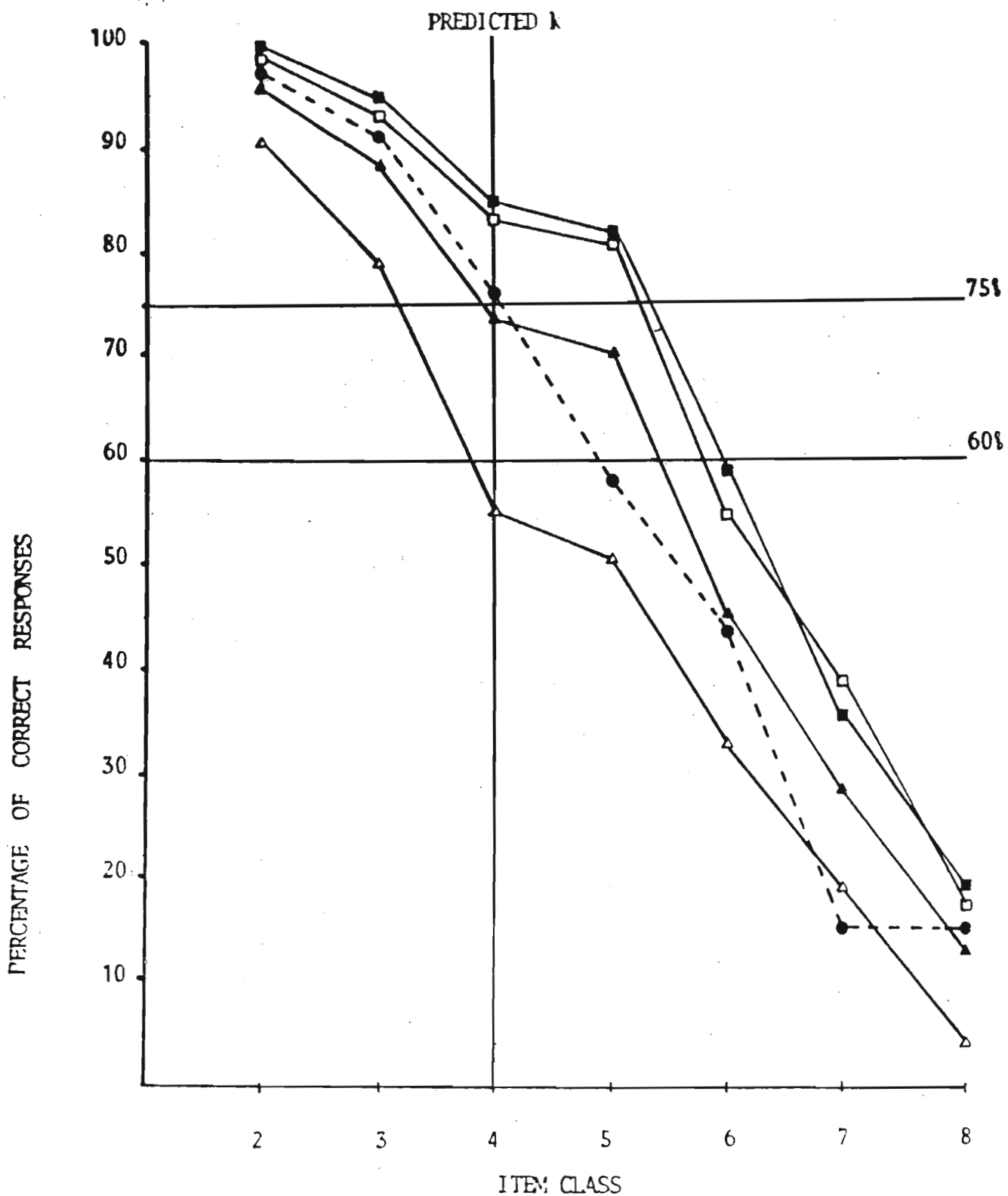


FIGURE 5.2

9 to 10 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N=114).

- TRIAL
- 1  $\triangle$  —  $\triangle$
  - 2  $\blacktriangle$  —  $\blacktriangle$
  - 3  $\square$  —  $\square$
  - 4  $\blacksquare$  —  $\blacksquare$
  - GOODMAN DATA  $\bullet$  - -  $\bullet$



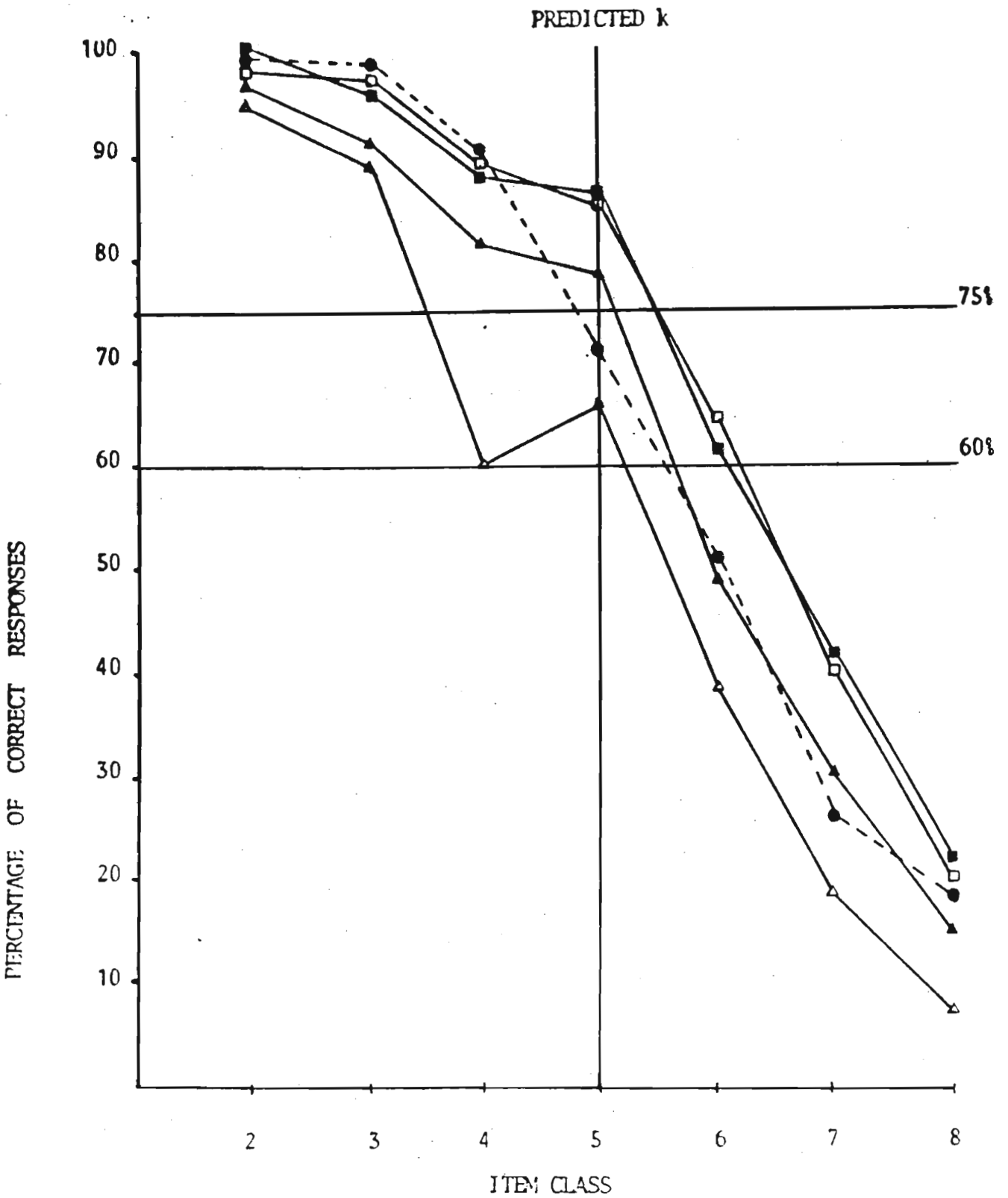












FIGURE 5.3

11 to 12 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N= 71 ).

TRIAL

- 1  — 
- 2  — 
- 3  — 
- 4  — 
- GOODMAN DATA  - - 

Goodman's criterion on Trial 1 but surpassed it by a wide margin on the following trials. Once again performance reached a "ceiling" on Trial 3 (see Table 5.4.1).

#### 11 -12 year olds (Figure 5.3)

On item class 4, the 11 - 12's succeeded on only 60 percent of the items, falling well below the Pascual-Leone and Burtis criterion of 75% for this class, and also well below the Goodman subjects. However their performance increased significantly on the three following trials (see Table 5.4.1).

Similarly on item class 5 they under-performed on Trial 1, but over-performed on Trials 2, 3 and 4.

On item class 6 performance fell on or below the 60 percent level on all four trials, as predicted by the Pascual-Leone and Burtis criterion. With regard to the Goodman criterion the children under-performed on Trial 1, reached criterion on Trial 2, and over-performed on Trials 3 and 4.

On each of the item classes 4, 5 and 6, performance improved significantly ( $p < 0.01$ ) from Trials 1 to 2 and 2 to 3, but reached a "ceiling" on Trial 3 with no significant improvement from Trials 3 to 4.

#### Trials 2 to 4 (Figures 5.4 to 5.7 respectively)

Figures 5.4 to 5.7 present the same data as Figures 5.1 to 5.3, but this time laid out separately for each trial. Several interesting features of these graphs must be noted.

Figure 5.4 shows that the 7 - 8's almost reach criterion on Trial 1.

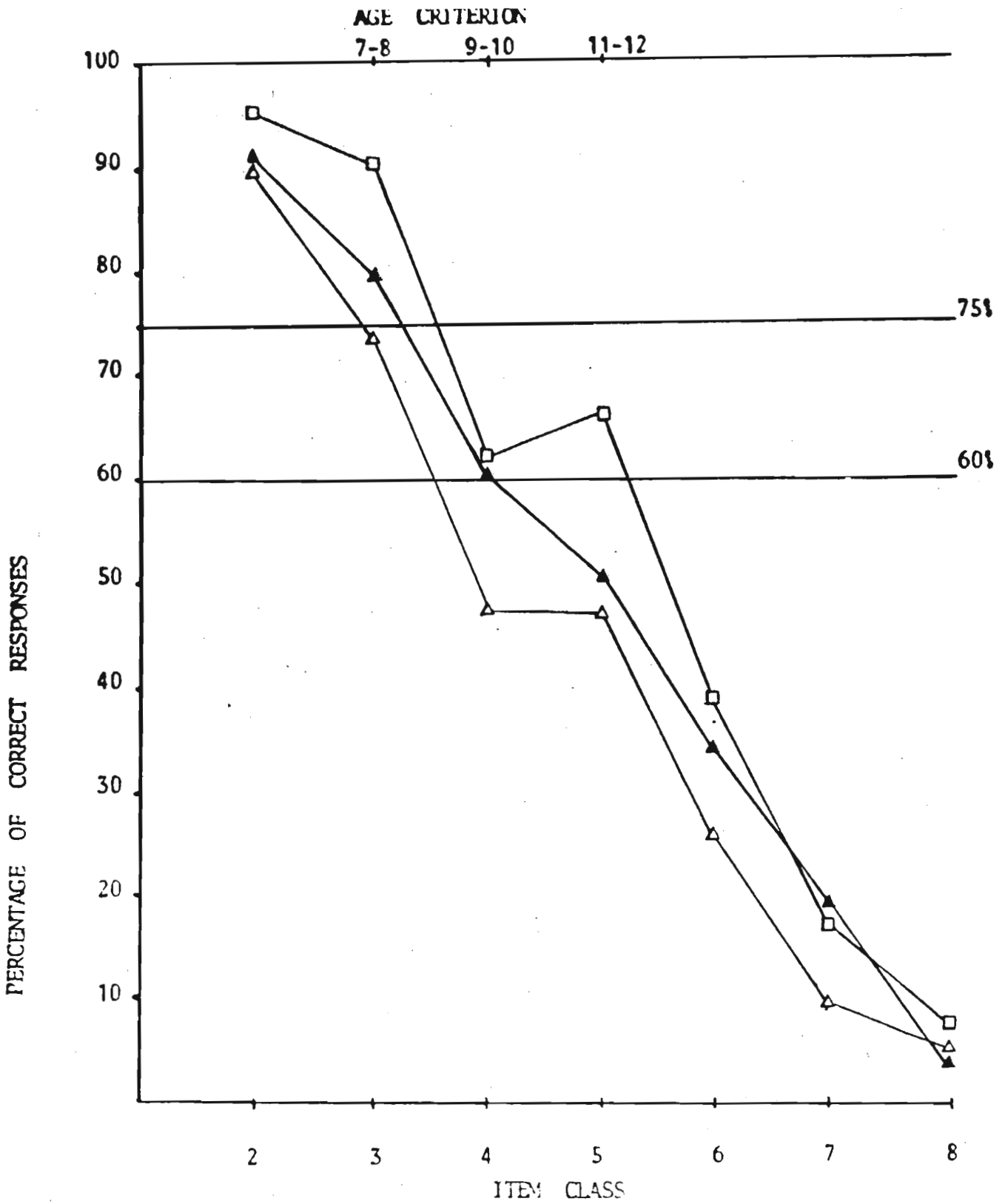


FIGURE 5.4

TRIAL 1 : PERCENTAGE OF RESPONSES CORRECT PER STIMULUS CLASS FOR 7-8's, 9-10's, AND 11-12's

- AGE
- △—△ 7-8 years (N=67)
  - ▲—▲ 9-10 " (N=114)
  - 11-12 " (N=71)

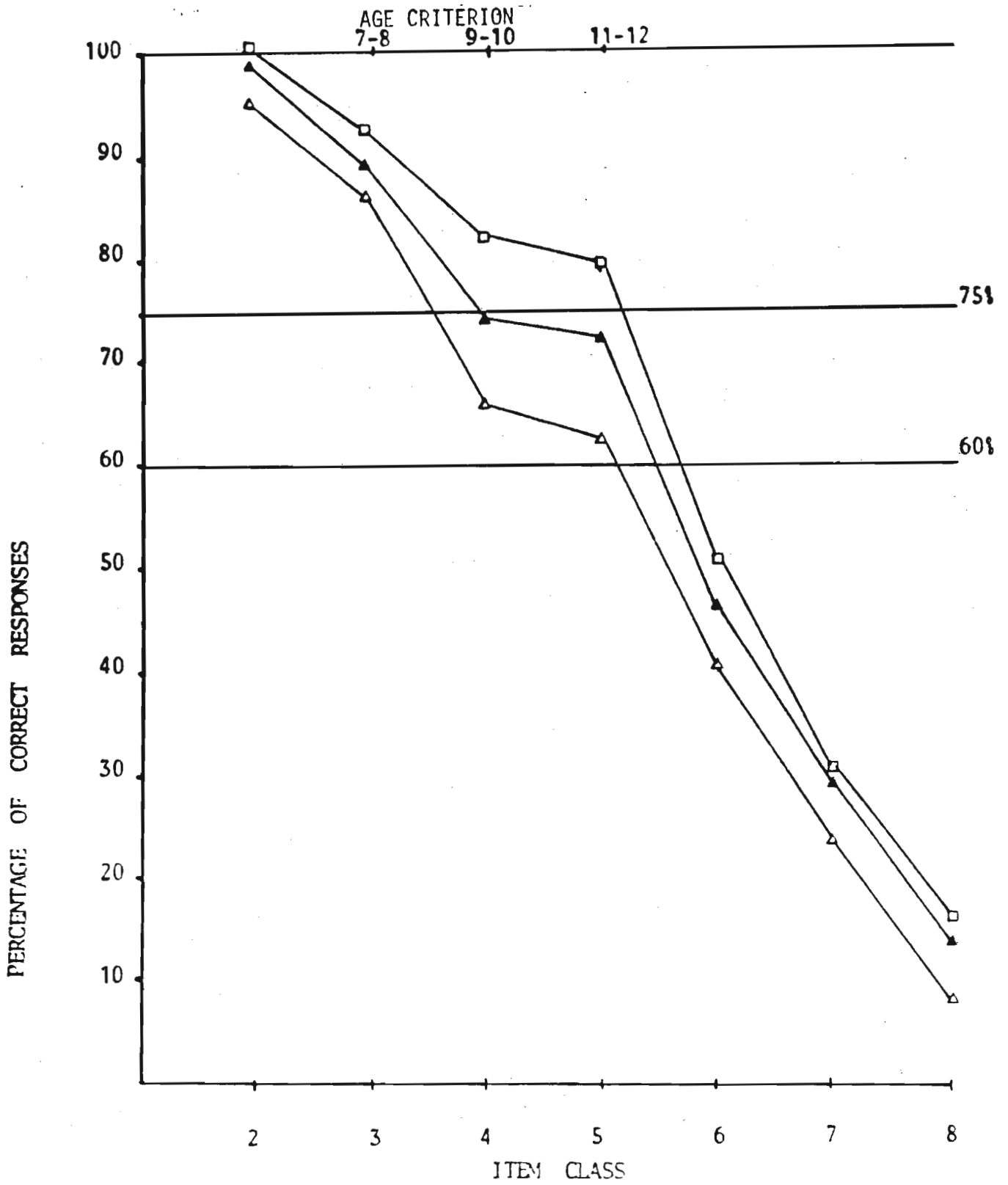


FIGURE 5.5

TRIAL 2 : PERCENTAGE OF RESPONSES CORRECT PER STIMULUS CLASS FOR 7-8's, 9-10's, AND 11-12's

- AGE
- △ — △ 7-8 years (N=67)
  - ▲ — ▲ 9-10 " (N=114)
  - — □ 11-12 " (N=71)

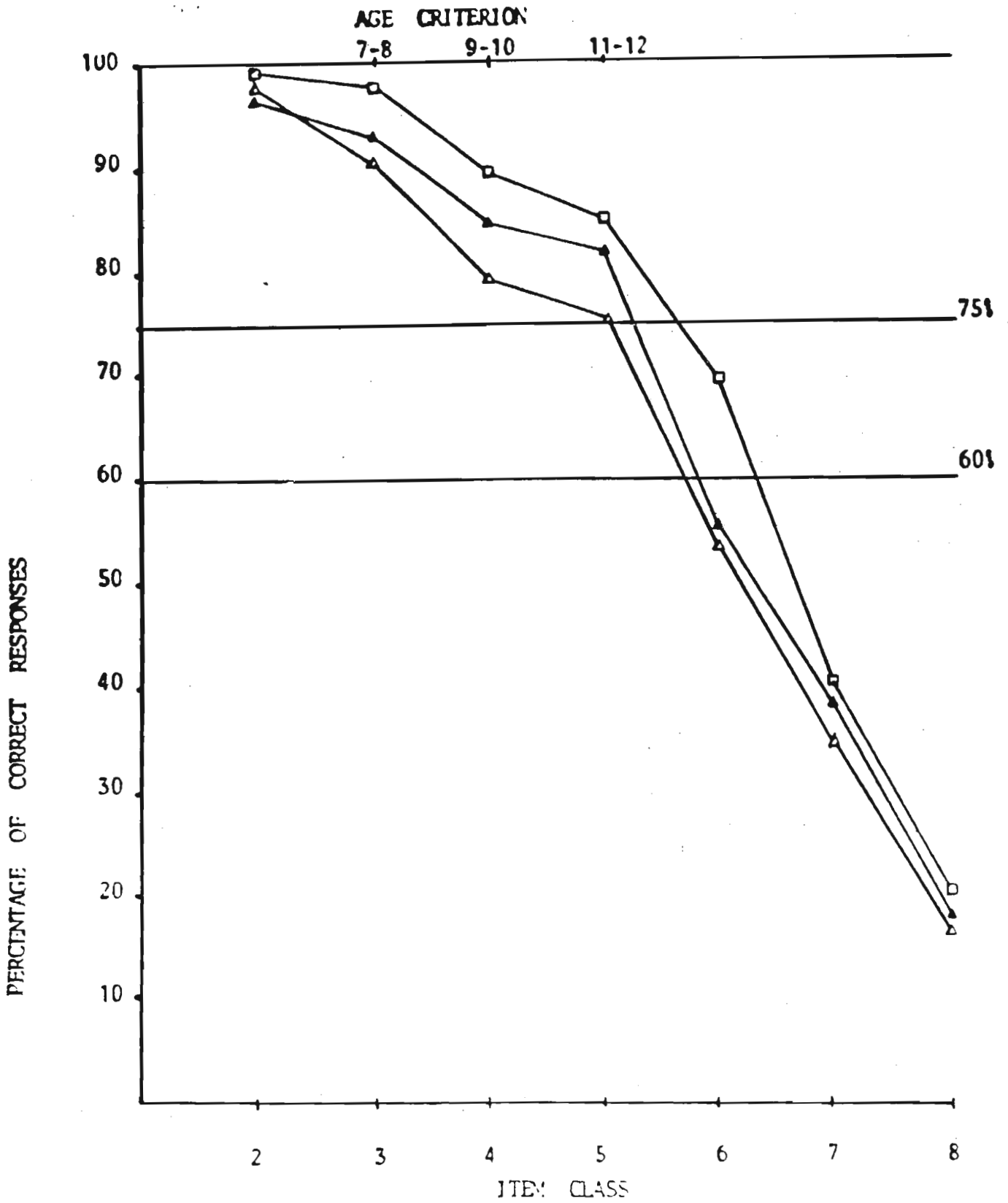


FIGURE 5.6

TRIAL 3: PERCENTAGE OF RESPONSES CORRECT PER STIMULUS CLASS FOR 7-8's, 9-10's, AND 11-12's

AGE  
△—△ 7-8 years (N=67)  
●—● 9-10 " (N=114)  
□—□ 11-12 " (N=71)

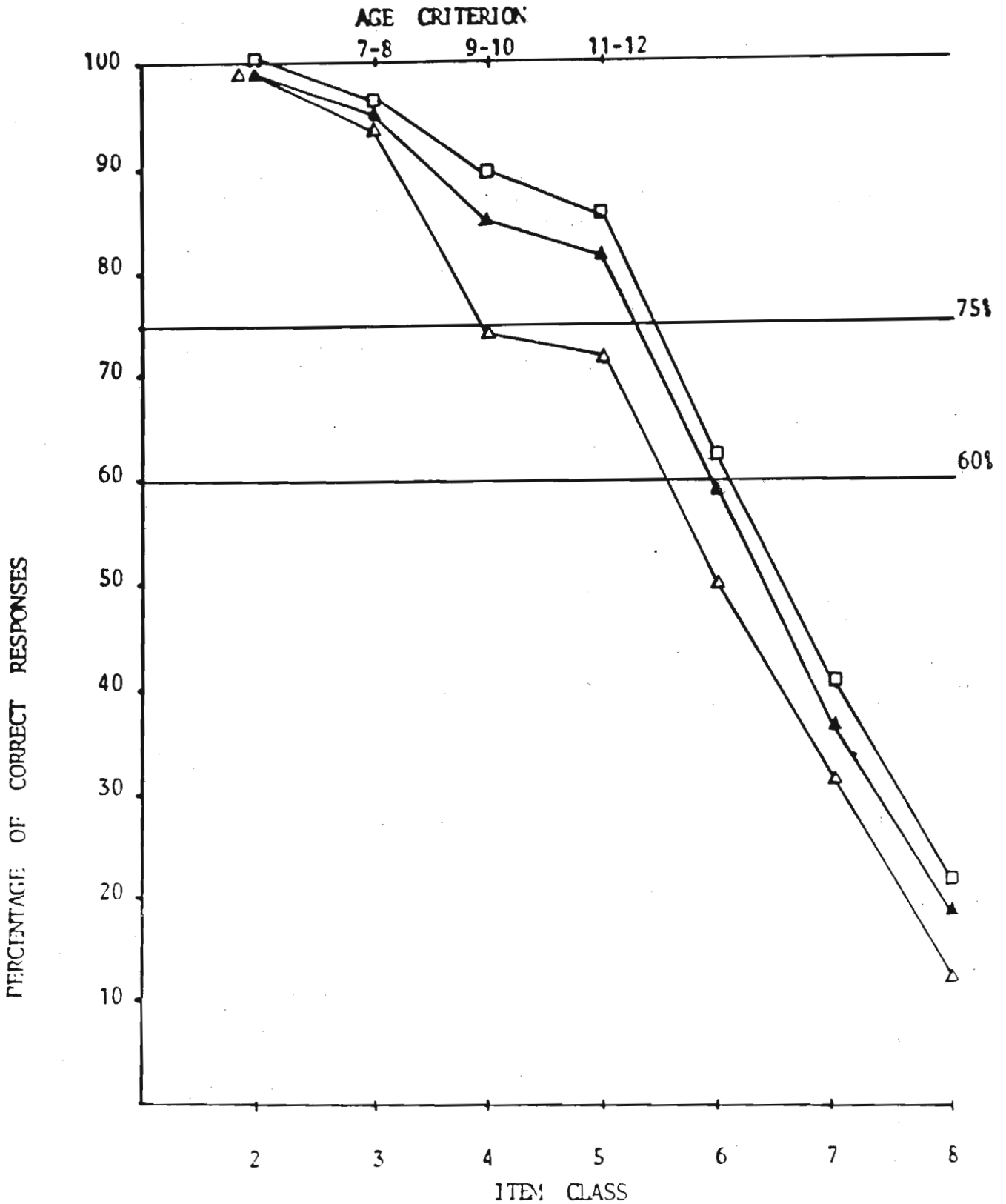


FIGURE 5.7

TRIAL 4: PERCENTAGE OF RESPONSES CORRECT PER STIMULUS CLASS FOR 7-8's, 9-10's, AND 11-12's

AGE  
 △—△ 7-8 years (N=67)  
 ▲—▲ 9-10 " (N=114)  
 □—□ 11-12 " (N=71)

However the 9 - 10's under-perform, reaching only the 7 - 8 level as defined by the Pascual-Leone and Burtis criterion. The 11 - 12's are not much better. Apart from surpassing the 60 percent mark by a narrow margin on class 5 items, they also perform at the 7 - 8 criterion level.

Figure 5.5 shows that by Trial 2, all three age groups have reached their age-appropriate level according to the Pascual-Leone and Burtis criterion.

On Trial 3 (Figure 5.6) although the 11 - 12's performance improves, it does not exceed the Pascual-Leone and Burtis criterion for this age group (apart from a minor over-performance on Class 6 items). However the 9 - 10's performance has reached the 11 - 12 criterion level, as has the 7 - 8 performance.

As has already been noted, there is no significant difference in performance on Trials 3 and 4. (Although there is a non-significant drop in the performance of the 7 - 8's on the higher item classes).

Thus the interesting fact emerges that on Trial 1 all the subjects perform more or less at the 7 - 8 level (apart from the 7 - 8's themselves who are only very slightly below). On Trial 3 the "ceiling" trial, beyond which there is no significant change, all the subjects perform at the 11 - 12 level (apart from the 11 - 12's who are slightly above on class 6 items).

In summary, overall trends in the data support the three predictive hypotheses laid out earlier in this section. The children underperformed on Trial 1 and reached criterion on Trial 2. Their performance improved from Trials 2 to 3 - and then reached a "ceiling", with no significant improvement from Trials 3 to 4. However while the general pattern of development in the present study supported the hypotheses, the k-scores at

which the 7 - 8 and 9 - 10 subjects reached their "ceiling" of performance were higher than those laid down by the TCO's theoretical predictions.

Using the Pascual-Leone and Burtis criterion for the  $k$  ( $k$  being the item class at which subjects of each particular  $k$ -related age group succeed at 75 percent, with less than 60 percent success at all higher item classes), by Trials 3 and 4, the 7 - 8 year olds were performing at a level of  $k = 5$ , that is two  $k$ -units higher than their age-appropriate level ( $k = 3$ ). On these trials the 9 - 10 year olds also performed at  $k = 5$ , one unit above their age-appropriate level ( $k = 4$ ). On the other hand, the 11 - 12 age group's performance conformed to the TCO's predictions. They performed at the  $k = 5$  level on Trial 2, and did not exceed it on the two succeeding trials. These points will be taken up in the discussion section.



## 6. DISCUSSION

6.1 The first section of this discussion suggests an explanation for two features of the data which do not appear to conform to certain of the TCO's theoretical predictions. The first of these features is the lack of evidence for stage-wise improvement from one age-group to the next. The second is the fact that the 7 - 8's and 9 - 10's exceeded criterion, while the 11 - 12's did not. This explanation requires (i) a detailed task analysis of the FIT itself, as well as (ii) an examination of the resources available to the individual to succeed on the test. This involves attention to the interaction between age-related developmental (context-free) resources and learning (context-specific) resources.

According to the TCO's "metasubjective task analysis" the M-demand for a task is the number of schemes that need to be mentally activated in order to execute the most demanding step in a task. One scheme needs to be activated continually throughout a task sequence. This is the executive scheme and represents the overall plan of action. This is the scheme labelled  $\underline{e}$  in the equation  $\underline{M} = \underline{e} + \underline{k}$ , and it is simply taken to be a constant amount of energy from stage to stage, counted separately from the other schemes in calculating  $\underline{M}$ -demand.

The other schemes involved at any step in task execution - those involved in the calculation of  $\underline{k}$ -scores - are one or more figurative schemes "representing past or present states of affairs", and an operative scheme representing a transformation or operation (Scardamalia, 1977, p. 33).

Before proceeding to a detailed task analysis of the FIT, attention must be given to the review of a large body of FIT data by Pascual-Leone and Burtis (1975) who found that the data's structure corresponded closely to an "equally-spaced additive conjoint structure" (Johnson, 1982, p. 17). In the case of the FIT this means the following in terms of the

relationship between M-power and item class (Goodman, 1979; Pascual-Leone, 1976):

1. For any age, a given probability of solving items of class  $x$  implies at least as high a probability of solving items of classes lower than  $x$ .
2. Older subjects succeed (at a given probability level) at higher classes than younger subjects.
3. The relation between age and item class is such that an increase of one unit of M-power (as estimated by age) is matched by success on items one class larger.
4. The highest item class passed at a probability level of 0.75 by subjects with an M-power of  $\underline{e} + \underline{k}$  is class  $\underline{k}$  (for example the highest class solved by the majority of 7 - 8 year olds ( $\underline{M} = \underline{e} + 3$ ) is class 3).

The following task analysis of the FIT test suggested by Goodman (1979) supports this outline of the relationship between M-power and item class : Successful performance on a FIT item requires the subject to identify in the intersecting set each of the separately presented figures in the presentation set. (In the intersecting set simple perceptual matching is not adequate for finding the relevant shapes, since the shapes in the intersecting set may differ in size and orientation from those presented separately). The identification of each shape involves a figurative scheme. At each step of this identification strategy, the shapes found so far must be kept in mind as each new shape is matched, and finally the whole set of shapes must be processed together by an operative scheme that picks out the area of common intersection. In this process the first figure identified plays a special role. Subjects most often peg the

first-identified figure as a boundary or "ground" within which the remaining shapes are inspected (Goodman, 1979). This is often overtly done by placing a finger or the pen on one figure in the intersection set to "narrow down" the area in which the intersection must fall. According to Goodman (1979) this analysis suggests that for any class  $x$ , with one figure acting as ground,  $x - 1$  figures must be identified involving  $x - 1$  figurative schemes. These schemes must be conjointly processed together with the one operative scheme representing the act of identifying the area of common intersection. This yields an  $\underline{M}$ -demand equal to the number of shapes in the intersecting set, which is the class value for each item ( $(x - 1) + 1 = x$  number of schemes).

The data support this task analysis on Trial 2, where the children performed as predicted. However the task analysis does not explain the improvement on Trial 3 insofar as it implies that the 7 - 8's should reach their developmental ceiling at  $\underline{k} = 3$ , the 9 - 10's at  $\underline{k} = 4$  and the 11 - 12's at  $\underline{k} = 5$ . As was noted in the results section, all these age groups reached their ceiling at  $\underline{k} = 5$ .

This section seeks to explain this aspect of the data in terms of :

- i) The effect of non- $\underline{M}$  factors on FIT performance, especially  $\underline{F}$  and  $\underline{L}$ .
- ii) The composition of the present research sample.

The next sub-section looks at the non- $\underline{M}$  factors that affect performance on the FIT, to show that  $\underline{M}$  is a necessary, but not sufficient condition for good performance, and that non- $\underline{M}$  factors (for example those related to  $\underline{L}$  and  $\underline{F}$ ) can lead a subject to the same performance as would a higher  $\underline{M}$ -power. This information will be linked to particular characteristics of the present study's sample, to show that these unexpected  $\underline{k}$  levels can be

explained within the parameters of the TCO.

### 6.1.1 Effect of Non-M Factors on FIT Performance

Before discussing the effect of non M factors on FIT performance, it must be stressed that the FIT was designed to be administered *once*, and not three or four times. Thus with practice it becomes an *overlearned* task. Thus the children's dramatic over-performance relative to the Goodman (1979) data on the later trials may be partly ascribed to the effect of practice, resulting in the development of strong, task-appropriate context-specific operators which reduce the task's M-demand. In addition Pascual-Leone and Goodman (1979) assert that in overlearned tasks there may be a decrease in executive demand.

"In an overlearned task the executive may need less M-boosting, thus leaving more M-energy free for use with other schemes, and consequently, increasing the measure of L (p. 324).

We can now turn to Goodman's (1979) comments on the effect of non-M factors on the FIT. Performance on the FIT does not always strictly conform to the TCO's theoretical predictions concerning M because according to the TCO certain factors other than M may intervene in performance (Goodman, 1979; Johnson, 1982; Pascual-Leone no date; Pascual-Leone, 1976). Goodman (1979) outlines three such factors : F and LC factors, executive strategy factors and "operative mobility effects" (p. 269). These are considered in turn:

#### 6.1.1.1 F and LC factors

To the extent that the intersecting set presents gestalt-like qualities where the pattern of the set is compelling as a whole, some items may present an F-*misleading* structure which impedes subjects in defining the

outlines of particular shapes. The pattern-like qualities of the intersection set may match the LC pattern-structures of the subjects such that the LC-boosted pattern of the figure as a whole conflicts with the task requirement that the subject separately identify the outline of each figure, because the outline of each figure has become embedded or submerged in the whole.

Skakich (1978) notes that this embedding problem may be especially strong in items that contain a triangle and at least one other shape with straight lines. She interviewed subjects as to the strategies they were using to solve FIT items, and found that on items with triangles, subjects "tended to confuse primary contour areas (for example the triangle as drawn) with secondary contour areas (such as new triangles or triangle-like shapes fortuitously created by the intersection)" (Skakich, 1978, p. 109).

From her interviews, Skakich (1978) identified three LC and F-facilitating factors which may serve as potential confounding factors in the FIT's measurement of M. The first of these is the tendency to perceptually identify the area of greatest *visual density* (the area of the intersecting set with the most lines around it) as the intersection area. This tendency is potentially facilitating particularly with some of the higher class items. *Size* is another perceptual cue. Subjects tend to identify the smallest area in the intersection set, also providing an easy solution to some of the higher class items. The third perceptual cue is *centrality*: items whose solution falls in the centre of the test set may be more easily solved than others of their class.

Thus on some items the influence of F and LC facilitating effects may

enable subjects with suitable executives, F and LC factors to solve items whose M-demand exceeds their M-power. It is important to note that effects that may be facilitating in one context may serve to be misleading in another.

#### 6.1.1.2 Operative mobility factors

Subjects that are able to vary their approaches to the FIT items are most likely to succeed, and least likely to be overwhelmed by misleading effects. Goodman (1979) refers to this ability as high operative mobility. Some items are best solved by choosing a dense portion of the pattern, and locating the figure that will serve as ground within it. Other items are best solved by locating a relatively segregated figure and using it to narrow down the search for a common intersection area. Since the same cues which are facilitating on some items are misleading on others, subjects who tend to take one particular approach (focussing on size or density for example) on all items will often fail.

Goodman (1979) refers to a second operative mobility factor that improves FIT performance : efficient perceptual-conceptual interplay. She outlines two aspects of an item's selection.

- 1) The first aspect is the initial perceptual identification of the relevant shapes, using a systematic procedure to identify each and every figure, discovering what lines of the patterns go with which figure and so on. The better the subject's LC perceptual repertoire, the more easily he/she will be able to follow a figure's lines and segregate it from the others
- 2) Once a figure is identified, the subject must hold it in mind, "but this holding must be conceptual, not perceptual, or else the figure

will interfere with the perception of other figures, and may itself be 'lost' as other aspects of the intersecting pattern are explored." (Goodman, 1979, p. 286). Furthermore, since the FIT is not a simple perceptual task the subjects should be able to identify a *specific* triangle, for example, as an instance of a *generic* triangle, and conduct the identification procedure on this basis.

This means that there must be a continual interplay between the initial perceptual identification procedure, and the "conceptual maintenance of the so segregated figure". (*Ibid*, p. 286).

#### 6.1.1.3 Executive strategies which reduce M-demand

The task analysis described above assumes that the subject uses the strategy taught in the task instructions : to identify and simultaneously keep in mind all the relevant figures. Parkinson (1975) and Pascual-Leone and Burtis (1975) have suggested an alternative strategy that could reduce M-demand and thus play a role in FIT performance. This strategy would begin by finding the area of intersection of two shapes, and then finding the intersection of this particular area with a third shape. By progressing in this way, at any one step one would have to simultaneously consider only the common area and the new shape to be intersected, allowing higher class items to be solved as easily as lower class items.

Goodman (1979) notes that the discovery of such a strategy without training has an M-demand of  $e + 5$  and therefore should only be accessible to the older subjects. It is unlikely that this strategy was used in the present study. If it had been used it would have caused subjects to perform beyond the level of  $k = 5$  on the test - and this was not the case.

#### 6.1.1.4 Implications of the influence of non-M factors on FIT performance



M-stage effects were found on Trial 2, but not on the other trials. The influence of non-M factors on FIT performance explains why M-stage effects were not found in these parts of the data.

"To the extent that strong non-M factors intervene in a given task, the M-stage constraints may not appear in performance ... the non-M organismic factors act as moderator variables and can be expected to mask, at least in certain contexts, the overt manifestation of the M-stage effect." (Goodman, 1979, p. 12).

In addition to noting the "masking" effects of F and L factors on the appearance of M-stages, attention must be given to the developmental course of the F and L operators. This does not coincide with the developmental course of the M operator. This fact, together with the composition of the sample will be used to explain the fact that with repeated testing the 7 - 8's exceeded their theoretically predicted performance level by such a wide margin, as opposed to the 11 - 12's who did not exceed criterion.

The TCO posits that each M-stage lasts for two years. Successive M-stages develop maturationally, beginning on odd chronological years. Thus 7 - 8's will have an M of  $\underline{e} + 3$ , 9 - 10's of  $\underline{e} + 4$  and 11 - 12's of  $\underline{e} + 5$ . A "pure" M-measure should yield constant performance on M-tasks throughout each two-year stage.

However M is the only metaconstruct that changes in power with age alone. Learning is a continuous and cumulative process, and thus the developmental course of learning-related operators such as LC and F (whose developmental course follows the course of expansion of the LC repertoire of schemes) exhibits *within-stage* changes. Both LC and F develop gradually and continually, and their developmental curve is linear to the M step-wise curve. Thus while children of even and odd ages have the same

amount of M-power, according to the TCO even-aged children are endowed with increased L-power and F-power and will thus be expected to perform better than their odd-aged stage-mates on tasks such as the FIT.

This even-aged advantage, as well as the importance of L, F and executive factors, will be related to the particular composition of the present research sample in the following section.

### 6.1.2 The Composition of the Research Sample

6.1.2.1 The children were drawn from the Dukemini Junior Primary School which offers schooling from Grade 1 to Grade 4, the first four years of schooling. The subject sample of children of ages 7 to 12 was drawn from the second, third and fourth years of schooling.

The law specifies that children should start school at the age of 6 years. Thus children who start school at the prescribed age and do not fail should be 6/7 in Grade 1, 7/8 Grade 2, 8/9 in Grade 3 and 9/10 in Grade 4. This means that by 10 years of age they are already at, or about to go to a *senior* primary school.

For this reason we can assume that children of 11 and 12 years of age who are still in the second, third, and fourth year of school have either failed one or more years of schooling or started school at an age of more than 6 years of age for some reason (which is not uncommon). Children who have failed at school are likely to have poor L, F and executive operators, since these are linked to successful school achievement. Children who for other reasons are in a school grade below their age potential may have had an inadequate opportunity to develop age-appropriate L, F and executive operators, due to inadequate exposure to age-appropriate learning material.

By the same token, children of 7 - 8 in this subject sample are likely to have age-appropriate L, F and executive operators, and/or have had an adequate opportunity to develop to their maximum cognitive potential. Thus it may be argued that by virtue of the particular parameters of the sample pool, the subject sample is composed of a group of above average 7 - 8 year olds, average 9 - 10 year olds and below average 11 - 12 year olds with regard to development of F, L and executive operators.

(A forthcoming research project will investigate the correlation of the subjects' measured M-power with their performance on a test of field dependence/independence (associated with the F-operator) and a test for L.)

On Trials 3 and 4 the 7 - 8's and 9 - 10's performed at above their theoretical age-appropriate level not due to an M-capacity exceeding the theoretical prediction for their particular age group, but due to strong L, F and executive factors. "The TCO suggests ... that non-M processes, eg. those related to L and F, can lead to the same performance as a given higher M-power level." (Goodman, 1979, p. 368).

6.1.2.2 A second feature of the composition of the sample may have contributed to the extreme over-performance of the 7 - 8's as opposed to that of the 11 - 12's. This is the fact that the 7 - 8 group consisted predominantly (76%) of 8 year olds, while the 11 - 12 group consisted predominantly (70%) of 11 year olds. This means that the 7 - 8 group was heavily weighted with older even-year subjects, while the 11 - 12 group was heavily weighted with younger odd-age subjects. This is important in the light of Goodman's (1979) evidence for the executive and figurative superiority of the even-year subjects of each developmental stage. Such subjects are usually more proficient for example at overcoming embedding

contexts (ie overcoming LC and F misleading effects), and more likely to be guided by LC and F facilitating effects. For this reason one would expect the 7 - 8's to be far more likely to exceed their age criterion than the 11 - 12's through the help of FIT-appropriate non-M factors.

Having suggested reasons for the deviation of the present FIT scores from the TCO's theoretical predictions, this discussion now turns to a more detailed analysis of the process of change/development from Trials 1 to 4 in terms of the functional structure of the metasubject.

## 6.2 Changing Metasubjective Processes from Trial 1 to Trial 4

In the light of the preceding section outlining the characteristics of the FIT, and the M and non-M resources available to the subject to succeed on the FIT, it is now possible to discuss in detail the changing metasubjective processes in operation from underperformance on Trial 1 to criterion performance on Trial 2 and overperformance on Trials 3 and 4. Investigation of such a process of confronting and mastering an unfamiliar task is the central issue in the present research framework which sees "... participants (in the world as) involved primarily through their confrontation with contradictions; contradictions between the familiar and the unfamiliar, or the old and the new, that highlights the issue of change" (Craig, 1985, p. 8). This section seeks to explicate this process of confrontation in terms of the interaction between mind/development (the context-free operators in cognition) and learning/culture (the context-specific operators) as postulated by the TCO's model of the bilevel organisation of metasubject.

This explication constitutes a rational reconstruction at the level of intrinsic generative mechanisms of the "psychological machinery" underlying the miniscule process of development provoked in the present research. This is done in an attempt to explicate the "deep structures" responsible for change.

### 6.2.1 Trial 1 : Underperformance

The following factors are postulated for *underperformance* on Trial 1 :

- 1) The subjects have a relative lack of experience relevant to tasks of this nature, as a result of growing up in a "non-western" culture where formal schooling is not predominant. This point is expanded in

Section 6.3. Due to poor FIT-related learning opportunities, the children have failed to develop the appropriate executives. Not having the necessary executive plans at their disposal, they have inadequate or inappropriate executive controls for the task - either simply failing to mobilise their full M-reserve, or else allocating it to inappropriate schemes, thus serving to hinder rather than facilitate success.

- 2) Due to the lack of appropriate executives to allocate the available M-reserve on Trial 1, the metasubject may also be at the mercy of misleading F, C and LC structures which will activate inappropriate schemes, causing them to become dominant, due to the executive failure to boost more suitable schemes to "over-ride" the misleading affect. Lack of experience also means that potentially facilitating F, C and LC factors are unlikely to be present.
- 3) Lack of experience of tasks of this nature would also be responsible for poor operative mobility factors on Trial 1, particularly with regard to efficient perceptual-conceptual interplay (section 6.1.1.2). It is postulated that on the first trial the children have not yet fully comprehended that the test is *not* a simple perceptual matching task, but involved matching shapes that often differ markedly, in size and orientation. Thus for example it involves identifying a *token* square as an instance of the *type* square, and conducting the identification procedure on this basis. It appears that by Trial 2 they have acquired a greater facility with this necessary perceptual-conceptual switch.

#### 6.2.2 Trial 2 : Criterion Performance

Had the FIT only been administered once, it might have been concluded that

the subjects lacked the ability to perform to criterion. However FIT results on the succeeding trials support the hypothesis that the children have the mental capacity, given the appropriate experience, to succeed. By Trial 2, after one exposure to the task, and two exposures to detailed task instructions, they perform to criterion. Thus by Trial 2 the children have developed FIT-appropriate executives. It is important to note that although the children are presented with the opportunities to learn these executives in terms of exposure to the task, they actually learn them *by themselves*. That is the learning is *intra-psychological* in the sense that the children are not trained in the use of specific executives.

### 6.2.3 Trials 3 and 4 : Overperformance

On Trials 3 and 4, the dramatic overperformance of the 7 - 8's and 9 - 10's, as well as the overperformance of the 11 - 12's on Class 5 items (their age-appropriate item class) is explained in terms of the development with experience of the task, of FIT appropriate F and LC facilitating structures and increased operative inability. In addition, with more efficient allocation of M to activate the necessary schemes, misleading F and LC effects have less power. Furthermore, as has already been mentioned (Section 6.1), with overlearning, the executive demand of a task may decrease, leaving more M than would normally be available to a child of a particular age group encountering new and varying tasks his/her everyday life.

These F and LC effects as well as increased operative mobility factors are all a function of learning/experience, and these are postulated to explain how the subjects achieved higher FIT results that would have been the case had the FIT been a "pure" M test. However, it is important to note that

although these facilitating learned factors enabled the children to overperform, there was a limit to their overperformance, reached on Trial 3. This means that there is a limit to the extent that L, LC and operative mobility factors can improve FIT scores and/or that there is a developmental ceiling on these facilitating factors. Goodman (1979) points to the possibility of developmental ceilings on non-M operators such as F and LC - an as yet unexplored issue.

In examining changes in the metasubject from Trial 1 to Trial 4, it is possible to observe how the full extent of a child's context-free cognitive potential lies dormant until he/she has sufficient experience necessary for its efficient mobilisation. Thus actualisation of his/her full M-potential depends on the development of appropriate executives. In turn the complexity of the executives that a child of a particular age can develop is limited by his/her age-determined M-power. Furthermore silent operators such as F and LC exist as propensities which every child is born with. However in order that they develop, the child must have appropriate experience. Thus although their origins are context-free, their developmental course is context-specific.



### 6.3 Mediated Learning Opportunities in Zulu-Speaking Society

In the previous section, the subjects initial underperformance on Trial 1 of the FIT was explained in terms of lack of FIT-appropriate executives. This was attributed to lack of experience of tasks of this nature as the result of growing up in a "non-western" culture where formal schooling was not predominant. This section looks at reasons for the lack of these executives on Trial 1.

It has already been mentioned that Zulu-speaking children have limited or no access to toys such as puzzles, tinker toys, drawing books and so on which are an integral part of the background of a child growing up in a "western" background. Even more important is that the fact that non-western child-rearers may not always mediate between the developing child and the external world in a way that is most appropriate for the development of concepts suited to formal schooling.

The present research has focused on the *intrinsic* generative mechanisms involved in development. The studies of Craig (1985), Mindry (1984) and Kok and Beinhart (1983) mentioned in this section work within Vygotsky's (1978) framework, investigating cognitive development at the level of *extrinsic* generative mechanisms. In other words they focus on the way in which cultural "recipes for living" are transmitted to the child through the mediation of adults.

Kok and Beinhart (1983) studied the way in which Zulu-speaking mothers instructed their pre-school children to solve puzzle tasks. They found that the mothers' instructions were not consistent with the demands of independent problem solving. Thus, for example, they tended to provide non-generalisable instructions - instructions on where to place particular

pieces of the puzzle, rather than rules that would "... build up the child's understanding of the situation as a specific instance of a more general class of similar kinds of tasks" (*Ibid.*, p. 52). This "inappropriate teaching style" was explained in terms of the fact that the mothers did not seem to be familiar with independent problem-solving tasks of this kind, and with instruction of a formal nature. Mindry (1984) looked at the teaching style of Zulu-speaking teachers, and found that there was no significant difference in their teaching style to that of the mothers in Kok and Beinhart's study. These studies suggest that Zulu-speaking children are not exposed to "mediated learning" (Feuerstein *et al.*, 1980) suitable for the development of the executives necessary for success in formal schooling.

Craig (1985) suggests that Zulu-speaking child-rearers in rapid transition between a "well-integrated and ordered traditional Zulu culture" (p. 281) and western social forms are faced with conflicting aims. They must simultaneously rear their children to be competent members of their own culture and competent members of western society to which they are relative newcomers. These two cultural systems often have conflicting social forms and goals. Thus, for example, she found that on the one hand the mothers expressed the wish that their children should have as much formal western schooling as possible. On the other hand, due to their own lack of experience of this phenomenon they lacked the "tried and tested recipes" to suitably equip their children for it.

"Mothers, or any other caretaking figures, must prepare children to participate as actors in a social group whose roles and expectations they may not themselves fully understand" (Miller, 1984, p. 22).

For this reason Zulu-speaking children come to school inadequately equipped with executives whose existence would simply be taken for granted

in schoolchildren in so-called western-industrialised-urban-technological-schooled society (*Ibid*, p. 21).

"They (the mothers) desire entry into, and successful participation in this institution, yet have not incorporated into their child-rearing a concordant support system in order to achieve this goal. For example, preparing pre-school children for school by teaching them school-related tasks, or helping school-children with homework, or encouraging verbal interaction, do not emerge as powerful forces in (their) indigenous theory of childhood. It seems that in some cases the intruding culture, or the new social forms that confront people, provides actors with *goals* but without the accompanying beliefs, desires, and actions that would render acquisition of these goals immediately accessible. Furthermore, judging from the mothers' regulation of their children during the problem solving situation, they seem to have goals different from those required by the formal school system ...." (Craig, 1985, pp. 277 - 278).

Thus Craig found, for example, that Zulu mothers stressed the importance of passivity and obedience in the childrens' behaviour : qualities which may often be antagonistic to the requirements of formal schooling that they become independent problem solvers. Their teaching styles did not encourage an exploratory, questioning attitude to the tasks.

"The indigenous theory of childhood reconstructed from the mother's interviews emphasises the importance of example and demonstration as teaching methods and observation and imitation as primary modes of learning required of children" (Craig and Miller, 1984, p. 9).

The focus of these researchers on extrinsic generative mechanisms complements the focus of the present research on intrinsic mechanisms. Both these levels will have to be accommodated in any attempt to facilitate the conditions for change that might emerge from research of this nature.

## 6.4 Conclusions

### 6.4.1 General Implications

In its focus on the intrinsic generative mechanisms at work in the metasubject, the present research has demonstrated that in spite of initial underperformance on the FIT, the subjects possessed the inherent mental capacity to develop the necessary executives intra-psychologically (once provided with the necessary external mediation in the form of repeated exposure to the task as well as detailed task instructions). In so doing this research has supported Pascual-Leone's contention that all children have the same M-power, and that performance differences among various groups of children are the result of different learning experiences. These result in different context-specific repertoires of cognitive structures that equip children best for tasks rooted in their particular cultural framework.

This conclusion has particular implications for South Africa, where "divide and rule", the central tenet of apartheid, creates the situation where racial differences are constantly emphasised at the cost of universal human characteristics.

"Any indication of what appears to be differences may provide justification for separation .... It has been argued by its proponents that apartheid should be viewed as a reasonable system in which people with different socio-historical traditions and context-specific experiences are able to co-exist" (Craig and Miller, 1984, pp. 1 - 2).

It is on the basis of such assumptions about the irreconcilable differences between race groups that the white apartheid ideologists justify their systematic discrimination against black South Africans in such a way that they are able to entrench their dominant position on the

economic, political and social fronts.

"The structures of South Africa sustain a situation in which it is whites (though not all whites) who are the accumulators of capital, the wealthy, and the powerful, while the majority of blacks (though not all blacks) are the unemployed, the ultra-exploited, the poor and the powerless" (Legassik, 1974, p. 30).

The present project has sought to undermine apartheid's insistence on the irreconcilability of racial differences in two important ways. First by the support it provides for the notion of universal cognitive capacities. Secondly by its focus on the generative mechanisms that produce change - or, in other words, enable the individual to overcome those particular constraints of his/her social and historical conditions that may serve to hinder particular changing goals in a rapidly changing society. Thus there seems to be little justification for this obsession with difference, or for the implication that cultural differences cannot be transcended. Furthermore, the present focus on change points to the possibility of transfer of social forms and skills from African to western groups and vice versa in such a way as to enrich and benefit both cultural groups.

On one level research of this nature serves to show up the spuriousness of the apartheid ideologists' assumption that racial differences are so unbridgeable, and communication between black and white South Africans so unlikely, that they should even live in different "national states". On another level it makes a contribution to psychology in general in terms of the light it throws on the way in which individual and social factors interact in mental functioning in any society. This takes us back to Miller and Craig's (1984) point that we become so enmeshed in our own particular frame of reference that we are unable to see how mind and culture interact in every aspect of our experience. Thus we turn to other

① *Indice de différences. Not. Miller*

cultures to gain the necessary perspective *not* to compare how people in other cultures do "*their* tricks", but to understand how we do "*our* tricks". (p. 14).

#### 6.4.2 Support for the notion of developmental stages

The present research has also made a case for Pascual-Leone's claim that there is a developmental ceiling to performance for each age group - a limit beyond which performance cannot improve due to stage-related limits in M-power.

This has particular implications for the cultural relativists' learning account of development as the gradual accumulation of context-specific experience. There is a popular and controversial trend in psychology in general to assert that "... the concept of stage will not, in fact, figure importantly in future scientific work on cognitive growth" (Flavell, 1977, p. 249). Brainerd (1978) has been a particularly influential exponent of this position, holding that the notion of developmental stages is not empirically verifiable. The present results support the existence of age-related stages. The evidence for developmental ceilings on performance is incompatible with the learning account of development.

#### 6.4.3 Heredity-Environment? : A Non-Issue

In conclusion it is suggested that the present evidence for the importance of both mind and culture in cognitive development, and the intricacy of their interaction, points to the folly of attempting to view them as separable systems, or to isolate one of these phenomena as a predominant factor in cognitive development.

In the light of results of this nature, the age old heredity-environment or mind-culture debate becomes a non-issue. On the one hand the present research framework supplements approaches such as that of the LCHC and Cole. It shows the limitations of their exclusive focus on context-specific aspects of cognitive development at the expense of context-free factors, thus precluding the explanation of how individuals and societies change in response to changing social and historical circumstances.

It also points to misconceptions at the other end of the spectrum in the work of researchers in the tradition of Jensen and Herrnstein who seek to explain all performance differences on cognitive measures in terms of the context-free aspects of cognition. They argue for qualitative genetic differences in the intelligence of various race groups (Jensen, 1969, 1972, 1977, 1981) or social classes (Herrnstein, 1973, 1977) - inherent differences in intellectual capacity.

This sort of work has been widely criticised. However while its detractors insist that environmental/SES differences are crucial determinants of performance, and allude to the existence of universal human competencies, they provide no empirical demonstration of these capacities, neither do they suggest the *processes* according to which context-specific and context-free aspects of cognition interact to produce performance. Thus, for example, the work of Kamin (1977a, 1977b, 1981) serves to show that Jensen has failed to prove a link between IQ and heredity, through his critique of the major sources of evidence that have been used to support Jensen's claims that IQ is inheritable.

"The data have repeatedly demonstrated profound environmental effects on IQ scores in circumstances where the genes cannot be implicated. The apparent genetic effects, upon analysis, have invariably been confounded with environmental factors that have been slighted or ignored" (Kamin, 1977, p. 225).

He ends his major book (1977) with Watson's famous dictum

"Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take anyone at random and train him to become any type of specialist I might select - doctor, lawyer, artist, merchant, chief and, yes even beggarman and thief ... regardless of the race of his ancestors" (Watson, quoted in Kamin, 1977, p. 229).

copy  
See Minich  
p. 16

However his work goes no further than asserting the strong possibility of environmental influences on performance. Pascual-Leone's theory provides a framework which fills this gap, and offers the possibility of showing exactly *how* the influences of learning/experience/environment may operate in the process of development or change.

By showing that individuals are neither prisoners of static cultural constraints nor victims of a variable genetic inheritance, Pascual-Leone provides "an explanation of how individuals do and are able to change their being-in-the-world." In so doing his work becomes a foundation stone for a "psychology of liberation". (Craig and Miller, 1984, p. 2).



### 6.5 Suggested Extensions of the Present Research

Two sorts of extensions will be suggested in this section. The first relates to specific issues arising out of this study's particular testing procedure, and the second relates to more general issues.

On the specific level, the present research project has taken the FIT RAC 794, a test designed to be administered once, and applied it four times. The result of this is that the possibility raised by Goodman (1979) of non-M factors influencing FIT scores is greatly increased. This is due to the fact that repeated exposure to the test gives the metasubject an increased opportunity to learn a variety of non-M facilitating mechanisms, which serve to confound the FIT's efficacy as an M-measure.

Thus, in order that the FIT be more successfully used in repeated testing of this nature, several issues need to be explored.

The first issue which must be addressed is the relation of FIT scores to F and L measures. An investigation of the relation between FIT scores and measures of field dependence-independence (Witkin and Berry, 1975) is already planned at Natal University, Durban. This measure is aligned to Pascual-Leone's F factors (Globersen, 1985).

Another problem that was raised in applying the FIT several times was that, in spite of the facilitating effects of learned F and L effects, a developmental "ceiling" was reached. This raises two possibilities that should be investigated. The first possibility is that of developmental restrictions on the F and L factors. The second possibility is that there is a limit to the extent to which F and L factors can facilitate FIT

performance, irrespective of whether there is a developmental restriction on their acquisition.

Another interesting issue is the fact that the metasubjective task analysis mentioned in the present research (section 6.3) is only one possible account of the executive strategy used on the FIT. Goodman (1979) has raised the issue of one alternative strategy available to older subjects (section 6.1.1.3). It would be interesting to examine the possibility of other alternative strategies, including those available to younger subjects.

Miller (pers. comm.) has suggested the possibility of an executive strategy which may be successfully used for the lower item classes 3, 4 and 5, but which would cease to be effective on higher item classes as F and LC misleading effects such as size and density factors intensified. The existence of such a strategy would throw more light on the present research's interesting finding that the 7-8's performance improved by two k-units with repeated testing, while the 11-12's improvement was relatively less spectacular. It would be informative in this regard insofar as it implied that more accessible strategies were available for the 7-8's to overperform than were available to the 11-12's (where the same degree of over-performance would require success on the higher item classes 6 and 7).

On a more general level the present research findings point towards an investigation into the precise nature of the executives required by formal schooling, and into the development of specific techniques in which teachers can be trained to better transmit problem-solving skills.

However to attempt to apply remedial measures at the metasubjective level alone may be likened to trying to lead a camel through the eye of a needle. The cognitive development of black South African children takes place within a complex of problematic social, political and economic levels, all of which must be addressed by the process of change.

BIBLIOGRAPHY

- Bhaskar, R. (1979). The Possibility of Naturalism. Brighton: Harvester.
- Brainerd, C.J. (1978). The stage question in cognitive-development theory. The Behavioural and Brain Sciences, 2, 173-213.
- Brislin, R., Bochner, S. and Lonner, W. (eds.) (1975). Cross-Cultural Perspectives on Learning. New York: Sage Publications.
- Bruner, Jerome (1984). Vygotsky's Zone of Proximal Development: The Hidden Agenda. New Directions for Child Development, 23, 93-97.
- Campbell, Sarah F. (ed.) (1976). Piaget Sampler. London: Wiley.
- Case, Robbie. (1974). Structures and Strictures: Some Functional Limitations of the Course of Cognitive Growth. Cognitive Psychology, 6, 544-573.
- Case, Robbie. (1978). Intellectual Development from Birth to Adulthood. A Neo-Piagetian Interpretation. In R. Siegler (ed.) Young Children's Thinking: What Develops?. Hillsdale, New Jersey: Erlbaum.
- Case, Robbie. (1980). A Developmentally Based Approach to the Problem of Instructional Design. Unpublished paper. Ontario Institute for Studies in Education. University of Toronto.
- Case, Robbie and Sandlos, Debra. (1980). Intellectual Development in Infancy: A Neo-Piagetian Interpretation. Paper presented at the Second International Conference on Infant Studies, New Haven, Connecticut.
- Cole, M. (1975). An Ethnographic Psychology of Cognition. In R. Brislin, S. Bochner and W. Lonner (eds.) Cross Cultural Perspectives on Learning. Beverley Hills: Sage Publishers.

- Cole, M., Gay, J., Glick, J. and Sharp. (1971). The Cultural Context of Learning and Thinking. London: Methuen.
- Cole, Michael, and Means, Barbara. (1981). Comparative Studies of How People Think. Cambridge, Mass.: Harvard University Press.
- Cole, Michael and Scribner, Sylvia. (1974). Culture and Thought. New York: Wiley.
- Craig, A. and Miller, R. (1984). Apartheid and South Africa: Liberation and Psychology. Unpublished paper. Natal University, Durban.
- Craig, A. (1985). Mothers and Children: An Analysis of Change. Unpublished doctoral dissertation. Natal University, Durban.
- De Avila, Edward, Havassy, Barbara and Pascual-Leone, Juan (1976). Mexican American Schoolchildren: A Neo-Piagetian Analysis. Washington: Georgetown University Press.
- De Georges, Richard and De Georges, Fernande. (1972) The Structuralists: From Marx to Levi-Strauss. New York: Anchor.
- Fabricius, William, V. (1983). Piaget's Theory of Knowledge: Its Philosophical Context. Human Development, 26, 325-344.
- Feuerstein, R., Rand, T., Hoffman, M.B. and Miller, R. (1980). Instrumental enrichment. Baltimore: University Park Press.
- Flavell, J. (1977). Cognitive Development. New Jersey: Prentice Hall.
- Furth, H.G. (1969). Piaget and Knowledge: Theoretical Foundations. New Jersey: Prentice Hall.
- Georgoudi, Marianthi. (1983). Modern Dialectics in Social Psychology: A reappraisal. European Journal of Social Psychology, 13, 77-93.

- Ginsberg, Herbert and Oppen, Sylvia. (1979). Piaget's Theory of Intellectual Development. Englewood-Cliffs: Prentice Hall.
- Globerson, Tamar. (1981). Mental Capacity and Cognitive Functioning: A Developmental and a Comparative Study. Paper presented at SRCD Convention, Boston.
- Globerson, Tamar. (1985). Field Dependence/Independence and Mental Capacity: A Developmental Approach. Developmental Review, 5, 261-273.
- Goodman, Doba Rebecca. (1979). Stage Transitions and the Developmental Trace of Constructive Operators: An Investigation of a Neo-Piagetian Theory of Cognitive Growth. Unpublished doctoral dissertation, York University, Toronto.
- Griffin, Peg and Cole, Michael. (1984). Current Activity for the Future: The Zo-ped. In B. Rogoff and J.V. Wertsch (eds.), Children's Learning in the Zone of Proximal Development. San Francisco: Jasley.
- Harre, R. and Secord, P.F. (1972). The explanation of social behaviour. Oxford: Basil Blackwell.
- Herrnstein, R.J. (1973). IQ in the Meritocracy. Boston: Atlantic Monthly Press.
- Herrnstein, R.J. (1977). Whatever Happened to Vaudeville? A Reply to Professor Chomsky. In N. Block and G. Dworkin (eds.), The IQ Controversy: Critical Readings. London: Quartet Books.
- Isbel, B.J. and McKee, L. (1980). Society's cradle: An anthropological perspective on the socialisation of cognition. In J. Sants (ed.), Developmental Psychology and Society. London: MacMillan.

- Jahoda, G. (1980). Theoretical and systematic approaches in cross-cultural psychology. In H.C. Triandis and W.W. Lambert (eds.), Handbook of Cross-cultural Psychology Vol. 1. Boston: Allyn and Bacon.
- Jensen, A.R. (1969). How much can we Boost IQ and Scholastic Achievement? Harvard Educational Review, 39, 1-123.
- Jensen, A.R. (1972). Genetics and Education. New York: Harper and Row.
- Jensen, A.R. (1977). Race and the Genetics of Inheritance. In N. Block and G. Dworkin (eds.), In The IQ Controversy: Critical Readings. London: Quartet Books.
- Jensen, A.R. (1981). Obstacles, Problems and Pitfalls in Differential Psychology. In Sandra Scarr, Race, Social Class and Individual Differences in IQ. New Jersey: Lawrence Erlbaum
- Johnson, Janice, M. (1982). The Figural Intersection Test (FIT): A Measure Of Mental (M) Attentional Energy. Unpublished paper. York University, Toronto.
- Kamin, Leon J. (1977) (a). The Science and Politics of IQ. Great Britain: Penguin Books.
- Kamin, Leon J. (1977) (b). Heredity, Intelligence, Politics and Psychology. In N. Block and G. Dworkin (eds.), The IQ Controversy : Critical Readings.
- Kamin, Leon J. (1981). Commentary. In Sandra Scarr, Race, Social Class and Individual Differences in IQ. New Jersey: Lawrence Erlbaum.

- Kok, Amanda and Beinhart, Charlene, (1983). The Development of Self Regulation in Zulu Children. Unpublished honours dissertation, Natal University, Durban.
- Kuhn, Deanna and Meacham, John, (1983). On the Development of Developmental Psychology. Basel: Karger.
- Laboratory of Comparative Human Cognition. (1982). Culture and Intelligence. In R.J. Sternberg (ed.). Handbook of Human Intelligence. Cambridge, Mass: Cambridge University Press.
- Legassik, Martin. (1974). Legislation, Ideology and Economy in Post-1948 South Africa. Journal of Southern African Studies, 1 (1), 5-35.
- Luria, A.R. (1978). Cognitive Development : Its Cultural and Social Foundations. Cambridge, Mass: Harvard University Press.
- Marcuse, Herbert, (1973). Reason and Revolution. London: Routledge and Kegan Paul.
- Miller, Marilyn and Pascual-Leone, Juan (1981). Disconfirming Jensen Experimentally: Intellectual versus Executive-Structural Deficiency in Underperforming Low SES Children. Paper presented at SRCO Convention, Boston.
- Miller, R. (1984). Reflections of Mind and Culture. Pietermaritzburg: University of Natal Press.
- Miller, R. and Craig, A.P. (1984). Cognitive Development and Social Change: Theoretical Issues. Unpublished paper. Natal University, Durban.
- Miller, R. and Craig, A. (1985). Exploring the Zone of Proximal Development: The Necker Cube Effect. Paper presented for the Third National Congress of the Psychological Association of South Africa.



- Mindry, Deborah (1984). The Development of Self-Regulation in Zulu Township Children: Phase II. Unpublished honours dissertation, Natal University, Durban.
- Moessinger, P. (1978). Piaget on Equilibration. Human Development, 21, 255-267.
- Parkinson, G.M. (1975). The Limits of Learning: A quantitative investigation of intelligence. Unpublished doctoral dissertation, York University, Toronto.
- Pascual-Leone, Juan (no date). Manual for FIT: Figural Intersections Test. Unpublished paper, York University, Toronto.
- Pascual-Leone, Juan (1970). A Mathematical Model for the Transition Rule in Piaget's Developmental Stages. Acta Psychologica, 32, 301-345.
- Pascual-Leone, Juan (1976) (a). On Learning and Development, Piagetian Style : 1. A reply to Lefebvre-Pinard. Canadian Psychological Review, 17(4) : 270-288.
- Pascual-Leone, Juan (1976) (b). On Learning and Development, Piagetian Style: II. A critical historical analysis of Geneva's research programme. Canadian Psychological Review, 17(4), 289-297.
- Pascual-Leone, Juan (1976) (c). A view of cognition from a formalist's perspective. In K.F. Riegel and J.A. Meacham (eds.), The Developing Individual in a Changing World Vol. 1. The Hague: Mouton.
- Pascual-Leone, Juan (1976) (d). Metasubjective Problems of Cognition : Forms of Knowing and their Psychological Mechanism. Canadian Psychological Review, 17(2) : 110-125.

- Pascual-Leone, Juan (1976) (e). Stages and Decalages: A Neo-Piagetian View. Unpublished paper. York University, Toronto.
- Pascual-Leone, Juan (1978). Compounds, Confounds, and Models in Developmental Information Processing: A Reply to Trabasso and Foellinger. Journal of Experimental Child Psychology, 26, 18-40.
- Pascual-Leone, Juan (1980). Constructive Problems for Constructive Theories: The Current Relevance of Piaget's Work and a Critique of Information-Processing Simulation Psychology. In R. Kluwe and A. Spada (eds.), Developmental Models of Thinking. New York: Academic.
- Pascual-Leone, J. and Burtis, P.J. (1975). FIT: A Group Measure of M power. Unpublished manuscript, York University.
- Pascual-Leone, Juan and Goodman, Doba (1979). Intelligence and Experience: A Neo-Piagetian Approach. Instructional Science, 8, 301-367.
- Pascual-Leone, J., Goodman, D., Ammon, P. and Subelman, Irene (1978). Piagetian Theory and Neo-Piagetian Analysis as Psychological Guides in Education. In J. McCarthy Gallagher and J.A. Easley, Knowledge and Development, Vol. 2. New York: Plenum.
- Pascual-Leone, Juan and Smith, June (1969). The Encoding and Decoding of Symbols by Children: A New Experimental Paradigm and a Neo-Piagetian Model. Journal of Experimental Child Psychology, 8 (2), 328-355.
- Pascual-Leone, Juan and Sparkman, Eric (1980). The Dialectics of Empiricism and Rationalism: A Last Methodological Reply to Trabasso. Journal of Experimental Child Psychology, 29, 88-101.
- Piaget, Jean (1966). Need and Significance of Cross-Cultural Studies in Genetic Psychology. International Journal of Psychology, 1, 3-13.

- Piaget, Jean (1970). Open discussion on Beilin's paper. In D.R. Green, M.P. Ford, and G.B. Flamer (eds.), Measurement and Piaget. New York: McGraw-Hill.
- Piaget, Jean (1971). Structuralism. London: Routledge and Kegan Paul.
- Piaget, Jean (1977). The Development of Thought: Equilibration of Cognitive Structures. New York: Viking.
- Piaget, Jean (1983) The Origins of Intelligence in the Child. Great Britain: Penguin.
- Piaget, J. and Inhelder, B. (1969). The Psychology of the Child. New York: Basic Books. (pp. 152-159 reprinted in Campbell, 1976, pp. 71-78).
- Rogoff, Barbara (1982). Integrating Context and Cognitive Development. In M.E. Lantz and A.L. Brown, (eds.) Advances in Developmental Psychology. Volume 2. London: Lawrence Erlbaum.
- Rowell, Jack, A. (1983). Equilibration: Developing the Hard Core of the Piagetian Research Programme. Human Development, 26, 61-71.
- Scardamalia, Marlene (1977). Information Processing Capacity and the problem of Horizontal Decalage: A Demonstration Using Combinatorial Reasoning Tasks. Child Development, 48, 28-37.
- Siegler, Robert S. (1978). Children's Thinking: What Develops?. New Jersey: Erlbaum.
- Skakich, S. (1978) Capacity, strategy and style factors in a mental processing capacity measure. Unpublished masters dissertation, York University, Toronto.

South African Institute of Race Relations (1984) Race Relations 1984 Survey. Johannesburg: SAIRR.

Vygotsky, L.S. (1978) Mind in Society. Cambridge, Mass.: Harvard University Press.

Van der Veer, R. and Van Ijzendoorn, M.H. (1985). Vygotsky's Theory of the Higher Psychological Processes: Some Criticisms. Human Development, 28, 1-9.

Voneche, Jacques (1984). Introduction. Human Development, 27, 227-232.

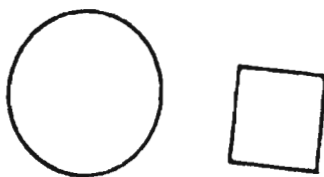
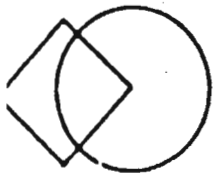
Vuyk, R. (1981) Overview and Critique of Piaget's Genetic Epistemology. 1965-1980. Volumes 1 and 2. London: Academic Press.

Wexler, P. (1982). Critical Social Psychology. London: Routledge and Kegan Paul.

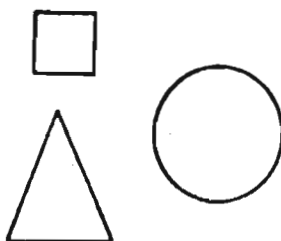
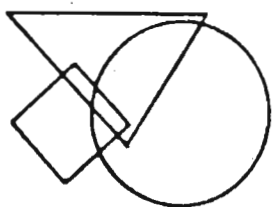
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APPENDIX A

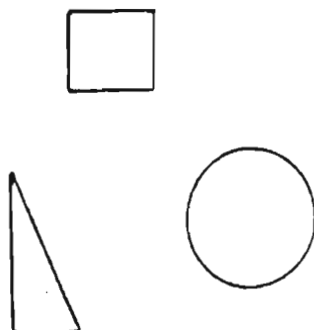
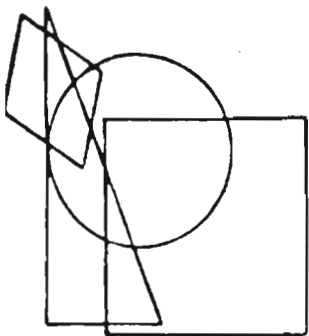
FIT RAC 794 : EXAMPLES OF EACH ITEM CLASS (reduced to 70% of the original size)



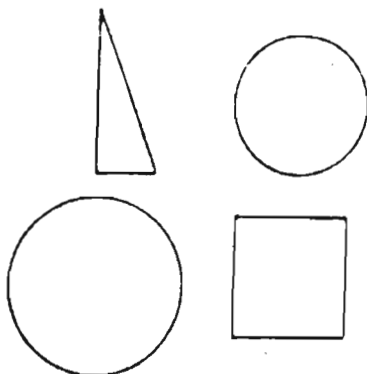
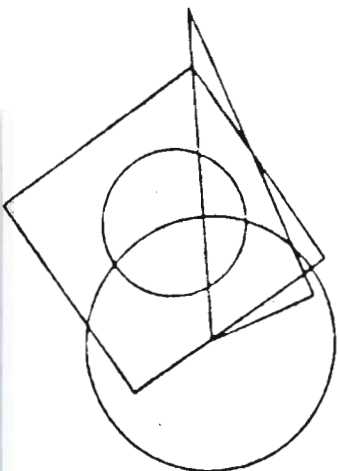
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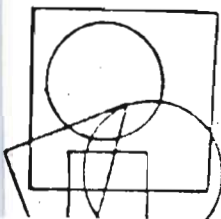
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CLASS 3+1

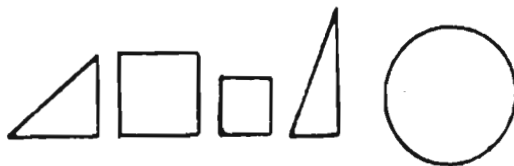
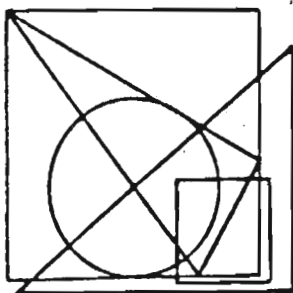


CLASS 4

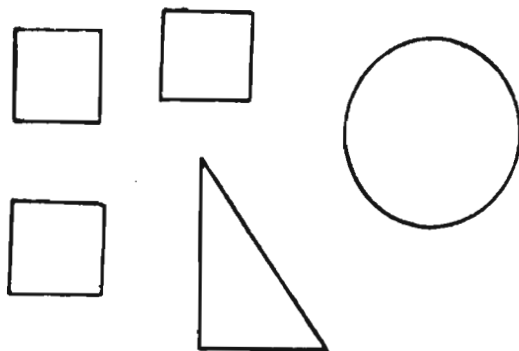
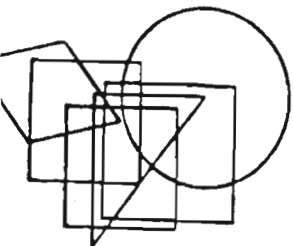


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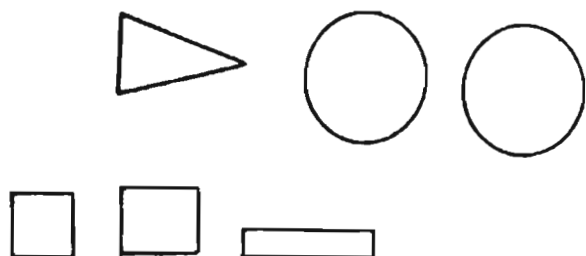
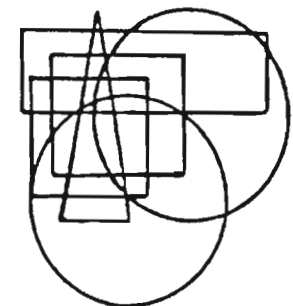
APPENDIX A (cont)



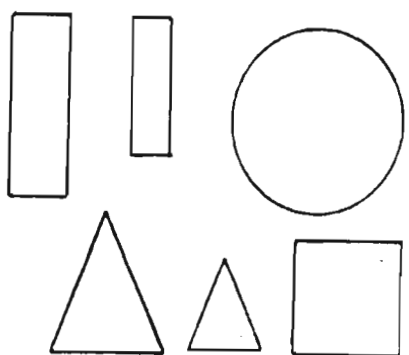
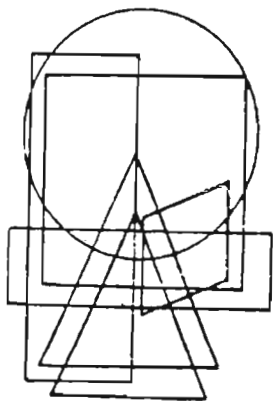
CLASS 5



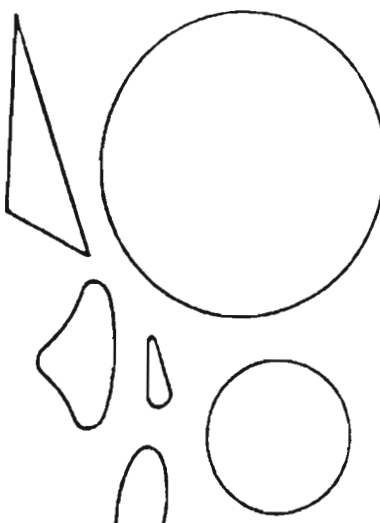
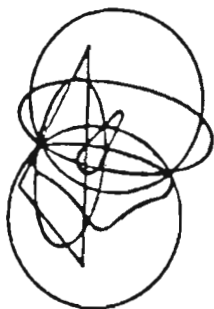
CLASS 5+1



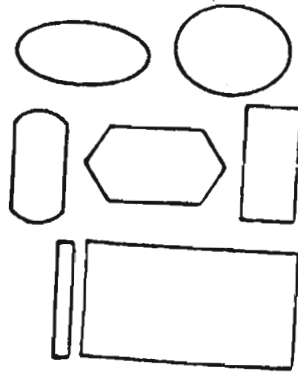
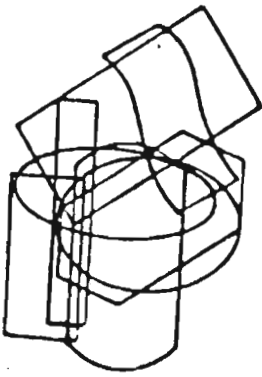
CLASS 6



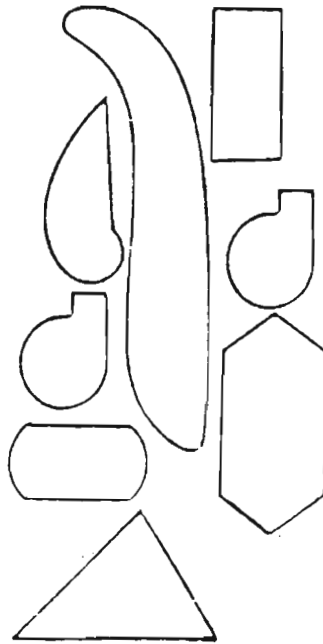
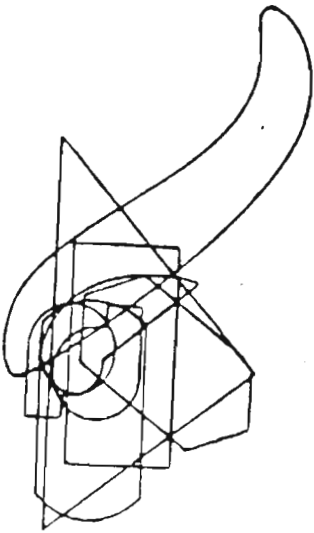
CLASS 6+1



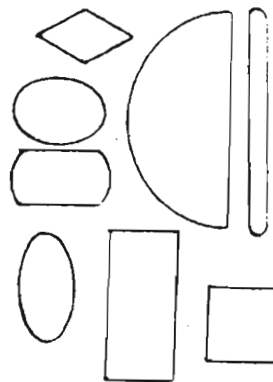
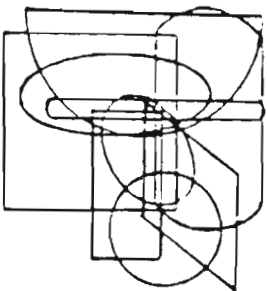
CLASS 7



CLASS 7+1



CLASS 8



CLASS 8+1

## APPENDIX B

Y-Scaling: Means and Standard Deviations for the Three Age Groups on Each Trial for the Seven Item Classes (Means above, standard deviations below)

Item Class	2	3	4	5	6	7	8
A1 T1	4.507 0.959	3.343 1.023	2.537 1.599	2.746 1.531	1.299 1.155	0.642 0.865	0.373 0.373
A1 T2	4.761 0.605	3.582 0.924	3.657 1.399	3.567 1.743	2.164 1.286	1.358 1.083	0.463 0.682
A1 T3	4.925 0.317	3.761 0.653	4.209 1.081	4.522 1.375	2.955 1.618	1.761 0.986	1.045 1.107
A1 T4	4.970 0.602	3.851 0.399	4.119 1.162	4.164 1.452	2.493 1.284	1.582 1.143	0.612 0.673
A2 T1	4.578 1.136	3.360 1.161	3.114 1.692	3.132 1.884	1.570 1.343	0.982 1.081	0.325 0.645
A2 T2	4.868 0.388	3.763 0.669	3.956 1.272	4.202 1.652	2.482 1.312	1.570 1.167	0.816 0.937
A2 T3	4.930 0.289	3.851 0.484	4.404 0.900	4.868 1.266	3.079 1.421	2.018 1.121	1.123 1.114
A2 T4	4.982 0.132	3.930 0.370	4.368 0.962	4.904 1.439	2.974 1.333	1.833 1.004	0.982 0.922
A3 T1	4.789 0.411	3.761 0.620	3.479 1.491	3.831 1.586	1.944 1.351	1.042 0.992	0.563 0.937
A3 T2	4.944 0.232	3.775 0.513	4.310 1.141	4.817 1.291	2.746 1.528	1.704 1.151	0.901 0.796
A3 T3	4.972 0.167	3.958 0.264	4.634 0.779	5.225 1.198	3.423 1.284	2.183 1.257	1.338 1.082
A3 T4	5.000 0.521	3.873 0.335	4.620 0.663	5.085 1.262	3.141 1.211	2.014 1.102	1.141 1.138

A1: 7 - 8 years

A2: 9 - 10 years

A3: 11 - 12 years

T1: Trial 1

T2: Trial 2

T3: Trial 3

T4: Trial 4



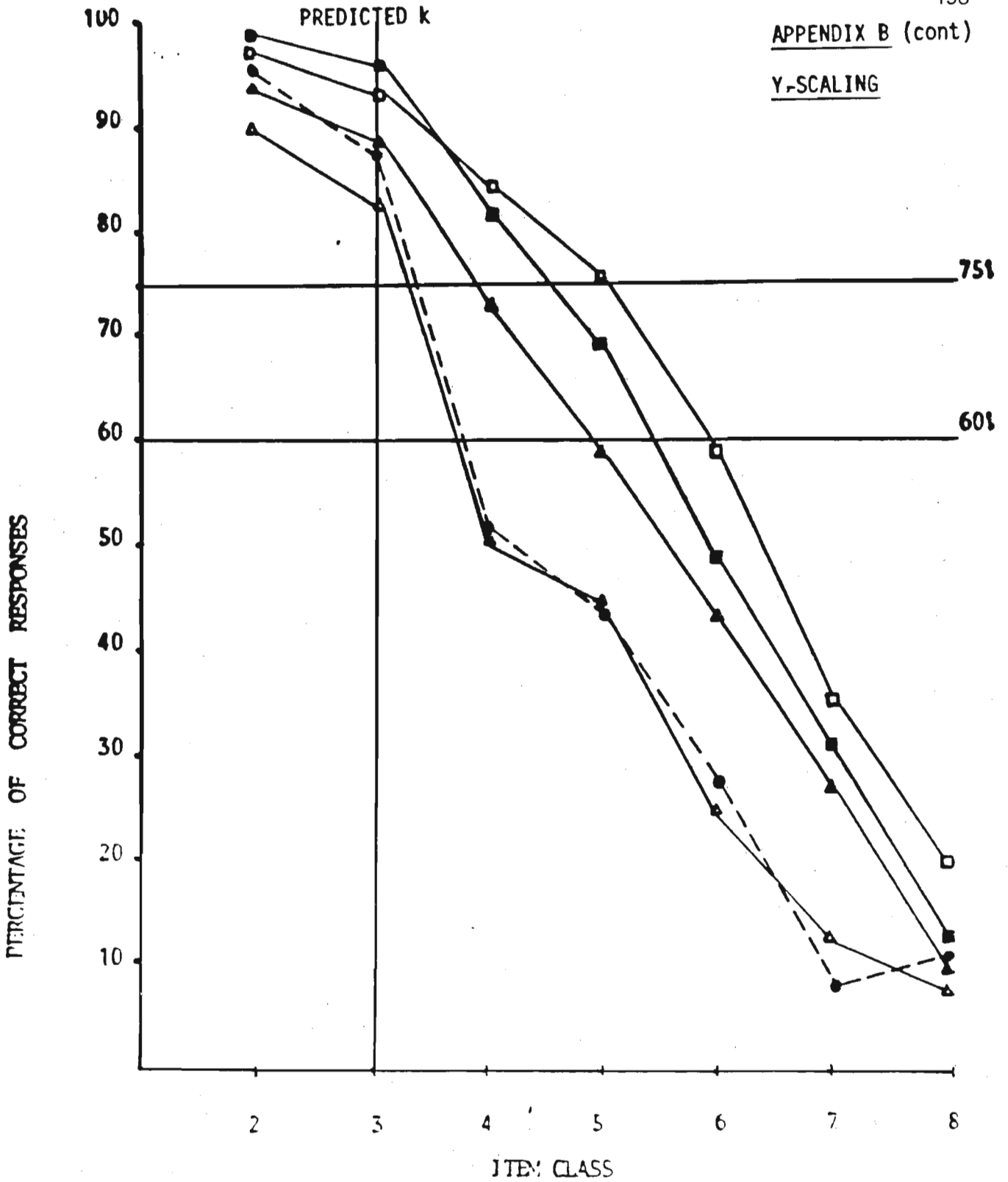


FIGURE B.1

7-8 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N= 67).

TRIAL

- 1 ———
- 2 ———
- 3 ———
- 4 ———
- GOODMAN DATA - - -

PREDICTED k

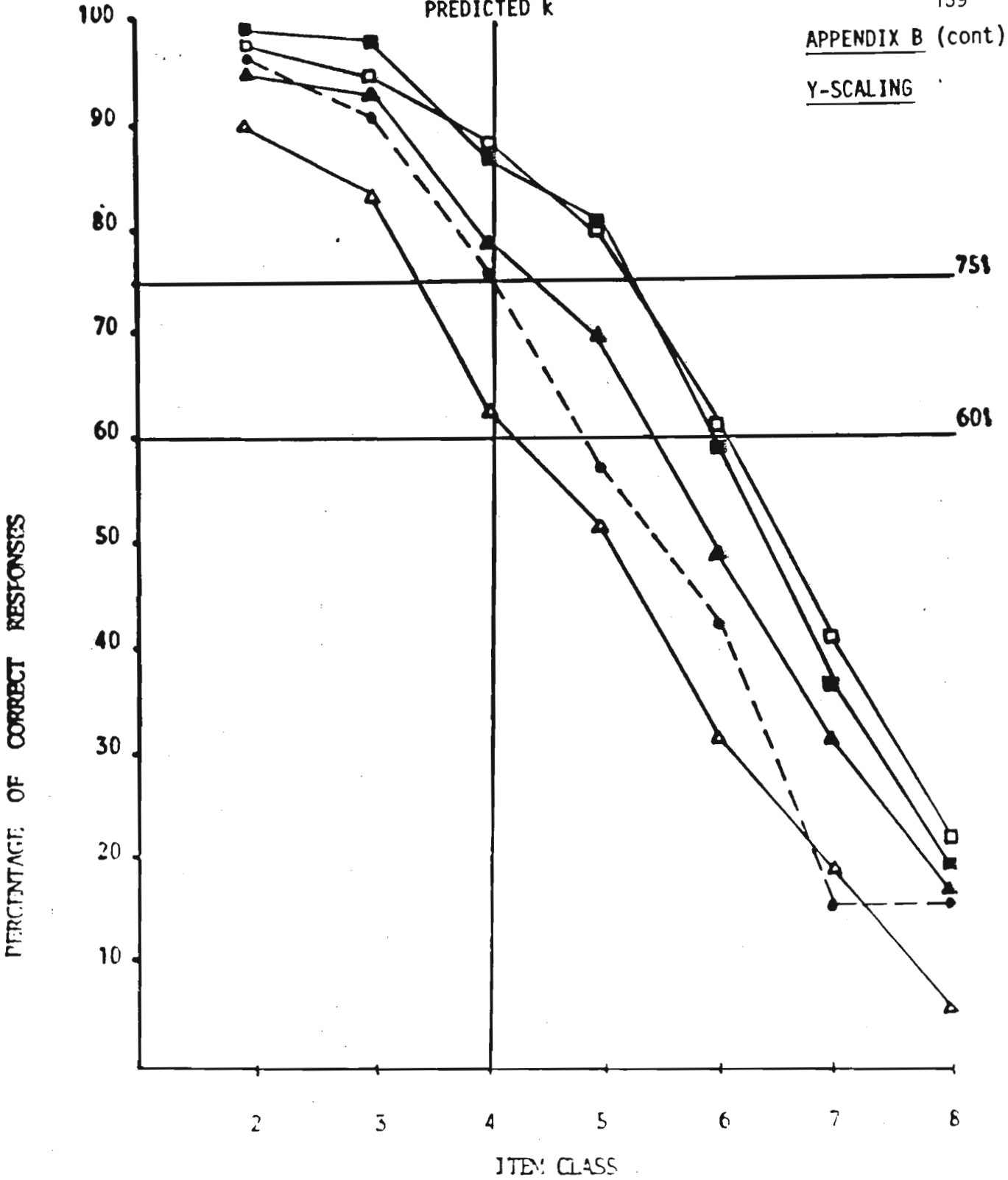


FIGURE B.2

9-10 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N= 114 ).

- TRIAL
- 1 ————
  - 2 ————
  - 3 ————
  - 4 ————
  - GOODMAN DATA

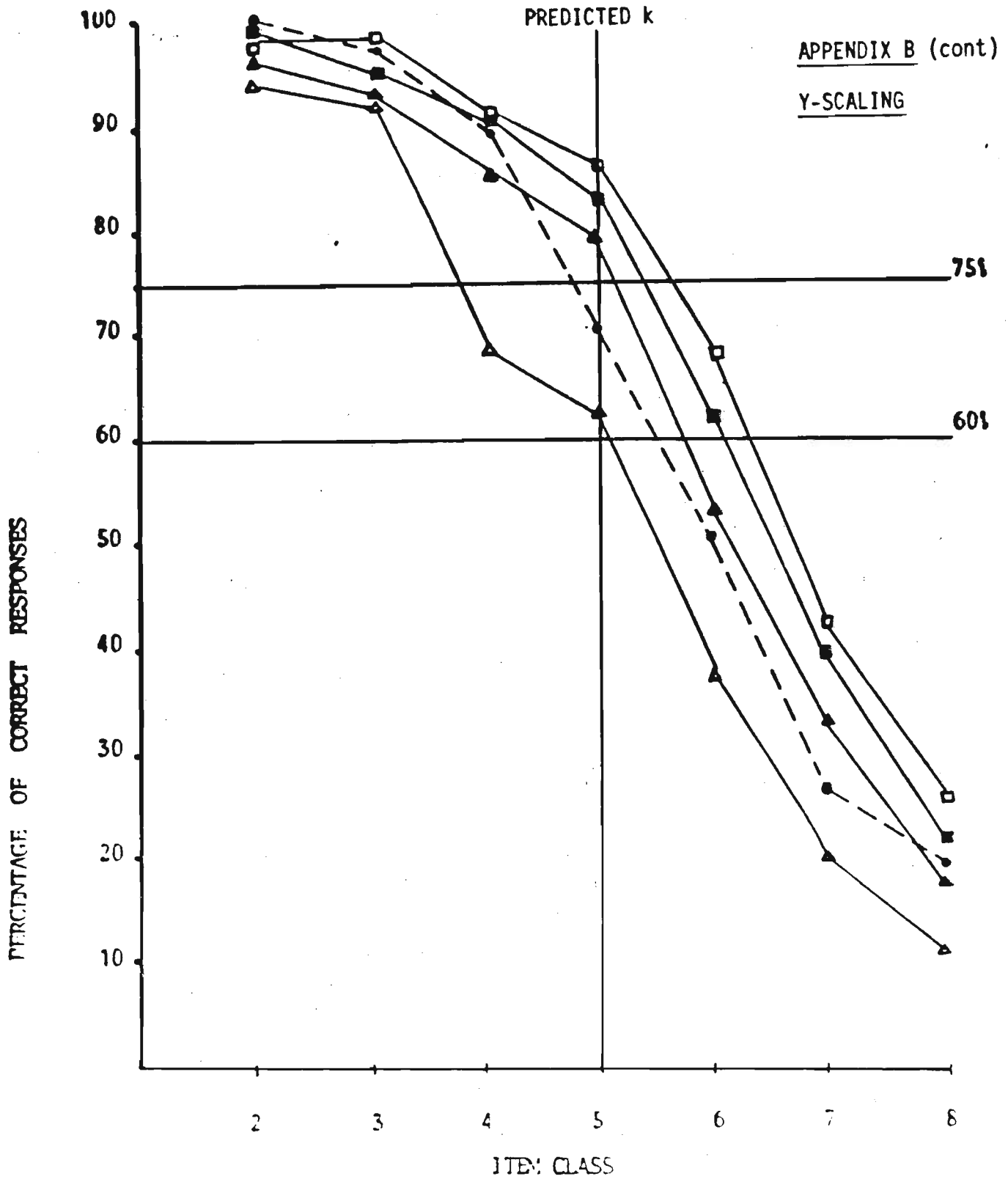


FIGURE B.3

11-12 YEAR OLDS: PERCENTAGE OF CORRECT RESPONSES PER ITEM CLASS FOR TRIALS 1 TO 4 (N= 71).

TRIAL

- 1 —
- 2 —
- 3 —
- 4 —
- GOODMAN'S DATA