

**Drawing as Thinking:  
An Enquiry into the Act of Drawing as  
Embodied Extension of Mind**

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## Declaration

Submitted in fulfilment of the requirements for the degree of Master of Arts (Philosophy) in the School of Religion, Philosophy and Classics, College of Humanities, University of KwaZulu-Natal, Durban.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. It is being submitted for the degree of Master of Arts (Philosophy) in the College of Humanities, University of KwaZulu-Natal, Durban, South Africa. None of the present work has been submitted previously for any degree or examination in any other university.

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## Abstract

This thesis opposes the theory of ‘drawing as expression’ - the idea that a drawing is nothing but a *post hoc* exteriorisation of a prior mental process. A counter-hypothesis is investigated instead - that the physical act of sketching is itself a thought process and that the new thought processes which it facilitates would be impossible or severely impaired if it were absent.

The conceptual framework for this investigation and the evidence for its hypothesis derive from three fields: firstly theories of the extended mind and embodied thinking from philosophy and cognitive science, secondly theories of drawing practice, and thirdly practitioners’ critical reflection on the significance of drawing in their own practice.

The fluidity, multidimensionality and indeterminacy of the cognitive processes typical for open-ended domains like planning, design and the arts tend to flummox the dominant – computational – approach in cognitive science. Theories of the extended mind and embodied thinking present an alternative which can handle these features comfortably.

*Theories of embodied thinking*, which hail from diverse disciplines – including philosophy, cognitive science and artificial intelligence – argue that cognition is not independent of the body, but enabled by embodied activity embedded in the environment. *Extended mind theory* suggests that certain active features of the environment actually constitute integral parts of human cognition. In such cases, the human organism is inextricably linked with an external entity in a two way interaction, creating a coupled system of which each part counts as fully cognitive. Clark uses the term ‘scaffolding’ to denote a broad class of cases in which such external structure is co-opted, annexed and exploited, thereby allowing us to achieve some goal which would otherwise be beyond us.

This leads to the central question of this thesis: can the act of drawing be understood with the help of theories of embodied thinking and the extended mind, and if so, how? A second, related question is how the example of drawing helps extend these theories. From this perspective design thinking and reasoning is to a large extent embedded in the act of drawing. Drawing, as a form of scaffolding, filters or guides perceptual, affective and cognitive attention and behaviour in ways only available to brains coupled with pencils and other drawing materials. (External representations can for instance be extended in space, rotated, manipulated, rearranged and interacted with in ways that internal representations cannot).

The *theories of drawing practice* studied for this research came mainly from art theory, design theory and empirical studies of how drawing contributes to the cognitive process. Clark and Karmiloff-Smith suggest that knowledge stored in some proprietary representational format often needs to be redescribed in some other, more suitable format to become accessible to other types of

representations and processes. A key role that drawing is found to play in multiple contexts (design, fine art, mathematics, etc.) is to draw to the surface implicit, previously unarticulated information for use by other procedures and the whole cognitive system.

Sketching plays many other roles in promoting the cognitive operations needed to tackle design problems, which are often so complex that individual reason would quickly be overwhelmed in the absence of environmental offloading. Sketching can compensate for limitations in human memory and information processing capacity, can help identify aspects of concern, relationships and patterns, as well as help maintain focus and generate new knowledge.

The South African artist William Kentridge's critical reflections on the significance of drawing in his own practice support extended mind theory. His reflections alert us to the materiality of the creative process and dovetail with recent attempts by philosophers and other theorists to explain creativity. In drawing cognition appears as a dynamic, multidimensional phenomenon in which explicit, implicit and tacit information all work together in an ensemble distributed across brain, body and world while utilising variable physical, technological and social resources. Because drawing is an activity which emphasises 'generic' aspects of creativity, studying it sheds light on many other forms of problem solving by humans. This echoes Kentridge's suggestion that drawing, as a slow motion form of thinking, offers a paradigm for illuminating thinking in general.

Drawing proves to be a good context for exploring questions about where cognitive processes reside. By extending cognition beyond the brain and into the world, we come to appreciate that external drawing processes in a cognitive system are at least as important as 'internal' ones, and that the marks on paper form an integral part of the apparatus responsible for the shape and flow of thoughts and ideas.

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## Introduction

Drawing is ubiquitous. As an activity and a topic, drawing stretches across many and diverse subject domains, ranging from the arts to the sciences. The study of drawing is informed by many disciplines (e.g. art, design, psychology and education) and exists in many contexts (art theory, drawing practice, history, philosophy and aesthetics). Drawings are made by artists, designers, scientists, mathematicians, engineers, architects, filmmakers, surgeons, illustrators, poets, children, cartographers, visionaries and many others. Depending on its context, drawing may be analytic, imaginative, poetic, descriptive, discursive, investigative, preparatory, visionary, associative, performative, generative. The fact that drawing straddles so many distinctions partly explains why discourse about drawing is riven with controversy, with little counting as consensual knowledge. All this makes it difficult to achieve a synoptic view of drawing. It seems to be simultaneously a fundamental, yet elusive manifestation of the human mind.

If one looks at the issues and fundamental questions around which the diverse discourses about drawing converge, one discovers the close relationship of drawing with thinking as a recurring motif. The proximity of drawing to thought is already suggested by the seminal texts on drawing (Hill, 1966; Arnheim, 1969: 79; Rawson, 1969) in their concern with the relationship between perception, conception, representation and visual production. Contemporary writers too cannot discuss drawing without reflecting on this intimate relationship (Downs *et al*, 2007; Dexter, 2005; De Zegher, 2003; Garner, 2008; O'Donnell, 2009; Treib, 2008). Emma Dexter captures this connection neatly: “Drawing’s proximity to thought is ever present in its meaning” (2005: 8). It is this intimate relationship between drawing and thinking that concerns me in this thesis.

The cognitive scientist Andy Clark, on whose work this thesis will draw extensively, brings this elusive cognitive activity into the equally elusive space of mind when he suggests that working on paper is “actually thinking on the paper” (2008: xxv). Clark argues that activities like drawing “quite literally extend ... the machinery of mind out into the world” (2008: xxvi) and should therefore be considered part of the mind. Clark regards sketching as “an integral process of artistic cognition itself” (2003: 77). This way of thinking – conceiving of the mind and things mental as extending beyond the brain and even skin of the person thinking – is called the Extended Mind view of cognition.

Clark argues that extending cognition beyond the brain and into the world is essential if we wish to explain the machinery of mind. In a rejoinder to the objection that the mind is probably not a “thing” and therefore not worth trying to locate, Clark (2010) offers this analogy: “That is not to say – heaven forbid – that it is a non-material thing. Rather, it might be a bit like trying to locate the adorableness of a kitten. There is nothing magically non-physical about the kitten, but trying to fine-tune the location of the adorableness still seems like some kind of error or category mistake. In the case of mind, I think what we have is an intuitive sense of the kind of capacities that we are gesturing at when we speak of minds, and so we can then ask: where is the physical machinery that makes those capacities possible? It is the physical machinery of thought and reason that the extended mind story is meant to concern.”

In this thesis I will argue that drawing represents an ideal domain for the development of this theoretical perspective, while the extended mind view in turn holds the potential to explain why and how drawing is so intertwined with thinking. In relating various discourses on drawing to theories of embodied thinking and the extended mind, the working hypothesis of this thesis will be that drawing is a profoundly productive thinking medium, situated across disciplines, a tool that extends the mind so as to access and bring into play multiple layers of mind (whether conscious or not) and world.

The argument of this thesis consistently, and essentially, opposes the theory of “drawing as expression” – the idea that a drawing is nothing but a *post hoc* exteriorisation of a prior mental process. To do this, an alternative hypothesis will be investigated: that the process of drawing/sketching itself is a thought process and the sketch something that facilitates new thought processes which would have been impossible – or at least severely impaired – in the absence of the physical drawing itself.

From this hypothesis the overarching question addressed by my thesis emerges: How can the act of drawing be understood with the help of theories of embodied thinking and the extended mind? This question will be addressed via more circumscribed questions such as: What does the physical process of drawing enable a subject to achieve that would otherwise be impossible or unlikely? What can drawing and sketching do that cannot be done internally by mental imagery? How is thinking with images different to thinking with words in writing and speaking? What can drawing do that words cannot do? Can processes of drawing be regarded as acts of thinking? What is the role of drawing in the cognitive

process; how does drawing function there? What modes of cognition are facilitated by drawing?

These subsidiary questions are related to more than one discourse, which makes investigating them a difficult, multifaceted enterprise. In negotiating these multiple dimensions my point of departure is always to ask what drawing does instead of what it is – investigating what the physical act of drawing enables in a subject that would otherwise not be enabled. Because my concern is to enrich the understanding of drawing as an act of thinking, the question regards drawing in the widest sense, rather than focussing on one specific type of drawing.

Pertinent to this study is Clark's assertion that "the single most important task" for a "science of the bio-technical mind" is the quest for a better understanding of "the range and variety of types of cognitive scaffolding, and the different ways in which non-biological scaffoldings can augment (or impair) performance on a task" (Clark 2002c: 29). (Clark (1998: 163) uses the term scaffolding to denote a "broad class of physical, cognitive and social augmentations [and/or exploitations of external structure,] which allow us to achieve some goal which would otherwise be beyond us".) By viewing drawing as a real world cognitive system, and investigating its range of "complex and iterated interactions and collaborations" (2001b: 154), this thesis aims to contribute to the ambitious agenda of the Extended Mind hypothesis. Clark (2001b: 154) warns that the study of such interfaces is not an easy task and demands new multidisciplinary coalitions as well as new forms of modelling and methods of analysis. For Clark (2001b: 154), "The pay-off, however, could be spectacular: nothing less than a new kind of cognitive scientific collaboration involving neuroscience, physiology, and social, cultural, and technological studies in about equal measure".

To approach the goals I set above, the conceptual framework for the research has been drawn from, and aims to synthesise, three fields of enquiry. The three fields are firstly, theories of drawing practice, secondly, theories of embodied thinking and the extended mind from cognitive science and philosophy, and thirdly, practitioners' critical reflection on the significance of drawing in their own practice. As a result, the perspectives brought to this thesis represent an eclectic mix of philosophy, physiology, neuroscience, computational, dynamical and domain-specific or cultural understandings, as well as

attention to environmental resources and opportunities. This is exactly the sort of mix Clark (2008: 219) recommends as a methodology for unravelling the extended mind.

Theories of drawing practice will be drawn from a number of disciplines including art theory, design theory and empirical studies of drawing's contribution to the cognitive process in diverse fields. This will allow an interdisciplinary exchange around the role of drawing as an active cognitive process in diverse environments (design, fine art, mathematics, etc.). Research on the role of sketching in for instance the design process indicates that it plays many roles in enabling and promoting the types of thinking pertinent to the cognitive tasks involved in design thinking, and for this reason it has been termed "an intelligence amplifier" (Cross, 1999: 36). This suggests that investigating it as a domain of cognition has the potential to generate valuable insights to complement current computational theories of mind, by representing thought processes that are not precise and articulate, but dense, ambiguous and unstructured. Lawson (2006) notes that attempts to explain design thinking pose questions to cognitive scientists' theories which exceed their limits. While the standard cognitive science approach is strongest when dealing with well-ordered problems, the ill-defined "wicked" problems characteristic of design prove to be more elusive.

Clark's (2008: xxviii) Extended Mind theory suggests that "certain forms of human cognizing include inextricable tangles of feedback, feed-forward and feed around loops – loops that promiscuously criss-cross the boundaries of brain, body and world". The loops referred to here denote an "intricate and iterated dance in which 'pure thought' leads to actions which in turn change or simplify the problems confronting 'pure thought'" (Clark, 1997:36). This view resonates with many ideas raised in theories of drawing and, together with other theories of embodied thinking, provides a valuable new perspective for reflecting on the act of drawing as thinking. Hailing from diverse disciplines including philosophy, cognitive science and artificial intelligence, these theories argue that cognition is not independent of the body, but enabled by embodied activity embedded in the environment.

Practitioners' critical reflection on the significance of drawing in their own practice will provide the third lens through which to view the act of drawing. Personal theories and reflections, particularly from respected practitioners, may contribute to developing insights into what it means to think more potently through drawing. When these have been

formulated independently from the theories above, but nevertheless reach similar conclusions, the consilience between them and the theories discussed above is a further reason to think that the latter are on the right track. In this regard, the reflections and observations of South African artist William Kentridge will receive particular attention towards the end of the thesis.

This thesis is divided into five chapters, each of which deals with a particular aspect of, or perspective on, drawing as thinking. Together these chapters provide a kaleidoscope of cases in which drawing bears witness to Clark's view of the human mind as something that "emerges at the productive interface of brain, body, and social and material world" (2008: 219).

Chapter 1 attempts to position Clark's bold view of mind and cognition within the broader framework of the sciences of mind. This brief sketch outlines the major theoretical frameworks historically used for the study of mind in order to provide a context for the discussion of some problems we will consider later.

Chapter 2 introduces and examines drawing as embodied embedded act of thinking. The first section gathers together several reflections which suggest that the body, and the hand in particular, play a crucial role – hitherto neglected – in the facilitation of thinking by drawing. These complementary observations, drawn from both theory and practice, set the scene for an appreciation of drawing as an integrated embodied cognitive process that blurs the lines between perception, action, memory, thinking and imagining. Different attempts to grapple with the mechanics of the drawing act highlight the complex relationship between physical and mental skill. Various empirical studies confirm how densely interwoven physical and mental skills are, as they indicate that the cognitive properties of persons who habitually draw are different from those of persons who don't. This evidence suggests that the act of drawing does indeed, as Clark suggests, sculpt, guide, filter and modify our own processes of perceptual, affective and cognitive attention. Because brains coupled with external resources seem to have unique functional and dynamical characteristics, a closer investigation is needed into the nature of those resources as well as the peculiarities of different interactions.

The second section of Chapter 2 develops the theme of skill and know-how by drawing on the ideas of Heidegger, Wheeler, Sutton, Clark, Polanyi and others. I consult their writings to grapple with the relationship between doing and knowing in representational terms. In

the light of these ideas, this chapter challenges the suitability of models of ‘representation as mirroring and encoding’ to depict the kinds of content involved in skills like drawing. Heidegger’s work on representation and technology offers a view of human cognition that includes different modes of encounter between the agent and her world. Wheeler’s unpacking of some of Heidegger’s seminal texts helps us appreciate drawing as operating at a different point of intersection between theoretical thinking and practical knowing. I include research findings as well as observations by artists and art theorists to provide empirical accounts of how subjects move between doing and knowing. Skill and expertise is shown to be dependent on flexibility in connecting thought and action, knowledge and movement, conceptual memory and procedural memory, conscious knowledge and embodied knowledge.

The final section of Chapter 2 expands on the previous section by looking at theories which attempt to explain how achieved skills and implicit knowledge develop to achieve the increasing flexibility and fluidity typical for higher cognition and creative thought. This section discusses Annette Karmiloff-Smith’s theory of Representational Redescription which suggests that the mind is “endogenously driven to go beyond behavioural mastery” and enrich itself from within through active redescription of its own stored knowledge. Karmiloff-Smith elaborates these ideas in a paper co-authored with Andy Clark, introducing a theme that will re-emerge throughout this thesis: how in multiple scenarios drawing enables *knowing how* to become *knowing that* by accessing implicit knowledge and generating new channels which connect different kinds of knowledge gathered in the system.

In Chapter 3 the discussion shifts to a consideration of the various ways in which theories discussed in previous chapters play out in the “real world”. Taking Clark’s notion of cognitive technology as a point of departure, this chapter gathers a range of contributions to the relevant debates to argue that the role of such technologies and practices deserves to be acknowledged more fully. Using the writings of Bruno Latour, Don Ihde, Dewey, Heidegger, Peter Galison and others, this chapter attempts to draw attention to the range of cognitive amplifiers and technologies impacting on human cognition. It also attempts to understand why the role of practice, technology and image in cognition has historically been neglected. This enquiry reveals a longstanding prejudice which assumes the supremacy of written or propositional language, and so confirms that certain aspects of human cognition are always situated in and affected by a complex socio-cultural world.

This chapter briefly explores the historical contribution of the graphic image and visualisation on paper to conceptual development, problem-solving and other advances in science and mathematics. The investigation interweaves discussions drawn from theory and practice relating to the domains of mathematics and science, as well as to research in neuroscience, so as to understand cognitive process as multidimensional. It suggests that greater attention to sensory, affective, and kinetic forms or dimensions of thinking will enrich understanding of the nature of human cognition and human cognitive accomplishment.

In Chapter 4 the discussion changes tack to investigate how drawing, with particular attention to the sketch, operates in the domain of art and design – a domain where the image is embraced and drawing is unapologetically acknowledged and recognised as a generative medium to stimulate visual invention and stretch mental capabilities. This theme is introduced by synthesizing aspects of older writings and contemporary deliberations on the nature and dynamics of inventive thinking, and the role of drawing in this dynamic. Despite marked contrasts in style and approach, the writings discussed agree in portraying and celebrating a kind of thinking that is unlike the thinking generally taken to be characteristic for science. The ideational drawing or thinking sketch is shown to be more than a mere mnemonic, didactic or communicative aid. Instead, it is in itself a way of thinking and reasoning, as much part of the cognitive process as brain processes are. As such, drawing does not fall clearly on one or the other side of the subject/object divide, and thus challenges the validity of thinking in terms of such a divide. This blurring of boundaries and putative dichotomies is part of the reason why drawing is so difficult to theorise: it resists our normal analytic categories.

The second section of Chapter 4 continues the theme of the sketch but attempts to unpack and decompose the properties of the cognitive operations involved for the purpose of discussion. This section addresses the role of gesture in the cognitive unfolding of the visual, spatial and conceptual processes involved in the sketch. I attempt to synthesise insights from a range of approaches to the role of gesture in drawing. These approaches conceive of gesture as engaging the person drawing and putting her in touch with multiple aspects of the body such as movement, kinaesthetic awareness, memory, perception, technique, etc. Gesture in drawing, and the inscription left by gesture, thus record – and afford an awareness of – modalities different to speech/language. David McNeill's analysis of gesture, together with observations by other theorists and researchers, is invaluable for

illuminating the role of gesture in drawing activity. Their work suggests that the intrinsically dynamical and temporal features of gesture and drawing play important representational or computational roles in shaping experience so as to accomplish or enrich thought. For McNeill gesture is an integral and active participant in thinking and speaking. His extensive research on the role of gesture suggests that gesture is best understood as the embodiment of a dimension of meaning rather than an expression or representation of it. Although gesture and words encode different kinds of information, McNeill conceives of them as coupled in a productive dialectic that drives thinking forward.

Section 3 of Chapter 4 zooms in on a related dimension of the sketch ensemble, namely the way it involves a dialectic on paper. This section investigates this dialectic by drawing on research into the nature of design reasoning with a view to determining how and why the sketch stimulates and enriches the design process. In a way that resonates with the findings on gesture outlined in the previous section, these studies show that the dialectic on paper engages different modalities of reasoning in a continuous reciprocal and productive exchange. The kind of dialogue evident here is in fact not peculiar to the sketching act or design reasoning, but is typical for human cognition in general. It does not only apply to the specifics of a particular domain, but illuminates a wide range of psychological and cultural phenomena. Conceiving of the sketch as a dialectic situation highlights the cognitive role of private speech and scaffolded action in assisting performance. This section concludes with a discussion of Clark's take on such practice as a process of self-stimulation in which the cognitive system uses gestures, marks on paper and other resources to drive cognitive processes along and expand the cognitive system so as to explore new paths through "thinking space".

The following section examines how the principles and theories identified above play out in the design sketch – how they help us understand why sketching is such an integral part of design thinking. The design sketch plays a crucial role in facilitating the shift from one kind of knowledge – knowledge about people, behaviour and goals – to another kind of knowledge – knowledge about artefacts. In doing so, it provides a novel window into human cognition and creative problem solving. This section looks at research into the familiar attributes of the sketch to address the question why encoding the outcome of thought processes in the sketch format should play such an important role in stimulating visual invention. This analysis, combined with diverse observations on the nature and emergence of imaginative mental imagery, suggests that the sketch exploits, complements



and augments the activity of the “opportunistic” brain. (Calling the brain “opportunistic” is a way to indicate that it does not operate in set, predictable ways, but will exploit whatever resources, new or old, will help it do its job.) The discussion supports Clark’s interpretation of such marks on paper as “elements in representationally hybrid thoughts”.

Chapter 4 concludes with a brief consideration of further cognitive and computational benefits provided by the sketch. The discussion starts with designers' own observations, often couched in metaphoric language, regarding the complex reasoning strategies facilitated by the sketch. These practitioners' remarks are supplemented by a more methodical analysis of how certain mental abilities are augmented and complemented by the distinctive computational or cognitive properties of external media. Empirical findings regarding limits to human memory, the ability to deal with complexity and to process information, help explain why humans often need to distribute computational activity into an extended environment. Research is also invoked in support of the claim that external representations can be operated on and interacted with in ways not possible with internal representations. This research moreover indicates that the rich assemblage of various forms of coded and uncoded, verbal, visual and tacit knowledge enables diverse associations and generates novel insights, thereby leading to superior solutions. Because of the complex cognitive interactions enabled by the sketch, the cognitive system composed of the person in interaction with an external representation – the sketch, in this case – has cognitive properties that are quite unlike the cognitive properties of the person alone.

Chapter 5 shifts gear to focus on the cognitive practice of the South African artist William Kentridge, whose whole artistic process revolves around drawing. This chapter draws on a variety of interviews, catalogues and other publications in which Kentridge’s insightful and articulate reflections on his own working process can be found. Kentridge sees drawing as exemplary for thought itself. For him drawing offers an alternative to strict 'rationality'; he embraces non-linear, image-based thinking – characterized as it is by ambiguity, improvisation, contingency, exploration, gaps, leaps and responses to unforeseen stimuli. His deep attachment to drawing as a primary route for arriving at knowledge suggests that drawing has become part of his whole mode of cognition. His non-heroic account of his own practice makes the nuts and bolts of his practice visible to the outside observer. In a way that is strongly reminiscent of the extended mind thesis, his account dissolves the boundaries of the skin and challenges the notion of brainbound thinking. His detailed descriptions and analyses of particular incidents, connections and strategies provide a rich

account of a real world cognitive system characterised by interactions among processes inside as well as outside the individual. (In his account the boundaries of the unit of analysis are for instance moves even further beyond the individual, to consider the cognitive properties of the studio).

Kentridge's anecdotes furthermore demonstrate, as well as reflect and elaborate on, an array of themes encountered in earlier chapters – doing versus knowing, the mind as an associative engine, doing as a mode of revealing, the untenability of ascribing supremacy to the word, scepticism about language and logic as the best way to arrive at meaning, exploiting the opportunistic brain, active representation as a means to access implicit knowledge, emergence, the role of gesture, movement and delay, distributed cognition, mediation and risk-taking, to name but a few. His practice thus demonstrates the “cognitive ensemble”, in which heterogeneous and multifaceted resources are embraced and integrated.

Section 2 of Chapter 5 takes a slight detour as it considers the implications of Kentridge's confession that to arrive at ideas and images, which “come so grudgingly”, he, like many other artists, needs all the aids and strategies he can find. We can generalise beyond his case to hypothesize that “finding images” and ideas is indeed an important problem that needs to be solved in every designer's and artist's practice. When we pursue this thread we end up challenging the notion of artistic genius. Dennett (2004) is unconvinced by Picasso's often-quoted and much debated statement: “I do not search, I find”, and formulates a Darwinian theory of creativity to show why. According to this theory the creative process, and thus also every work of human genius, involves an enormous quantity of trial and error procedures, with only a tiny fraction of the output of these procedures being selected or recognised as valuable. Dennett argues that the historical and material dimensions in which the creative process is embedded also need to be brought into the equation. The upshot is a recognition in Clarkian terms of the cumulative complexity of the material structures we create, which systematically develop and transform our thinking so that we ultimately “self-engineer ourselves to think and perform [create] better in the worlds we find ourselves in” (Clark 2008: 59).

The final section of this chapter attempts to pull the threads from the preceding chapters together. In it the relationships between skills and mind-tools, vehicles and content, agent and environment are explored via an exchange of ideas between Clark, Dennett, Kentridge

and others. Drawing, as both a representation of human cognition and a mode of human cognition, provides an ideal meeting point and stage for these dimensions of mind to interact. Kentridge's conception of drawing as a model for how we think and construct meaning provides the point of departure for this exchange. The upshot is a view in which human cognition [thinking] involves complex interactions between various kinds of mind-tool, where neither propositional content nor non-propositional content is privileged in accounting for how understanding really works. On Kentridge's view drawing offers an alternative to overly rational accounts of how we arrive at meaning. He suggests that the strategies and discoveries of artists are applicable beyond the sphere of art.

Together these chapters assemble compelling evidence for Clark's thesis that external representations such as drawings, mathematical inscriptions, models, etc., become worlds in themselves with which the brain and body can interact productively. By paying attention to the larger organism-environment system rather than just focusing on individual organisms, extended mind theory provides a lens that helps us to understand why "drawing is everywhere".

## Chapter 1

### Approaching the operations of thought

*“To draw is never a transcription of thought (in the sense of writing) but rather a formulation or elaboration of the thought itself at the very moment it translates itself into an image”* (Fisher cited in De Zegher and Newman, 2003: 222).

The suggestion that drawing is in essence the materialisation of the operations of thought, rather than a representation of a pre-specified thought, resonates with Andy Clark’s (2008: xxv) understanding of such an act as *“thinking on paper”*. Clark (2008: xxv) argues that the circuit through pen and paper is part of the whole physical ensemble determining the shape and flow of thoughts and ideas. Because these scribbles, still taken to belong to that particular ‘drawer’, effectively function *“as part of the cognitive circuitry”*, Clark argues that this outward loop should be viewed as a functional part of an extended cognitive system. Such cognitive circuits extending to the body and the world are the material foundations for many crucial aspects of human thought and reason. This could explain how humans can *“be so very special while at the same time not so very different, biologically speaking, from the other animals with whom we share both the planet and most of our genes”* (Clark, 2003: 10).

In Clark’s (2003) account of human nature, what makes us uniquely human is our capacity to continually restructure our own mental circuitry on an ongoing basis. Informed and driven by empirical evidence from philosophy, psychology and neuroscience, he perceives *“the old puzzle, the mind-body problem”* as involving *“a hidden third party ... the mind-scaffolding problem”* (2003:11). For Clark (2003), a full understanding of science, morals and ourselves – both as individuals and as species – requires a recognition of the way in which our distinctively human thought and reason arise through looping interactions between material brains, material bodies, and the complex environment provided by culture and technology.

The extended mind thesis is a relatively new hypothesis about the extended nature of mind. Since the late nineties it has been attempting to install a new paradigm in the sciences of the mind (Bietti, 2010: 97). In order to position Clark’s bold view of mind and cognition within this framework, a brief sketch outlining the major theoretical frameworks

historically used for the study of mind is necessary. The sketch does not aspire to be a serious intellectual history; it only serves to provide a context for the discussion of the problems we will consider later. The emphasis will therefore be on those conceptions and theoretical metaphors for cognition that are relevant to a conception of drawing as thinking.

“The old puzzle, the mind-body problem” which Clark (2003:11) refers to above, has a long and deep history, which continues to be part of any conversation about cognition. Narratives about the philosophy or science of mind often use Descartes’ conceptualisation of mind as starting point. Descartes is traditionally considered to be the creator of modern dualism, which views the domain of mind and soul as set apart from that of the physical world (Wheeler, 2005: 21). Descartes’ argument for a radical distinction between mind and body formed the foundation of a view of the mental realm as divorced from spatiality and as a result intangible. Ever since this dividing line was drawn, the philosophy of mind has grappled with the so-called mind-body problem. Descartes proposed that interaction between mind, body and world happened in the pineal gland of the brain (Wheeler, 2005: 21). This idea was gradually replaced by the notion of symbolic representation. The idea is here that the mind holds representations which “stand in for or encode the world” (Wheeler, 2005: 24). The intellectual origins of cognitive science are to be found in this representational thesis, which arose when scholars in numerous fields began to develop theories of mind and cognitive processes, asking how thought itself is materially possible.

The term cognitive science came into being in the late 20<sup>th</sup> century, to designate a new field of research that brought into play a combination of psychology, linguistics, neuroscience, computer science, artificial intelligence and philosophy - with as common objective to understand the workings of the mind, and discover the broad principles underlying these workings (Thompson, 2007: 3).

### **1. Philosophical approaches to the mind**

Thompson (2007: 4) succinctly points out how three major approaches - cognitivism, connectionism and embodied dynamism - can each be identified by the basic metaphor each uses to view the mind. These three approaches characterises the mind as respectively a digital computer, a neural network and an embodied dynamic system.

## 1.1 Cognitivism

The model of the mind as a computer, which in the 1950s completely transformed the scientific approach to cognition, is today known as ‘classical cognitive science’ or ‘good old artificial intelligence’. It treats mental processes as essentially identical to a computer’s information processing, to propose that the thinking brain constitutes “a physical symbol system” in which symbolic representations are manipulated (Newell and Simon, 1976). “Cognitivist explanations focus on the abstract problem-solving characterization of cognitive tasks, the structure and content of symbolic representations, and the nature of algorithms for manipulating the representations in order to solve a given problem” (Thompson, 2007: 5).

The computational account of mental processes claims that neither representing information nor doing computations would be possible without a representational vehicle in the form of a language of thought. The language of thought hypothesis is a version of what Wilson (2004: 147) calls an *encoding view* of mental representation: “simply put, encoding views hold that to have a mental representation, M, is for M to encode information about some objects, property, event, or state of affairs m.”

The idea that cognitive processes are essentially computational was appropriated by the representational theory of mind, which regards mental states, mostly, as inner representational states. “The idea that there are internal representations is a deep assumption of the most influential branches of philosophy of mind and cognitive science” (Wheeler, 2005: 6). The basic idea here is “that there exist, in the cognizer’s mind, entities or structures (the representations) that stand in for (typically) external states of affairs” (Wheeler, 2005:6). The representational theory of mind maintains “that we interact with the world perceptually and behaviourally through internal mental representations of how the world is (as the effects of perceiving) or how the world should be (as instructions to act)” (Wilson, 2004: 145). This view portrays a *subject* as regarding – i.e. *representing* – a separate *objective* world to be a particular way (Wheeler 2005: 25). Cognitive science then endeavours to explain how it is that representing agents take the world to be a certain – possibly incorrectly – way (Wheeler, 2005: 58).

Because cognitivism does not explain how computations in the brain lead to or otherwise relate to subjective experience, it adds a ‘mind-mind’ problem to the long-standing mind-body problem. Cognitivists face difficulties in explaining the relation between

computational states and experience – how a brain can have experiences and accomplish reasoning (Thompson, 2007:7). Cognitive anthropologist Edwin Hutchins (1995) criticises the cognitivist view for its mistaken projection of a sociocultural human activity – computation – onto something occurring inside one person’s brain. What has to be modelled is essentially the abstract computation that is achieved through the physical activity of a body that uses pen and paper to manipulate symbols in an environment that is simultaneously material, social and cultural. This activity is not restricted to what happens in the head but extends into a socially constituted physical world that is indispensable for computation, and actively contributes to the thinking process (Clark and Chalmers 1998, as cited in Thompson, 2007:7). A view that makes cognition a wholly or essentially intracranial phenomenon disregards all of this.

Wheeler (2005: 9) calls into question any claim that the classical computational approach can provide a good model for intelligent behaviour in the real world. While this approach seems convincing when it comes to accounting for those forms of reasoning or problem solving requiring little more than logic, and occurring in settings that are well-ordered, it cannot capture those forms of thinking at which humans excel (and classical computer models don’t), for instance the ability to extrapolate from past situations to new ones, or the ability to solve problems where the available information is incomplete, garbled or unreliable. As Wheeler (2005: 9) confirms, “In other words, classical systems have often seemed to be rigid where we are fluid and brittle where we are robust. Into this cognitive breach stepped connectionism”.

## **1.2 Connectionism**

Connectionism started making a mark for itself in the early 1980’s. Using the neural network as its principal model, it threw down the gauntlet to cognitivism, claiming that the physical-symbol-system model flew in the face of the neurological evidence, and that neural networks were good at all sorts of important cognitive tasks where symbol processing failed, or faltered (Thompson, 2007: 8). “According to connectionism, artificial neural networks capture the abstract cognitive properties of neural networks in the brain and provide a better model of the cognitive architecture of the mind than the physical symbol systems of cognitivism” (Thompson, 2007: 9).

Although connectionists and cognitivists differ on the precise *nature* of the internal representational system, the fundamental *idea* of internal representation as the vehicle of

specific contents has been retained by both (Clark, 1997: 143). Despite disagreements as to the extent to which representations are explicit or implicit, there tends to be agreement that both are nevertheless “species of a more general notion of internal representation” (Clark and Toribio, 1994: 404). The classic view of explicitness involved the ‘cut and paste’ processing of strings of symbols, while the connectionist mode of representation, by using complex numerical vectors and basic operations of pattern recognition and pattern transformation, does not require that knowledge of a domain needs to be represented explicitly. In contrast to computationalists, connectionists view the tasks of representation and processing as being inextricably intertwined (Clark and Toribio, 1994: 403).

By making the perceptual recognition of patterns the fundamental process underlying intelligence, connectionism no longer conceives of the mind as being trapped inside the head. Henceforth thought processes are taken to loop between the individual brain, the body and the environment (physical as well as social), each of which plays an indispensable role. The individual brain or mind no longer wears the pants, so to speak. For connectionism the crucial features of step by step reasoning and thought that uses language result from the flexible, context-dependent ways in which neural networks interact with representations outside the head, such as mathematical symbols, diagrams, and natural language, and not (simply) from the brain’s juggling of symbols, inside the head (Thompson, 2007: 9). This allows connectionism to account for capacities, such as flexible generalisation, which are difficult to achieve in the classical architecture (Wheeler, 2005: 10).

However, as long as connectionism still did not take into account any sensory and motor interaction with the external world, the mind was still conceived as operating inside the head, using inputs and outputs artificially supplied by the theorist to solve problems defined by the theorist. This begged the question of how these inputs, outputs and problems are structured or defined in the wild, in the absence of such an external theorist. Although connectionism expands the reach of the computational mind, it still does not tell us how the divide between the computational and the phenomenal mind is to be bridged (Thompson, 2007:10).

### **1.3 Embodied – embedded cognitive science**

The embodied and embedded approach has become more prevalent, in philosophy as well as in the various sub-disciplines making up cognitive science (Clark, 2009). The embodied approach emerged in the 1990’s together with a revival of scientific and philosophical



interest in consciousness, and a renewed willingness to address the explanatory gap between scientific accounts of cognition and human subjectivity and experience. The embodied approach criticises the computational premise that mind and world are distinct and independent of each other, and more specifically the notion that cognition is disembodied and boils down to abstract mental representation (Thompson, 2007: 10). Instead, it views cognition as employing skilful know-how in action that is both situated and embodied. Varela *et al.* (1991: 172-173) explain the term embodied as follows:

By using the term *embodied* we mean to highlight two points: first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context.

In addition to the connectionist emphasis on dynamic systems that spontaneously organise themselves, it maintains that cognitive processes arise out of on-going non-linear and circular sensorimotor exchanges between brain, body, and environment. Rather than viewing the mind as a neural network in the head, it is viewed as a dynamic system that is both dynamic and in the world. The world of the cognitive being is thus not presented as an external realm which is pre-specified and represented internally by its own brain, but as a relational domain which is enacted or produced by the autonomous agency of the being in question with its characteristic mode of engagement with its environment. Experience is therefore essential if we want to understand the mind and hence requires careful phenomenological investigation (Varela *et al.*, 1991).

John Haugeland (1998: 236-237) also uses the terms *embodied* and *embedded* in a paper in which he asserts that:

If we are to understand mind as the locus of intelligence, we cannot follow Descartes in regarding it as separable in principle from the body and the world... Broader approaches, freed of that prejudicial commitment, can look again at perception and action, at skilful involvement with public equipment and social organisation, and see not principled separation but all sorts of close coupling and functional unity... Mind, therefore, is not incidentally but *intimately* embodied and *intimately* embedded in its world.

Kiverstein and Clark (2009: 1) recognise the above passage's rich content and the multiple threads connecting it to a variety of more circumscribed projects within the embodied-embedded approach. "It mentions body, perception, action, skill, equipment, social

organisation, close coupling, and functional unity”. Although Clark notes that in the study of mind as “embodied, embedded, and enacted” there are possible tensions between divergent underlying strands of thought, I shall argue that many of these threads can help us to broaden and sharpen the enquiry into the act of drawing as an embodied extension of mind.

Clark (1997: 173) too wishes to give an adequate account of the active nature of perception and the way our cognitive organisation reflects our physical involvement in the world. But his approach is much more sympathetic to representationalist and information-processing analyses than that of Varela *et al.*, who oppose to the idea that “cognition is fundamentally representational”. Instead of rejecting the idea of internal representation Clark (1997: 173) aims to rethink our notions about the contents and formats of various representational states and processes. In Clark’s (1997: 143) vision for a mature cognitive science, the shift towards embodiment and embeddedness does not mean a rejection of the more traditional explanatory apparatus of computation and representation: “minds may be essentially embodied and embedded and still depend crucially on brains which compute and represent”.

Wheeler (2005: 11) gives a pithy formulation that could serve as the battle cry of the embodied-embedded approach: “cognitive science needs to put cognition back in the brain, the brain back in the body, and the body back in the world”. Accordingly, for this approach the paradigm case of cognition is *online intelligence*. “A creature displays *online intelligence* just when it produces a suite of fluid and flexible real-time adaptive responses to incoming sensory stimuli” (2005: 12). Wheeler (2005:12) illustrates the difference between off-line and online intelligence by way of two scenarios. An example of *online intelligence* would be having to navigate a constantly changing environment without bumping into anything. In contrast, an example of *off-line intelligence* would be forming conjectures about what the weather will be tomorrow, or mentally weighing up the costs and benefits of relocating to another city. Many mental processes will fall clearly into one or the other category, even if others straddle these categories (2005:12).

The emphasis on online intelligence recognises that biological brains have evolved primarily as devices designed for controlling actions, rather than for doing mathematics and logic. According to current thinking in a variety of the disciplines which form part of cognitive science, “on-line intelligent action” depends not only on what happens in the

brain, but also on hybrid processes which engage aspects of the external world along with aspects of the body which do not count as part of the neural system. Embodied-embedded cognitive science therefore tends to adopt a dynamical systems perspective on cognitive processing (2005: 13). The dynamic systems approach also, usefully, views cognition as an intrinsically temporal phenomenon. It describes how internal and external forces shape the state of the system over time. Such accounts straddle organism and environment, treating them as a coupled system. Clark (2008:25) uses the example of two wall-mounted pendulums that become swing-synchronised over time as an example of how this process allows an elegant explanation of such a coupled system. Here the shape of the space is partially governed by the on-going movement of the other pendulum, which is also continually influenced by the movement of its neighbour.

#### **1.4 The Extended Mind**

In their well-known 1998 paper “The Extended Mind”, Clark and Chalmers (1998: 8), define a coupled system as involving cases where “the human organism is linked with an external entity in a two-way interaction, creating a coupled system that can be seen as a cognitive system in its own right”. They argue that a coupled process should be regarded as a cognitive process when all the components in a system play an active causal role and collectively determine behaviour. “If we remove the external component the system’s behavioural competence will drop, just as it would if we removed part of its brain” (1998: 8-9). The external features are therefore “just as causally relevant as typical internal features of the brain” (1998: 9).

The Extended Mind hypothesis is accordingly “maximally opposed” (Clark, 2008: xxviii) to the brainbound model of cognition. It claims that in some situations, things – artefacts, media or technologies – can have a cognitive life, “with histories often as idiosyncratic as those of the embodied brains with which they couple. The realm of the mental can spread across the physical, social and cultural environments as well as bodies and brains” (Sutton, 2010: 189). It argues that “thinking and cognising may (at times) depend directly and non-instrumentally upon the on-going work of the body and/or the extra-organismic environment” (2008: xxviii). In such circumstances cultural artefacts (such as language or drawings) and technological developments become literal extensions of the human cognitive system. Such an extended cognitive system goes beyond just using tools to extend a human’s capability.

In his account of the history of Extended Mind thinking John Sutton (2010: 189-225) distinguishes two distinct, but compatible motivations and styles of work within the Extended Mind literature. He hopes that his description of these two agendas or “waves” within Extended Mind can allay confusion amongst critics and proponents. The key commitment which they share is that “external symbol systems and other ‘cognitive artefacts’ are not always simply commodities for the use and profit of the active mind: rather, in certain circumstances, along with the brain and body which interacts with them, they *are* (part of) the mind” (2010: 190).

The first wave, which is grounded in the ‘parity principle’ (Clark and Chalmers, 1998), has attracted most criticism. It claims that cognitive states and processes stretch beyond the brain and into the external environment when the relevant parts of the environment function in the same way as indisputably cognitive processes in the head do. So, if external features act just like internal features do, and are just as causally relevant, the difference in their location is absolutely inessential. This assumption relinquishes conventional, individualist divisions between brain, body and world, as it recognises that objects can have a cognitive life as part of the subject (Sutton, 2010: 194).

The second wave builds naturally on the first and is based on a ‘complementarity principle’, which claims that within an extended cognitive system, “external states and processes ... need not mimic or replicate the formats, dynamics or functions of inner states and processes” (2010: 194). Instead, different components can play distinctive roles and possess dissimilar properties, contributing in complementary ways to making thinking and acting flexible. Complementarity-orientated accounts in the EM framework will therefore frequently emphasise the difference between external and internal contributions (Sutton, 2010: 194). The notion of *integration* of such distinctive types of processes then becomes equally important, as what is achieved is not possible via either type of process alone. Integration style arguments show how cognition (and the mind) involves a hybrid process in which internal as well as external processes are coordinated in order to complete tasks (Menary, 2010b: 228).

The current project, with its attempt to show that the creation of and engagement with sketches and drawings is integral to our cognitive processing and as a result transforms our cognitive capacities would thus support the perspective of *cognitive integration*. The integrationist views the differences between the internal and external components of such

extended cognitive processes as equally or even more significant than the similarities. This view recognises that with respect to certain cognitive functions, cognition extends into the environment precisely because internal processes *cannot* or *do not* do everything external processes are capable of (Rowlands, 2009: 3). Extended Mind models are thus concerned with the *unique* contributions made by any relevant external element, such as its distinctive structure, relative *stability* and resultant possibility for manipulation and exploitation (Rowlands 2009: 4).

In this project, the Extended Mind view outlined above will be used to integrate a range of approaches to extended cognition. It will be used to combine accounts of embodiment – the ways we interact bodily – with accounts of the environment – the way in which external elements could play a role unlike, but complementary to, the brain’s style of storage and computation – as well as with accounts of how external vehicles shape and transform cognitive capacities. Such accounts will invite us to view mind and cognition in ways that “cease to unreflectively privilege the inner, the biological and the neural” (Clark, 2008: 218). Hutchins (2011: 437) agrees with Clark that “we need a lot more careful documentation of real world cognitive systems” in order to understand exactly how much they contribute to “the organisation of ecological assemblies<sup>1</sup>”. Based on years of studying “cognition in the wild”, Hutchins believes that cultural practices – “the things people do and their ways of being in the world” (2011: 440) – “account for much of what is needed to account for the organisation of human cognitive systems” (2011: 445).

The brief sketch above indicates that the sciences of mind are in a state of flux as the implications of notions of the mind as embodied, embedded and extended are considered. In the chapters to follow, the question of whether the practice of drawing could illuminate aspects of embodiedness, embeddedness, and extension of mind will be considered. It is hoped that putting the cultural practice of drawing – as a real world cognitive system – on view will help cognitive scientists and philosophers to better approach the question of whether processes occurring outside the brain, or at times even outside the body, can form genuinely cognitive parts of cognitive processes.

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<sup>1</sup> Clark (2008: 13) introduces the “principle of ecological assembly” as an important characteristic of embodied, embedded cognition. According to this principle: “the canny cognizer tends to recruit, on the spot, whatever mix of problem-solving resources will yield an acceptable result with a minimum of effort”(2008: 13). Elsewhere he expresses very similar ideas by means of the expression ‘the opportunistic brain’.

## 2. Approaching drawing as thinking

We know that we are in difficult territory when most attempts to define drawing “invite[...] frustration or obsession in attempting to clarify something which is slippery and irresolute in its fluid status as performative act and idea; as sign, and symbol and signifier; as conceptual diagram as well as medium and process and technique” (Petherbridge, 2008: 27). James Elkins (Berger and Savage, 2005: 106) confirms this complexity when he, in conversation with John Berger, positions drawing as “the site of the most sensitive of negotiations between the hand, the eye, and the mind” where “all the intricate philosophy of marks, signs and traces plays out.” While Downs *et al.* (2007: x) celebrate drawing as “a model of representation that maps the fragmented simultaneity of thought, accessing memory, visual fragment and intangible imagination”, they too profess that “the nature of drawing appears to inhabit an area that facilitates a level of ambiguity and a dynamic that promotes non-definition and the non-conclusive” (2007: xx).

The seminal texts on drawing (Hill, 1966; Arnheim, 1969; Rawson, 1969) are all concerned with the relationship between perception, conception and representation, suggestive of a close relationship with thinking. Edward Hill (1966: 5) employs a phrase strikingly similar to Clark’s terminology to convey the essential spirit of drawing: “to empty one’s mind of all thought and refill the void with a spirit greater than oneself is to *extend the mind* into a realm not accessible by conventional processes of reason”. Although his interpretation retains a sense of mystery, he recognises that the complexity of levels at which most draftsmen operate can only be obscured by reducing the artistic intention of drawing to ‘self-expression’ or ‘representation’ or ‘investigation’. Drawing needs to be understood as a “dynamic affair”, involving different levels of intention: probing one’s own image, testing the interplay of shapes, lines and tones as well as the ritual participation in the act itself (Hill, 1996: 8). Hill (1966: 39) presents the act of drawing as an exercise of eye and mind to facilitate visual ideas – “never born whole from ether”, but rather the consummation of complete participation in experience, “total experience, everything – visual and nonvisual, concrete and conjured, empirical and fantastic – that is the configuration of our lives”.

Despite the fact that contemporary writing about drawing is extremely diverse in approach and content, it tends to revert to stereotypical eulogies about drawing’s remarkable powers and enduring means of representation rather than attempting to explain the nature and origin of these powers (e.g. Petherbridge, 1991; Dexter, 2005; Kovats, 2005; Downs *et al.*,

2007). Many years after Hill asked, “what are the mechanics of drawing?” (1966: 43), Steve Garner (2008: 23) can thus still remark: “Just how drawing supports cognitive processes, particularly creativity and the emergence of ideas, has been much discussed but little evidence has been used to construct a foundation of knowledge on which we might all build”.

## **2.1 What tools are needed to explain such a complex phenomenon?**

The complexity and technical virtuosity exhibited in works of art often bring with them “a certain cognitive indecipherability”; they tantalise, they frustrate the viewer unable to recognise at once, “wholes and parts, continuity and discontinuity, synchrony and succession” (Gell, 1998: 95). But what tools are needed to explain or understand such a complex phenomenon, which if viewed as an artefact, different to other/everyday objects, can present itself as a “miraculous” creation because its “coming into being” is “inexplicable except as a magical, supernatural occurrence” (Gell, 1998: 68)? Phenomena like these are prone to be explained by the “magic dust” error, a complex of seductive but mistaken views that the neural machinery itself is “blessed with some inherent property that enables [it] to act alone as the circuitry of mind and intelligence” (Clark, 2008: 136). Extended mind theory aims to shed light on phenomena that are otherwise treated as mysterious and impervious to analysis or explanation, by showing that what matters is the functionally supported causal flow either within or beyond the bounds of skin and skull. It rejects the idea of a single, omnipotent, agent hiding inside the brain, responsible for all the real thinking. Instead it suggests that the ‘coming into being’ of a drawing can be better described as an emergent phenomenon as it displays “interesting, non-centrally-controlled behaviour”, resulting from the manner in which numerous simple components within a system interact with each other (Clark, 1997: 108).

A phenomenon like drawing, which is rooted in factors that spread across the organism and its environment, will require an explanatory framework that is well suited to modelling both organismic and environmental parameters, within a framework which will facilitate an understanding of the complex interactions between the two. Clark (1997: 123) argues that complex emergent phenomena demand new modes of explanation and study to complement (not compete with) more familiar analytic approaches. They require “a mix of explanatory tools, combining Dynamical Systems constructs with ideas about

representation, computation, and the information-processing role of distinguishable subcomponents” (1997: 123).

The investigation of drawing would in turn help answer the call from proponents of the extended view for a more interdisciplinary approach to the study of cognitive practices. The Extended Mind thesis embraces a variety of kinds of mental representations. Wilson (2010: 183) proposes that the Extended Mind task is to understand these different practices and what it is that makes them representational, examining what forms such activities take, and “just how they bring about the effects they do”. Cognitive integration arguments emphasise the hybrid nature of extended cognition, and “attempt to understand the nature of the integration between internal and external processes as elements of a hybrid process” (Menary, 2010b: 229). This shift suggests a methodological reorientation, to a methodology which “is not traditional conceptual analysis, but an interdisciplinary, pluralistic motley” (Wilson, 2010: 183). To understand drawing as a representational practice will require various means, including historical analyses of its emergence and sociological and psychological analysis of the conditions under which it operates (Wilson, 2010).

From the perspective of the Extended Mind thesis the focus of the following chapter will be *how* drawing makes possible and encourages forms of thought which are “not accessible by conventional processes of reason” (Hill, 1966:5). What follows then is an attempt to collect a range of reflections on drawing which straddle theory and practice, drawing from – as well as interweaving – disciplines and practices such as fine art, design, philosophy and cognitive science, in the hope that these complementary contributions can somehow interlock and inform one another to build a more cohesive account of drawing. As a distinct form of cognitive extension, drawing will first be viewed as an embodied practice, firmly grounded in perception and action. This will be followed by an attempt to appreciate this practice in combination with an understanding of the context and nature of the drawing systems themselves – how they are generated and manipulated for some goal in a particular situation as an act that extends, enhances and amplifies cognition.



## Chapter 2

### Drawing as embodied embedded act of thinking

#### 1. The act of drawing

##### 1.1 The hand enters thinking/thinking is of the hand

In some reflections on the drawing act the role of the body, and of the hand in particular, is considered central to its meaning. Hill (1966: 1) perceives the *act* of drawing as the genesis of the subject of drawing. For Hill (1966: 2) the making of a single stroke represents a conjuncture of three factors: materials, muscular action, and pictorial (artistic) intention. Rawson (1969) views the essence of drawing as a record of a two dimensional movement in space, made by a tool acting as a kind of surrogate for the hand with its fingers. He considers this movement to constitute the fundamental nature of drawing; its structure produced by actions carried out in time.

The French psychoanalyst Serge Tisseron (1994: 36) lyrically describes how the “thrown-out” gesture of the hand conjures up the line as its trace. The inscriber uses the hand to pull back the thought that has been cast out in the act of inscription. “This back and forth motion, tossing and retrieving”, contributes to the constitution of a mental framework capable of containing thoughts. “The hand’s drawing gesture is an essential movement by which thought learns to think itself through. At first it darts out like an unruly horse, which is later led back and tamed, bound to the line which the hand holds fast upon the paper” (1994: 36).

The French philosopher Derrida regards the exploratory movement of the artist’s hand, searching and groping, perhaps never reaching its goal, as the definition of drawing. “He presents drawing as an intransitive activity; our attention does not focus on the image we perceive, a represented world, but on the representation of that world – as activity” (Alphen, 2008: 60). Derrida is one of a number of philosophers who theorise the act of inscription. Noland (2009: 207) remarks that “theorizing the gestural component of inscription has been a secret preoccupation of philosophy and aesthetics for a long time. A glance at the major texts of continental philosophy reveals the startling frequency with which the act of inscription is evoked as an exemplary instance not of communication or expression but of an opportunity for an experience of the body in the here and now”.

The German philosopher Heidegger (1993: 381) too regards the activities of the hand as important in thinking. He advances the notion that thinking is a handicraft when he states “every motion of the hand in every one of its works carries itself through the element of thinking”. He asserts that the craft of the hand is richer than our limited imaginations take it to be – it not only grasps and catches, or pushes and pulls; but can also reach and extend, receive and hold, carry designs and signs. “It is self-evident the importance of prehension within thinking. To grasp something is to know it” (Rosenberg, 2008: 111). The metaphorical use of the word “grasp” thus reminds us that grasping is a cognitive act as much as a physical one – “grasping, more than any other primordial action of the human body, combines perception and action” (Streeck, 2009: 40). The hand is not only an organ of action and perception, but also the organ “with which we shape the world while at the same time receiving information about it” (Streeck, 2009: 52).

*Prehension* is the technical term for the phenomenon whereby the body’s movements anticipate and act in advance of sense data. Sennett (2008: 154) brings this meaning to mental understanding as well as physical action: “you don’t wait to think until all information is in hand, you anticipate meaning. Prehension signals alertness, engagement, and risk-taking all in the act of looking ahead; it is in spirit the very opposite of the prudent accountant who does not exert a mental muscle until he or she has all the numbers”. Rosenberg (2008: 111) likewise expands the term to identify *Ap-prehension* (sic) – the mind becoming aware of, “seizing”, bringing into the mind’s hold – as an element in ideational drawing: where the hand as a conjectural hand then proceeds to stir and disturb, dislodge, carry and connect.

When the French philosopher Michel Serres (cited in Rosenberg, 2008: 111) talks of inventive thinking he, too, relates it to the hand, which has no single function – it is unstable and undetermined, undifferentiated as it can make of itself a pincer, fist or claw. He regards the hand as “not an organ”, but “a naked faculty”, “a capacity for doing, for becoming claw or paw, weapon or compendium”. The notion of the hand as faculty appreciates the hand’s capacity to manipulate and transform, and, ultimately to craft other arrangements that allow one to think differently. The hand as faculty does not accept what differentiates, demarcates and fixes in place the world and its objects (physical and mental) as something immutable beyond challenge and play. As the hand enters thinking and thinking can be of the hand, it displays the ambiguous nature of the body (Merleau-Ponty,

1995: 178) – it reveals a third category of bodily existence where the performing body can transform both the world and self

## 1.2 Thinking in action/action as thinking

In an interview for a book on conceptual drawings, the neurologist Frank Wilson (O'Donnell, 2009: 176) describes this kind of absorbed activity which occurs when “artists, dancers and musicians sort of get lost in time as they use their body to create something, and when that happens I think they are simply experiencing one of the many consciousness potentials we have”. Wilson suspects that “the thing about the hand” that is so specific to the creative process is that although we really do have an extraordinary amount of control over the hand “it takes a lot of time”. Wilson (O'Donnell, 2009: 176) believes that the amount of time required means that everything else has to be excluded from consciousness and that this is the reason why sketching works: “because it’s a meditative process in which the nervous system is using the body as a way of re-experiencing relationships in the world”. In drawing as ‘thinking-in-action and action-as-thinking’, “physical and mental processes are linked isomorphically and crimped together – at one and the same time mental and physical” (Rosenberg, 2008: 109). At this juncture thinking is *presenced*, not re-presented, in the immediacy of the thinking act; ideational drawing is ‘thinking’ and not ‘thought’ (2008: 110).

The drawing act is thus depicted as an integrated process where *hand and mind and materials* are not independent entities but fundamentally inseparable, evolving together as, to use Merleau-Ponty’s (1995: 164) words, “thought and expression are simultaneously constituted”. As embodied cognition, drawing results from bodily interactions with the world and “depends on the kinds of experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed” (Thelen, 2000: 5). Clark (2008: xxvi) interprets this notion of *meshing* as a type of continuous intermingling between cognitive activity and the perceptuomotor basis from which it seems to emerge, where our thoughts, actions and perceptions are all deeply enmeshed with each other.

Downs *et al.* (2007: xii) view the generative force of drawing as emanating from precisely such a continuous integrated process: “Drawing plays with appearance; it oscillates between seeing, thinking, remembering and imagining, controlling and being controlled as

the image emerges. It is continuously and simultaneously shifting itself in the course of its making”. A parallel continuous integrated process is evidenced in studies on brain function during simple reaching tasks. Thelen (2000: 8) draws on such studies to support her argument for “a distributed, multiply determined cognition, where the lines between perceiving and acting and between remembering and planning are blurred and shifting like drops of oil on a puddle”. These studies have shown that one and the same neuron often responds to several aspects of the same task, i.e., the same neuron responds when the visual stimulus was presented and responds again when it was time for memory, or a motor decision to kick in. This leads Thelen (2000: 12) to ask:

Is this a visual neuron or a motor neuron or one representing the stimulus in memory? It does all of these things. The line between what is perception, what is action, and what is cognition is very hard to draw. Indeed, maybe we experience our existence in the world as seamless and integrated because the brain is everywhere processing that existence as seamless and integrated.

These wide-ranging observations all suggest that drawing’s identity is intimately connected with the actions performed to bring a drawing into being, something we may lose sight of when the focus is on the fact that drawing deals in pictorial representations. Things are called ‘drawings’ because they are *drawn* as opposed to another way of producing a picture, or an image. To draw, in the most general sense, means to act upon something and make it move as if by a pulling force. It is therefore not sufficient to view drawing only as a pictorial representation.

### **1.3 The complexity of the drawing act and of drawing skill**

Drawing is a particularly complex procedure (Feagin, 1987; Frith & Law, 1995; Cohen, 2005; Seeley & Kozbelt, 2008). It involves a variety of cognitive, perceptual, and motor processes. The activity involved is both bodily and conceptual in character, with bodily aspects sometimes overshadowing the conceptual, and sometimes the other way round. It therefore needs to be viewed in cognitive as well as physiological terms. We can ask different sorts of questions about drawing skill: how it is attained, how it is stored in memory, how it is summoned in appropriate settings, and how it develops to expertise. Drawing skill furthermore involves different kinds of knowledge and is used in diverse real world contexts. The drawing act is thus complex. How should this complexity be represented? In order to address this question I will pause to consider some attempts to

understand the mechanics of drawing, as well as broader but pertinent contributions regarding issues of skill and know-how.

Frith and Law (1995) suggest that an initial internal representation (in what they call the ‘inner eye’) is needed to compute the sequence of muscle movements needed to draw a cube from memory. Alfred Gell (1998: 45) proposes that the act of drawing a chair begins with the desire to make an index, which will refer to this chair. This act of drawing is preceded (whether the object is present or not) by an act of visualisation or “inner rehearsal”<sup>2</sup> of the drawing to be made. Characteristically, for Gell:

Because one’s hand is not actually directly controlled by the visualised or anticipated line that one wants to draw, but by some mysterious muscular alchemy which is utterly opaque to introspection, the line which appears on the paper is always something of a surprise (1998: 45).

Here one is little more than a spectator of one’s own attempts at drawing, which involve a series of ‘generate and test cycles’. Frith and Law likewise admit that how that image is interpreted or how it generates movements to create similar images in the outside world is highly resistant to explanation.

Gombrich (cited in Feagin, 1987: 164) argues that even the most skilful artist cannot be expected to control every quality of the stroke. He proposes an “impulse and subsequent guidance” account of drawing where subsequent marks are made in response to the visual feedback from what is already drawn. Feagin expresses doubt that these subsequent strokes can be “mere impulses” and proposes a third possibility between controlling every detail and impulse: a guided system that allows for muscular variations and/or randomising within limits. She describes the process as typically starting with a mental representation, intention, memory, perception or an idea that is used to generate representations of actions one *can* perform. When one has learned to draw by developing this kind of control, the process is no longer a matter of using a means to achieve a separately conceived end, “but one where the end is integrated into the representation of the action performed” (1987: 164). Skill depends on the degree of integration of the action sequence, which in turn partly depends on the experience with the actual material with which the drawing is done.

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<sup>2</sup> Such “initial internal representations” or “acts of visualisation” or “inner rehearsal” should probably not generally be conceived of as being highly determinate – as determinate as external representations tend to be. Below we will discuss research indicating that the internal and external representations function very differently.

Because drawings are products of actions, drawing skill requires “an integrated mental representation” of what is *drawn*, rather than of what is *pictorially represented*” (Feagin, 1987: 163). Feagin differentiates between *pictorially representing* things and *drawing* by pointing out that one does not *learn* to pictorially represent but you do learn to draw. Making a drawing requires a kind of psychological control which governs or informs the action, which is not the case for pictorial representation. She proposes that the integrated mental representation is not a representation of a muscular sequence, but of an action ‘content’ which allows certain freedoms of physical movement. Since the intimate connection which exists between drawing something and the action one performs is not present in the case of pictorial representations, drawing should more closely resemble what an *action theory* identifies as an action rather than pictorially representing or merely placing marks on a paper (1987: 166).

In order to appreciate what actions are integral to the skill evident in an act of drawing, Feagin (1987: 167) distinguishes skills as ranging between extremes of physical skills and mental skills. Mental skills require comparatively less physical and more cognitive development (such as logical inferences or skill at chess which does not reside in one’s behaviour): “nothing would be lost by another person’s performing the physical motions under instruction from, say, a paralysed chess player”. The behavioural component of drawing however is not replaceable, as one cannot learn to draw from books. It requires feedback during the process of drawing, becoming aware of what movements will produce what kinds of lines, tones, and shapes. One’s perceptions need to be united with the mechanics by the use of feedback and control. “However, a major component of learning to draw is mental. It involves a change in one’s conceptual apparatus in a way that is commonly described by the phrase ‘learning to see.’ This does not involve somehow acquiring more sensory input, but “changing the cognitive use to which sensations are put” (1987:167). Since the development of drawing skill involves a change in mental states or activities, i.e., a change in content, it cannot only be described extensionally. The degree of competence involved in drawing involves the character of what is psychologically governing the performance. Drawing skill is consequently often described by referring to the character of one’s mental competencies or failings, for instance by saying: “he’s just not very good at analysing relations between volumes” (1987:168).

## 1.4 Cognitive change

Feagin's proposal that drawing changes the cognitive use to which sensations are put, is similar to Kozbelt and Seeley's (2008: 157) observation that artists thus "see-with" a novel class of knowledge which derives from the practical requirements of artistic creation. Gombrich (referred to in Kozbelt, 2008: 100) maintained that knowledge of this sort is encoded in schemata (a schema is an underlying organisational pattern or structure which determines how a person relates to experienced events). Kozbelt (2008:100) deems Gombrich's model highly relevant to the study of the relationship between mental competencies and drawing skill. He develops Gombrich's model by referring to empirical studies which help us to understand this "staggeringly complex phenomenon". Gombrich views artists' methods as partly constituted by an ensemble of viewing strategies that are largely learned from artists' experiences in their milieus. Artists' schemata "might include such varied components as a declaratively encoded expert knowledge base; procedurally represented motor skills; default problem solving goal-plans; and evaluation criteria with cognitive, perceptual, or emotional bases, plus other factors" (Kozbelt, 2008:100).

Psychological research indicates that the cognition of artists and non-artists differs; artists demonstrate more skill at a variety of tasks involving cognition, perception and visual memory than do non-artists (Winner and Casey, 1992; Kozbelt, 2001). These results raise the question: how does artists' experience affect their visual cognition? While one can assume that artists are better at drawing compared to non-artists, do they surpass non-artists on perception tasks *not* involving drawing? Kozbelt (2001) investigated the relation between drawing and perception in a series of tests that involved art students and non-artists on two task-sets. He found that artists eclipse non-artists in visual analysis tasks and that such perceptual advantages correlate statistically with drawing skill.

Kozbelt (2001) concluded that the same visual procedures used for drawing are employed for the perception and analysis of two-dimensional figures. Artists' superior performance on both tasks along with correlation analysis indicate that art students were not only more skilled than beginners in the visual motor processes exclusive to drawing, but also in the visual processes involved in analysing patterns and in drawing. This difference becomes understandable if we keep in mind that achieving a correspondence between what is being drawn, the drawing itself, and what the artist wishes to draw requires intensive visual analysis and comparison. The artist often has a set of viewing strategies, resembling

Gombrich's concept of schemata, which co-determines the visual features that will be attended to or emphasised and incorporated into what is drawn (2001: 718). The drawing activity involves interactive comparison and evaluation of the artist's plan, what the visual world offers to the eye, and what has been drawn. Experience gained through this interaction may yield understanding about objects' properties and spatial relations, but also about strategies for attending to and analysing these properties and relations. The differences between artists' visual processing and that of non-artists relate to artists' knowledge and flexible methods for getting to grips with important structural features of objects and images. It is likely that artists possess declarative knowledge (e.g. of basic proportions of a body or that a face's central features form an inverted triangle which is bisected by the midline of the head) together with the procedural knowledge needed for analysing and rendering such important structural features. "This knowledge makes them cognitively different from non-artists" (Kozbelt, 2001: 719).

In a more recent publication Kozbelt and Seeley (2008) endeavour to arrive at a model to explain these results. Because drawing ability is valuable for a wide variety of tasks and situations found in visual education, these authors use drawing as an exemplar of the effect that technical proficiency has on perception. The fact that educators rely so heavily on drawing when teaching art students skills in visual analysis indicates just how notable such effects are. Kozbelt and Seeley (2008) provide neurophysiological and behavioural evidence to support their argument that as artists acquire the skills needed for drawing, they "develop specialized spatial schemata and related motor plans that guide attention and enhance the perception of stimulus features diagnostic for the identities of objects and scenes in ordinary contexts" (2008: 168). They arrive at the conclusion that "although artists perceive the world differently than (sic) non-artists, this is not the product of an innate capacity. Rather, it is a matter of the selective deployment of learned perceptual strategies originally derived from, and dedicated to, the process of artistic production" (2008: 168-169).

These studies thus suggest that the act of drawing, in Clarkian (2008: 48) terms, deliberately and systematically sculpts and modifies our own processes of selective attention. They furthermore support Sutton's (2008: 37) assertion that neuroscience can certainly not be the study of the brain alone, "for brains coupled with external resources may have unique functional and dynamical characteristics apparent only when we also attend to the nature of those resources and the peculiarities of the interaction". The upshot of considerations like



these is that it is safe to conclude that the act of drawing filters or guides perceptual, affective and cognitive attention and behaviour in ways that are indeed peculiar to brains coupled with pencils and other drawing materials.

## **2. Drawing skill represented**

### **2.1 Representational challenge**

To represent within AI the complex interconnection of cognitive, perceptual, and motor processes involved in drawing skill is a challenge. Wheeler (2005:175) observes that to rebuild such complex and vastly distributed and interconnected networks, “by building inner representations of those networks (as atomic nodes and the links between them) looks to be, at best, positively Herculean”. Hubert Dreyfus (1991; cited in Wheeler, 2005: 174) identifies the issue of skill as an important theoretical difficulty flowing from orthodox AI’s standard strategy of accounting for context by adding inner representations which stipulate context. To create a computer programme for generating behaviour that responds appropriately to contextual variations and subtleties in the real world, the practitioner of good old fashioned artificial intelligence will have to explicitly code for all these variations and subtleties. In practice, this process will require that existing code be endlessly revised or supplemented by new code. “The result is a computationally debilitating increase in the number of representations required, and in the number of associated rules that determine how those representations may be systematically combined and transformed” (Wheeler, 2005: 177). In contrast, solutions arrived at in the embodied and connectionist approaches will tend to adapt flexibly and elegantly to new situations.

Dreyfus (1991:117) describes skill as the ability to “come into a situation with a readiness to deal with what normally shows up in that sort of situation”. To account for the type of fluid intelligent embodied activity involved here, and how it differs from reasoning that takes an explicit form, Dreyfus offers a phenomenological account of everyday expertise. He argues that there are two types of intentional behaviour that are irreducible to each other: “deliberative, planned action and spontaneous, transparent<sup>3</sup> coping” (Sutton, 2007: 768). Dreyfus’ account of the transition from being a novice to becoming an expert in a practical skill proposes that it entails gradually letting go of any dependence on explicit rules or on conscious reflection. He perceives explicit thinking and memory as a secondary

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<sup>3</sup> That is, skilful coping without reflection

phenomenon in the exercise of real expertise, where “psychological principles or maxims are like training wheels which an expert cyclist has long abandoned” (Sutton, 2008: 49). Dreyfus thus understands embodied skill (doing) as a particular kind of knowing, which is not reliant on verbally articulable or conscious propositions before decision and action (Sutton, 2007:768).

Clark (2002b: 385) questions Dreyfus’ argument that learning and skilful action can be effectively explained “without recourse to mind or brain representations”. In response to Dreyfus’ proposal to view experience as leading to fine grained dispositions to respond to the precise details of the current situation Clark (2002b: 386) asks: “in virtue of what is the expert able to make these discriminations? And why does this resource (whatever it is) fall short of counting as internally represented knowledge of some kind?” Clark argues that if the knowing does not essentially involve symbols, rules and propositional data structures, but instead a fine-grained capacity to distinguish between situations, it does not demonstrate that internal representations of some substantial kind are not involved. He suspects that what Dreyfus actually objects to is the idea of something like inner vehicles of objectivist content, “where that means, inner items that stand for states of the world irrespective of our behavioural engagements with the world” (Clark, 2003: 386).

## **2.2 From “representation as mirroring and encoding” to “representation as control”**

Clark is not willing to discard the explanatory apparatus of representation. His vision for a mature cognitive science insists that the shift towards embodiment and embeddedness should not mean a rejection of the more traditional explanatory apparatus of computation and representation: “minds may be essentially embodied and embedded and still depend crucially on brains which compute and represent” (1997:143). How we think about cognition would thus shift from models of “representation as mirroring and encoding” to models of “representation as control”; – what would change are ideas about the *kinds* of content involved (Clark, 2002). Reflecting on what such representations code or specify, Wheeler (2005: 197) suggests that in encoding the world, the crucial things is the scope for action it affords. What cognition is primarily built around is *know-how*, not *knowledge that*. What has to be represented is *how* the world can be dealt with in a particular context, not *that* it is a particular way, independently of our possible actions. The representation is action-oriented from scratch, rather than there being an initial, action-neutral representation to which representations concerning action are only subsequently added.

An illustration within the context of drawing activity would be artists' productive strategies, which Kozbelt and Seeley (2008: 163) argue, "encode the general shapes of objects and scenes *relative to* medium-specific constraints on artistic production". Such a strategy therefore does not mirror (reflect) the environmental structure itself but is rather *about* (concerned with) environmental structures and opportunities.<sup>4</sup> Sutton (2008: 48) argues that once the dynamic, active and context sensitive nature of skills is understood, "successful fusions of phenomenological and cognitive scientific accounts of complex embodied skills will often need to retain the appeal to inner and outer representations".

### 2.3 Knowing-how and knowing-that

As indicated earlier, the standard distinctions between '*knowing-how*' as referring to procedural knowledge and '*knowing-that*' as declarative knowledge, become blurred when reflecting on the kind of knowledge required in competent drawing. The kind of knowing that is involved in drawing has many of the characteristics of tacit knowing as described by the philosopher Michael Polanyi (1969; 1973). Polanyi viewed skills and all intuitive insights as grounded in "tacit knowledge", a term he introduced to explain experiential knowledge. Tacit knowledge is obtained through what Polanyi calls "indwelling" – an active bodily participation in the things one is learning: "we pour ourselves out into them and assimilate them as parts of our own existence. We accept them existentially by dwelling in them" (1973: 59). Learning is done by example, through trial and error, and through the process of apprenticeship. A lot of un-theorised teaching in art and design schools resides in the passing on of tacit knowledge between tutor and pupils (Petherbridge, 2008). Historically students learned to draw from copying paper and three-dimensional models, as well as watching teachers and studio masters at work, or observing corrective sketches made on the side of the students' drawing paper. Petherbridge (2008: 34) describes this kind of learning as "the optical spur for osmotically absorbing gestures, intervals of lines, rhythms of working, technical shortcuts and so on" and notes that tacit knowledge "serves to naturalise the practices that escape verbalisation or codification".

As one indwells tools as extensions of the body, and the various dynamics involved in a skill, one goes through a series of "integrative acts", through which one tacitly grasps the full meaning of a process or task, a kind of bodily "Aha-experience" (Sorri, 1994: 19). An example of how such integrative acts become part of one's bodily cognition is when

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<sup>4</sup> Clark (2002: 386) explains that the relation which is at stake here is more like a lock and a key than a scene and a photo.

actions are performed as integrated wholes rather than as a sequence of separate actions. As drawing becomes second nature, you start *'thinking in drawing'* as a Frenchman would start *'thinking in English'* as his skill in English reached a certain level. A striking fact about this kind of know-how, often referred to as kinaesthetic memory, is that the *sui generis* experienced movement dynamics displayed are "at once both familiar and yet quintessentially tailored kinetically to the particular situation at hand" (Sutton, 2008: 49). For Sutton (2007: 765) skill memory does not arise from a single source or experience, but out of repeated training over a long period, out of routines and practices and multiple similar experiences. Mastery of a skill is thus an example of tacit knowing, where explicit knowledge is neither necessary nor sufficient for tacit knowing. Tacit knowledge involves the kind of knowledge that we cannot fully articulate, where we know more than we can tell. Haugeland (1998: 311) argues that one reason for the difficulty to "say what we do" is that "the procedure requires the cooperation of the environment in a way that remembering the procedure does not".

Polanyi distinguishes between focal and subsidiary awareness, where we are focally aware of that *to* which we are directing our attention and subsidiarily aware of those things that we are directing our attention from or through. (For instance, in order to hit a nail with a hammer, it is necessary to attend focally to driving the nail into the board, while only subsidiarily attending to holding the hammer). He further maintains that all human activity lies somewhere on a continuum between the poles of bodily activity and conceptual activity, with most human activity a mixture of these two polarities (Sorri, 1994:16). Polanyi distinguishes cognition itself as a continuum between the two poles of tacit and explicit knowing with the cognitive dimension of human experience a result of the interaction between the two. Tacit knowledge, which is more fundamental, and also the basis of explicit knowledge, arises from the interaction between subsidiary awareness and bodily activity. Explicit knowledge is the result of focal awareness interacting with conceptual activity (Sorri, 1994: 18). Haugeland (1998: 143) describes tacit cognitions as "those evinced in the cognitive behaviour of the system, quite apart from whether they are held explicitly or implicitly".

## **2.4 Heidegger on practical engagement**

An important forerunner to views that no longer constrain knowing to the realm of inner states and processes was Martin Heidegger. Heidegger (1980) proposes that we know the

world through handling long before there can be any question of knowing it theoretically. Heidegger suggests that the primary relationships we have with the world are with those things that we deal with practically. Clark notes that “[t]he image of mind as inextricably interwoven with body, world and action [is] already visible in Heidegger’s *Being and Time* (1927)” (1997: xvii). According to Heidegger, our practical engagement with the world – which is also our *primary* engagement with it – is not that of a disengaged subject who represents the world in a way that is neutral regarding the relevant possibilities for action; rather it entails what Clark calls “*functional couplings*” (Clark, 1997:171). Heidegger put forward *Dasein* (being there) as the essence of cognition – “a mode of being-in-the-world in which we are not detached, passive observers but active participants” (Clark, 1997: 171). For Heidegger our skilled practical dealings with the world are fundamental to all thinking and intentionality. His foregrounding of tool use was an early indication of doubts as to “action-neutral” types of inner representations and is echoed in Clark’s focus on action-orientated cognitive processes in which organisms and parts of the environment are equally and inextricably involved (Clark, 1997; 171).

Although cognitive science is too young to have been commented on by Heidegger, and his concern with the explanation of the human mind is different in emphasis and scope, Wheeler (2005: 16) suggests that Heidegger’s account of ordinary cognition, which completely rejects Descartes’ separation of mind from body and mind from world, lays the foundations for a cognitive science that would finally leave Cartesian dualism behind. He even goes so far as to suggest that “embodied-embedded cognitive science is implicitly a Heideggerian venture” (2005: 223).

Many of Heidegger’s ideas, and especially his critique of an instrumentalist understanding of the human – tool relationship, can be used to challenge customary ways of thinking about the drawing process. Current art education emphasises conceptual and theoretical knowledge while materials, skill and process are regarded as being merely instrumental, to be used in the execution of a pre-existent idea, rather than as themselves being productive (Petherbridge, 2003; Bolt, 2006). Heidegger’s notion of handlability and concerned dealings, offers an opposing approach in which knowledge is seen as emerging from artistic practice.

## **2.5 Smooth coping and “its own kind of sight”**

Wheeler (2005: 128) uses the term “*modes of encounter*” to describe the various relations between the individual and the world that take centre stage in Heidegger’s analysis of ordinary cognition. Heidegger (1980: 98) proposes that the mode in which we relate, by and large, to things is as *equipment*. He uses the expression “*readiness-to-hand*” for the unique and distinguishing type of “intelligibility” found when any entity is encountered as equipment. Heidegger maintains that the most straightforward and most telling (most “primordial”) way of relating to a piece of equipment is by handling it skilfully with our bodies, rather than by observing it in a distanced theoretical or cerebral manner (Wheeler, 2005: 129). In the embodied-embedded approach the term of art for this primordial form of encounter is *smooth coping*. According to Wheeler (2005: 134), smooth coping can be understood as “a process of real-time environmental interaction involving the subtle generation of fluid and flexible context-specific responses to incoming stimuli, not responses to representation-based or reason-based control”.

Wheeler (2005: 129) observes that although *smooth coping* is now commonly regarded as “embodied knowledge-how”, the idea of knowledge-how was still unfamiliar when Heidegger (1980: 95) wrote that “[t]he kind of dealing which is closest to us is...not a bare perceptual cognition, but rather that kind of concern which manipulates things and puts them to use; and this has its *own* kind of “knowledge”. He continues: “this activity is not a blind one; it has its own kind of sight” (Heidegger, 1980: 98). Heidegger thus argues that, since our primary experience of things is as equipment, *embodied know-how* turns out to be the primary form of our everyday understanding of the world – *not* the “bare perceptual cognition” of ‘knowing-that’ something is the case (Wheeler, 2005: 130).

Barbara Bolt (2006; 2007; 2010) proposes that Heidegger’s notion of concernful dealings could help us understand art as a domain where our handling of materials and processes through which the work of art comes into being produces its own kind of sight. This kind of knowledge/sight is evident in the observations made by artists David Hockney and William Kentridge on the skill displayed in the drawings of Ingres. Hockney and Kentridge are both prolific draftsmen. From his own experience as someone who draws, Hockney was convinced Ingres could never have achieved such an extraordinary level of accuracy if he had to rely only on direct observation and freehand drawing. William Kentridge, elsewhere, in an observation on drawing’s ability to reflect a process of labour and a sense of work, of a specific but not perfect hand, similarly observes that: “An Ingres drawing might be the exception. They often look like they were not done by human hands but by

some divine skill” (cited in Auping, 2009: 233). These drawings showed no fumbling lines of a drawer battling to “see” and record freehand. Both Kentridge and Hockney’s observations are grounded in a form of tacit knowledge that arises through handling materials in practice.

The disbelief Hockney experienced when inspecting Ingres’ drawing of Madam Godinot led him to perform a series of drawing experiments, in which he demonstrated that drawings made using a Camera Lucida showed the same confident quality of line of Ingres’ drawings. According to Hockney (2006: 13) only “an artist, a mark-maker, who is not as far from practice, or from science, as an art historian” could have made such observations and posed such questions. Bolt (2006) argues that Hockney’s sustained work with graphite pencils, charcoals, paint, and especially the struggle to render the three dimensional reality “out there” in two dimensions, lies behind his distinctive way of seeing, his distinctive logic.

## **2.6 Transcending the subject-object dichotomy**

This brings us back to Heidegger, specifically his notion of circumspection. According to the Heideggerian approach “smooth coping involves a form of awareness in which the contrast between subject and object plays no part” (Wheeler, 2005: 131). This suggests that the dichotomy between subject and object is foreign to the epistemic situation in which the cognisor normally finds herself. Heidegger calls the awareness that is typical for the standard situation *circumspection* (Wheeler, 2005: 131). When handling equipment becomes second nature to us, we cease being aware of the equipment as part of our world; we become so *absorbed* in the task at hand that any consciousness of self as a subject opposed to a world of objects disappears.

James Elkins (1999: 166) observes this lack of subject-object awareness in the relationship between artist and the half-formed work where “neither is in control, neither clearly “makes” the other”. He compares the painter with the alchemist and says that “the experiment” of art changes the experimenter, and there is no hope of understanding what happens because there is no “I” that can absorb and control concepts – nothing has meaning apart from the substances themselves. Elkins (1999: 166) believes that artists know the feeling that others can only weakly imagine, of being so close to their work that they cannot distinguish themselves from it. This lack of distance seems to extend beyond the process as artists often suffer from criticism when they do not have a clear awareness of the distance between themselves and what they have made: “In that state of mind there

is no distinction between theory and practice, observer and observed, substance and allegory, observation and empathy. They are their work” (1999: 166).

Although thinking in terms of object and subject becomes inappropriate, Wheeler (2005: 132) cautions that it does not mean that careful performance becomes unthinking, without *any* awareness. For Heidegger, *circumspection* is a form of awareness in which there is only the experience of the on-going behaviour; the knowledge (“sight”) in question here is primarily or even exclusively one that is orientated to action (2005:132).

## **2.7 From everyday cognition to the theoretical attitude**

Since drawing frequently involves reason-based control, it cannot always/entirely be accommodated by the notion of smooth coping or what Wheeler (2005: 135) calls “everyday cognition”. To arrive at a broader picture of drawing, it will help to consider the rest of Heidegger’s analysis, which also discusses “less everyday forms of cognition” such as science (2005: 135). Taking his cue from Heidegger’s analysis, Wheeler (2005: 135) is careful to disentangle the skilled practice of ordinary cognition from scientific practices. Science pursues a unique type of disengaged explanation – becoming a scientist *means* “adopting the theoretical attitude” (Wheeler 2005: 135). Phenomenologically this is a very different mode of encountering the world, in which we experience the world as what Heidegger calls *presence-at-hand* (Wheeler, 2005:135). Only in encounters of this kind do things really become ‘objects’ that are not transparent (in revealing to us the world, rather than themselves) but determinate. This change is accompanied by a corresponding change within the individual who now becomes a subject *tout court*, and represents the world so as to understand and predict its workings. In so doing, the world now appears as objective and independent of him. The subject-object structure is thus necessarily part and parcel of the scientific encounter with the world (Wheeler 2005: 136).

## **2.8 The un-ready to hand**

Wheeler (2005: 139) regards Heidegger’s “less famous and regularly ignored” phenomenological category of the *un-ready-to-hand* as equally crucial to understanding human cognition. Wheeler’s (2005: 139) preferred term for referring to things that are un-ready-to-hand is *practical “objects”*. We stop experiencing these things as transparent and start experiencing them as identifiable objects. When this happens, we become “practical problem-solver[s]”. The difference between such practical thinking and systematic



scientific thinking can at times become negligible – practical thinking may sometimes come close to the analytical scrutiny typical of science. Wheeler gives the example of an expert watchmaker who utilises his insight into the basics of watch design to help him fix watches.

Wheeler (2005: 141) summarises Heidegger’s analysis of everyday cognition accordingly: “smooth coping and the theoretical attitude are distinct modes of encounter with the world. However they lie at the endpoints of a spectrum of subtly different cases that collectively constitute the complex intermediate domain of the un-ready to hand”.

Following Wheeler’s analysis I would argue that the *un-ready-to-hand* provides a bridge between drawing practices that are grounded in materiality and process, and those that are theoretically based. The practice of drawing occurs at different points of intersection between practical thinking and theoretical knowing. Positioning it in the domain of un-ready-to hand as understood by Wheeler (2005: 142) seems apt:

[P]ractical problem solving in the domain of the un-ready-to-hand – is a spectrum of intermediate cases. At one end of this spectrum we have cases of problem-sensitive action that share much in common with, indeed fade into, cases of smooth coping while, at the other, we have cases of practical thinking that share much in common with, indeed fade into, cases of detached theoretical reflection. The first group of cases can be grouped together with smooth coping under the banner of online intelligence, the second with detached theoretical reflection under the banner of offline intelligence. Stationed in between, there may be various hybrid styles of intelligence.

Wheeler (2005: 142) conjectures that the spectrum outlined above could be correlated to another spectrum: the spectrum of different types of explanations in cognitive science. Explanations in cognitive science would then be more computational when dealing with cognitions regarding what is present-at-hand but increasingly action orientated, dynamic and non-representational for cognitions regarding the domain of the ready-to-hand. Explanations regarding the unready-to-hand will need to be more complex, ranging from purely representational dynamical systems accounts to more computational ones (Wheeler 2005: 142). The un-ready-to-hand thus described then also seems to move closer to Clark’s (1997: 49) idea of action-orientated representations as: “representations that simultaneously describe aspects of the world and prescribe possible actions, and are poised between pure control structures and passive representations of external reality”.

## **2.9 Between doing and knowing**

Within this more complex domain, which lies in the middle ground between doing and knowing, applying explicit criteria to judge such knowledge can become difficult (Sorri, 1994: 20). Because this kind of knowledge is partly tacit, partly explicit, cognitive activity remains open ended and flexible between articulable formulations of explicit knowledge and almost completely nonverbal tacit knowledge. The language used in this middle ground range therefore tends to be metaphoric in nature, where “knowers are forced to speak indirectly rather than directly, because subsidiary awareness does not submit to conceptual precision” (Sorri, 1994:24). Students are advised to think about or imagine an action in a particular way in order to understand something that cannot be explicitly articulated. James Elkins (2006) observes how painting instructors and music instructors tend to use extravagant metaphors like “You should put some more bite into that”, in order to get their point across. It is precisely such mental images that support Sutton’s (2008: 49) view that even though verbal descriptions cannot capture or direct this kind of complex acquired skill, a clear division between knowing and doing cannot explain “grooved embodied engagement”. One therefore cannot assume that when there is no linguistically or “explicitly inscribed” information, no content is involved (2008: 50).

## **2.10 Sculpting and shaping towards expertise**

Elsewhere, Sutton (2007: 763) explores the difference between “explicit autobiographical remembering” and the type of habitual or “procedural memory” involved in the complexity of embodied skills such as those found in playing cricket. While acknowledging that “thinking too much” can at times interfere with accomplished embodied skill, Sutton thinks that experts actually *do* use mental techniques to regulate their performance. He suggests further that such explicit thoughts and recollections need not be rigid, but can be as active, dynamic and responsive to the situation as implicit cognitions have been taken to be by various writers (Sutton 2007:763).

One way to avoid drawing a hard and fast line between knowing and doing is to zoom in on the intelligence of embodied thinking and the diverse ways in which thinking and doing interact. To be truly expert it will have to be possible, and sometimes necessary, to mould and fine-tune skills. For this implicit knowledge-how may need to be supplemented by explicit knowledge. Experts sometimes need to ‘go back to basics’ in order to reconstruct a particular embodied sequence, restore focus or remember a particular relevant principle to bring to bear on a current task (2007:773). Sutton (2007, 2008) uses the example of experts

using verbal hints and labels as “instructional nudges” to show that personal-level thought processes and the sub-personal processes that underpin proficiency are more intertwined than the simple top-down reprogramming of a merely mechanistic skill. Sutton (2007: 773) refers to pianist David Sudnow’s idea that condensed sayings such as “jazz hands” constitute “embodied maxims”, in which all kinds of history are “condensed ... into the arms and shoulders.” The language in cases like this – often usefully fuzzy metaphors or phrases – becomes a kind of abbreviated compendium of “caretaking practices” whereby entrenched habits can be tweaked and remodelled (2007: 774).

The notion of caretaking practices is compatible with the suggestion made by Cohen (2005) that artists’ novel attentional strategies enable them to depict what they perceive more accurately. Artists’ schemata are examples of such strategies when they serve to rid the perception of an object of all the effects of practical knowledge on that perception. Kozbelt and Seeley (2008: 157) examine a range of findings to support their argument that artists’ schemata can influence perception in various ways: “They direct attention to features and characteristics of an object or scene that might otherwise go unnoticed or unperceived. Further, they provide artists with frameworks for the relative placement of objects and their parts, which help locate their expected positions in the visual field (e.g. the central features of a face form an inverted equilateral triangle horizontally bisected by the midline of the head)”.

These methods of visual analysis validate Clark’s (2008: 48) suggestion that inner rehearsal can play an important affective role or support a kind of “perceptual restructuring” via the controlled disposition of attention. Skill can sometimes require purposeful simplification of the task at hand in order to rein in the mind and make sense of otherwise confusing and perplexing problems. This often involves suppressing entrenched cognitive-affective-embodied routines so as to turn such problems into “tractable pattern matching tasks” (Sutton, 2007: 777). Clark’s notion of “material symbols” suggests that such schemata are not instructions imposing explicit contents on the body: as a material symbol such a schema plays a temporary but critical role as “a new fulcrum for the control of action” which may for instance smooth out the cognitive flow sufficiently to help us re-orientate it (Sutton, 2007: 774).

The openness that is needed to cope with highly dynamic conditions shows that “part of what it means for embodied procedures to be genuinely inhabited and alive is that they

alter and develop further: this depends on the existence of a flexible set of links between doing and knowings, between skills and plans, between action and memory” (Sutton, 2007: 775). A study by Ellen Winner (1993) investigating exceptional artistic development in children takes as its point of departure the way in which exceptional drawings made by ordinary Chinese children seem to challenge Arnheim’s conception of visual thinking. Arnheim (1969: 297) had argued that “no...training of the mind is accomplished by the mechanical copying of models, aimed at measurable correctness”. Winner uses China as a striking illustration of the prowess evident in children who have been taught skills through painstaking and repetitive exercises. Children as young as three are given very basic schematic formulas to copy in a methodical accumulation of increasingly complicated steps. The result is that the average Chinese child produces drawings and paintings as skilled as those of much older children, or even adults, in the West. The method of teaching is based on copying in an additive and highly formulaic manner (Winner, 1993: 40).

Chinese nursery children surprised Winner in an informal unrehearsed test when they produced highly skilled observational drawings of a western baby pram in which they went way beyond the formulas which had been used to teach them. Because the quality of their drawings surpassed that of the average western child of the same age, Winner (1993: 40) infers that these children may have indirectly gained skills in visual thinking and observation from their laborious copying exercises. For Arnheim (discussed by Kozbelt, 2001:719), both seeing and creating involve the “grasping of significant structural features or patterns through principles of visual organisation”. Perhaps it is their particular expertise regarding the essential characteristics of images or objects, and their acquired habit of *using* these characteristics when drawing, that explains the edge these Chinese children have over their Western peers, suggests Kozbelt (2001:719). It is evidence of the openness to and attentiveness to the specifics of the situation that is required by the adaptable exercise of embodied skills found in expert knowledge. Sutton (2007: 49) views such expert knowledge as a forging of active and flexible links between knowing and doing, where action is not insulated from thought.

The same flexibility is evident in artists’ deployment of formal strategies. Although such strategies are first acquired as explicit rules, they are later enriched by spatial schemas. These schemas are obtained implicitly as the artist learns to exploit the possibilities of the techniques she has mastered for producing marks and making visual discriminations. Learning entails selective attention, however, so that it is “more efficient if implicit

processes are bootstrapped by explicit knowledge, and declarative knowledge of basic proportions and drawing techniques should provide a perceptual advantage to trained artists in at least some contexts” (Seeley and Kozbelt, 2008: 163). Kozbelt’s (2001: 707) research on expertise in visual cognition found several artists reporting that they use formal methods or systems (such as mathematical systems of perspective) in dynamic situations which require active visual pattern analysis. This suggests that these strategies might contribute to their expertise.

Leonardo da Vinci (cited in Kozbelt, 2001: 707) advised the painter to always “have in mind a kind of routine system to enable him to understand any object that interests him”. Ingres advised artists to “draw with your eyes when you cannot draw with a pencil”, and Paul Cézanne taught that “nature should be treated through the cylinder, the sphere, the cone” (Kozbelt, 2001:707). Clark (2008: 48) argues that in cases where experts use such self-scaffolding they are “doubly expert”: expert at the task in hand while at the same time expert at using well-chosen prompts and reminders to maintain performance in the face of adversity. Artists and designers often report idiosyncratic ways of directing their perceptual attention. One example is artist Paul Kaiser’s account of a “doubled vision” depending on whether he views ordinary movements of the body with “dance eyes” or with “film eyes” (Thain, 2008:78).

Another relevant issue to add to the discussion of skill concerns the location of expert skill and knowledge. Clark (2002b: 387) proposes that it is possible that aspects outside the neural system - such as the tone of the muscles or length of the fingers - also play a vital role in the expert’s ability to respond so deftly to the demands of the world. Haugeland (1998: 228) asserts that performance depends on a range of other *specifically relevant* permanent changes in bodily structures: “muscles of the requisite strengths, shapes, and limberness must be developed and maintained – differently for different skills”. Clark (2002b: 387) argues that when expertise relies on engagement with – or mediation by – for example a blind man’s cane, expertise “also threatens to leak out into the surrounding environment”.

If the relationship between explicit knowledge and the fluid wisdom of the body-mind is not one of direct competition, but rather a situation in which expertise is partly “the easy, fast mastery of the links between memory and action, between thinking and doing”, then the intersection between ‘thinking’ and ‘doing’ will be better addressed by theories which focus attention on the “intricate interweaving” that takes place between ‘thinking’ and

‘doing’ in the performance of skilled activities (Sutton, 2007:776). Sutton (2007: 779) concludes that,

both developing and enacting high levels of skill require us not to cut intellect and emotion off from our embodied, grooved performances, but to achieve and then access unusual flexibility in linking thought and action, knowledge and motion, conceptual memory and procedural memory

In all the cases considered above, the two-way commerce between brain, body and world shows that the forms of our embodiment, action, and engagement are not fixed. It suggests that although conscious knowledge and bodily knowledge are distinctive ways of knowing each with its own distinctive effects, they often function in a coordinated way. Drawing can thus be understood, as Katherine Hayles (2006:9) suggests of literature, as a technology, which creates new pathways between these different types of knowing which “typically remain unevenly articulated with one another”.

### **3. Representational Redescription**

In this section I want to pick up on some of the themes of the previous section and consider some additional theories that address the intricate interweaving of brain, body and world within the drawing act. These theories also attempt to explain how our achieved skills and implicit knowledge develop so as to achieve the increasing flexibility and fluidity typical for higher cognition and creative thought.

The theory of Representational Redescription, originally the brainchild of the psychologist Annette Karmiloff-Smith (1986; 1990), contains various suggestions that are germane to this discussion. According to this model the mind has an intrinsic drive to go beyond behavioural mastery and to redescribe, or re-represent, what it knows to itself in progressively abstract forms. Karmiloff-Smith is interested in how the ability to map and explore one’s own mind develops. This interest motivated a series of carefully designed experiments, some of which involved the observation and analysis of the development of flexibility in children’s drawing skills (Karmiloff-Smith, 1979; 1990). A striking feature of development is that once a child is proficient in a certain domain, it does not simply keep on repeating the behaviour that has proved successful in the past.

Karmiloff-Smith’s work on children’s drawing was strongly influenced by computational concepts from AI. According to the Representational Redescription model knowledge is

represented in different formats at different levels. Her experiments indicate that human learning often starts by forming exactly the kind of interwoven knowledge structure typical of connectionist systems. A number of researchers in the connectionist fold have shown interest in models of learning and have acknowledged, even emphasised, that connectionist systems are entirely in accord with tacit knowledge, as described by Polanyi (Nelson and Nelson, 2003). A paper co-authored by Andy Clark and Karmiloff-Smith (1993a: 513), focuses on “how to achieve flexibility, manipulability, and transportability within a broadly connectionist setting”. They claim that although connectionist models explain the *first* phases of learning in some new area rather well, they are weak at modelling those changes in representation which distinguish the advanced and expert practitioners of a particular field from their less able peers.

### **3.1 From knowledge ‘in’ the system to knowledge ‘to’ the system**

The subtle changes that occur in children’s performance are paralleled in the connectionist field when neural networks become more powerful, be it because of changed patterns of input or through the use of additional concealed units. However, the representations that we ascribe to such networks do not exist explicitly in some identifiable part of the network; they are but an implied feature of how the network as a whole performs. “Whilst this is the endpoint of learning in a connectionist network, in the human case it is the starting point for generating redescrptions of implicitly defined representations” (Clark and Karmiloff-Smith, 1993: 488). Clark and Karmiloff-Smith (1993: 492) characterise the knowledge embedded in a first-order special-purpose pattern recognition/connectionist system as “inextricably intertwined” which in effect generates a representation system that is adapted to that specific domain. At this first level procedural/implicit or tacit knowledge is so entangled in the network of connections that “it is knowledge in the system, but it is not yet knowledge to the system” (Clark and Karmiloff-Smith, 1993: 495).

Without control structures that are able to unpick parts of the web while it preserves others, such interweaving “makes it practically impossible to operate on or otherwise exploit the various dimensions of our knowledge independently of one another”. This poses a problem if we need our knowledge to generalise in an adaptable manner (1993: 495). The representational redescription approach proposes that humans are different to connectionist networks in this respect, as they cannot but continue to develop a series of supplementary representations. We are hereby enabled to process and utilise our own

stored knowledge in ever more flexible and mutually independent ways. The following quote sums up the Representational Redescription claim:

For the genuine thinkers, we submit, are endowed with an internal organisation which is geared to the redescription of its own stored knowledge. This organisation is one in which information already stored in an organism's special purpose responses to the environment is subsequently made available, by the RR process, to serve a much wider variety of ends. Thus knowledge that is initially embedded in special-purpose effective procedures subsequently becomes a data structure available to other parts of the system (Clark and Karmiloff-Smith, 1993: 487-488).

### **3.2 Representational change**

Karmiloff-Smith's (1979; 1986; 1990) data suggest that knowledge already represented in an implicit form spontaneously translates to explicit representations when new skills are rehearsed. As these representations progressively develop at ever-higher levels, previously acquired knowledge can be utilised in ways that were initially impossible. Skills which, though fairly sophisticated, could not be modified easily now become more flexible and adaptable. To investigate this representational change, a number of studies were conducted of how children draw. Over fifty children aged between four and eleven years old produced six drawings each. The children were first asked to draw 'a house', followed by further requests for 'a house that does not exist', 'a pretend house', and so on. Children were also invited to draw a man, followed by a 'funny man', etc. Each child was then observed closely to determine how they went about the drawing task.

The results showed that the flexibility of the child's drawing ability increased with age. Four year olds were only able to delete elements in certain ways and make simple changes regarding shape and size. Ten year olds can be more adventurous in their approach. They added new components, altered the way components or the entire image was positioned or orientated, and even added parts coming from other conceptual fields (Clark and Karmiloff-Smith, 1993:501). The older children's ability to adjust, change and integrate representations across domains thus increased.

Karmiloff-Smith hypothesises that this expanded imagination is the result of children generating explicit representations of what was before only known implicitly. Implicit knowledge can be applied, but not reviewed or modified. Explicit descriptions, on the other hand, enable modifications that are only possible thanks to the redescription of the task or skill in different – and especially: more general – terms (see Boden, 2004: 80).



Because the four year olds' drawing skill functions so predominantly at an implicit level, they cannot move beyond a rigid, "automatic" sequence of bodily operations and can barely generate any alternative versions of the things produced as part of mastering the skills in question.

A drawing skill is initially acquired as an inflexible chain of physical gestures. In this phase the mind represents the skill in terms of a rigid succession of components, which is either carried out from start to finish or not at all. At this level the skill is inflexible and does not allow for re-ordering of the parts or the insertion of extra elements into the drawings.

Drawing the first line activates a series of steps that cannot be interrupted or amended.

The level of description that follows is less constrained and allows steps to be removed one at a time and the sequence to be altered without interfering with the subsequent drawing procedure. This is possible because the skill is represented as a set of separate units, each of which can be repeated or repositioned separately to produce a variety of possible arrangements. As representation develops further and becomes more explicit still, the arrangement of, and relations between, the second level units becomes more elastic. A ten-year-old child's conceptual space involves many more dimensions than that of the four year old, thereby again making the range of what can be produced broader and more interesting. According to Karmiloff-Smith "conscious self-reflection" is the consequence of multi-levelled representations of the type described here (Boden, 2004: 84).

Boden (2004: 85) argues that it is very likely that the type of representational changes shown to occur after a child has achieved fluency in drawing skills also allows adults to generate multi-dimensional conceptual spaces by redescribing previously acquired skills in successively more sophisticated ways. When a skill becomes more multi-dimensional and refined, and subject to sophisticated control, it allows all sorts of structures that were formerly merely *implicit*, as well as *domain-specific*, to become available to awareness. As implicit mental processes become supplemented by more or less explicit maps of these processes, the conscious exploration of possibilities is made easier.

Clark and Karmiloff-Smith (1993: 515) conclude that the Representational Redescription model depicts the "true cognizer" as a multi-faceted representor of its (external and internal) world" who "must somehow manage a symbiosis of different modes of representation". They argue that the Representational Redescription model guarantees such a symbiosis by "invoking a developmental process in which the more structured

representations arise as a result of the system's endogenous drive towards the analysis and re-representation of its own cognitive states" (Clark and Karmiloff-Smith, 1993: 515). The Representational Redescription model thus complements the ideas of Heidegger and others discussed earlier, by implying that human cognition operates within a context of activity, through the representational actions or deeds performed in the world. The way in which active re-representation allows us to construct new and perhaps more complex representations is a theme that will recur throughout this thesis. The suggestion that re-representation enables *knowing how* to become *knowing that* makes the environment a crucial extension of our minds.

## Chapter 3

# Drawing as technology and image – mediating dichotomies in complex cognitive economies

### 1. From embodiment to cognitive extension

As a “means whereby we achieve higher orders of flexibility”, (Clark and Karmiloff-Smith, 1993: 13) the Representational Redescription process sheds some light on our ability to display what Clark (2008: 58) calls second-order cognitive dynamics: “a cluster of powerful capacities involving reflection on our own thoughts and thought processes”. According to this view inscriptions on a page can reflect, and then systematically transform, our thinking and reasoning about the world. Clark (2008: 68) suggests that when the plastic brain factors the procedure and the information-bearing role of such external supports and artefacts into our cognitive routines, it creates “hybrid cognitive circuits that are themselves the physical mechanisms underlying specific problem-solving performances”. For Hutchins (1995: 290) the question of individual learning then becomes the question of “how that which is inside a person might change over time as a consequence of repeated interactions with these elements of cultural structure” – that is, these artefacts and other external props of a cultural nature. Clark (2003: 78) discerns first a developmental loop, “in which exposure to external symbols adds something to the brain’s own toolkit” as well as a persisting loop, “in which on-going neural activity becomes geared to the presence of specific external tools and media”.

Clark (2001a: 131) uses the term cognitive technology to describe the assortment of “technological props, aids and scaffolding (pens, papers, pc’s, institutions...) in which our biological brains learn, mature and operate.” Over time we begin to purposefully structure our worlds in ways to encourage better thinking and adapt to our cognitive strengths and weaknesses. Clark (2003) speculates that all of art, science, education, and culture are testimony to this runaway process. Bruno Latour (1990), the French philosopher and sociologist of science (whom Clark (2003: vii) acknowledges as an important influence on his own thinking), rejects grandiose theories about changes in the mind or human consciousness, in the structure of the brain, social relations etc. Positing “great divides” and dichotomous distinctions between the prescientific and the scientific (... cultures,

minds, methods, societies ...) may be useful for analysis but provides no explanation, being “on the contrary ... the things to be explained” (1990: 2). Latour (1990: 3) believes that writing and imaging craftsmanship needs to be taken into account: “They are both material and mundane, since they are so practical, so modest, so pervasive, so close to the hands and the eyes that they escape attention”. Like Latour, Clark (2005: 8) believes that the omnipresence of “cognitive amplifiers” (pen, paper, models, words...) tends to blind us to the significance of their role in everything that is distinctive about human thought.

### **1.1 Extending and transforming**

Once we take these material structures seriously, the question becomes exactly what forms these structures and related activities take, and in what way they generate the effects they do (Wilson, 2010: 183). Don Ihde (2003) examines technological relations to understand the different ways our embodied selves are meaningfully but differently configured in each. Technologies that are taken *into* one’s experience by perceiving *through* them (such as the familiar example of the blind man’s cane) are described as “embodiment relations” (2003: 508). Echoing Heidegger, Ihde (2003:508) describes how such technology withdraws and becomes a “quasi-me”. He (Ihde, 2003: 509) argues that technologies not only extend bodily capacities, but also transform them. “They change the basic situation, however subtly, however minimally”. (That some such changes will be subtle or minimal does not preclude that others will be radical). Technologies in use have an essential ambiguity, since relations that are embodied have the ambiguous effect of on the one hand magnifying or amplifying, and on the other reducing or placing aside, that which is experienced through them. The telescope, for example, amplifies the sight of the mountains on the moon, while it also removes the moon from its setting in the expanse of the skies: “what is revealed is what excites; what is concealed may be forgotten” (2003:511).

### **1.2 Hermeneutic relations**

In a similar vein, Latour (1990: 15) observes that in laboratory practice “messy objects” – such as bleeding and screaming rats – are discarded and distilled into a tiny set of extracted inscriptions and figures (diagrams, blots, bands, columns) on paper, which then become “*all that counts*”. Such inscriptions demonstrate a different existential human-technology relation, which Ihde (2003: 512) calls “hermeneutic relations”. Ihde (2003: 512) uses the term “hermeneutic technics” to describe a kind of activity which involves a special interpretive action similar to the reading process. He describes writing as technologically

mediated language and reading as a specialised perceptual activity and praxis, which calls for special modes of action and perception. Ihde likens text to a chart that in a peculiar way refers beyond itself to what it represents. The chart itself becomes the object of perception while simultaneously referring beyond itself to what is not immediately seen (Ihde, 2003: 513). These technologies make the world accessible in ways impossible for naked perception. An example would be images or words that present us with what is otherwise remote from our time and place. Hermeneutic relations thus allow us to *read* ourselves into any possible situation without being there (Ihde, 2003:519).

Once mastered, drawing or writing – like any other skill – becomes an embodied hermeneutic technics (Ihde, 2003: 514). Descriptions may now take a different shape so that what is referred to is referred to by the text and *through* the text. Hermeneutic transparency transforms experiential structures and makes present the world of the text or image. This presence is a *hermeneutic* presence in that it occurs *through* looking (or reading) and takes its shape in an interpretive context. While the inscriptions may elicit all sorts of strikingly rich imaginative and perceptual phenomena, it is *through* inscription that such phenomena occur (Ihde, 2003: 514). The same of course happens with a wide variety of hermeneutic technics we employ. While a hermeneutic seeing mimics sensory perception insofar as it is also a kind of *seeing as*, it is instead a referential seeing. The movement from embodiment relations to hermeneutic ones can be very gradual, as in the history of writing. Readable technologies extend hermeneutic capacities *through* the instruments, while the reading itself retains its bodily perceptual relation with or towards the technology (Ihde, 2003: 516).

According to Latour (1990: 15), what is missing in the debates around perception is a recognition of how scientists start *seeing* something the moment when they stop looking at nature and start looking at inscriptions alone. As two-dimensional images these inscriptions allow challenging three-dimensional objects to become easier to comprehend. When this image is not clear enough, it will be simplified further to enhance and accelerate its readings (Latour, 1990: 15). In this way human reason becomes able to grasp what might otherwise be elusive or challenging to hold in mind.

The relevance of this to our topic is that once one starts sketching (on the basis of perception or thoughts), the sketch itself becomes a perceptual object which can supplement, or in the limiting case even displace, the perceptual thoughts that prompted it.

The output of a previous process of perceiving, thinking and acting becomes the input of a new process perceiving, thinking and acting. In this way the sketching changes the problem and makes it tractable. This cycle can obviously be repeated indefinitely. Only an intellectual prejudice could make us think that solutions reached in this way – by iterated procedures, via externalisation, and relying heavily on perception – could just as well have been reached in one step, not employing externalisations (that is, not looping into body and world), and relying solely on propositional thought, to the exclusion of perception.

### **1.3 How inscription and visualisation adapt to our cognitive strengths and weaknesses**

The following observation by Tversky (2011: 502) adds to Ihde and Latour's take on hermeneutic seeing and enhanced perception:

The processes that abstract, schematize, supplement, and distort the world outside onto the world of a page, filtering, leveling, sharpening, categorizing, and otherwise transforming, are the same processes the nervous system and the brain apply to make sense of the barrage of stimuli the world provides. Attention is selective, ignoring much incoming information. The perceptual systems level and sharpen the information that does come in; for example, the visual system searches for the boundaries that define figures by sharpening edges and corners, by filling in gaps, by normalizing shapes. Cognition filters, abstracts, and categorizes, continuing this process, and symbol systems carry these processes further.

The foregoing observations indicate how inscriptions and visualisations, adapt to our cognitive strengths and weaknesses while it amplifying cognition. By shrinking, integrating, editing and abstracting further, these inscriptions enable the human mind to perceive, conceive and understand new relationships, and gain new perspectives and interpretations. Tversky observes that many kinds of visualisations, like maps, “distort the ‘truth’ to tell a larger truth” (2011: 502).

### **1.4 The medium is the message: image and technology**

While historians of science have traditionally devoted relatively little attention to the means of producing images and their epistemological significance, the last thirty years have seen some shifts in attention to a greater emphasis on practice and material culture (Wise, 2006). Much of this work attempts to get close to the “technical contents” of discovery, experimentation, replication, argumentation and representation in the process of knowledge production (Henderson, 1995: 274). In a meditation on mediations, Latour

(1998: 422) notes that attention to practice has shifted the locus of science, “portrayed in the past by stressing its two extremities, the Mind and the World”, to the middle, to “humble instruments, tools, visualisation skills, writing practices, focussing techniques and what has been called re-representation. Through all these efforts, the mediation has eaten up the two extremities: the representing Mind and the represented World”. Latour (1998: 422) adopts McLuhan’s (1967) slogan “the medium is the message” to serve his emphasis on *practice* and the accompanying increase of insight into the *fabrication* and *transformation* of information. He regards this shift in attention as an important, daring and adventurous move by philosophers of science. This move brackets out the internal Mind and the World out there, so as to focus attention on the middle ground, where practice, inscription, instrument, writing, etc. are recognised as the active part, and not simply “the means for a Mind to gain access to the World” (1998: 426).

The move to pay attention to practice and technology is indeed brave in view of the longstanding dichotomy between doing and knowing. In *The Republic*, “Plato relegates *techné*, the activities of the technical artisan, to the lowest rung of his socio-political hierarchy and at the same time characterises an attenuated and immaterial form of *techné*, that of the totalitarian social engineer, as the purest and most important of social activities” (Hickman, 2003: 370). The philosopher John Dewey perceives this positioning of the artisan at the bottom of the social hierarchy as the consequence of Plato’s motivation for censorship of the work of the plastic and dramatic arts. Plato regards the methods of *techné* as too powerful to be left in the hands of artists and craftsmen, where they would pose a threat to the ‘thinkers’ of the Republic (see Hickman, 2003: 370). Aristotle fostered a view of *techné* as representative of the imperfection of human imitation of nature – itself the grand artisan. The ancient Greeks were consequently equally prejudiced against the impermanent materials utilised by artisans and craftspeople.

Dewey argues that the Greeks’ “unfortunate attitude towards *techné*”, resulted in the notion of a science of “demonstration”, “contemplation”, and an attempt to possess something already finished, and “out there” and complete (Hickman, 2003: 370). Dewey warns that such a limited approach will fail to increase our knowledge of things as they are. In contrast to this approach, Dewey regards the advance of modern science, the science of Copernicus, Galileo, Kepler, and Newton, as the result of what practitioners were *doing* more than the result of what they *thought* they were doing (2003: 370). He believes that the genius of the new science was its discovery that “knowledge is an affair of *making* sure, not

of grasping antecedently given sureties” (2003: 371). Dewey’s insight that inquiry into materials *precedes* and *conditions* inquiry of a more conceptual variety, accords well with Heidegger’s proposal (discussed earlier) that we come to know the world theoretically only after we have come to understand it through handling.

In Heidegger’s (1993) essay “The Question Concerning Technology” his critique of an instrumentalist understanding of the human-tool relationship gives technology an ontological importance by viewing it as a way of revealing. “Technology is therefore no mere means. Technology is a way of revealing ...it is the realm of revealing, i.e., of truth... It is as revealing, and not as manufacturing, that *techné*, is a bringing forth” (Heidegger, 1993: 318-319). Dewey (cited in Hickman, 2003:374) maintains that to grasp what is peculiar to human interaction with the world it is necessary to grapple with it at the technological level. Knowledge and the success of science follows upon that interaction, it is due not so much to “scientific temper” as to “scientific technique”, which is “concerned with the methods by which matter is manipulated”.

On this view there is no basis to posit a methodological gap between the enterprise of *thinking in or with* materials on the one hand, and thinking by means of conceptual tools on the other: “intelligence with respect to materials is fully the equal of intelligence with respect to those enterprises we normally consider ‘conceptual’”(Hickman, 2003: 372). Dewey’s claim that human knowledge is advanced only by the cooperation of material thinking and conceptual thinking with each other is clearly articulated in his *Art as Experience* (1934: 46):

Any idea that ignores the necessary role of intelligence in the production of works of art is based upon identification of thinking with use of one special kind of material, verbal signs and words. To think effectively in terms of relations of qualities is as severe a demand upon thought as to think in terms of symbols, verbal and mathematical. Indeed, since words are easily manipulated in mechanical ways, the production of a work of genuine art probably demands more intelligence than does most of the so-called thinking that goes on among those who pride themselves on being “intellectuals”.

### **1.5 Word vs. image**

Dewey’s words not only address the issue of technology, but also point to a longstanding prejudice which deems mediation of thinking by words as superior to other forms of mediation. Like Dewey, Barbara Stafford (1996) questions the notion that thinking with



words is superior to other forms of thinking. Stafford (1996: 23) finds it ironic that despite the far-reaching intellectual and practical implications of visualisation for how natural science, the social sciences and the humanities are conducted and theorised, the same culture remains stuck in a deep logo-centrism. (By logo-centrism she means: “that cultural bias, convinced of the superiority of written or propositional language, that devalues sensory, affective, and kinetic forms of communication precisely because they often baffle verbal resolution” (Stafford, 1996: 23)).

Mitchell (1986: 47) suggests that one reason why the difference between words and images seems so fundamental is because “they are not merely *different* kind of creatures, but *opposite* kinds”. He observes that different media or types of sign are best able to mediate different things, with each then tending to claim sole possession of the “nature” to which it gives access (1986: 43). Mitchell (1986: 43) asserts that the reason why we think of the word-image relation as a tussle for territory is “because this relationship reflects, within the realm of representation, signification, and communication, the relations we posit between symbols and the world, signs and their meanings”. Norton Wise (2006: 79) too notes that “images are a uniquely stubborn case”; with their issues of trust and depth they have long “infected science and its history with a series of dichotomies ... They have often appeared, on the one hand, as much too powerful, likely to lead to the deceptive excesses of imagination rather than the calm reflections of reason, and, on the other, as much too weak, capable of illuminating only the surface of things rather than their deep structure”.

Such observations bear out Sutton’s (2008) claim that we cannot suppose that all persons in a given shared cultural environment will relate to cognitive artefacts in the same ways, or that each artefact will keep being used in the same way as time progresses. Latour (1998) and Hutchins (1995) note that the range of mediated performances is vast and therefore difficult to approach or account for. By emphasising complementarity, the extended mind thesis offers a framework for understanding the numerous and diverse relations (and types of relations) in which inner and outer resources can stand to each other. It also acknowledges that agent-artefact relations need not be symmetric or clear-cut. This emphasis promotes detailed attention to how different external resources, because they differ in format, dynamics or function, allow and promote quite different styles of interaction and coupling in particular contexts, as becomes clear from case studies (Sutton, 2008: 43). According to Sutton (2008: 44) we will have to address questions concerning design, control and power if we want to correctly assign artefacts to roles and to users in

specific, intricate cognitive economies. An interdisciplinary cognitive science would find diversity in the composition of media and objects, as well as in how available such objects are at different times and how people actually engage with them.

### **1.6 Drawing at the interface: mediating different modes of knowledge production**

My project does not allow any comprehensive exploration of these ideas. Nevertheless the investigation into the cognitive role of drawing does indeed, as Sutton (2008: 44) suggests, at times encounter issues of control, power and context as significant dimensions involved in establishing its role in “complex cognitive economies”. Because drawing is or can be a performative act, representation, idea, symbol, sign, display, image, theoretical inscription, diagram, as well as being a medium, process and technique, a clear and simple distinction between *doing* and *knowing*, skill versus theory, words versus image, science versus technology/art, and ‘primitive’ sensory thought versus higher conceptual modes does not apply here. Drawing plays this ambiguous role in a wide variety of disciplinary contexts, ranging from art to science; it actively intervenes in various fields of knowledge. I would argue that it is precisely this ambiguous role that explains drawing’s presence and intrusion at the interface or intersection of these contentious dichotomies, where it serves as a mediating structure to join different modes and spheres of knowledge production.

Hutchins (1995: 290) suggests that procedures or “mediating structures” that are used to perform a task should not be viewed as something that “stands between” *other* things, but rather as one of many operational elements that are brought into co-ordination when performing a task. Latour (1998: 424) too cautions that the notion of mediation cannot be defined as what is “in between” the “bygone representing Mind and the represented World, but rather as that which *produces*, in part, the elements that come in and out of mediation”. We must acknowledge not only that the “medium is the message” but also that “slightly different type of media will produce enormous differences in types of messages”.

### **1.7 Visually constituted knowledge**

When we investigate examples of visually constituted knowledge we discover that images have become indispensable to our own ability to understand the world and sciences we study. As a form of visualisation, drawing plays an important role in understanding processes, structures, climate models, artificial life and myriad other topics of contemporary research. In his editorial comment and overview of some essays on the main

modes in which images of natural objects and processes were made in the course of the history of science, Wise (2006: 75) concludes that because of a tradition of thinking dichotomously, visualisation was never understood adequately: the dichotomies misleadingly suggested that it was important for art, but not for science; for museums, but not for laboratories; for geometry, but not for algebra.

Latour (1990: 4) recognises and explores the significant role of the image and visualisation on paper in his attempt to illuminate “how many cognitive abilities may be, not only facilitated, but thoroughly explained by them”. Latour suggests that a better understanding of visualisation could help us better understand our modern scientific culture – where it came from, and what is distinctive about it.

One take on the impact of visual representation is that of the art historian William Ivins (1973; cited in Latour, 1990: 7), according to whom what was rationalised in ‘the scientific revolution’ was not the mind, not the eye, not philosophy even, but *sight*. Ivins regards perspective as an essential determinant of science and technology because it creates “optical consistency” which allows the viewer “to move through space with, so to speak, a return ticket” (Latour, 1990: 8). As is the case with maps, such “optical consistency” creates new possibilities of movement, where “you can go out of your way and come back with all the places you passed... written in the same homogenous language ... that allows you to change scale, to make them presentable and to combine them at will” (Latour, 1990: 7). The contrivances of perspective, projection, map, logbook, etc. shift attention from the other senses to vision; absent things and disparate places are brought together into one dimension and one conversation.

Edgerton’s (cited in Latour, 1990: 7-8) analysis of the use of Italian perspective in printed pictures draws attention to how drawings bring together things of nature and things of fiction when the same perspective that is used to render nature, is used to depict religious or mythological themes or utopias. All these disparate things become subjected to the same “optical consistency”. Impossible palaces can be drawn realistically and possible objects are drawn as if they were utopian ones, real things can be drawn in separated fragments, or in exploded views, and can be added to the same page at different scales, angles and perspectives. For Latour this optical (1990: 8) consistency confirms (as was suggested by Ferguson, 1977) that the “mind” has at last “an eye”.

The optical consistency allows an assortment of things of possibly diverse provenance to be transformed into diagrams and numbers, to be measured and migrated through different scales (Latour, 1990: 15). These inscriptions can be *reproduced* and distributed cheaply to gather different times and places in another, single, time and place. All these qualities enable multiple images, diverse in origin and scale, to be *reshuffled* and *recombined*, *superimposed* and *brought together* in the same space. Only once this has been done, can connections be made in the mind, as with metaphor (Latour, 1990: 19).

An important benefit of the inscription is that it can be *made part of a written text* and brings with it all there is to see that it writes about. Because inscriptions are two dimensional, they can easily be combined with geometry, and allow their users to work on paper with rulers and numbers, in the process simultaneously manipulating three-dimensional objects “out there” (Latour, 1990: 19). Geology and economics can be brought into the same space through good documentation. “Most of what we call ‘structure’, ‘pattern’, ‘theory’ and ‘abstraction’ are consequences of these superimpositions” (Latour 1990: 19). Wise (2006: 76) similarly notes how maps pass from description and classification in the domain of natural history to causal analysis in the domain of natural philosophy<sup>5</sup>: “They simultaneously constitute new things and invoke explanations of them”. The way in which the visual representations transform knowledge from the empirical to the theoretical demonstrates not only Heidegger’s view that handling precedes theoretical knowing, but also how drawing as technology brings about “revealing”.

Latour (1990: 21) observes that just as inscriptions manipulate other “things”, inscriptions are manipulated even further, with as upshot that a handful of elements can ultimately manipulate all the other things on an immense scale. An example of this relates to Galileo: a simple modification in the geometry he used allowed him to link many different problems, something that those working before him could not “visually accommodate”, as the diverse shapes they were working on did not suggest any interconnection between them (Latour 1990: 21). According to Drake (Latour, 1990: 21) Galileo’s connection was so effective because he created a geometrical medium which combined geometry and physics in a material form. Galileo’s diagram held synoptically three domains whereas that of his predecessors held only one (Latour 1990: 21). Cognitive psychologist Herbert Simon (Latour, 1990: 21) notes that experts use similar strategies in their use of diagrams so that they can establish quick links between many unrelated problems. Simon (1982: 168) notes

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<sup>5</sup> The old term for natural science.

that although both experts and novices draw diagrams to help them in their thinking, a striking feature of the expert is his or her “ability to represent a problem (often graphically) in such a way that the relation between the initial and final conditions is immediately evident”.

While Latour considers the larger implications of these smaller operations and manipulations, Simon’s (1982:166) insight regarding the nature of expert skills suggests that these inscriptions are important because they allow “problem solution by recognition ... The expert looks at an equation, notices a familiar feature that immediately activates a production, obtains a new equation, notices a third feature, which fires a final production and the equation is solved. Three acts of recognition, are required, each of which is based on stored memories, and can be achieved almost without conscious attention” (Simon, 1982: 166). The expert is thus depicted as using the external inscription in a tightly bound cognitive process. The external inscription shapes and transforms cognitive capacities by providing a different kind of functionality to internal vehicles.

Such operations also support the cognitive integrationist view that the manipulation of external vehicles is a *prerequisite* for higher cognition and that embodied cognition is a precondition for these manipulative abilities (Menary, 2010b: 232). The cognitive integrationist view is a branch of the extended mind thesis, which highlights the cognitive role that external vehicles can play. Menary (2010b: 229) suggests that one way to better understand the nature of the integration between elements of a process such as the one described above “is to think of hybrid cognitive processes as enacted skills or capacities for manipulating the environment”. However he warns that “we should not forget that the embodied cognizer is embedded in a physical and social environment, and that environment contains norms which determine the content of environmental vehicles and how we manipulate them” (2010: 229).

### **1.8 Hidden drawings**

In an essay titled “The suppressed drawing: Paul Dirac’s hidden geometry”, Peter Galison (2000) identifies such regulating norms when he explores the role of drawing in the work of theoretical physicist Paul Dirac (1902 -1984). By paying particular attention to the mediating work of things, Galison reveals how reasoning through drawing came to be classed as something to be suppressed, a most private refuge of thought. His investigation

demonstrates that the use of different external formats is conditional on their geographic location, institutional validation and historical path.

Such restrictions are evidence that circumstances are indeed not superfluous to signs or unnecessary in analysis: rather they are “built into the act of use” (Sutton, 2004: 519). Galison reveals the tension that exists between the *de facto* use of drawing by individual scientists and the intimidating power of institutional models and mathematical regimes which prescribe the form in which one’s thoughts should be articulated to the world – and drawing is typically proscribed, rather than prescribed.

What Galison (2000: 145) finds fascinating about Dirac is the apparent contradiction between how he presented his work and how he arrived at it. Dirac was viewed as the theorist’s theorist, recognised for the fundamental equation that today bears his name. (It describes the relativistic electron.) Dirac never used diagrams publicly. His books on general relativity and quantum mechanics contain not a single figure or diagram. He was known for his rigorous algebraic solutions and austerity of prose, never showing any schematic diagrams or visualisations in his papers. Galison (2000:146) was therefore astonished at what he found in the Dirac archives. In comments penned in preparation for a 1972 lecture, Dirac confesses: “I prefer the geometric method. Not mentioned in published work because it is not easy to print diagrams”. This meant that Dirac has published and worked on both sides of the divide of visualisation and formalism. This split has, for generations, riven both physics and mathematics (Galison, 2000: 146).

In an undated account Dirac explained that projective geometry had a strange beauty and power that fascinated him and had a “profound influence” on him. It gave results “apparently by magic; theorems in Euclidian geometry which you have been worrying about for a long time drop out by the simplest possible means” under its power (cited in Galison, 2000: 147). Relativistic transformations of the mathematical quantities became surprisingly easy when the geometric reformulation was used. “My research work was based in pictures – I needed to visualise things – and projective geometry was often most useful” and further “when I came to publish the results I suppressed the projective geometry as the results could be expressed more concisely in analytic form” (Dirac cited in Galison, 2000: 147).

Dirac’s suppressed geometrical work prompts Galison to consider the nature of scientific reasoning. Galison traces the history of how this physicalised geometry – geometry

grounded in spatial intuition, visualisations, and diagrammatics – collapsed under the language of an autonomous science. His narrative tracks how the status of projective geometry as a state religion at the time of the French revolution entered a precipitous decline so that by the time and in the person of Dirac it had become a repressed and private form of reasoning and knowledge production. Galison compares private scientific visualisation with the schematic and exploratory form of private sketches which precede painting. Private scientific visualisation and sketches would, without requiring rigor, precede the public, published scientific paper. “In such a picture the interior is psychological, aleatory, hermetic, and un-rigorous while the exterior is fixed, formally constrained, communicable, and defensible” (Galison, 2000: 148). Galison (2000: 150) is here reminded of Sigmund Freud, for whom the visual was primary, preceding and conditioning the development of language. The pictorial, unconscious form of reasoning is of a different species from that of conscious, logical, language-based thought.

As for projective geometry as a state religion: during the late eighteenth century, descriptive geometry (later known as projective geometry) was proclaimed by mathematicians, engineers and *Polytechniciens* to be much more than just a useful tool, as they argued that geometry would “hold together reason and the world” (Galison 2000: 152). For the mathematician Gaspard Monge and his *Polytechnique* School, physical processes including projections, section, duality, and deformation became means of discovery, proof, and generalisation. For many *Polytechnique* engineers, geometry was more than practical – rather it was valued as towering above all other forms of knowledge as the ideal of well-grounded argumentation. Descriptive geometers insisted that projective geometry could play a central role in improving the French working class, and Dupin (cited in Galison 2000: 153) proclaimed that geometry: “is to develop, in industrials of all classes, and even in simple workers, the most precious faculties of intelligence, comparison, memory, reflection, judgement, and imagination”.

However, as analysts displaced the geometers, geometry lost its lofty status. A “new, vastly more abstract, rigorous, and algebraic mathematics” was coming into prominence, emphasising “rigor, axiomatic presentations, and perfect clarity in definitions” (Galison, 2000: 158). This was the prevailing current against which Dirac had to swim. For him the geometric nature of his work was a form of *argumentation*, an effective structure and a means to explore the unknown (Galison 2000: 160). At a gathering of geometers Dirac expressed his heartfelt sense that pure mathematics had nothing over the applied. He

contended that there was a deep mathematical beauty in the specifics of the “actual world” that was obscure to the pure mathematician. “To draw diagrams, to picture relationships – these were the starting points for grasping why the universe was as it was” (cited in Galison 2000: 158). In a fragment called “The Physicist and the Engineer,” Dirac maintained that mathematical beauty existed in the approximate reality of the actual world in which we live, not in the realm of pure and exact proof (Galison 2000: 159).

### **1.9 Image as source of intuition**

The mathematician Henri Poincaré (1854 - 1912) had preceded Dirac as an exponent of the counter-current which did see great scientific value in the image. Poincaré saw images as the source of intuition and the means for keeping mathematicians in contact with the real or concrete world (O'Halloran, 2004: 131). Poincaré's as well as Kekulé's descriptions of their eureka episodes are filled with images. Arthur Miller's (1995) research on imagery and the visual imagination led him to claim that many twentieth-century and nineteenth-century physicists were highly visual thinkers. While mathematical symbolism may be seen as more powerful as it divides the world into black and white, large and small, visual images “can represent *shades of grey*, *ranges of size*, and *degrees of those external attributes that viewers use in making inferences*” (Messaris cited in O'Halloran, 2004: 132). The mathematician Sha Xin Wei (cited in Elkins, 2006: 18) suspects that although the nondescript little gestures and scribbles that mathematicians draw when they are working out problems together cannot be correlated with the rigorous equations and geometric figures they eventually produce, “they provide just the right level of openness and nuance to help the process of discovery”.

### **1.10 Multidimensional reasoning integrates diverse components and strategies**

The Cambridge master of geometry H. F. Baker (1923), another important exponent of the counter-current, defended the value of the study of the fundamental concepts of geometry by saying that it “requires the constant play of an agile imagination, and a delight in exploring the relations of geometrical figures; only so do the exact ideas find their value” (cited in Galison, 2000: 159). The value of the visual for science is borne out by a study by Root-Bernstein supporting the “hypothesis of correlative talents” namely, that the most creative scientists tend to have also pursued strong interests in the arts (Rocke, 2010: 329). A further hypothesis proposes that “the most influential scientists have always non-verbally imagined a simple, new reality before they have proven its existence though complex logic,



or produced evidence through complicated experiments” (Rocke, 2010: 329). Root-Bernstein (cited in Rocke, 2010: 329) explains the connection between the two hypotheses as following: “[The] ability to imagine new realities is correlated with what are traditionally thought to be non-scientific skills – skills such as playing, modelling, abstracting, idealizing, harmonizing, analogizing, pattern forming, approximating, extrapolating, and imagining the as-yet unseen – in short, skills usually associated with the arts, music, and literature”.

Although historians generally describe imagery as mental phenomena rather than physical scientific representations, Rocke’s (2010) examination of the use of the visual imagination by chemists in the nineteenth century presents a wide range of evidence, which indicates an interconnected world of images, models, and paper tools. Depending on the context and circumstances, scientists use both strategies – their imaginations, as well as “paper tools” and symbolic systems to explore the world beyond the immediate reach of the senses (2010: 340).

Bolstered by a number of case studies, Nersessian (2008: 161) argues that it is exactly this interplay between mental models and diagrams which suggests that diagrams should be understood not as mere aids to thinking, but as “components of reasoning processes”. Nersessian’s (2008: xi) investigation of conceptual development in science shows that scientific reasoning is multidimensional and that processes of mental modelling, imagery, analogy and conceptual change are so interwoven that an integrative account becomes indispensable. A growing body of research which shows that model-based reasoning is a signature practice of the sciences supports her argument that the modelling practices of scientists are “in themselves ways of reasoning and understanding that are exploited both in creating and using theories” (2008: xii).

Studies on the role of mental animation in mechanical reasoning show that when participants are provided with diagrammatic representations of pulleys and gears, they can perform imaginative causal transformations from these static representations. More realistic representations elicit more tacit, physical knowledge, such as of friction, whereas schematic representations stimulate more analytic strategies such as comparing size and angle (Nersessian, 2008: 113). The role that imagistic representations play in this process is to facilitate perceptual inferences and simulation processes, and thus bypass constraints in existing propositional and formulaic representations (2008: 200). Mechanical reasoning is thus also best thought of as an interactive reasoning process, which depends on the flexible

combination of different strategies to draw on different abilities and memory stores (Hegarty, 2004). Nersessian (2008:160) introduces the notion of “internal-external representational coupling” to explain the role of external visual representations in these mental modelling processes. “That is, the external representation and the internal models are best understood as forming a system in deriving inferences”.

### **1.11 Interaction between internal and external representations**

Nersessian’s (2008: 161) research on the use of visual representations in science suggests that there are *correspondences* rather than *resemblances* between internal and external representations. Manipulating the components of a diagrammatic representation as one perceives it or acts on it can consequently lead to corresponding transformations of the mental model (2008: 161). Such reports validate Rumelhart *et al.’s* (1986: 46) earlier account of internal symbol processing and reasoning with mental models: “not only can we manipulate the physical environment and then process it, we can also learn to internalise the representations we create, “imagine” them, and then process these imagined representations – just as if they were external.” Hutchins (1995: 312) however cautions that internalisation does not involve simply copying some content from the outside world into some internal storage medium, but is rather a process of interaction in which a new process is created. The result is that “what used to look like internalisation now appears as a gradual propagation of organised functional properties across a set of malleable media” (1995: 312). Kirsh (2010: 441) describes this interaction as a back and forth process: “a person alters the outside world, the changed world alters the person, and the dynamic continues”. The role of the external representation is to facilitate coordination or synchronisation between what goes on inside the head and what goes on outside. Kirsh (2010: 443) argues that such “interactive cognition helps subjects to compute more deeply, more precisely, and often more broadly”.

In this way the properties of viewable and drawable structures prime an assortment of visual and physical association, which may be unlike and more extensive than associations prompted by verbal accounts. This is evident in a study that investigates the sources of mathematical thinking. In response to the divergent and even contradictory introspective reports by mathematicians about the nature of mental representations used in mathematics, Dehaene *et al.* (1999) use empirical methods in cognitive neuroscience to probe this issue. They use behavioural and brain imaging evidence to demonstrate that the human capacity

for mathematical intuition may emerge from the *interplay* between linguistic competence and visuo-spatial representations. They show that “exact calculation is language dependant, whereas approximation relies on nonverbal visuo-spatial cerebral networks” (1999: 970). This chimes with the well-known fact that many prominent mathematicians are mediocre or even bad at calculations. They conclude that their results “provide grounds for “reconciling the divergent introspection of mathematicians” by showing that “multiple mental representations are used for different tasks” (1999: 973).

### **1.12 No single mind tool**

The diverse accounts related above indicate that human understanding and grasp of meaning very often involves a kind of hybrid thought, which no *single* mind tool could support. It is rather, as Clark (2002a: 89) suggests, the result of the “interplay and links between skills dependent on the representations of number words and skills dependent on the biologically basic resource for approximate arithmetic”. Dirac and other scientists’ drawings are thus better understood as mediating structures, or in Clarkian terms, as “hybrid representational vehicles” used to co-ordinate “the activation of a variety of content-relevant internal representations” (Clark, 2008: 53). Appreciating drawing as a mediating structure could illuminate Wise’s intuition that it is *at the intersections* of various dichotomies that much of the creative work of science occurs. Wise (2006: 79) argues that once the subject of “making visible” in science leaves the domain of mere illustration or mere technology and becomes a matter of “making knowledge”, the making acquires a much higher status. Such a shift positions the makers of images, along with their materials and techniques, in the same space with writers and readers of verbal ideas. “The dichotomy of doing versus thinking, craftsperson versus creator of ideas, and body versus mind (or the senses versus the intellect) must then be transformed into overlapping actions, or intersections, where the “and” of collaboration replaces the “either/or” of intellectual conceit” (2006: 79).

By extending cognition beyond the brain and into the world, we gain a different sense of the nature of scientific reasoning and an appreciation for why scientists use such a wide range of criss-crossing mechanisms. The discussion above not only demonstrates that the thinking subject is always linked to a broader intellectual community, but also that the thinker is, as Hutchins (1995: 316) suggests, a “a very special medium that can provide coordination among many structured media – some internal, some external, some

embodied in artefacts, some in ideas, and some in social relationships”. This is opposed to views according to which everything special about the thinker is reduced to the quality and the nature of her intracranial processes.

### 1.13 Complexity and invisibility

The complexity and richness of interaction of mediation structures of different sorts partly explains skilled performers’ difficulty or inability to account for their own task performance (Hutchins, 1995). The study of visualisation in scientific practice is further complicated, as we saw, by the fact that scientists “rarely recount their work-related imaginative peregrinations”, because “mental images may seem downright embarrassing” in a culture which celebrates precision, reproducibility, universality and materiality (Rocke, 2010: 328) and privileges the verbal above the imagistic. Latour (1998: 436) claims that the study of visualisation in scientific practice is not ideal because what is revealed is only a freeze-frame of a larger process of transformation that is very difficult to follow, “a proper form of invisibility”. When Latour (1998: 423) compares mediation and visualisation in science and mediation in the arts, he notes that while the continuing presence of art mediators remains essential to the arts, “scientific mediators have to have a way of escaping their origin”. He provocatively warns that if the work of mediations in the sciences is erased further

a powerful scenography is then generated: a calculating Mind, a calculable World, a substance that lies under its passing attributes, and the medium of language to circulate between. All the other types of mediation will now be evaluated according to whether or not they are able to provide an accurate “access to the world.” And of course, by comparison, all of these other forms of mediations will be found wanting, and will be condemned as so many fantasies or so many outright lies (Latour, 1998: 427).

In short, in the conventional view mediation is always ‘*mere* mediation’ – it never wears the pants.

The discussions above suggest that the scholarly community cannot simply say “all of them” to account for the many ways in which the mediators unfolding and are embedded into one another. The arts on the other hand allow the association and combination of many different elements in the genesis of a work, with no real need to extract from this complex its “real core” (Latour, 1998: 423). The visualising skills of those who are allowed to “escape this indictment” (1998: 427) may offer an easier access to an insight into the creative/productive powers of the mind. To the arts is thus where we are headed next.

## Chapter 4

### The sketch

#### 1. Thinking space

##### 1.1 The drawing as epistemological object

From the time when Leonardo da Vinci (1452 - 1519) recommended the use of ambiguous indistinct marks to stimulate visual invention, practitioners in the domain of art and design have unapologetically celebrated sketching as a strategy to stretch mental capabilities. This forms a marked contrast with the practice in science and maths, where the role of sketching tends to be downplayed, if not denied. In his analysis of a series of Leonardo's preliminary sketches, Martin Kemp (1981: 56) describes his revolutionary drawing style as a "brainstorm of dynamic sketching". For Kemp (1981: 68), Leonardo's preparatory drawings provide valuable insight into the "extreme fluidity of his creative methods":

They show that the painting's format never settled in his mind into a fixed pattern, which could be systematically realized in a series of orderly steps in the normal manner. The flow of thoughts cascaded onwards in a rough and tumble of ideas, sometimes splashing off in unexpected directions – unexpected, we may suspect, even to Leonardo himself.

Kemp (1981: 78) views Leonardo's experimental drawings as a "complex picture of interaction between form and content, each adjustment in one reciprocally affecting the other..." Such a view suggests that Leonardo's drawings are not the result or expression of pre-thought ideas but rather evidence of the uncertain nature of the artistic process and the immense possibilities it contains.

Edward Hill's (1966: 34) seminal work on drawing similarly discusses strategies to stimulate visual invention: "Invention may, however, require more from drawing, for at times the imagination must be actively incited to create." Hill refers to Alexander Cozens' eccentric essay (published in 1785), which aimed to present a method that would aid discovery of fresh compositional constructions. His method involved blotting, broad and hasty brushstrokes which, because "rude and unmeaning", would allow several possible

interpretations. Cozens (cited in Hill, 1966: 35) claimed that “the method ‘is extremely conducive to the acquisition of a theory’ and ‘this theory is, in fact the art of seeing properly’”. Hill (1966: 35) concludes: “Creative invention occurs for him, not before the individual nature, but in a circumstance where recollections and associations might be brought forward from memory spontaneously and with spirit”.

Terry Rosenberg (2008: 109) contemplates the nature and dynamics of inventive thinking and knowledge creation that operates in ideational drawing – a type of drawing and drawing process “where one thinks with and through drawing” to make discoveries and find new possibilities. Perhaps better known as the thinking sketch, ideational drawing is “a thinking space – not a space in which thought is re-presented but rather a space where thinking is presenced” (2008: 109). Rosenberg (2008: 110) draws on Heidegger’s 1951 essay, “What calls for thinking”, to propose this kind of drawing as a tool or as an “epistemological object” which provides an occasion for a form of thinking that attracts thinking. As a form of thinking, the ideational drawing produces a form of knowledge that is unlike that validated by academia or scientific rationalism (2008: 112).

In his deliberation on “what calls us to think” Heidegger (1993: 367) contrasts “calculative kinds of thinking, however vital to the conduct of the sciences”, with another kind of thinking, that of the poet, which is “less exact but no less strict”. Heidegger (1993: 373) provocatively asserts that although science always and in its own fashion has to do with thinking, “science does not think”. He advises that in order to learn how to think, “we must assert less and listen more” (1993: 366). Heidegger (1993: 374) elaborates: “We can learn thinking only if we radically unlearn what thinking has been traditionally”. For Heidegger, what calls us to think is that which is thought-provoking. “And, what is thought-provoking has not been thought (yet); it turns away, withdraws from us”. Thinking, so described “is what is drawn in (to) the draft of withdrawal” (Rosenberg, 2008: 110). Rosenberg uses Heidegger’s text to understand how drawing may be both “being pulled into” (drawn into) and “making marks and producing images”(2008: 110). These images and marks “produce a field of attraction for ideas” into which “[w]e are drawn into making drawing and the drawing draws us into further thinking” (2008: 110). Ideational drawing is thus “a form of thinking that attracts thinking – it is prenotional” (2008:110).

## 1.2 “Otherly” arrangements of thinking

Rosenberg (2008: 111) additionally takes his cue from Rajchman’s (2000) *Deleuze Connections* to describe how the traces of the cognitive hand attempt to produce the “otherly” arrangements of thinking that allows us to approach the ‘architecture of the impossible’. The ideational drawing “produces (ideas) in a particular calculus, which links knowing and un-knowing in different dynamics...” (Rosenberg, 2008: 112). Rosenberg (2008: 111) likens ideational drawing with poetry because it “constructs and educes otherness the way poetry does and uses this otherness of thinking (poetic thought) as a process of poiesis or invention”. Poetry is here understood as a “carnival of possibilities” (Rosenberg, 2008: 112) – as a creative letting go of the calculus of means and ends. He likens the way that the known and un-known and possibly even the unknowable operate on one another, to the way the sea and land effect each other – “the sea (unknowing) constantly redrafts the shape of the shore” (2008: 112).

The poetic process evident in ideational drawing in this manner provides an epistemology, which, although it starts with what is given as in mathematical proof, differs in that it does not assume what is given to be stable. The process of ideational drawing works to disrupt normal processes by a critical and creative questioning of “what is” (Rosenberg, 2008: 112). Rosenberg’s (2008: 113) depiction of the ideational drawing draws heavily on the ideas of Michel Serres to describe it as an innovative, turbulent and fertile space, “overgrown with vegetal matter combined and intertwined”, which brings in the world in its voluptuousness, where things are arranged, deranged and rearranged. Objects are connected to other objects and spaces, to spaces, objects to spaces, and so on in an enthusiasm to see what is possible (2008: 114).

## 1.3 The mangrove effect

Clark (1998: 176) makes strikingly similar observations in his use of the mangrove forest as a metaphor for our ability to display a certain type of thought where “we generate a trace in a format which opens up a range of new possibilities”. The mangrove forest grows from a floating seed that starts off by rooting itself in shallow mud flats in the water. The seedling then sends a complex system of vertical roots through the surface of the water, to trap floating soil, weed and debris. With time, the accumulated trapped matter becomes an island, which grows larger and larger until it can merge with other islands to eventually extend the shoreline out to the trees. Clark (1998: 176) suspects that “the Mangrove effect”

– where the land is gradually built by the trees – is operative in some species of thought when words or images are not always “rooted in the fertile soil of pre-existing thoughts”. Reminiscent of Heidegger and echoing Rosenberg, he presents poetry as an example of this phenomenon. Clark (2008: 176) describes poetry as a situation in which words are not just used to express thoughts but it is often rather the properties of the words that ultimately determine the thoughts that the poem comes to express.

This kind of thinking is thus not merely the expression of pre-existing thoughts. In ideational drawing one relinquishes a hold on thinking so as to see what leaps in thinking the act of drawing can produce. Heidegger (1993: 373) asserts that there is no bridge to cross the gulf between thinking and the sciences: “there is no bridge here – only the leap”. This kind of thinking allows an engagement with what Serres calls a “chaotic logic”, an attempt “to understand without concepts” through a “fluid blending of subject and object” (Rosenberg, 2008: 116). Through a conjecturing hand the ideator tries to dis-appear into the thing he is drawing so as to gain “an absence that thinks” (Rosenberg: 116). We are thus reminded of Heidegger’s (1980) description of circumspection, the kind of dealing which has its own kind of knowledge or sight, a form of awareness in which the contrast between subject and object plays no part. Rosenberg (2008: 123) laments that the “intractable difficulties” in writing about the “chaotic logic” at work in ideational drawing means that it is under-appreciated as a subject for research. “One thinks with the stochastic reflexes of the hand; and these reflexes cannot be understood fully in reflection. The thinking hand eludes the mind’s grasp” (Rosenberg, 2008: 123).

#### **1.4 Where, then, is the mind?**

The reciprocal interaction between drawing and the drawer prompts John Berger (2005: 123) in conversation with his son Yves, to ask the existential question: “where are we when we draw?” In “Being There” Clark (1997: 68), asks a similar question: “Where, then, is the mind?” Berger proposes two kinds of spaces, the place where we are, and the one the drawing puts us in (different in each pictorial tradition). Yves Berger (2005: 123) suggests another, third, kind of space – “[o]ne that belongs to the movement between the one who is drawing and what is being drawn?”. He relates the process to an electric circuit: “something passes from what I look at to me and from me to it” and whether one is drawing from a model or from a sensation, the question is the same: “how to go back and forth almost simultaneously?” (Berger, 2005: 124).



Clark (2008: xxv) argues that where such back and forth working on paper occurs, what happens is literally that the machinery of mind is extended out into the world. It functions as a process, which, *were it done in the head* alone, “we would have no hesitation in designating as part of the cognitive circuitry”. Even though brains remain the seat of consciousness and experience, the *flow of thoughts* that is had by the brain depends on a continual, and essential, interaction with outside resources (Clark, 1997: 68). Clark (2008: xxvi) believes that such bodily and extrabodily loops and extended cognitive circuits indeed form part and parcel of particular forms of intelligent performance, and proposes that understanding when and why this can be so would shift the way we generally conceive of mind, reason and agency.

### **1.5 Cognitive circuits and ensembles**

Clark (2008: 74) identifies one key characteristic of such fluent, integrated unfoldings as the delicate temporal integration of multiple participating elements and processes. Numerous reflections on drawing observe a complex simultaneity within a non-linear thinking space that allows for overlapping relationships, uncertainty and a play between parts (De Zegher and Newman, 2003: 71). For Downs *et al.* (2007: xii), this temporal integration entails a complex simultaneity within the drawing act, as “drawing moves between observation, studying the visible (the present tense), reference (past and memory) and projection (future tense and what is absent)”. Gell (1998: 95) perceives drawing, music, and dancing as united by a certain cognitive indecipherability manifested in performance: “Drawing and music and dance tantalize our capacity to deal with wholes and parts, continuity and discontinuity, synchrony and succession”. Artist Avis Newman (De Zegher and Newman, 2003: 72) notes that the properties of drawing, “its lines, marks, surfaces, its characteristic colourlessness, its acts, gestures, rhythms, and spaces of thought”, are “in practice so multifaceted as to continuously express the existence of all the others”. Artist Jean Fischer (De Zegher and Newman, 2003: 220) likewise describes the act of drawing as a space in which “I lose myself ... the drawing is becoming thought ... [l]ike being caught up in the rhythm of a dance or a jazz ensemble, or mesmerised by the intonations of a poetic reading”.

The notion of an ensemble, where all the parts are taken together, so that each part is only considered in relation to the whole, is appropriate to describe the complexity of the sketching act. Because the interactions between the internal and the external resources are

highly complex, nested and non-linear, analysis of the active machinery that might explain such cognitive performance presents a challenge. Clark (2008: 116) argues that in such scenarios it may be a bad idea to attempt to understand the performance and potential of such extended cognitive ensembles by decomposing them into fragments and then reassembling these fragments. While cognitive science has been primarily concerned with the inner elements of such extended systems, the extended system theorist hopes to uncover further principles that govern the larger hybrid organisation itself (Clark, 2008:115). It may not be enough to understand and then put together the properties of pen, paper and trained brains involved in such integrated operation of the extended thinking system. This is similar to the situation in neuroscience, which studies not only the main neural substructures and their capabilities but also the complex nonlinear interactions between them and the larger scale processes to which they contribute (Clark, 2008:116).

As a cognitive practice, the sketch ensemble as depicted above is part of the cycle of cognitive processing and not merely a non-cognitive causal support of a process in the head. It requires an epistemology where the virtues of the ensemble cannot be reduced to the virtues of any of its parts taken separately. While acknowledging the highly integrated nature of the sketch, the following discussion will unpack and decompose properties of this cognitive operation for the purpose of discussion. It will show however, that each cognitive contribution is so closely linked to the contribution of others, and in so complex a manner so that it is difficult to determine where exactly thought emanates from.

## **2. Gesture**

While the visual properties of drawing clearly play an important role in this cognitive unfolding of visual, spatial and conceptual processes, an important factor is that they require physical embodiment (in the form of the gestures involved in producing a drawing). Avis Newman (2003: 77) describes thought in respect to drawing as “a mental process of formulation connected to the organisation and coordination of manual acts”. As “gestures organise the world in their own fashion, which is fundamentally different from the way in which words organise the world” (Streck, 2009: 120), the role of movement and gesture cannot be disregarded when viewing the drawing act. The meaning of gesture is theorised and understood differently by different discrete disciplines. In drawing, gesture can be a form of personal experience as well as conveyer of abstract and predetermined meanings. A variety of perspectives and approaches can thus be brought to bear to consider not only

the symbolic dimension of drawing but also its physical enactment. The dynamic tension between these different dimensions of meaning seems to be a key feature pertinent to the role of gesture in extending cognition within the drawing act.

## 2.1 Kinaesthesia

Carrie Noland (2009: 17) depicts gesture as a “performance” that “engages the body in a temporality that is rememorative, present, and anticipatory all at once”. This suggests that gesture plays an important role in facilitating the complex simultaneity and interactivity evidenced in the ideational drawing/sketch. One approach to understanding the role of gesture is to appreciate gesture as movement. Noland (2009: 2) argues that because gestures naturally belong to the realm of movement, they make available kinaesthetic sensations that provide more than what the gestures themselves may suggest or achieve within the culture. So while the body in writing or drawing may be completing a task, it is at the same time gauging space, sensing pressure and resistance, adjusting to variations of weight. “These kinaesthetic experiences that exceed communicative or instrumental projects affect the gestures that are made and the meanings they convey” (2009: 2). While gesturing as a motor phenomenon sculpts the active body, changing it into a kind of artificial technical extension of the body, it “also affords an opportunity for *interoceptive* or kinaesthetic awareness ” (2009: 2).

Kinaesthesia is usually used to refer to sensations of bodily movement, position and muscle tension that the conscious mind can access. These sensations are passed on to the mind from the nerves of the muscular, tendinous, and articular systems (Noland, 2009: 9-10). Gibson (cited by Paterson) views kinaesthesia as part of the haptic system, which, in perceiving the body’s movement, cuts across several perceptual systems. It is accordingly “a sense that utilizes a range of nerve information including that of muscular tension and balance from the vestibular system, collectively returning sensations of movement” (Paterson, 2012: 482). Streeck (2009: 208) argues that this kind of perception contributes to gesture as a medium of understanding: “gesture incorporates haptic epistemology: it is driven by the body’s practical acquaintance with a tangible environment that it has forever explored, lived in, and modified ”. Gesture and movement in drawing can help to put the drawer in touch with this embodied history.

Results from numerous empirical investigations suggest that kinaesthesia should be considered as a sixth sense, which similar to sight, prompts both conscious and

unconscious behaviours (Noland, 2009: 10). Noland (2009: 10) argues that kinaesthesia thus “opens up a field of reflexivity in which the subject becomes an object (as body) of her own awareness”. As gestural act and movement, drawing very likely triggers a range of conscious memories as well as sensory memory held in the body. For Noland (2009: 10):

The kinaesthetic body sense, then, is vulnerable to the intervention of culture at the very moment when the situated subject must make propositional sense (meaning) of what she feels. That is, it is precisely when sensations produced by holding a posture or executing a gesture become available to “introspection,” or conscious awareness, that they must be mediated by language or by equally culture-specific systems of visual imagery. The intervention of culture is necessary to transform the inarticulate workings of the nervous system into the *experience* of a particular subject.

The idea that cultural intervention is necessary “to transform” a particular type of knowledge, echoes the suggestion made by Clark and Karmiloff-Smith (1993b) that knowledge stored in a specific representational format (for instance analogue, or kinaesthetic), may be limited to that format and therefore not be usable by other processes, except if a way is found to re-represent it in an appropriate format. They (Clark and Karmiloff-Smith 1993b: 571) suggest that “where the representational relations are not in the same format, then, in order to build flexible and new relationships across the representations from different domains, the representations supporting particular domains ultimately have to be redescribed into a similar format”.

Noland (2009: 16) contends that when the body operates within a biological and/or cultural context, the body “affords a type of awareness that is ‘agentic’ in the sense that it plays a role in what a subject does and feels”. Because gestures interact with other mind and body operations, Noland (2009: 16) calls them “organs of distributed agency”. Gestures activate the physical senses “to engage ‘the dynamic mentality of one’s neuromusculature’ in decision-making processes on many planes”(2009: 16). Artist Joseph Beuys (quoted in Temkin *et al.*, 1993: 73) confirms this insight in his description of his own practice of drawing:

it is not only a description of the thought...you have also incorporated the senses...the sense of balance, the sense of vision, the sense of audition, the sense of touch. And everything now comes together: the thought becomes modified by other creative strata within the anthropological entity of the human being.

These observations imply that a particular type of awareness and relationship between an agent and the world is brought about in performing the gestural drawing act.

Andre Leroi-Gourhan (Noland, 2009:15) argues that from a developmental point of view, there is no clear dividing line between gestures that are instrumental and those that are expressive, “both are “*chaines operatoires*” (operational chains) that produce kinaesthetic experience as part of the recursive loop of correction and refinement over time”. All gestures, whether communicative, instrumental or aesthetic, “involve the body in a double process of active displacement (through the contraction of the muscles) and information gathering (through the neuro-receptors located along these muscles)” (2009: 15). Tim Ingold (cited in Noland, 2009: 15) suggests that all motor activities could be regarded as “skill sets” – described as “sequences of gestures or gestural routines, that generate kinaesthetic feedback as part of their dual function (operational and cognitive, or information gathering)”. Gesture is thus a crucial component of drawing as an embodied performance that realises an act of production, which is, as suggested earlier by Bolt (2006), transformative and not merely representational.

## **2.2 What words cannot say**

When attempts are made to position drawing in relation to writing and language, it is the ability of gesture to capture what symbolic media cannot that is repeatedly pondered. Giorgio Agamben (2000: 58) depicts gesture as being productively situated between different modes of representation: “the gesture is the exhibition of mediality: it is the process of making a means visible as such. It allows the emergence of the being-in-a-medium of human beings ... [t]he gesture is essentially always a gesture of not being able to figure something out in language”.

## **2.3 Imagery: not rival but integral to language**

Some theorists celebrate visual or gestural thinking to the extent that it is presented as the rival of verbal thought. Brian Rotman (2002: 432) contemplates whether bringing gesture out “from under the shadow of the spoken word” could instate a different order of mediation by the body, to replace a linguistic/spoken modality with an experiential one. Rotman (2002: 433) suggests that to realise what the body is capable of in the absence of speech, “it is necessary first to dumb the body, de-organise it, divest it of speech, silence it – so that no longer governed by the sayable, it may become the field of other productions,

other desires, can be alive to other semiotics, other mediations (here the gestural) that speech...has always been only too pleased to elide”.

Rudolph Arnheim (1969: 243-244) reveals a similar approach with his view of language as “a mere auxiliary to the primary vehicles of thought, which are so immensely better equipped to represent relevant objects and relations by articulate shape”. He (1969: 244) then goes on to say that the function of language is “essentially conservative and stabilising which tends to ‘negatively’, make cognition static and immobile”. Arnheim views gestures as revealing the imagery of thought. He argues that gesture’s abstract and spare nature aid thinking by limiting itself intelligibly to “what matters” (1969: 117). Arnheim (1969: 108) describes the imagery of thought as selective, elusive, with a quality of sketchiness “invaluable for abstract thought in that it offers the possibility of reducing a theme visually to a skeleton of essential dynamic features, none of which is a tangible part of the actual object”.

While David McNeill (1992: 267) agrees with Rudolph Arnheim’s view on the important role of images as a medium of thought, he disputes the portrayal of verbal thought as the adversary of visual thinking. McNeill (1992: 268) contends that it is not necessary to reject language to argue that imagery is the medium of thought. Bolstered by data from many years of research and empirical case studies on the use of gesture in free speech, McNeill (1992: 268) persuasively argues that physical gesture is an integral part of a single mental/brain/action process, which also, and centrally, involves language. McNeill offers a conception of language as inseparable from imagery where the imagery in question is embodied in the gestures as active participants in speaking and thinking. Imagery in this context is not photographic but rather a spatial-actional form which, driven by its meaning, iconically materialises meaning (McNeill, 2005: 56). Agamben (1999: 77) likewise argues that “gesture is not an absolutely non-linguistic element but, rather, something closely tied to language. It is first of all a forceful presence in language itself, one that is older and more originary than conceptual expression.”

Numerous examples from diverse domains such as mathematics and music suggest that there are other kinds of thought that seem to be truly different from verbal thought (1992: 270). McNeill’s point of departure is that language has two dimensions, static and dynamic, which combine via an imagery-language dialectic (materialised in gesture and speech).

McNeill (1992: 270-271) expands on an approach introduced by Lev Vygotsky, Soviet psychologist of the 1930's, which visualises thought as two intersecting circles:

one circle nonverbal, the other linguistic, and the intersection is what he called the verbalisation of thought and the rationalisation of language. The intersection is where the synthesis of image and word takes place, and where the transformation of thought into a linear-segmented hierarchical form occurs. Outside the intersection there may be language without thought and thought without language.

## 2.4 Productive dialectic

McNeill's (1992: 272) research suggests that mental life is the active synthesis of opposite modes of representation rather than being a matter of linear, automatic information processing. McNeill's analysis of the implications of a dialectic is pertinent not only to the imagery-language dialectic but also to the ongoing dialectic often observed within the drawing-thinking act. A dialectic implies a conflict or opposition of some kind, followed by a resolution of the conflict through further change and development. In contrast to the analytic, combinatoric, linear, and defined nature of linguistic form, gesture is global, synthetic and instantaneous. "The disparity of these modes is the "fuel" that propels thought and language; the dialectic is the point at which the two dimensions intersect" (McNeill, 2005: 4). Because both modes operate simultaneously in the mental experience of the speaker and represent the same idea, their dialectic constitutes a "benevolent instability" that, in search of some quarry, fuels thinking for speaking (2005: 18).

## 2.5 Material carriers and dimensions of meaning

By introducing the notion of a "material carrier" as "the embodiment of meaning in a concrete enactment or material experience" McNeill (2005: 98) suggests that the gesture *is* the very image. The action of gesture is a dimension of meaning, it is "not an 'expression' or 'representation' of it, but *is* it" (McNeill, 2005: 98). By jointly drawing on Merleau-Ponty's view of language where meaning *inhabits* the word, and Heidegger's emphasis on "being", McNeill develops a conception of gesture as a form of being: "gestures (and words, etc. as well) are themselves thinking in one of its many forms – not only expressions of thought, *but thought, i.e., cognitive being, itself*" (2005: 99). Just as gesture and speech are not only communications or reports to the speaker, but are ways of being cognitively present, the gesture in drawing can be understood as part of the person's "taking up of a position in the world, a momentary state of being" at that moment (McNeill, 2005: 99).

The analysis of numerous examples of gestures of both concrete and abstract kinds shows that gestures reveal what is regarded as relevant and salient within the context they appear in. McNeill (1992: 128) believes that the reason why gesture seems to be better able than speech at conveying “shadings of relevance” lies in the contrasting natures of gestures and speech. While speech contains mandatory components, gestures are idiosyncratic and not controlled by a system of standards. McNeill (1992: 133) suggests that it is consequently conceivable that we *require* the gesture to identify what was pertinent in the context. Gesture thus allows us to observe thoughts as they occur because they are unconstrained by systems of rules and standards, and “cannot help but expose the relevant dimensions of the speaker’s thought”. As thinking in one of its many forms, gesture thus provides a distinctively gestural way of delivering meaning (2005: 23).

McNeill (2005: 38) argues that because most gestures are multifaceted they are better viewed as “dimensions” of thinking than categories: “A given gesture can have loadings across dimensions and in this way contain space for all the meanings – semantic, pragmatic and poetic that it may embody”. Iconic, metaphoric, deictic or temporal features can all be integrated in the same gesture. Metaphor, as a fundamental property of gesture, expands imagery beyond concrete references to encompass abstract meaning (2005: 46). While in speech they are fleeting, gestures that produce drawings, diagrams and other inscriptions persist on paper. As the visible traces of these visuo-spatial, abstract, conceptual, metaphorical dimensions of meaning they invite interpretation, and can be subjected to many of other perceptual processes that ultimately contribute to understanding, inference and insight.

Susan Goldin-Meadow (1999; 2000; 2006) also investigates the role of gesture in thought. Like McNeill’s studies, her inquiry into the nature and organisation of human gesture suggests that gesture is in fact integral to the process of thinking rather than serving as a mere prop for communication. Like McNeill, Goldin-Meadow (1999) argues that the act of gesturing is not merely an expressive appendix to learning, reasoning and cognitive change, but an integral component actively contributing to all of these. Gesture provides an alternative (analog, motoric, visuospatial) representational format to the digital format of words. Gesture thus expands the set of representational tools available by bringing nuances that would be unavailable in the absence of visual or motor formats. As the permanent traces of gestures, this rich set of meanings is captured and visualised in drawings where they represent aspects of experience that cannot be conveyed through any other format.



Goldin-Meadow (2006) explores the impact of restricting gesturing on thought by comparing two otherwise similar groups of children who were told to memorise a list and then to solve some mathematical problem before trying to recall the list. Experimenters compared the effects of eliminating gesture through instruction and eliminating it by natural preference, with the results indicating that memory was equally impaired by the lack of gesture, whether by instruction or by spontaneous inclination. Goldin-Meadow (2006: 38) interprets these results as suggesting that when we gesture, this in some way engages or reduces the total cognitive load with which the brain has to deal, thus making more resources available for memory.

Another explanation suggests that when a speaker gestures, this reduces her load since gesturing is a motor activity that energises the memory system (Goldin-Meadow, 2006:38). When gesture accompanies speech it conveys meaning imagistically and so accesses information different to that accessed by speech. “Gesture thus lets speakers convey thoughts they do not have words for and may even play a role in changing those thoughts” (2006: 38). The process of change may be facilitated by offering an alternative route in which developing ideas can be tried out and expressed (1999: 427). Gesture further enriches thinking by bringing novel (and perhaps contradictory) information into the existing context without disrupting the current system. Goldin-Meadow (1999: 427) posits that gesture’s mimetic and analog format is an ideal modality within which to access and consider notions that are not yet fully developed enough to be encoded in speech. Gestures enacted and depicted in drawing therefore allows for these additional modes of information to interact and coordinate with other modes of understanding.

## **2.6 Self-stimulation**

While both McNeill and Goldin-Meadow perceive the physical gesture as forming an integral part of the cognitive process, each has a different take on this. For McNeill technical “growth points” arise where imagistic (analog) and propositional (digital) elements jointly constitute a specific idea and initiate a cognitive event. Goldin-Meadow understands growth points to be “collisions in meaning space”. Our thinking progresses when such collisions are resolved through gestural loops into the material world (Clark, 2008: 127). Clark (2008: 123-128) draws on Goldin-Meadow and David McNeill’s research to support his claim that when we gesture this is an essential element of a “coupled neural-bodily” process of becoming. Here we have a thinking operation extending right into the

non-neural body – “not simply a motor-act expressive of some fully neurally realised process of thought” (2008:125).

Clark (2008: 125) construes McNeill’s image-language dialectic as a productive coupled dialectic between encodings in the visuomotor format and encodings in the verbal format. McNeill’s analysis of the neural systems involved in generating spontaneous gesture provides support for Clark’s (2008:127) view of the physical act of gesturing “as part of a unified thought-language-hand system whose coordinated activity has been selected or maintained for its specifically cognitive virtues”. Clark expands this idea by comparing the case of gesture with the self-stimulating automotive arrangement of a turbo-driven automobile engine. In such an arrangement the exhaust flow powers the turbo by spinning a turbine which in turn spins an air pump, compressing air into each cylinder, thereby allowing more combined fuel to generate more explosive power. The evidence suggests to Clark (2008:131) that “gesture is *both* a systemic output and a self-generated input that plays an important role in an extended neural-bodily cognitive economy”.

## **2.7 Structuring, shaping, accomplishing**

Shaun Gallagher (2005: 121), in response to Goldin-Meadow and McNeill’s studies, supports the suggestion that gesture assists in accomplishing and shaping thought, even when the person has no explicit awareness of her gestures. The empirical evidence that one does not have to be conscious of embodied functions for them to accomplish thought effectively, confirms Gallagher’s (2005: 122) dictum: “gesture and language works in a pre-noetic manner”. Gallagher (2005: 2) uses the term pre-noetic to denote the hidden contributions of the body to how mind and consciousness are structured. These aspects are often inaccessible to reflective consciousness “because they happen *before we know it*” (2005: 2). Although this pre-noetic performance helps shape consciousness, it is not explicitly present as a content of consciousness. Nevertheless, it orientates the body and plays an essential role in paving the way for conscious perception, memory and judgement (the noetic factors). “In just such performances the body acquires a certain organisation or style in its relations with its environment. For example, it appropriates certain habitual postures and movements; it incorporates various significant parts of its environment into its own schema” (Gallagher, 2005: 32).

Just as a specific spatial perspective “shapes” whatever is explicitly experienced, the act of drawing may “shape” or “structure” experience, much as gesture does, and often indeed

crucially involving gesture itself, in order to accomplish thought. Because the pre-noetic functions underpin and affect explicitly intentional experience, the minutiae of movement (for example the contraction of certain muscles), are intentional in so far as they underpin wider intentional activities (Gallagher, 2005: 33). Gallagher admits that questions regarding the cognitive effects of gesture become forbiddingly difficult when we think of cognition as a completely internal process. He suspects and suggests “that certain aspects of what we call mind just are in fact nothing other than what we tend to call expression, that is occurrent linguistic practices (‘internal speech’), gesture, and expressive movement” (2005: 121 footnote).

Clark (2008: 126) argues that in gesture we see a cognitive process whose material implementation involves loops that overflow the bounds of the brain, a process very similar to what occurs whenever we simultaneously write (or draw) *and* think. It is not that we first have fully formed thoughts, which subsequently are transcribed onto paper, instead “the paper provides a medium in which, this time via a kind of coupled neural-scribbling-reading unfolding, we are enabled to explore ways of thinking that might otherwise be unavailable to us” (2008: 126). By materialising thought in a gesture taking place in the external world, a fixed material presence is wittingly and unwittingly captured and given form in the drawing act.

### **3. From gestural dialectic to dialectic on paper**

At this point of the discussion it is fitting to introduce another closely related dialectic that is played out within the sketching act as a result of the visible traces these gestural images leave. The conversion of gesture into a trace allows multiple dimensions of meaning to become visible (registered and suspended in time) and thereby provide occasions for reflection and understanding. Tversky *et al.* (2009) recognises how gestures, in similar ways as discussed above, complement and supplement other modes in explanatory tasks. When gestures are captured on paper, they combine and integrate with other modes to contribute a rich set of meanings regarding size, shape, pattern, style, position, direction, order and quantity - both in a literal and a metaphorical sense. Their abstract connotations, mood, feeling or attitude can also be captured, each enhancing and developing the global meaning.

Visualised on paper, transitory positions become permanent places and transitory actions become inscriptions and forms. “Because they persist, they can be subjected to a myriad

perceptual processes: compare, contrast, assess similarity, distance, direction, shape, and size, reverse figure and ground, rotate, group and regroup; that is they can be mentally assessed and rearranged in multiple ways that contribute to understanding, inference, and insight” (Tversky, 2011: 500). The sketch thus becomes a tangible space or gathering ground in which multiple ways of knowing can be negotiated in a kind of dialogue. Intangible ideas become more concrete through gesture and trace, where they connect and interact with knowledge in other forms and formats, whether coded or uncoded, linguistic, visual, or tacit. Katherine Henderson (1998: 204) maintains that these tangible actions construct the drafter’s visual culture and way of seeing, literally and figuratively: “years of drawing and thinking and thinking and drawing mean that the two become wholly intertwined”.

### 3.1 Interactive imagery

Analogous to McNeill’s (2005) depiction of gesture as *enactment of imagery*, Gabriella Goldschmidt (1991) proposes that sketching *functions to extend mental imagery* within a systematic dialectic which involves a circular feedback loop between imagery (internal representation) and sketch (external representation on paper). Through the additive process of sketching, the page soon shows or suggests unexpected arrangements and relationships among the graphic elements that allow new interpretations, and are produced fairly easily by drawing on further input from memory structures. Goldschmidt (1991: 131) refers to such self-generated sketching as “interactive imagery”. She argues that the self-generated sketch “talks back”, with its backtalk reflecting “some of the sketcher’s innermost, tacit, otherwise untapped knowledge, biases, concerns, and preferences” (2003: 87). When a sketcher ascribes a meaning to the unintended results of a quick freehand sketch, this enables her to use it as a source of new information and thus make it serve as a tool to enhance design reasoning, especially in the “front edge”, conceptual phase. Designers cultivate and exploit this inherent cognitive ability, which is already in evidence in young children.

Goldschmidt (2003) is interested in how the “backtalk” of a sketch – either one that is still in development, or one that has just been completed – assists in generating and strengthening ideas. She uses a developmental axis to demonstrate how children find new information while reading their sketches, which then leads to redefinitions or refinements in what they take their sketches to be about. She shows that designers typically follow a

similar procedure in the initial idea-generation stage of the design process. Observation of children under the age of three showed that they make scribbles to which they then ascribe representational meaning retroactively, mostly in response to a given question. This suggests that very young children do not make symbolic representations intentionally, but rather only read representational meaning into their scribbles once they are completed (Goldschmidt, 2003: 73). Even children as young as the age of two appear to have the ability to infer representational meaning from their own scribbles. The derived meaning seems to be directed by the properties of shape of the figures or the things that the child is occupied with at the time.

While older children use conventional and largely universal schemata to depict favourite objects, people or scenes, this conventional representational behaviour is abandoned when attempting to represent something new. Older children make similar inferences when they explore and experiment with the act of drawing. Goldschmidt argues that these characteristics of graphic production are continued later on in childhood, maintained through adulthood, and ultimately constructively used by experts when solving design problems (Goldschmidt, 2003: 73).

To better understand the way sketching “engenders meaning”, Goldschmidt (2003: 74) gives a detailed analysis of a fragment from an older child’s drawing activity. A nine-year-old child, Naomi, who took part in what was termed a drawing game, was asked to respond to a picture shown her, by making a drawing whilst talking aloud. Goldschmidt took particular interest in what the child said about aspects of the drawing that could not be traced back to the photograph on which the drawing was based. For certain details, such as very prominent buildings and the representation of hair, Naomi used conventions that contradicted what was depicted in the photograph. These departures from the photograph seemed to flow from a special interest in buildings that were old or tall, an interest which seemed to owe nothing to the photograph. Her own personal interest in old and tall buildings entered the process and was enacted in the drawing. Further insight was gained from her representational behaviour, which showed that she arrived at the interpretation of pregnancy simply because she had happened to draw the woman’s dress too large. “In other words, this was not a premeditated notion, but one that resulted from Naomi’s reading of what Schön<sup>6</sup> called the drawing’s ‘backtalk’” (2003: 78). Goldschmidt (2003: 78)

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<sup>6</sup> Schön, D. 1983. *The reflective practitioner: How professionals think in action*

notes that Naomi's "after the fact attribution of meaning" is also evident in younger children's drawing.

Naomi's interpretations illustrate a principle which Goldschmidt (2003: 78) formulates as follows: "one reads off the sketch more information than was invested in its making". It shows that, although a sketcher often does not have a clear or developed idea of what is about to be drawn, the act of drawing creates unforeseen graphic relations on the page, which may, if the sketcher attends to them, trigger further meanings that can be read into and enrich the rationale of the developing scenario. This is often the case in the initial phase of the design process, where the designer's ability to extract information from her own sketch enhances her ability to approach a design problem by enlarging the problem space.

### **3.2 Dialectics of sketching**

In another research project, Goldschmidt (1991) investigates the nature of design reasoning during sketching. Careful observation of architects engaged in intensive, fast freehand sketching in the early phase of a design task, reveals that sketching participates in design reasoning through a special kind of visual imagery. Goldschmidt (1991:123) identifies a pattern of pictorial reasoning, which she calls the "dialectics of sketching". Reminiscent of the imagery-language dialectic observed in gesture, this dialectic moves between two modes of arguments, which relate to the figural and non-figural aspects of potential forms. Goldschmidt (1991: 131) describes this dialogue of short sequences as arguments shifting between "seeing that" and "seeing as" arguments. "Seeing as" arguments are directly related to sketching, as they involve analogical reasoning and reinterpretation of figural properties of the sketch or the emergence of new figures. "Seeing that" arguments are non-figural, reflective claims concerning the design. These "arguments" are the designer's efforts to explore and reason about the task.

The physical motions (moves) in response to the arguments lead to further drawing, which in turn feeds new arguments. Shifts happen cyclically within and across moves, the order of which is not important as shifts occur both ways in response to a guiding rule. Protocols revealed that all "seeing as" arguments were produced while sketching, whereas "seeing that" arguments were produced while sketching as well as while scrutinising the sketch. This dialectic allows the designer to bridge two central aspects of design – the specific physical result and the knowledge in abstract, conceptual form (without specific physical

referents) – by translating “the particulars of form into generic qualities and generic rules into specific appearances” (Goldschmidt, 1991: 139).

Goldschmidt (1991: 140) acknowledges that this kind of dialogue, and the “seeing as” and “seeing that” modalities themselves, are not only found in sketching and designing, but also in a wide range of psychological and cultural phenomena. “Seeing as” occurs when physical metaphors are used in any discipline and has triggered many new developments as well as important breakthroughs, discoveries, or inventions. Her study focused on small-scale creative cognitive operations in reasoning while sketching. Compared to design protocols involving little or no sketching, sketching protocols showed far more “seeing as” arguments, and the ongoing dialectic between *as* and *that* arguments was detected nowhere else. Even the use of diagrams or flow charts does not show the unique dialectical pattern between these two modes of visual reasoning that is brought about by sketching (Goldschmidt, 1991: 140).

This dialectic has been recognised by many other researchers and is also referred to as the “graphical conversation with the materials” (Schön, 1983) or “having a conversation with the drawing” (Lawson, 2006). While mental imagery has been acknowledged as an important and useful cognitive resource in solving unusual, innovation-related, design and other creative problems, the materiality of sketching or interactive imagery gives it advantages over mental images, partly because the latter tend to fade away so rapidly (Goldschmidt, 2003: 82-3). Donald Schön (1983: 157-8) notes: “The act of drawing can be rapid and spontaneous, but the residual traces are stable. The designer can examine them at leisure. The pace of action can be varied at will. The designer can slow down to think about what he is doing. On the other hand, events that would take a long time in the built world – the carving of a slope, the shaving of the trees – can be made to happen immediately in the drawing”. The drawing thus allows the designer to step back momentarily and reflect and in this reflection, or re-evaluation, the designer perceives patterns, which in turn encourage another cycle in drawing.

### **3.3 Dialectic as scaffolded action**

The view of the sketch as a dialectic situation is suggestive of and compatible with two more Vygotskian ideas, in which the role of *private speech* and of *scaffolded action* are seen as important to cognitive development. Vygotsky was the pioneer of the notion that the use of shared language had a significant impact on cognitive development. Clark (1998: 163),

drawing on Vygotsky develops his own use of the term *scaffolding* to denote “a broad class of physical, cognitive and social augmentations which allow us to achieve some goal which would otherwise be beyond us”. An example of scaffolding is when a child is allowed to temporarily succeed thanks to the guidance, in the form of public speech of another human being, and then can later on, through private speech, conduct a similar dialogue with herself so as to guide behaviour, to focus attention, and to caution against usual errors (Clark, 1998: 164). More recent developmental research (Berk, 2004: 75-106) found that self-directed speech (vocal or silent inner rehearsal) is an important cognitive tool to guide behaviour, work through ideas, understand one’s experiences, and direct and control problem-solving actions.

How can a self-directed tool manage to play a guiding role when it seems mysterious “how we can tell ourselves anything we don’t already know?” Clark (1998: 165) suggests that this question can be approached by viewing language as a special kind of thought in which the actual thoughts are constituted by the words and sentences of language (1998: 165).

Goldschmidt takes up the same perspective when she maintains that the making of sketches is “thinking itself” (2003:80). She finds it telling that during the Renaissance, incomplete, partial, rapidly hand drawn images, or study sketches, were called “pensieri” – also the word for “thoughts” in contemporary Italian.

### **3.4 “A distributed, semi-anarchic cognitive engine”**

McNeill, Goldwin-Meadow and Goldschmidt’s studies collectively indicate that the generative impact of gesture and its trace is a result of the dynamic relations between divergent modes of thinking within a mutually generative circuit. As an integrated cognitive system, the sketch act involves a variety of distinct parts whose contributions, although hugely different, participate in a generative dialectic between unlike cognitive modes. The sketch thus validates Clark’s (2008: 131) hypothesis that in some recognisable cognitive processes *outputs* are created (speech, gesture [traces], expressive actions, written words) that are reprocessed as inputs, and in this way drive the cognitive process along. It would thus be incorrect to say that gestures and traces merely clothe or materialise preformed ideas. Instead, gesture and trace emerge as interacting parts of what Clark (2008: 133) calls “ a distributed, semi-anarchic cognitive engine, participating in cognitively potent self-stimulating loops whose activity is as much an aspect of our thinking as its result”.



Clark's (2008: 133) picture of cognitive extension rejects the idea of an inner executive and instead considers the possibility of a set of more or less influential resources acting in parallel, with different components gaining the upper hand in different stages. By moving away from the image of an inner executive, space is made to reconceptualise the cognitive contribution of our practices of self-stimulation as practices that co-determine the way in which our thoughts originate or are constructed. Such processes thus expand our thoughts as opposed to merely maintaining them. In such a loose-knit, distributed representational and information-processing economy, materialised imagistic content may augment, refine, expand and sometimes productively conflict with other elements in the same thinking space. Together, the dialectics of gesture and sketching fits Clark's (2008: 135) model of self produced outputs which enter into loosely coupled forms of coordination dynamics to allow the overall system to explore trajectories through "thinking space".

### **3.5 Epistemic actions and cognitive routines**

If the conjectures of the preceding discussion are correct, gestures and traces, amongst other self generated structures, form part of an integrated on-going coupled dialectic which has survived precisely because of the cognitive capacities it enables. If the ideational drawing is a productive thinking space, it is no surprise that Rosenberg (2008: 110) proposes that we view it as an "epistemological object". It epitomises the notion of an "epistemic action" as presented by Kirsh and Maglio (1994: 513), for: "external actions that an agent performs to change his or her own computational state"(1994: 514). Clark (2008: 73) cites Kirsh to suggest that in such closed-loop interactions respect for the hallowed boundary between what is internal and what is external not only hinders analysis, but also does not have the computational significance we tend to ascribe to it:

Once we conceive the agent environment relation to be a dynamic one where agents are causally coupled to their environments at different temporal frequencies with less or more conscious awareness of the nature of their active perceptual engagement, we are moving in a direction of seeing agents more as managers of their interaction, as coordinators locked in a system of action reaction, rather than as pure agents undertaking actions and awaiting consequences (Kirsh, 2004: 7-8).

Clark (2008: 74) expands on this idea when he considers "the swirl of organisation" involved in such integrated unfoldings:

In such cases, the brain is not required explicitly to represent the availability of such and such information from any given internal or external location.

Instead it simply deploys a problem-solving routine whose fine structure has been selected (by learning and practice) so as to assume the easy availability of such and such information from (for example) such and such a visual location via the performance of such and such a gross motor action.

Assumptions about the problem domain have here become built into whole perception-action loops. Clark (2008:75) proposes that the structuring of resources in such complex distributed “problem-solving ensembles” should be thought of in terms of implicit meta-cognitive commitments where the possible availability of useful information need nowhere be represented in the brain.

## **4. The design sketch**

While the foregoing discussion has been concerned with capturing the dynamic nature of the sketch ensemble, the following section will look at how the principles, arguments and theories identified above apply in practice. With the notion of drawing and sketching as a potent thinking tool in hand, we will address the question of how its dynamics play out in the context of design and fine art.

### **4.1 “An integral part of the thinking act”**

Clark (2008: 58) suggests that once second order cognitive dynamics allows us to “think about our own thinking”, we can purposefully structure our world so as to stimulate, support and extend our own cognitive capacities. Clark notes that we often marginalise the unique input given by these external operations, and talk as if the biological brain deserves all the credit. Research on design thinking however shows no reservations in designer’s disclosure of drawing as “an integral part of the thinking act” (Lawson, 2004: 52) and “the designer’s principal means of thinking” (Herbert, 1988: 93). Design reasoning is described as embedded in the act of drawing, which is used to rapidly develop an “object to think with” (Do and Gross, 1966: 3). Many of the leading designers interviewed by Lawson (2004: 52), described a feeling of being almost incapable of thinking without a pencil or pen in their hands. Some would break off the conversation to fetch pencil and paper; others needed an array of pencils to select different pencils for different aspects as the conversation proceeded. Reference to a “thinking pencil” (2004: 53) and a need for different drawing tools to facilitate diverse modes of thinking in various phases of the design all imply a deep dependency on the drawing instrument. Such dependence suggests

that Clark's proposal that the pencil be considered as equivalent to the neuron within a complex cognitive economy is not as far-fetched as it is sometimes made out to be<sup>7</sup>.

Despite the emergence of sophisticated computer technology sketching, as advocated by Leonardo, is still one of the preferred activities of artists and designers. Goldschmidt's (2008: 29) extensive investigations into contemporary design practice indicate that "despite the proliferation of potent digital visualisation means... freehand sketching continues to be practiced by almost all designers throughout the design process". She argues that because of its "extraordinary cognitive advantages ... sketching will continue to reign in design until other means of visualisation will be capable of emulating its supremacy" (Goldschmidt, 2008: 29). Goldschmidt (2003: 72) describes sketching as a representational ability of a unique sort needed for inventive purposes such as poetry, visual art or design. Inventive processes require the ability "to use the representational act to reason with on the fly" (2003: 72). Nigel Cross (1999: 36) depicts sketching in design as a kind of "intelligence amplifier", a fundamental tool which is far more than a simple external memory aid; it facilitates and promotes the exploratory, opportunistic and reflective modes of thought that are pertinent to the cognitive tasks typical for design thinking.

Lawson and Dorst (2009: 10) explore the "complex and sophisticated" process of design in an attempt to discover what knowledge, skills, attributes and experiences are necessary to design "fluently and to good effect". They note, as Nersessian (2008: xi) did a propos of the domain of science, that design "remains a human activity beyond the capability of artificial intelligence and therefore poses some interesting challenges to the computational theory of mind that lies behind such work" (2009: 15). Lawson and Dorst (2008: 10) challenge the idea of the "talented designer", a notion they perceive as implicit in much design education and criticism. They argue that design is instead, as much other human cognitive activity, a complex collection of skills. They identify the ability to draw as one of the central skills in designing: a designer who cannot sketch is likely not to be able to "converse freely with the situation" (2009: 52). They are here referring to Donald Schön's (1983) remark that designers interact with representations (sketches, texts, models, etc.) in a conversational way. Cross (1999: 30) observes that the designer's reflective thinking processes appear to pivot around the interaction between internal mental processes and

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<sup>7</sup> See debate between Andy Clark (Defending the bounds of cognition) and Fred Adams and Ken Aizawa (Coupling, constitution and the cognitive kind: a reply to Adams and Aizawa) in Menary, R. 2010a. *The extended mind*.

external representations in sketch form. This dialectic process needs to have some medium – the sketch – “which enables half-formed ideas to be expressed and to be reflected upon: to be considered, revised, developed, rejected and returned to” (1999: 30).

Clark (2008: 76) argues that when external props and aids (that is, external to the biological unit) play such a profound role in shaping and directing our thoughts, these should be depicted as an essential part of the mechanism of human reason. Because our interaction with these external media is so ubiquitous and reliable that our biological brains expect its presence “as much as they expect to encounter weight, force, friction and gravity”, much of the wide-ranging cognitive capacities which we uncritically classify as mind and intellect may in fact be properties of the broader, extended system of which the human brain is simply one part – albeit an important one. Such a view is in agreement with Lawson’s (2004: 62) claim that if we wish to understand the drawings that designers do, we need information beyond those drawings in order to interpret them. “Quite simply they cannot be viewed as self-contained symbol systems. They are likely to make reference to material in ways that are so ambiguous that no automated system of analysis could possibly understand. Effectively you must know what was in the designer’s mind in order to read the drawing” (2004: 62).

The extended mind view would however say that the drawing is a central part of what was in the designer’s mind. Lawson’s point could then be reformulated as: it is impossible to understand the drawing on its own – it has to be related to other parts of the designer’s extended mind. This need then not only be what was happening in the designer’s biological brain, but also what the larger context was in which the drawing and the neural state occurred.

## **4.2 Approaching wicked problems**

Lawson (2004:18) notes that design activity and designer’s drawings have been of interest to cognitive science because designers “externalise so much thinking through drawing and conversation”. Accounting for the connection between external and internal mental structure thus presents a considerable challenge (2004: 31). Drawings are accordingly examined for the knowledge embodied in them and the insights they can give us into the relationship between the representation that is made in the drawing and the rest of the extended mind of which it is a part. Cognitive science tends to explain the problem solving

process by reference to well-structured problems, such as puzzles and complex chess games. However, such explanations do not apply to the domain of design.

Cross (1999:31) observes that while one of the goals of some Artificial Intelligence research may be to devise a mechanism that can take a design brief as input and generate a resolved design drawing or some other data as output, such a process does not seem to exist within human beings. Human designers need a gradual design process, which involves a series of sketches. Clark (1998: 180) suggests that classical Artificial Intelligence erred by confusing the capacities that belong to the linguistically enhanced and environmentally extended agent with the capacities of the naked brain. If the crude division between the biological agent and an external scaffolding of ideas persisting on paper is questioned, one may indeed ask how the boundary between the mind and the rest of the world should be conceived of and where it should be located.

In his 1995 book *Sketches of Thought* Vinod Goel suggests that the kind of mentality that designers perform challenges traditional cognitive science: “as we move away from circumscribed puzzle-game domains, like crypt-arithmetic, into more open-ended cognitive domains like planning and design, and continue in the direction of the arts (literature, poetry, painting, music, etc.), cognitive science’s ability to explain the relevant cognitive processes approaches zero” (1995: 6). Goel (1995: 6) suggests that “something qualitatively very different is going on here”. The problems that designers solve are not well-formulated but ill structured, open-ended and because of their “fundamental *indeterminacy*”, often referred to as “wicked” (Buchanan, 1992: 15). In design problems there may be an unlimited number of states that offer an improvement over the current state, and no one state can essentially be thought of as optimal (Lawson, 2004: 19). To understand the design process compared to prescribed and circumscribed domains like chess, Lawson (2004:20) likens design with playing with a game on a board that is not divided into cells, with pieces and rules that can be made up along the way and later changed and redefined as the game progresses.

Goel (1995: 128) argues that design is a process that involves the manipulation and transformation of representations. For him it is of crucial importance that design involves a very substantial shift from verbal to graphical information. The brief generally is mainly a set of human needs, objectives and desires and preferred behaviour. The production drawing on the other hand, is a representation of material elements, their interrelations and

construction particulars. The designer uses a series of other representations to convert one set of knowledge about people, what they do and what their objectives are, into another set of knowledge about artefacts, relations, structure and physical attributes (Lawson, 2004:59). To convert information about the objectives and behaviour of people into information about the structure and relationships of artefacts is challenging exactly because the two systems of information cannot be plotted directly onto each other in predictable or theoretically describable ways (Lawson, 2004: 60). Instead, doing so requires extensive knowledge and insight and a process that involves assimilation and integration, where a single part of the solution may simultaneously solve many parts of the problem. The sketch seems to play a crucial role in facilitating this integrative process.

### **4.3 Sketch Properties**

Goel (1995) argues that there is something about the nature of sketches that promotes this transformation. Traditional cognitive science is unable to explain this transformation as its analysis of symbol systems is chiefly concerned with the relationships between symbols rather than what they represent. Converting design drawings into a limited mathematical notational arrangement might support a logical chain of arguments but it is to be doubted that the nature of the knowledge embodied in those drawings would be better understood (Lawson, 2004: 59). Sketching as a representational format clearly supports design thinking in ways that more determinate and precise representations cannot. Goel (1995: 189) regards the symbol system of sketches as extremely powerful and productive with an important role to play in human cognition and creativity. He argues that the computational theory of mind cannot do justice to the entire range of representational skills that the human cognitive system exhibits.

Goel (1995: 9) argues that the implication of the dominant approach in the computational theory of mind, the Fodorian one, is that thoughts or contents which cannot be embodied in a language with CTM (computational theory of mind) – properties or propositionally structured items, are unthinkable. “This position relegates all human symbolic activity that lacks these properties to the ‘emotive cries of animals’. It simply excludes too much” (Goel, 1995: 9). Human symbolic activity ranges over a wide variety of symbols systems that serve different cognitive functions. He argues that there are many ill-structured problem spaces “where mental representations need to exhibit very un-CTM-type properties, in particular, properties associated with symbol systems of sketching” (Goel, 1995: 14). Goel’s basic

intuition is that there is a close relationship between the structure of our thoughts and the structure of our symbol systems. Experimental findings show that the disjointedness and unambiguous, non-dense properties of CTM-systems in fact hinder solving ill-structured problems. Such problems require instead symbols systems with the structural properties of sketching (Goel, 1995: 15). Goel argues that accepting a cognitive role for external symbol systems that lack the CTM-properties accordingly requires postulating internal symbol systems that lack the CTM-properties. The extended mind depiction of such external resources as complementing the same old (essentially pattern recognising) resources of the biological brain, rather than recapitulating or transfiguring them, offers a persuasive attempt at explaining how sketches contribute to the “remarkable transformation” (Lawson, 2004: 61) from problem to solution in design.

Fish and Scrivener (1990) also attempt to understand how the familiar attributes of sketches – the hurried line, rough marks, scribbled lines, washes and untidy images - support and stimulate visual invention. The authors propose that sketches assist the mind to translate structurally descriptive and propositional information into a spatial depiction which can be scanned to extract novel and possibly game-changing information, potentially leading to a new depiction. This is something on which the brain’s strength at pattern recognition can act. “The *descriptive - to - depictive* translation process is a *one - to - many mapping* intrinsic to inventive thought” (Fish & Scrivener, 1990: 118). Fish and Scrivener argue that it would be helpful to examine the special attributes of sketches in order to gain some understanding of the cognitive processes with which these vague scribbles and marks interact.

#### **4.4 Importing structural – and content-novelties**

The evidence that sketches play an important role in our cognitive processes leads Goel as well as Fish and Scrivener to conjecture that at least some of the system of internal representation *shares* the density and ambiguity characteristic for sketching. While their analysis of the properties of sketches leads these authors to make inferences about internal symbol systems, the perspective developed by Clark offers a different approach. Instead of viewing these external formulations as a pre-existing inner code whose basic features and properties are then simply redone in an external format, these external formulations are depicted as *importing* their structural – and content – novelties onto our cognitive horizons. This facilitates new thoughts, by in effect allowing other thoughts to congeal as types of

static object, while structural novelty allows an array of operations and manipulations that do not come readily to the biological brain. Clark (1998:163) argues that the value of such external artefacts thus lies partly in their “role in re-shaping the kinds of computational space that our biological brains must negotiate in order to solve certain types of problems or to carry out certain complex projects”.

If we pursue this approach, the question of how and why the properties of sketches as encodings in a particular format can play such an important role in informing, shifting, altering and broadening our thinking in productive ways becomes worth considering. According to Fish and Scrivener as well as Goel, the properties of sketches which support and stimulate visual invention can be broadly identified as the following:

*Sketches contain deliberate or accidental indeterminacies* that are important in their role of preserving alternatives. This ambiguity is also important to delay commitment or the premature crystallising of ideas (Fish & Scrivener, 1990; Goel, 1995). For an artist or designer multiple readings provide opportunities to consider alternative interpretations, recall pertinent (but previously unconsidered) design cases, and suggest particular operations to apply to the representation. They can also direct ways to restructure or reinvent a design problem (Gross, 2001).

*Sketching uses abbreviated two-dimensional sign systems to represent three-dimensional visual experience* (Fish and Scrivener, 1990: 118). Sketching uses lines with a variety of descriptive meanings (some of which are culturally acquired) and sometimes supplements lines with written notes. Descriptions may have arbitrary, learned rules of interpretation which link the sign system to the represented objects (such as abstract ideas or design constraints). Sketches are also depictive in the sense that they provoke visual experience resembling that associated with the objects or scene represented (e.g. the shape of a structure which would be difficult to describe). Sketches typically include a mix of description and depiction, suggesting that they serve to support the mental translation between two modes of representation (Fish and Scrivener, 1990: 119).

*Sketches contain selective and fragmentary information.* Information that may be only implicit in an image must be extracted and made available for other mental processes, such as verbal thought or to feed a program of motor commands controlling the pencil.



*Sketches are dense* in that their components and marks are closely compacted together so that marks can belong to one or another symbol or sign. For Goel a field of reference is dense if “between any two referents there is a third” (1995: 167). Density also contributes to transforming one character into another because of the reduction in distance between characters. As a result of the condensed space between marks, lines and shapes, the referential content of ideas allows multiple interpretations and so ensures that possibilities are not excluded.

Sketches show a *degree of coarseness* that allows marks to belong to many different classes of inscription and so remain non-committal about identity (Goel, 1995: 191).

Fish and Scrivener (1990: 122) consider research which indicates that percepts and mental images have a similar structure and format, share the same representational medium and compete for the same modality processing capacity in the brain. From this they argue that if they share the same visual processes and have a shared neural medium it seems likely that percepts arising from sketches can facilitate and amplify mental imagery. In addition, the sketch probably exploits imagery processes that evolved for different ecological functions such as recognising partly occluded objects through reconstructing images from perceived parts and fragments (1990: 123).

#### **4.5 Hybrid forms of seeing**

Fish and Scrivener (1990: 124) propose a “spatial hybrid theory of sketching” to explain how these properties of the sketch amplify and assist the manipulation of mental images and provoke the generation of new ones. Their hybrid percept-image hypothesis describes sketches as “incomplete visual structures that amplify the inventive and problem-solving uses of mental imagery” (Fish and Scrivener, 1990: 124). They outline three ways in which sketches can do this. First, sketches supply a framework allowing us to manipulate spatially superimposed mental imagery, in a percept-image hybrid. They also provide ambiguous or vague signs on which our innate recognition mechanisms can operate so as to produce new imagery useful to invention. Sketches thirdly facilitate the translation from an unambiguous mode of description to one that can be depicted spatially in multiple ways.

The notion that a percept-image hybrid is at work to amplify inventive uses of mental imagery accords well with Colin McGinn’s (2004: 48-55) proposal that imaginative seeing is a hybrid form of seeing which brings together mental images and percepts. McGinn (2004:

39) argues that mental images are neither percepts nor thoughts but rather “a third category of intentionality” which needs to be added to the twin pillars of perception and cognition. He argues that imaginative seeing is a distinctive type of mental category that should be added to our inventory of sensory representations (2004: 48).

McGinn adduces Wittgenstein’s (1953) famous discussion of “seeing as” in the *Philosophical Investigations* to support this view. When Wittgenstein introduces the concept of “seeing as”, he supplies an example of a triangle on the page, followed by suggesting seeing it as a solid, as a geometric diagram, as a mountain, as a wedge, as an arrow, and as various other things. He thus introduces the concept “by first generating a percept in the reader and then suggesting a number of different “interpretations” that can be imaginatively placed on it” (2004: 48). Wittgenstein (cited in McGinn, 2004: 49) writes: “the aspects of the triangle: it is as if an image came into contact, and for a time remained in contact, with the visual impression”. McGinn (2004: 49) elaborates on this idea:

we might say that the perceptual component of a case of seeing-as (such as the triangle) is not subject to the will, but the imaginative component is; yet the two fuse in a special kind of visual experience that is neither simple percept nor simple image. Rather it is as if the image comes to permeate the percept, to inhabit it, reach out to it, clothe it.

#### **4.6 Reinterpretation and emergence**

The capacity to apply a hybrid form of seeing and multiple readings in response to ambiguous figures demonstrate a potent visual cognitive effect that is exploited by designers and artists on a daily basis. Sketches are therefore not mere aids to lighten cognitive load or to make new combinations. Artists and designers use the ambiguous marks and blank spaces of the sketch to afford opportunities for new interpretations, alternatives, transformations, and discovery. Reinterpretation and emergence – seeing the drawn representation in novel ways – is an important theme in the literature on the role of sketching in design and inventive processes (Edmonds *et al.*, 1998; Purcell and Gero, 1998; Gross, 2001; Tversky, 2010). Mark Gross (2001) defines emergence as the “perception of (unintended) patterns in a representation” and later more concisely: “emergence is pattern recognition”. His research regarding sources of the multiple readings or “emergent shapes” complements and confirms Goel’s (1995) findings regarding the properties of the sketch. Sources of alternate interpretations are: intersecting figures (where the intersection of two or more figures creates recognisable subfigures), alternative configurations (when a

configuration's parts can be grouped in several ways) and figure ground reversals (when a new figure is formed by the edges of several drawn figures) These multiple readings perform numerous functions: "they recall relevant but previously unconsidered design cases, they suggest specific operations to apply to the representation and they can suggest ways to restructure or recast a design problem" (Gross, 2001).

The accounts above describe the sketch as a strategy which deliberately exploits and complements the activity of the pattern completing brain to encourage the recognition of emergent relationships and properties. Clark (2008: 130) argues that when such elements are *selected* or *maintained* to encourage better cognising, those signals are not 'merely causal' but surely part of the cognitive system itself. Clark (2008: 129) concedes that a sequence of gross physical gestures [or marks on paper] could never implement a cognitive process in their own right, but that their cognitive role *emerges* in co-ordination with key forms of neural activity. Gross (2001) confirms such co-ordination between marks on paper and neural activity when he cautions that the role that experience has on shape emergence through recognition should not be ignored. While he recognises the visual-cognitive effect that artists and designers exploit when confronted with ambiguous images, he warns that a view of emergence which emphasises specific geometry (such as closed figures created as by-products of intentional drawing) fails to appreciate the important role of drawing context and the trained eye: "The trained eye may see more, or different, shapes in the same drawing than the eye of the casual observer" (Gross, 2001). To recognise more is often referred to as a skill when painters, photographers and architects speak of "learning to see". Emergence is accordingly not *in* the eye of the beholder, but "*emergence is the eye of the beholder*" (Edmonds *et al.*, 1998). Bryan Lawson's (2004, 2009) research on designers' drawings suggest that the designers' ability to perceive ideas about functions from the forms of their drawings almost certainly depends on both the drawings themselves and the knowledge they already possess.

#### **4.7 The consequences of an external view**

Emergence as discussed above is driven by perception (Edmonds, *et al.*, 1998: 25). By providing an external view the sketch enhances the perceptual conditions necessary for reinterpretations to occur. Visual display gives access to knowledge, as well as to skills that are unavailable from internal representations. Verstijnen and Hennessey (1998: 522) investigate the need for an external view by asking "What limitations do mental processes

have that requires sketching?”. They use multiple case studies, which together support the conclusion that mental images are more difficult to scrutinise than pictures (1998: 532). Chambers and Reisberg (1985) showed that while existing interpretations of an ambiguous figure cannot be reversed in mental imagery, new interpretations were possible when allowed to visually inspect the figure (Verstijnen and Hennessey, 1998: 523).

Other psychological studies revealed that combining images in mental imagery is easy but that discovery of unanticipated novel components in mental imagery is more difficult than in visual perception. As a result they distinguish two forms of processing in imagery, namely “restructuring” and “combining” (Verstijnen and Hennessey, 1998: 525). Experiments involving component detection and figural combination were carefully structured to take into account the differential impact of expertise, intelligence and memory span and creativity on these processes. The Component Detection Task showed that existing parts can be extracted from a configuration without restructuring but novel parts cannot (1998: 529). The Figural Combination Task required memorising of components to later combine in mental imagery. The results confirmed that discovery in mental imagery is easy when it is predominantly a combining task but that complex visible junctions are only possible when restructuring is done via sketching. Sketching allows the perceptual inspection of one’s own memory-based drawing to lead to the discovery of new structures which could not be obtained from the mental images (1998: 532). These functions are all compatible with the extended mind view of the sketch as an environmental operation which changes the problem space for human brains, and an external resource in a format which complements the brain’s capacity for perceptual and pattern completion (Clark, 1998: 169).

#### **4.8 Associative system as “workshop of the possible”**

Margaret Boden (2004: 142) believes that the computational properties of connectionist systems can help us to understand “how a richly associative system like the brain could function as “a workshop of the possible”. Boden explains that although the network carries out no deliberate search, the space for possibilities changes when another input regularity is picked up by the shifting connection weights. The network picks up dimensions of possibility of a very subtle kind, without any crude inductive “priming”, it is not necessary to tell the system what to look for before it can find it. Boden (2004: 143) suggests that connectionist ideas firstly help us to comprehend how and why the memory need not be

primed to look out for meticulous answers, secondly explain why it can benefit from serendipity and thirdly tell us why, if it is so primed, it is more probable that certain ideas will be picked up. For Boden (2004: 143) the connectionist system suggests processes of pattern-completion that might enable a poet to recall a past context from a single phrase, explain how two ideas could blend in the memory to give a third and even suggest how a psychological mechanism may overlay one pattern on another without losing either: “In brief, we can now say something specific about how the hooks and eyes of memory might find each other, and how they might clip together”.

#### **4.9 “Drawing trajectories through representational space”**

Clark (2008:53) explains that although it is a strength of a connectionist system that new information has an automatic impact on similar previously stored information, and that the retrieval of information is very sensitive to context, “advanced thought and reason require the ability to reliably follow trajectories in representational space and to reliably lead others through certain trajectories”. Connectionist minds are ideal candidates for extensive external scaffolding such as using pen and paper to complement the fundamental fluidity of connectionist systems. Drawing accordingly provides a means to drive, sculpt, discipline and stabilise our dynamic mental spaces (Clark, 2008: 53-4).

Marks and images on paper are thus better viewed, as Elman (2004: 306) suggests of words, as very similar to other kinds of sensory stimuli, in that they have a direct impact on mental states; they do not “have meaning” but are “cues to meaning”. Self-generated sketches work as artificial input signals that prod and guide flexible natural systems for coding and representing information to proceed along reliable and worthwhile thinking paths. The sketch so demonstrates how “the symbolic environment can impact thought and learning both by selectively activating other internal representational resources and by allowing the material symbols themselves, or shallow image-like internal representations of them, to act as additional fulcrums of attention, memory and control” (Clark, 2008: 54). Clark (2008: 54) suggests that in “the maximum strength version” of the extended mind thesis (which views some external interactive causal processes as actually constituting cognitive processes), “these shallow symbolic objects can even appear as elements in representationally hybrid thoughts”.

## 5. Beyond dialectics and emergence: Brief discussion of more cognitive advantages of the sketch/drawing

To further pursue the investigation of how drawing as an external visual representation complements rather than recapitulates or transforms the basic mode of processing that we share with other creatures, the following section will briefly consider further computational benefits of the sketch, which partly explains its enduring role in the design process.

Findings from design research indicate that, in tandem with the benefits of productive dialectics and emergence as described above, sketching plays a variety of roles in enabling and promoting the kinds of thinking required for the cognitive tasks typically faced by designers and others who use mental imagery for invention and solving problems.

Do and Gross (1996: 2) note that designing, drawing and interpreting are activities that are not easily separated. The lower-level activities of drawing and interpreting stand in the service of design activities, while the larger objectives of design steer the activities of drawing and interpreting. Drawings supply continuity and change in a working process which involves a dynamic and cyclic mixture of cognition and perception conveyed graphically by drawings (Herbert, 1988: 31).

*Empirical studies regarding the role of design drawing indicate the following broad ways in which drawing can enhance cognitive performance:*

### 5.1 Memory augmentation (storing and recalling data)

This is the most generally acknowledged and most obvious property of external representations. Where in the previous section the focus was on how drawings as external images can facilitate invention – *changes* in our mental processes –, the focus here is on how they can introduce greater *stability* in our mental processes. A range of studies represent drawing as one of many cognitive tools invented to facilitate memory and thinking by compensating for limitations in human memory and information processing at the same time that they take advantage of the visual displays (Purcell and Gero, 1998). Limitations in memory can be reduced by offloading cognitive outputs to external displays that can be inspected and re-inspected.

The designer appears to have a particular way of thinking which is exploratory and integrative. Because this way of thinking involves bringing a whole lot of issues from outside into the argument, it broadens the terms of reference and thus makes it cognitively very challenging to think about everything at once (Lawson, 2004: 52). Lawson (2004: 52) believes that drawing facilitates the performance of this “mental juggling act” – keeping in mind the many relevant factors, which are often so disparate that they have no obvious relation to each other. Goldschmidt (2002) likens the self-generated sketch to a design “laboratory” which allows one to try out anything that comes to mind and explore relationships in and between images generated from long-term memory. The sketch provides an arena in which large amounts of information are brought into play in a selective manner, so that they can interact when relevant, and so that the implications of the attempted solution concept can be considered as it develops.

In this context it is worth noting that the size of the drawing seemingly matters – over half of the designers interviewed by Lawson (2004: 55) prefer to think via small sketches, with people like le Corbusier sketching prolifically to record things as a vast experiential archive. Rather than putting their energy into a small number of larger, more worked out drawings, working on a size smaller than A4 allows the designer to concentrate and take everything in at a single glance (Lawson, 2004: 56). A related strategy to assist the designer to obtain a strong mental model of the design space while helping attentive memory to hold the large quantity of information gathered, is using a big wall, markers and sticky notes, an arrangement which “allows for the progressive escape from the mess of content that has been gathered” (Kolko, 2010: 19). Limitations in the amount of information that can be kept in mind and operations that can be applied are remedied by putting relevant information close to particular operations so as to exploit people’s enormous capacity for recognising many different patterns. Unlike what is typical for the mental realm, the complexity of the drawing as a physical object has no significant negative effect on its stability (Kirsh, 2010: 447).

In a seminal paper in cognitive psychology, Miller (1956) argued that the capacity of short-term memory was limited to seven – add or subtract two – chunks of [meaningless] information. Edward Tufte (2003: 23) points out that rather than implying rules for the amount of information presented, “the deep point of Miller’s work is to suggest strategies, such as placing evidence within a context, that extend the reach of memory beyond tiny clumps of data”. Our capacity to remember is increased by building larger chunks of

information through a process of recoding. We do this by grouping or organising bits of information into familiar units or chunks such as words or images. Miller (1956) acknowledges that as a form of recoding imagery seems “much harder to get at operationally” than the more symbolic kinds of recoding. In a sketch or picture it is usually not even clear what seven chunks of information are.

Nickerson (1965: 156) demonstrated a different side of human memory: “our somewhat more impressive ability to remember complex *meaningful* (my italics) stimulus configurations, as, for example, pictures of people, places, and things”. He demonstrated experimentally that given appropriate stimulus materials and an appropriate task situation, a surprisingly large amount of information can be retained in memory (Nickerson, 1965: 156). While it is not clear just what gets stored, it is clear that not much detail is needed to recognise an image on a later occasion. Strategies to aid recognition may be to abstract, ignore or filter features before committing things to memory. Associations may be formed between content in an image (such as a nonsense shape), and content in long-term memory (such as a map of country) (Nickerson, 1965: 159). Compared to short-term memory, the capacity of long-term memory is very large.

In a classic study, Newell and Simon (1972; as cited in Purcell and Gero, 1998: 404) propose a view that problem solving consists of an ensemble of cognitive processes that take place in short term memory, with relevant knowledge being retrieved from long-term memory. This approach to short term memory was later developed by Baddeley (1992; as cited in Purcell and Gero, 1998: 404) to also comprise other kinds of cognitive activities such as image formation. According to their model most cognitive activities, for instance thinking and problem solving, are so complex that short-term memory cannot cope with them on its own. They propose that sequential processing is required to store the outcomes of earlier stages of a process so that they can be used in later stages. Knowledge from long-term memory similarly needs to be retained and made available for on-going processing. This form of memory is now identified as working memory (1998: 404).

Because material in short-term memory deteriorates quickly, a mechanism is needed to restore the material in short-term memory by re-accessing material held in long-term memory stores. Newell and Simon (1972) propose that when the limit of short-term memory is exceeded, the problem is decomposed into sub-problems, and problem solving then takes place incrementally. Short-term memory consequently entails serial or sequential



processing (Purcell and Gero, 1998: 407). External aids to memory, for instance drawings diagrams and written notes, have an important role to play here. In combination with strategies like outlining sub-problems or sequential processing they can help monitor progress and order the sequence – thus reducing the load on working memory. In some cases this refreshing involves rehearsal via sub-vocalisation, that is, talking to oneself, as discussed earlier (Purcell and Gero, 1998: 405). Complex thinking and problem solving involves verbal recall, the recall and rehearsal of spatial information, as well as non-spatial visual properties such as colour.

The complexity of design problems appears to exceed the capacity of working memory. The design of an artefact, for instance, involves using a wide array of visual information about materials, their colours, textures and other features, as well as propositional knowledge from a number of disciplines relating to the structure, manufacture, functions and potential experience of the artefact (Purcell and Gero, 1998: 408).

Protocol studies done by Goel (1995) support the claim that design problems require decomposition, serial processing and the use of external supports to memory. Goel (1995: 114) distinguishes four phases in the design process – the structuring of the problem, preliminary design, refining the design, and filling in the details. It would seem that the designer has to think or reason differently in each of them (Goel, 1995: 114). His careful analysis of the problem-solving process shows how drawing moves from unstructured sketches to clearer and more accurate representations as the design progresses from its inception to its completion. Additionally, two types of transformations are evident in the drawings: lateral transformations (from one idea to another) and vertical transformations (from less to more detail within the same idea). Lateral transformations, associated with unstructured sketches, predominate in the preliminary design phases, whereas vertical transformations manifest during the later stages where the design is refined and detail is added.

## **5.2 Simplification**

Closely related to drawing's role in memory augmentation is its contribution to environmental simplification so as to lessen computational burden. According to Lawson (2004: 40) the reductive or simplifying properties of design drawings are deliberate attempts to remove information and to reduce complexity. "Once descriptive complexity is reduced, processes of selective attention, and of action control, can operate on elements of

a scene that were previously too ‘unmarked’ to define such operations over” (Clark, 2008: 65). The sketch is used to first identify and subsequently reflect upon essential details – details that, if not recognised, could hinder – or in any case significantly effect – the eventual implementation of the ultimate, fully articulated design. The sketch enables the identification and recollection of pertinent knowledge in order to identify such critical features (Cross, 1999: 35).

Before the drawings begin, abstract concepts are formed in order to select and organise the raw data involving the functional, physical and cultural context of the project. Abstraction not only arranges data, but also has to sacrifice data that cannot fit into the intended structure. Even before a structure is formed the internal processes of perception and cognition suffer a loss of information (Herbert, 1988). Such drawings, which may be problem or solution focussed, can include what would normally be called charts, graphs or diagrammatic representations which, with few visual qualities of real objects, cannot be considered pictorial (Lawson, 2004; Tversky, 2011). While they tolerate some uncertainty regarding certain attributes as well as regarding the constraints imposed on feasible solutions, the drawings used in the initial stage of the design process embody valuable abstract and high-level design knowledge (Gross et al, 1988).

### **5.3 Connections and relationships**

The archetypical design bubble diagrams characteristic of the design profession show key connections between elements, spaces and routes, and are in essence a topological graph. Bubble diagrams make it possible for some knowledge to be conveyed accurately and unambiguously (relationships), while it includes additional information, which is decidedly vague (size or location), and completely removes all other information (for example plan shapes) (Lawson, 2004: 41). By allowing a temporarily limited and simplified view of the state of affairs, or presenting circumscribed characteristics of the nature of the problems being solved, a diagram focuses attention on those characteristics, thereby helping the designer to get his “head around” the situation (Lawson, 2004: 42). Studies which demonstrate that grasping abstract relations and learning abstract principles is generally better when concrete non-essential details are suppressed, suggest to Clark (2005: 11) that too much detail and realism can result in committing to solutions or theories prematurely and is thus often counter-productive.

Abstract diagrams are also used to describe things like a movement system through a building, an electric wiring layout or colour scheme to list constraints and to record various ideas that come to mind. Tversky (2011: 524) notes that ideas that are indispensable to thought and originality are often not visible. She identifies a specific kind of symbol, which she calls a glyph, as a visual means of communicating shared concepts for which no likenesses are available. These are simple characters like arrows, points, blobs or lines, whose meanings stem from their geometric or gestalt attributes in context. They can visualise relations, forces, networks and other meanings that enhance communication and interpretation. To fulfil these functions with the use of words would be difficult or clumsy. Visual depictions are easily recognized, can access meaning faster and have greater distinctiveness and memorability than descriptions in words (Tversky, 2011: 516). The use of frames, lines or grouping by proximity is more effective than words to point out conceptual, concrete, abstract, virtual or spatial relationships between elements (Tversky, 2011). By outlining some aspects of the design problem, diagrammatic drawings furthermore summarise that knowledge in a user-friendly way, thus relieving the designer from the responsibility of remembering all the relevant information (Lawson, 2004: 43). Drawings are accordingly both more and less than externalisations of mental images as they can omit, distort, add things to reality, and show different points of view on reality (Tversky, 1999).

#### **5.4 Interactivity**

Kirsh (2010: 445) is critical of reducing the value of external representations and interaction to claims about offloading memory. This misconception downplays the significant difference between memory and perception. Kirsh (2010: 446) argues that the medium specific nature of encoding cannot be ignored and suggests that utilising the world for external computation may well be more important than using the world as external storage. He elaborates:

Things in the world behave differently than things in the mind. For example, external representations are extended in space, not just in time. They can be operated on in different ways; they can be manually duplicated, and rearranged. They can be shared with other people. Tools can be applied to them. These differences between internal and external representations are incredibly significant. They are what makes interactivity so interesting (Kirsh, 2010: 446).

It is as a result of such physical rearrangements in space that new aspects of meaning can be discovered that cannot be detected internally. Kirsh (2010: 448) remarks, “Once a structure is in the public domain it has a life of its own”. Chambers and Reisberg’s (1985) studies on mental imagery suggest that ambiguity is difficult to detect in a mental image because the subject seems to sustain their image under an earlier interpretation or conception, which closes it to new interpretations. Kirsh (2010: 448-449) elaborates: “When externalised and in the visual field, however, the very process of vision – the way the eye moves and checks for consistency – typically drives them to see the ambiguity. When a structure is probed deeply enough, relations or interactions between parts that were never anticipated may be easy to discover”.

The dynamic nature of sketching allows transformation of representations, as it provides the graphic means to add information from our experience, to delete or to draw-over, in search of a clearer more defined idea. Drawing thus provides a mechanism which focuses attention and monitors the progress towards goals and sub-goals, while ordering or structuring the sequence in which they are attended to. Do and Gross’s (1996: 5) extensive observation of architectural designers’ performance, both when teaching design as well as in practice, indicates that initial repetitive traces are drawn to identify aspects of concern, to bring focus to drawn shapes, to recognise “emergent” shapes in the drawing and to define shape alteration. This may be followed by the use of a different tones or inscriptions on top of old marks in order to obtain or reveal a form from the ambiguous and sketchy beginnings, or by drawing and overtracing to simplify or edit an idea to become an abstract form. The repeated outlining, overtracing or redrawing serves to select or draw attention to an element, help shape emergence by focusing on and refining a specific interpretation. Through such parsing, re-interpreting and re-grouping of component lines, sketching facilitates problem restructuring by identifying explicit and implicit relationships, relationships among shapes and forms, potential mechanisms, as well as reference material from memory or databases. These strategies enforce stable properties on the environment to lessen computational burden and encourage inferences to be made by the designer.

### **5.5 Organise, manipulate, prune and filter**

The process of physically drawing out content-affinities, moving content around and placing related items next to each other is more about finding ‘good’ rather than ‘right’ relationships, where the crucial connections are typically multi-faceted and complex (Kolko,

2010: 19). Kolko (2010: 16) argues that such activities, which to a newcomer may appear to be a mess – “sketches, incomplete sentences and crude diagrams lacking adequate captions or descriptions” – should be understood as synthesis methods. During a process of synthesis designers try to organise, manipulate, edit and filter the information that has been gathered into an organised structure that is cohesive and clear. “The mess actually represents the deep and meaningful sense making that drives innovation” (Kolko, 2010: 16). Because externalised ideas can be discussed, described, accepted, or rejected by multiple people they can be incorporated into a larger process of synthesis (Kolko, 2010: 18).

These tangible operations, superimpositions, and rotations culminate in what Kirsh calls “the power of construction” (2010: 451) – an important virtue of external interaction not achievable by the brain alone. Clark (2005: 11) suspects that the manner in which such stand-ins change and relax the time-based constraints on everyday performance is equally important. The procedures that are applied to a model or a prototype appear unconstrained compared to the time constraints involved in the case of environmentally coupled perceptual-motor action. In design and fine art situations the agent actively creates the very structures which she then responds to and is in charge of (Clark, 2005: 12). This would explain the frequently noted sense of risk-taking that accompanies the design process. Clark (2005: 12) speculates that it is possible that this relaxation of temporal constraints allows us to utilise an evolutionarily younger set of neural cognitive strategies: “ones that make richer contact with episodic memory systems and explicit knowledge, and are known to be major players in time-delayed as well as imagination based responses”.

## **5.6 Parallel lines of thought**

Sketches furthermore allow designers to manage multiple levels of abstraction concurrently – for instance thinking about the global concept while simultaneously thinking about the details of applying or executing it (Cross, 1999: 35). In one and the same drawing of a machine, Leonardo will for instance often combine details, plans, elevations, and trajectory lines. In this manner, drawing allows the designer to consider and reason about many aspects at once. The drawing can thus accommodate more than one line of thought at a time and facilitate shifts in attention. These parallel lines of thought co-evolve – one line of thought may for instance consider a building as a sequence of spaces while another line of thought is concerned with the resolution of the urban context.

## 5.7 Interplay between words and images

Sketches by their very nature accommodate the gathering of various forms and formats of knowledge in the same space: coded and uncoded, visual, verbal, geometrical, arithmetical and tacit knowledge. This rich assembly assists the generation of insights at the point where these components of reasoning meet. There is for instance no neat division between the roles that words and images play in the process of design. Lawson and Dorst (2009: 138) remark that although design has become associated much more with the graphic image (which can be strong, powerful and have longevity), the important role of words used by designers while developing their designs and discussing them is much more likely to go unrecorded. Analysis of video recordings of design groups in action suggests that it is often exactly in the *combination* of drawing and talking that the interesting things happen. Cross (cited in Lawson, 2004: 88) observes that observing drawing and talking together reveals “the development of design ideas not necessarily as creative ‘leaps’ but as ‘bridges’ between ideas as the words enable transitions between ideas which look abruptly different if we only look at the drawings”.

Peterson (1993) investigated how conceptual or semantic knowledge relates to imagery-based knowledge through a number of experiments. In one such experiment, one group of participants was instructed to think of as many associations as possible when they were presented with the *word* rabbit or duck, while a second group had to generate associations from *images* of rabbits and ducks. It turned out that there was a very low proportion of common associations between the two different conditions. This suggests that we draw different associations from long-term memory when prompted by imagery than when prompted via words (Peterson, 1993: 183). Peterson (1993: 183) argues that imagery thus expands the knowledge base we can draw on to facilitate finding superior solutions. Peterson suggests that novel solutions can be produced when attending to mental imagery since the knowledge that is retrieved via imagery tends to be so different from that retrieved via words. Purcell and Gero (1998: 415) elaborate in response: “Problems solved using imagery based knowledge may appear to be unusual when the usual is defined by propositional or semantic knowledge”.

Another experiment by Peterson (discussed in Purcell and Gero, 1998: 419) showed that words access more conceptual and propositional knowledge compared to images, which access more perceptually based knowledge. Design needs both types of knowledge and

absence of either type could result in inappropriate design when important facets of a problem might not be addressed. Designers use written notes as well as drawings as ways of accessing the two distinctive types of knowledge. Conceptual knowledge is possibly accessed by talking, and the combination of this with drawing as found in design groups maximises the retrieval of both abstract knowledge together with knowledge about physical forms and materials. Purcell and Gero (1998: 419) suggest that it may be that there is a subtle interplay between verbal activity and imagery, with each accessing a different type of knowledge. Verbal activity in the initial stages relates to formulating the conceptual issues or constraints of the issue, acts as an external memory aid and possibly frees working memory for the imagery to retrieve physical forms of knowledge so as to progress from the conceptual to the physical. Drawing in that case could serve to explore the suggestions presented by this type of knowledge.

The materiality of drawings explicitly involves the visual and motor cortex and primes a constellation of visual and physical associations, which, as we saw above, may be different from associations derived from verbal accounts (Kirsh, 2010: 443). A ruler in hand prepares measuring actions and thinking processes while protractors stimulate thoughts of angles and degrees (2010: 443). In contrast to the more general formulation provided by words, the physical constraint and visual hints provided by working with tools and external structures in an incremental and interactive process is evidently advantageous (2010: 443).

## **5.8 Expanding cognition**

In such complex cognitive interactions as described above we see the cognitive impact of the presence of what Clark (2008: 52) calls “hybrid representational vehicles”, which can enable and activate a wide variety of thoughts that rely on the coordinated action of a variety of resources. The dynamic and interactive nature of the sketch expands cognition by activating, complementing and co-ordinating a wide array of internal representations containing relevant content.

The range of computational benefits we have rehearsed here confirms that drawing is not limited to the preservation and expression of pre-existing thoughts but rather makes available ideas, strategies and pathways that are not obtainable by individual, un-augmented brains. While the role of the opportunistic brain is crucial and special, its true power can be seen to lie in mediating a wide variety of complex and iterated processes that are looped through the external environment as a source of complementary capacities (Clark, 2003:

68/75). The interactions involved in drawing cannot be reduced to processes that can be simulated, generated, and controlled in the brain. The drawing, as an external structure, gives access to new operations; it can co-ordinate and encode structures of greater complexity – all different ways to enable more efficient computation, change the domain and ultimately increase the breadth of cognition (Kirsh, 2010: 442).



## Chapter 5

### **“Sweep away the magic dust, sack the inner executive, [and] embrace the motley crew of cognitive processes”**

#### **1. William Kentridge**

The South African artist William Kentridge presents a valuable voice within this investigation, not only because he views drawing as a model for knowledge and thinking (Christov-Bakargiev, 1999: 8), but also because he is particularly generous with exposing all the intricacies of his process (Krauss, 2000:9). In addition, his need to acknowledge the medium, method and process by which the representation is achieved, results in an end product where “the process of facture remains visible” (Christov-Bakargiev, 1998: 12) in a kind of drawing that is remarkably responsive and sensitive to its own condition (Krauss, 2000: 10). Kentridge likens the enclosed space of the studio to an enlarged head, not just physically but also psychically: “the pacing in the studio is the equivalent of ideas spinning around in one’s head, as if the brain is a muscle that can be exercised into fitness, into clarity” (2009: 13). Kentridge equates drawing with thought itself: “drawing is a testing of ideas; a slow-motion version of thought. It does not arrive instantly like a photograph. The uncertain and imprecise way of constructing a drawing is sometimes a model of how to construct meaning. What ends in clarity does not begin that way” (Christov-Bakargiev, 1998: 8). His interest in “less synchronic, more time-based art practice relates partly to the larger question of whether drawing can act as a metaphor for the way we think” (Christov-Bakargiev, 1998: 17).

Drawing never loses its centrality in Kentridge’s productions, regardless of which discipline he works in. Although his oeuvre, which spans more than three decades, cuts across various mediums – drawing, printmaking, film animation, sculpture, books and performing arts – drawing is always at the core of this work. For Kentridge drawing is not a preliminary activity but a primary one. His deep-rooted attachment to drawing is unequivocal when he says: “Even when there are long periods when I haven’t drawn, I still think of myself as a draftsman” (Bester, 2011: III).

He recognises that the activity of drawing is indispensable, as it is only when physically involved in a drawing that ideas begin to emerge: “There is a combination between drawing and seeing, between making and assessing that provokes a part of my mind that otherwise is closed off” (Kentridge, 1999: 119). Kentridge (Kentridge and Breidbach, 2006: 70) confesses that the one place where nothing happens [he cannot think] is when sitting at his desk: “It’s a disaster”. In contrast, the physical activity of making the drawings is an intensive process: “It is a comfort in a practical sense, it is very central to me in times of distress or depression, that physical activity in a primitive, therapeutic way works to calm me down to make things” (2006: 70).

### **1.1 Cognitive integration and cognitive character**

The central role that Kentridge gives to drawing, alongside various other strategies to assist his thinking, demonstrates a route to cognitive extension which Richard Menary (2012: 147) calls “enculturated cognition”. Enculturated cognition does not hold that artefacts themselves extend our mental capabilities, but rather that the *practices* that are developed for working with artefacts, and the information related to them, extend our cognitive abilities by improving and transforming them (2012: 147). Menary (2012: 148) argues further that when such processes are diligently maintained and actively structured, such a “practice of epistemic diligence” becomes integrated into our cognitive characters. As drawing is “not simply a discrete part of the whole” in Kentridge’s art, but instead “insinuates itself into the way he thinks and certainly into how he constructs images” (Auping, 2009: 228), both the notion of cognitive integration and cognitive character are pertinent when viewing Kentridge and his work in terms of cognitive science.

### **1.2 “Aids, stratagems and incantations”**

Kentridge’s practice involves various strategies which have become so central to his working process that he admits that he cannot think without them. He deliberately selects different tactics (what Clark and Dennett would call practices of self-stimulation) for images to emerge. Devices used include playing with language or working from the demands of technical aspects of his process. Although these things should supposedly be outside the scope of the narrative, they open onto the conceptual and so become strategies to discover ways *into* the work (Kentridge and Breidbach, 2006: 71). A key factor at play in this process is that the work does not emerge from a predetermined idea, but from being

open to suggestion and the potent value of ambiguity and uncertainty. For Kentridge this process has emerged out of necessity, as he confesses that he “needs all the aids, stratagems and incantations” he can find because ideas and images “come so grudgingly” (Kentridge, 1999: 119). Rosalind Krauss (2000: 6) interprets Kentridge’s process – where the technical opens onto the conceptual – as a kind of automatism that allows spontaneous improvisation while absorbed in a range of agencies Kentridge calls Fortuna. He uses the general term “Fortuna” for this “range of agencies, something other than cold statistical chance, and something too outside the range of rational control” (Kentridge, 1999:119). As a strategy, Fortuna has supplied Kentridge with many visual and conceptual links, enriching his plot with new characters and landscapes.

As an example of meaning stemming from the technical, Kentridge (Kentridge and Breidbach, 2006: 36) recounts how it took about a year and a half to understand that the erasures were part of the meaning and part of the interest in his animated films. “It struck me very forcibly that most of the things of interest I’ve done haven’t been things that I’ve known about or planned. They’re usually things I’ve struggled against and that have been let in out of necessity” (2006: 36). Just as in the case of allowing the puppeteers to be visible in his work with Handspring Puppet Company, the erasures brought with them an entire chain of significant content (2006: 37). He recognises a balance between time and image and recalls as an example his effort to imagine what image would have the sexual power of an erotic gift to be given from Soho to Mrs Eckstein, his lover. A horse galloping around his hand would have been “insane” – too difficult and time consuming (2006: 55). A fish however proved to be easily drawn and recognised, erased, put in a new position and in an hour could be made to leap and jump. The image arose not out of deciding the perfect image for this gift, but out of a consideration of what was manageable to do. The fish, “wet and a bit like sperm”, was a “good fortune”— another example of how practical limitations, which one supposes have little to do with the image, in fact become part of its meaning (2006: 55).

The significance that Kentridge gives to his process provides support for Menary’s (2012: 149) argument that such “cognitive abilities to create, maintain, manipulate and deploy information for cognitive success are what really count when considering integrated cognitive abilities and cognitive character”. In contrast to using artefacts to “outsource” complexity and computing, such integrated cognitive abilities rely on the integration of consistent belief-forming *processes* to extend and transform what we are able to do (Menary,

2012:148). Cognitive agency depends upon integrated cognitive abilities in a different way than it does upon the reliability of artefacts or the environment. Kentridge's [cognitive] practice goes beyond a mere embedded and scaffolded account of cognitive abilities – the practice itself is what Menary (2012: 148) would describe as “part of the cycle of cognitive processing” and “not merely causally supportive of in-the-head processes”

### 1.3 “The doing is to see”

For Menary (2012:152), the clearest example of the extension of a cognitive ability – when “the inside is transformed to be more like the outside” – is when cultural practices and representations “get under the skin and transform the processing and representational structure of the cortical circuitry”. Symptomatic of such under the skin practice, is Kentridge's (Kentridge and Breidbach, 2006: 84) claim that the concrete starting point for a drawing is always *doing*: “The doing is to see”. He stresses that the *impulse* to start is not an idea or an image of the finished thing but rather a sort of enthusiasm or a charge, a craving to work, “taking two pieces of card and put[ting] one behind the other and see what that starts to suggest, how it shifts and changes” (2006: 85). Kentridge (2006: 99) explains that the starting point of his work is not theoretical. “The starting point is the urge to work. It doesn't have to do with any knowledge about the process; it even has to do with a partial blindness of being in the middle of the process, being part of it”. Kentridge (2006: 103) compares his trust in the blind intelligence at work in this process with the trust one has in the process of constructing a sentence when we speak. “I am trusting that in the same way that one's brain and tongue combine to get some communicable sense into the world at the end of a sentence, a similar process will happen through the sequence of the drawing”.

Coming from a very logical and rational family and with an eminent lawyer as father, Kentridge deliberately uses drawing as a way of arriving at knowledge, opinions and meaning that came through a path different to rational or legal reasoning - not subject to cross-examination. He explains: “There is no expectation in drawing that you are going to have the kind of reasoning that a legal argument has. So to be making drawings, it is natural that you start in the centre. You don't have a plan about the whole thing. You don't have to write a dissertation about the drawing, before you make it. You start at some point in the middle, you follow, you expand. You follow where it is going” (Kentridge and Breidbach, 2006: 70). Kentridge (2006: 70) describes his process as “partly a projection of the image you have in your head; it is partly a reception, what you recognise as the drawing

proceeds". Such an account fits with Clark's (2008: 131) remarks about what happens when certain cognitive processes create outputs which are recycled as inputs to move the cognitive process forward.

Because Kentridge recognises the role of his process and medium, he purposefully uses drawing as a "double-edged practice" which embraces both intentionality and chance as means to explore how perception and experience are transformed into knowledge. In line with Clark's (1998: 176) idea that "we generate a trace in a format which opens up a range of new possibilities", Kentridge (interviewed in Auping, 2009: 234) remarks that it is the textures and tones made by charcoal that in themselves lead to the activity flourishing. He is suspicious of the possibility of a direct, positive communication of meaning and thus welcomes imperfection, failures, shadows and oblique glances rather than direct views (Christov-Bakargiev, 2009: 115). For Kentridge, drawing is not about setting something in place, establishing static symbols or definitions: "The single viewpoint of the head-on image is on shaky epistemological ground. The contradictions and dislocations are the interesting things, rather than the consistencies" (Christov-Bakargiev, 1998: 17).

#### **1.4 Exploiting the natural condition**

Kentridge consequently actively structures his world to exploit what he perceives as the "natural condition" of continuously trying to solve riddles, making predictions of order, working fast to make associations, taking leaps to fill in the gaps, trying to make things make sense. "Things may simply not make sense, but try as hard as you like not to, your mind is trying to make sense of them. It is always a process of meeting the world halfway and then trying to get it to make sense in terms of what one knows already" (Kentridge and Breidbach, 2006: 60). A technique used to reduce intentionality and control is the tearing of black paper as an exploration of the chance encounter between the gesture of tearing and the semi-random shapes it generates (Christov-Bakargiev, 2009). Examples of this process can be seen in the roughly torn shadow puppets which "emerged through a process of tearing sheets of paper almost at random and then seeing what happens if one puts them together and were to move them. "It is about seeing, not what you know, but what you recognise" (Kentridge and Breidbach, 2006: 62) and again: "It is not about an active intelligence; it is about a category of recognition, which is there fighting to come out the whole time" (2006: 63). This fits in with Clark's emphasis on procedures in which intelligence is manifested especially by acting on the external world, and then using the

brain's natural flair for pattern recognition to identify (potentially) valuable material for further use and elaboration.

Kentridge (Kentridge and Breidbach, 2006: 64) recalls working with school children of seven or eight and asking them to do a picture of a dinosaur doing a back somersault in the air. Their response was that it would be *impossible*, as “they don't know how to do it”. “But if you tear some shapes out, a piece for the tail, a piece for the body, neck, head, legs and fit them together as the animal and move them under your hand, you recognise what it is doing and you can get seven year old kids to do a completely beautiful image of a dinosaur doing a back somersault in mid-air” (2006: 64). He compares this strategy with “finding” scenes in his films firstly through a degree of uncertainty, an indistinct or vague form with undeveloped options to explore and play with and secondly, by adjusting such segments with your hands until they yield an interesting result. “You know it by recognizing it, rather than knowing it before. You may not know what the shape of a lion or a dog is, but you can certainly recognise it as you see it. And this is halfway between drawing it and simply recognizing it” (2006: 64).

### **1.5 *Making connections***

Kentridge (Kentridge and Breidbach, 2006: 83) remarks that the “thinking thinking” done in an interview is different to the visual thinking used in making films, where the principle is absolutely from the visual backwards. As with Clark's mangrove, Kentridge's description of associative meaning is secondary and partly reimposed in the conversation, once the event has actually happened, trying to find the logic that must have been there, rather than starting from the logic directly. But even though theoretical explanations and implications follow behind, Kentridge believes that those enthusiasms and excesses of energy towards working, are not completely random, but have to do with the making and coming together of a series of connections through which the sense is made. Kentridge (2006: 84) notes how the different elements, different impulses and causes, different lines of association come together to make meaning: “the theory finds its root”. His practice so demonstrates a “sense” of logic advocated by Deleuze, a logic that shows that “in contrast to the traditional logical sense, there exists such zones of indeterminacy, secretly accompanying most forms of organisation, and that thinking has a peculiar relation to them” (Rajchman, 2000: 5). Just like Kentridge needs to manually shift things to find images, this logic happens through *making* connections. Rajchman (2000:6) explains that “connection

requires a style of thought that might be called “empiricist” or “pragmatist””. The principle is “something one must make or do, and learn by making or doing...we must always *make* connections, since they are not already given” (Rajchman, 2000: 6).

Barbara Stafford (2004: 325) also identifies making connections as an alternative route to arrive at knowledge. Stafford (2004: 325) argues that association becomes a type of non-linguistic expertise specific to the domains to which we have had the most exposure: nature, the human body and morals. Clark (1997: 53) likewise argues that the brain is an associative engine, and that its internal representations are action – and context specific, the result of iterated interactions with our surroundings. Stafford (2004:325) elaborates: “Consequently, noticing contiguities and contingencies is a mode of embodied knowing and an alternative to rational or analytic thought”. Stafford (2004:326) argues that this “in-betweening” mental motion corresponds to the inferring “leaps” of analogy and is “not reducible to language”. Kentridge draws abundantly on his non-linguistic expertise through strategies like leaving gaps between images at the beginning in order to find space for other and new associative elements or connections to join in (Kentridge and Breidbach, 2006: 107). Breidbach (Kentridge and Breidbach, 2006: 108) views this “state of partial emptiness” and its accompanying creative leaps as equally constitutive for the structure of the film as is its literal multi-layeredness.

### **1.6 “Images of inauthentic origin”**

Kentridge (1999:118) confesses a fascination with where images thrown up by incidental circumstances come from. He calls such evocations “images of inauthentic origin” (1999: 118). An example of such an image is when a coffee plunger, used by the central character Soho, became a mineshaft and thereby opened up a whole film for him. The meaning of the relationship between the bed and Soho and the mine developed so that Soho was eventually seen “excavating from the earth an entire social and eco history” (Krauss, 2000:7). The radical shift in scale between Soho’s world and that of his labourers displays how “every mirror gesture made by Soho triggers a corresponding reaction, on a momentous scale, for the miners who are, literally, under his thumb” (Cameron *et al.*, 1999:60).

Kentridge (1999: 118) describes how the drawing of the caffetiere in the film could easily have been a teapot, but it was the caffetiere that was in his studio that morning. “And it

was only when the plunger was half way down, in the activity of the drawing, erasing it, repositioning it a few millimetres lower each time that I saw, I knew, I realised (I cannot pin an exact word on it) that it would go through the tray, through the bed and become the mine shaft. The sensation was more of discovery than invention” (1999:118). His sense of “relief at not having overlooked what was in front” of him (Kentridge, 1999: 118) corresponds with the depiction of this kind of thinking in Rajchman’s *Deleuze Connections* (2000: 7): “But this pragmatism – this And - is not an instrumentalism, and it supposes another sense of machine. It is not determined by given outcomes, not based in predictive expertise. On the contrary, its motto is “not to predict, but to remain attentive to the unknown knocking at the door”” (Rajchman, 2000: 7). Even though this and other images and material are central to the film, they are not merely the expression of pre-existing thoughts: “None of them came about through a plan, a programme, a storyboard, neither obviously did they come about through sheer chance” (Kentridge, 1999: 118).

### **1.7 Movement**

Movement is another element crucial to Kentridge’s process – it is not merely instrumental or incidental but is as integral to the work as the marks on the page. The activity of walking is “both a practical necessity and a need” (Kentridge and Breidbach, 2006: 69). Each time he walks away and returns, there is a quick look at the drawing, “a fresh view” of it (2006: 69). Kentridge (2009: 13) calls this pacing from and towards the sheet of paper “walking, thinking, stalking the image”. Conscious that it will take about twenty small alterations to draw a line down the sheet of paper, Kentridge is optimistic that at some stage in his ritual progression towards the bottom of the page, he will have an idea about what follows. “So it’s a mesmerizing process” (Kentridge and Breidbach, 2006: 69).

Kentridge (cited in Thain, 2008: 68) defines animation as: “not the art of drawings that move but the art of movements that are drawn; what happens between each frame is much more important than what exists on each frame”. He thus suggests that the space that is opened up between each frame is a potent device to stimulate the creative process. Alanna Thain (2008: 68) expands this idea to propose that an “enchanted materialism” can be found between frames – as a potent site that welcomes the “emergence of the unanticipated” (2008: 69). Thain (2008: 71) views Kentridge’s technique as a form of animated dance, in which “the charge of indeterminacy of the dancing body (as an assemblage between Kentridge, charcoal, studio and his sense of timing) retains a force that



exceeds the idea of the trace”. Such potency validates the notion of drawing as “a kind of kinaesthetic *channelling* of an artist’s consciousness” (Butler *et al*, 2009: 194).

## 1.8 Suspending and expanding

Christov-Bakargiev (quoted in Thain, 2008: 73) describes Kentridge’s reworking of the image through erasure as “a way of suspending the present”. Thain (2008: 72) enlarges this idea in viewing Kentridge’s “movement between”, as a kind of dance that equally creates delay and suspense. When Kentridge’s movement suspends the present, a dispersive agency provides an “expanded presence” where – by stalling the body – he calculatingly invites chance (Thain, 2008: 79). Thain (2008: 79) consequently proposes that artistic intentionality ought to be understood as something beyond mentality and thought that is only expressed by the body. She suggests that there is in addition the intense movement of the body “that lends a productive vagueness to the process” (Thain, 2008: 79). The notion of suspending the present resonates with Elderfield’s (1971: 15) portrayal of drawing as a *suspension of narrative* in which “the act of working selects from a jumble of perceptions – events, situations, words even, as well as visual memories – alighting on one with recognition.” That moment is suspended in the rendering process that is both explanatory and exploratory, for it simultaneously realises and reveals together (1971: 15). Elsewhere, Kentridge (2009: 13) identifies yet another form of “productive procrastination” – when the “the pacing is sometimes replaced by sharpening of pencils, gathering of materials, hunting for just the right music – all different forms of productive procrastination”. It is interesting to not how diverse and unexpected the forms are that Clark’s looping of cognitive processes through the external world can take.

When Breidbach (Kentridge & Breidbach, 2006: 57) asks, “What is the dynamic of this game you describe, if not rational thought? Does it emanate from movement or do you call it association or is it the insistence of the graphic repetition and alteration on the paper?” Kentridge responds that there is not a single but many different points of entry from which an image [thought] emerges (2006: 58). He describes how one scene began with a thought about having fat cows and thin cows, which then led to complex interrelated memories and associations with the pharaohs’ dream, the sea, droughts in the country, newspaper photographs, a particular part of the country, an African choir on the beach. One woman then stood out to remind Kentridge of his nanny, who belonged to this particular church

sect, and with her came a young boy, who became Soho's younger self. Eventually the film became very much about the journey of the boy (Kentridge & Breidbach, 2006: 60).

### **1.9 Interplay between memory and imagination**

The rich interplay between memory and imagination in Kentridge's creative performance is in harmony with neuro-scientific research, which indicates that "memory and imagination are not the distant cousins they once seemed: both derive from the same cellular and neurological processes and are intricately intertwined in the 'matter' memories are made of. Memory can be creative in reconstructing the past, just as imagination can be reconstructive in memorizing the present ..." (van Dijck, 2009: 164). The various points of entry from which images emerge in Kentridge's work furthermore echo contemporary findings in neuroscience which suggests that there is "no such thing as a single location for memory" (van Dijck, 2009: 160). Studies of the neurological and genetic workings of memory show that there is not only one route between one brain system and one type of memory:

Instead, the establishment of memories depends on the working of the entire brain network, consisting in turn of several memory systems, including semantic and episodic memory, declarative or procedural memory. The hunt for the location of memory, undertaken by scientists of various disciplines, has come up with a staggering distributed answer to the question, in fact defying the very possibility of pinning down one type of memory to a single place in the brain (van Dijck, 2009: 160).

Breidbach (Kentridge & Breidbach, 2006: 57) remarks that Kentridge's process of construction brings about a high level of complexity, which she perceives to be something that reveals the complexity of visual thinking: "images accrue complexity. They concert with each other". Her observation is compatible with the neuroscientist Antonio Damasio's (1999: 216) use of the orchestra as metaphor to describe the mind's function. Van Dijck (2009: 161) proposes that the symphony orchestra, together with Clark's metaphor of "mindware" (2001b), offers a more appropriate metaphor than the connectionist metaphor to explain the function of memory. (Clark's metaphor of mindware counters the notion of the brain as a fixed set of neurons and genes by suggesting that the mind extends into the world through the use of "mindware", technologies and processes which includes the body and environment as necessary parts of the process of cognition.) Van Dijck (2009: 161) argues that akin to a symphony orchestra that needs a brass section, a string section and a percussion to perform a composition, memory is better understood

as an arrangement of combined efforts that results in a brief performance. He suggests that the extended symphony-metaphor may also account for recent neuro-scientific research that indicates that memories change every time they are “performed” by the brain (van Dijck, 2009: 162). Research by neuroscientists and clinical psychologists concurs that memories of individual experience are not ever perfectly clear and fixed copies of earlier experiences but are to a certain degree recreated each time they are activated (van Dijck, 2009: 162).

Sutton (2006: 282) sees a promising partnership in cognitive science between the investigation of memory and the independent set of concerns regarding “distributed”, “situated”, and “embodied” cognition, or “the extended mind” hypothesis:

these views share the constructivist stress on cognitive practices, by which internal representations are incomplete contributors in a context-sensitive system rather than fixed determinants of output: and they too focus on the ongoing interactive dance between brain and world through which, by forms of ‘continuous reciprocal causation,’ adaptive action results (2006: 282).

Kentridge intuitively exploits the possibilities described here, and confirms that the “stuff” of memory might stem from the external object itself as well as from the way the brain constructs it. He explains that his propensity to go back to images and objects from his childhood is less concerned with the objects themselves, and rather more an attempt “to use them as a talisman”, to retrieve something of the lucidity of sensation he would have had as a child (Cameron, 2001:71). Such a strategy not only displays an individual style in remembering, but also exemplifies what Damasio (cited in van Dijck, 2009: 163) calls an “emotionally competent object”. He uses this term to denote an event or object (such as seeing a painting or landscape, or listening to a song) that is at the source or basis of a brain map and provokes a particular sensation. Kentridge’s desire to retrieve a lost clarity of sensation harmonises with neuro-scientific theories that argue that what matters about the external object or memory trigger is not its material nature, but the content it represents (van Dijck, 2009: 164).

Unlike some cultural theorists who locate the “matter” of memory in the tangibility of mediated memory objects, van Dijck (2009: 166) would locate memory in their agency, “the way they interact with the mind”. Van Dijck (2009: 168) agrees with the extended mind view that new neuro-scientific insights are important evidence of a reciprocal shaping

of object/technology and brain/mind, but he expands this doubled-edged concept to suggest that memories are also mediated by the socio-cultural practices and forms through which they manifest themselves. This is so because although facilitated memories are physical prompts or prods for future recollection, produced by the pencil or some other medium, they are items of inscription and communication through which humans “perform acts of remembrance and communication at the crossroads of body, matter, and culture” (van Dijck: 171).

Kentridge’s anecdotes depict a methodology comprising a myriad of activities and relations – remembering and imagining, searching and discovering, doing and recognising, looking and moving, intentionality and chance. The complexity of such an ensemble of drawing, studio, charcoal, found objects and the leaps in between, is a far cry from a rational, linear train of thought. By recognising his reliance on these various agencies, Kentridge seems to support Clark’s (2008: 138) call to “sweep away the magic dust, sack the inner executive, [and] embrace the motley crew of cognitive processes and the fragmentation of the flow of control”. Clark (2008: 138) argues that the hypothesis of extended mind “allows us to see clearly that where ongoing human cognitive activity is concerned, there are usually many boundaries in play, many different kinds of capacity and resource in action, and a complex and somewhat anarchic flux of recruitment, retrieval, and processing defined across these shifting, heterogeneous, multifaceted wholes.” For Kentridge (1999: 119), “this reliance on Fortuna in the making of images or texts mirrors some of the ways we exist in the world even outside the realm of images and texts”.

## **2. Finding images somewhere between chance and reason**

### **2.1 “Images come so grudgingly”**

Kentridge’s confession that he “needs all the aids, stratagems and incantations” he can find because ideas and images “come so grudgingly” (Kentridge, 1999: 119) raises an interesting issue regarding the nature of the process of conceptual innovation and creation. His reliance on external devices to “find images” suggests that the notion of creative innovation provides a fitting proving ground for confronting the concepts of extended cognition with artistic practice.

Together with physical work Kentridge identifies found objects as important non-theoretical facets of his work – “a kind of poetry of necessity” (Kentridge and Breidbach,

2006: 111). Kentridge (1999: 118) remarks that many artists surround themselves with images, objects and photos to act as talismans in the “finding” of images. Kentridge is interested in found objects

in a sense of things that exist in the world and are *recognised* as being part of what one wants to put into art rather than being simply *searched* for in the brain. One hopes for the process of recognition while walking around outside either looking for a piece of text or for an object to draw, hopes to make a link between something that is already stored inside. One is constantly searching for a sense outside that corresponds, is referring or amplifying, what is inside (Kentridge & Breidbach, 2006: 111).

The design process likewise draws on found images and objects. Goldschmidt (2003: 85) postulates that one reason why architects tend to surround themselves with visual displays is because such displays provide rich sources of visual information (colours, spatial relations, shapes) that may prove to be valuable in future design tasks. Providing designers with visual displays has been shown to increase the rated creativity of architectural designer’s solutions, with a further increase when designers are explicitly instructed to use analogy in combination with these displays. Goldschmidt (2008: 85) relates these studies to evidence which shows that architects eclipsed other professionals – including artists and scientists – at isolating and identifying basic geometric shapes hidden in larger, more complex images. Together these results suggest that experienced architects are accustomed to scanning visual displays in search of “hidden” material that could be useful in their work.

## **2.2 “I do not search, I find”**

The notion of ‘finding images’ is also reminiscent of an often-quoted statement by Picasso in which he claims: “I do not search, I find”. Goldschmidt (2002) is not prepared to buy into Picasso’s statement, and suggests that we may safely assume that if Picasso did indeed find successful solutions “it is because he was constantly on the hunt: his search mechanism was always “on”, though in the background most of the time, unconsciously, for the most part”. Goldschmidt (2002) suggests that “the treasure hunting instinct” may be a trait of particularly creative people. The search for “something to work on” is a notable part of the design process. Margaret Boden (2004: 31) is likewise sceptical of Picasso’s statement when she questions Picasso’s suggestion that no reflection is involved: “how did he know he found it, when he found it?”. Later, when Boden (2004: 142) attempts to relate creativity to the parallel processing found in connectionist networks, which do not use explicit rules, she concedes however that “one can almost imagine the

network saying, with Picasso, 'Je ne cherche pas: je trouve!' But the connectionist *trouaille* is decidedly less mysterious”.

### 2.3 “Skyhooks” vs. “cranes” – Dennett’s Darwinian theory of creative process

Daniel Dennett (2004: 273) also questions Picasso’s remark. In his outline for a Darwinian theory of creative intelligence, Dennett quotes Picasso’s provocative statement as the perfect expression of the “anti-Darwinian answer” to the question of “what then is a mind?

Picasso purports to be a genius indeed, someone who does not need to engage in the menial work of trial and error, generate and test, research and development; he claims to be able to leap to the summits of the peaks - the excellent designs- in the vast reaches of Design Space without having to guide his trajectory (he searches not) by sidelong testing at any way stations. As an inspired bit of bragging, this is *non pareil*, but I don’t believe it for a minute (Dennett, 2004:274).

When Dennett refers to design space this forms part of his broader interpretation and elaboration of Darwin’s theory of natural selection, which can be applied to a theory of design in general. Well-designed organisms are organisms that are “fit” for their environment (Thompson, 2009:62). How do we explain the existence of such organisms? Thompson (2009:62) positions Dennett’s approach as follows: “Dennett rejects the idea that we can explain design by appealing to a pre-existing Design (the Platonic option) or a conscious Designer (the theistic option). He describes such explanations as ‘skyhooks’ – devices hanging from the sky with no visible means of support that still do the heavy lifting in design space”. To explain design and designers, Dennett instead offers the notion of “cranes”. They function as accelerators which increase the speed of evolution beyond a chance accretion of tiny cumulative steps. Cranes such as sex and language are not inexplicable skyhooks, for they can themselves be understood as a product of evolution (Thompson, 2009: 62).

Dennett (2004: 274) argues that Picasso’s prolific output of drawings, which at times explore dozens of variations on one and the same theme, is evidence enough against the truth of Picasso’s claim that he did not “engage in a time-consuming, energy consuming exploration of neighbourhoods in Design Space”. Dennett rejects the “myth of the artist blessed by a spark of genius”. He suggests instead the possibility that we should appreciate works of human genius as the result of “time-consuming, energy-consuming processes of mindless search through ‘primeval chaos’, processes which tend to automatically preserve

fortuitous occurrences when they occur”. Dennett suggests (2004: 273) that a Darwinian explanation for the achievements of creative skill would depict the mind as a crane: “A mind is a crane, made of cranes, made of cranes, a mechanism of not quite unimaginable complexity that can clamber through Design Space at a giddy – but not miraculously giddy – pace thanks to all the earlier research and design, from all sources, that it exploits”. Consequently he suggests that Picasso did not have a miraculous skyhook but employed a superb collection of cranes instead.

The sketches Picasso made while preparing for Guernica have also stirred a recent, related debate over the nature of his creative process (Simonton, 2007: 329). The debate focuses on whether his sketches validate a Darwinian or non-Darwinian notion of how the creative process works. Rather than a systematic process that is driven by expertise, Darwinian theories propose a process of blind variation and selective retention. This view stands in contrast to arguments that creativity is just one particular manifestation of regular problem solving. In his book *Origins of Genius*, Simonton (1999) has extended this model to develop a theory of creativity according to which

creativity requires the generation of a certain amount of ‘blind’ ideational variants that are then selected for development into the finished product. These variants are blind in the sense that the creator has no subjective certainty about whether any particular variant represents progress towards the goal rather than retrogression from or diversion away from the goal (Simonton, 2007:331).

The creator accordingly relies on what is effectively a trial and error process which yields more ideas than are ever likely to be used (Simonton, 2007:331).

After careful analysis of Picasso’s sketches in terms of sequential and figural progression towards the final version of the painting, a range of independent judges concurred that the creative process underpinning Picasso’s Guernica, is best described as Darwinian (Simonton, 2007: 340). It appears as if the artist proceeded by first gathering several possible variations of each main figure and only at a later stage selected the final image from that set. Simonton argues that the fact that the final selection would often be one that emerged earlier in the series of sketches, is evidence that creativity relies on a process of blind variation in which Picasso could only see where he was going once he got there (2007: 340). We are here reminded of Kentridge who had to wait about a year and a half before he understood that the erasures were part of the meaning and interest in his films.

Kentridge's unpredictable creative process, driven by diverse imagery and associative richness, certainly seems to lend support for Simonton's account. While Kentridge actively explores forms of agency that reduce control and invite chance, he positions his form of artistic agency as "something other than cold statistical chance, and something too outside the range of rational control" (Kentridge, 1999: 119). His active pursuit of making connections, taking leaps, encouraging indeterminacies and recognising solutions challenges and exceeds a straightforward, systematic, logical process. Kentridge moreover agrees that this "rather arcane way of working" generates a large amount of images that have to be rejected (Kentridge, 1999: 119).

In response to anti-Darwinian fears that a Darwinian account would diminish "the Finder, the Author, the Creator", to the extent that it vanishes, Dennett (2004: 276) proposes that "we should recognise that the boundary between authors and their artefacts should be just as penetrable as all the other boundaries in the cascade [of cranes]". Like Clark, Dennett extends Dawkins' view according to which the beaver's dam is equally as important to the beaver phenotype as its teeth and fur, to propose that the boundaries of the human creator are similarly responsive to extension. Dennett argues that each individual mind will itself be made up of multifarious parts, including "a cascade of higher-order reflection devices, capable of generating ever more rarefied and delimited searches through pre-selected regions of the vast space of possible designs" (Dennett, 2004: 277). Dennett believes that it is important to recognise that genius is essentially the consequence of natural selection and entails an extended series of generate and test procedures.

The notion of improvisation provides a different angle from which to look at Dennett's ideas on the relationship between self and its debt to all earlier "research and design, from all sources". Rosalind Krauss' (2000: 10) discussion of Kentridge's reliance on Fortuna draws on philosopher Stanley Cavell's concept of an "automatism"—used by him to relate to what in traditional art might have been called the "broad genres or forms in which art organizes itself". Cavell (cited in Krauss, 2000: 10) explains that "in mastering a tradition one masters a range of automatisms upon which the tradition maintains itself, and in deploying them one's work is assured of a place in that tradition". An automatism [medium] is "a peculiar blend of the kind of liberating release of spontaneity that we associate with the Surrealists' invocation of the word 'automatism' and the set of learned, more or less rote conventions (automatisms) contained within the traditional media" (Krauss, 2000: 11). This allows for improvisation as well as the opportunity to test the



validity of a given improvisation. “Reliance on formula seems to allow the fullest release of spontaneity” (Cavell cited in Kraus, 2000: 11).

## **2.4 Between chance and reason**

Krauss (2000: 11) relates Kentridge’s technique – “something other than cold statistical chance, and something too outside the range of rational control” (Kentridge, 1999: 118) – to Cavell’s notion of improvisation. The quandary of choosing between absolute mechanisation of chance or utter submission to total organisation is resolved by “the taking and seizing of chance – which is another way of naming the capacity to improvise” (Krauss, 2000: 11). Both improvisation and automatism carry weight within this process.

“Improvisation now names both the freedom and the isolation of the artist operating without the guarantees of tradition” (2000: 11). In invoking Fortuna, Kentridge acknowledges much of this. The automatism he found works itself out in a continuing series where his methodology positions procedure before meaning in the hope that it will bring about meaning: “the hope is that without directly plunging a surgeon’s knife, the arcane process of obsessively walking between the camera and the drawing-board will pull to the surface, intimations of the interior” (Christov-Bakargiev, 1998: 112).

Kentridge shows no unease, no fear that his reliance on “Fortuna” would amount to “a loss of selfhood”. He does not succumb to the temptation “to establish principled boundaries or to erect polar opposites between insightful and blind processes of search” – a temptation that Dennett (2004:279) perceives as reverting to the old essentialist Cartesian viewpoints. He therefore does not need Dennett’s (2004: 277) advice that the creator “must learn not to be oppressed by the revelation that on close inspection, even on close introspection, a genius dissolves into a pack rat, which dissolves in turn into a collection of trial-and-error processes over which nobody has ultimate control”. Perhaps the source of Kentridge’s comfort is his belief that however one finds an image, “however you come to it, even if it seems to be entirely directed by the medium or circumstances, in the end the work will be about who you are. It will be revealing who one is. I think it protects you from the idea of self-knowledge, which you think you are going to express. It opens you up to discovering much more about yourself or about the world” (Kentridge & Breidbach, 2006:12). His perception thus denotes a critique of the expressionist view by acknowledging that only by letting go of yourself, entering into a rough-and-tumble with the world, do you end up discovering that you have revealed something about yourself.

### 3. Drawing as a model for thinking

As a particular mode of thinking, drawing has thus far been presented in terms of an interplay between issues of representation, computation, dynamics, embodiment and situatedness. If we assume Kentridge's conception of drawing – drawing as a slow-motion form of thought – and view it as a model of how to construct meaning, it holds potential as a space or an interface on which to map an exchange of ideas between Clark, Dennett, Kentridge and various other people who have thought about thinking. The intimation of drawing as a search space in the preceding discussion provides a point of entry to engage with Clark's (2002a) exploration of Dennett's ideas on skills and mind-tools, on the one hand, and contents and vehicles, on the other. Dennett's (2000) foregrounding of skills and mind-tools moves the focus from basic notions of internal representations and computation to pay attention to the intricacies of agent-environment interaction in which “no mind-tool or class of mind-tools are (sic) essentially privileged in an explanation of thought and understanding” (Clark, 2002a: 89). It is striking to see how this scenario plays itself out within the drawing act.

#### 3.1 Tools and skills matter most – back to Heidegger

According to Clark (2002a: 68), in Dennett's view of the nature of cognition “tools and skills take centre stage and ... the primary ‘vehicles’ of content are the embodied capacities of whole agents embedded in a cultural and ecological niche”. Dennett rejects the idea that “anything worth calling a representation” (in the world or in the head) is considered fundamental. “What is fundamental are the skills bequeathed by the tools that build know-how tacitly into the system” (Clark, 2002a: 67). Dennett distinguishes between explicit and implicit or tacit ways in which information may be embodied in the system: “Explicit representations, by themselves [are] quite inert as information bearers...they become information bearers only when given roles in larger systems” (Dennett quoted in Clark, 2002a: 68). This is only possible if the system is so designed that it moves and acts in the world or go from one representation to another. This again requires it to be part of a system that has acquired some tacit knowledge (“know-how”), which are able to put the representations to work. Tacit knowledge is consequently fundamentally of greater value than inner codes and internal representations (Clark, 2002a: 68). In Dennett's depiction of what *matters* about minds and persons, intelligence and meaning, tools and skills are

positioned at the centre of the embodied capacities – a vision which Clark views as “startlingly close to a Heideggerian vision of the nature of cognition” (Clark, 2002a: 68).

Clark (2002a: 69-72) identifies three sub-themes that are prominent in Dennett’s work: firstly, biological cognition is augmented and transformed by external tools, secondly, external symbols “somehow pave the way for ‘florid representing’”, and thirdly, “florid representing” is what sets apart a genuine “understander” from a mere “believer”. The view that external tools provide the types of internal reasoning and external manipulation that *fit* our pattern-matching brains, bodies and evolutionary culture is a theme pursued by Clark in his own work on the extended mind.

### **3.2 From a scratch and a muddle to clarity**

To explain how these tools got there in the first place, Dennett proposes that our minds have the ability to “recognise” or discover tools when familiarising ourselves with “found objects” (Clark, 2002a: 70). He proposes that certain kinds of “tool-discovery-procedure” are the outcome of blind trial and error learning, and not a process of pre-conceived design where thoughts about the fit between tools and problems guide a search for good tools (Clark, 2002a: 69). The suggestion here is that “recognition of tool/problem fit, if fit comes at all, may well come after the event of successful use” (Clark, 2002a: 70). In such a scenario an initial “playing around” and a mere “familiarising themselves with objects in their environments” may well lead to the spotting of affordances (Clark, 2002a: 69). Kentridge’s open ended process where “you start with a scratch and a line and a muddle and you try to find clarity” (Auping, 2009: 238) seems to rehearse Dennett’s insight. “Drawing, at least for me, is always turning a corner, and I can’t always see what’s around the corner. In a sense, you just keep drawing”. He elaborates later: “In the hope that it will turn a corner, and reveal something I cannot see at the beginning” (Auping 238).

Recognising the power of these tools opens up the space for thinking about thinking, which enables what Dennett (2000: 18) calls “florid representing”: when representing appreciates that you are manipulating something that *represents*, something that is about other objects, it is “deliberate”, “knowing”, “self-conscious”. This “knowing”, “witting” or “florid” representation depends on the previous unknowing use of external objects, and so is just a special case of found objects as tools (Clark, 2002a: 71). These objects enable us to acquire the *idea* of representation, which then primes the development of more mind-tools.

Dennett's Heideggerian sounding claim that "words do things with us" (quoted in Clark, 2002a: 70) can easily be extended to "images do things with us". While Dennett emphasises language, Kentridge believes that drawing is the first step towards most imaging (Auping, 2009: 244). Auping, responding to Kentridge, relates Vasari's notion that drawing is the "purest form of thinking"; learning to draw then turns out to be one of the first steps towards understanding what representation is all about (Auping, 2009: 244). For Kentridge drawing is rather an activity that gets close to being a visible external equivalent of an invisible internal process: "Drawing and all art making is about negotiating the space between what we know and what we see" (Auping, 2009: 244). For Kentridge, the strategies of drawing – of working from an empty piece of paper and uncertainty towards marks on paper to which meaning accrues – are pertinent to many other forms of thinking (Auping, 2009:245).

Clark (2002a: 82) detects a potential tension between Dennett's emphasis on "skilled engagement between agent and world" as the origin of all content, on the one hand, and his view of "florid representing" as generally the sign of "real understanding", on the other. Clark suggests that seeing how these notions interlock is critical to understand Dennett's account – an exercise that offers a constructive view on the relationship between doing and knowing within drawing. Clark (2002a: 82) explains the fit as follows:

The objects (the manipulanda) involved in florid representing bear the contents they do only in virtue of a bedrock of skills and capacities, rooted in multiple non-propositional mind-tools. But florid representing depends on making those skill-based contents into *objects* suitable for the exercise of *other* (non-propositional) skills – skills of combining, shuffling and so on. And it is this "objectification" of certain aspects of content that supports the highly versatile and open-ended range of thought characteristic of (and perhaps uniquely characteristic of) human understanding.

This view does not privilege any type of vehicle of content to support "real understanding". Real understanding emerges instead from the interactions between these multifarious mind-tools (Clark, 2002a: 82).

### **3.3 A different route to knowledge**

Kentridge's studio is a place of such interaction, which he describes as a "full frontal assault" of the manifold processes and thoughts in which an artist may be absorbed at the same time (Scopa, 2012). He often reminds us that "the non-verbal discoveries" generated

from this “multiform engagement” are not easy to translate from the workplace to an interview or lecture room. Kentridge perceives the artist’s capacity to work on multiple aspects as depending on the fostering of a “necessary stupidity”. “The necessary stupidity refers to the activities which you can’t really explain in a rational way... as soon as you start to explain them rationally, they are extremely foolish and don’t have a logical sense, but nonetheless are extremely important” (Scopa, 2012). He thus underlines both the value and the nature of non-propositional content.

Kentridge’s deliberate abandonment of linear thinking and his commitment to the image suggest that he is in active pursuit of such non-propositional knowledge not accessible through rational thinking. Dennett suspects that such non-propositional aboutness is fundamental to our cognitive machinery (Clark, 2002a: 80). Dennett is critical of the notion of “content capture” in the study of intelligent systems (Clark, 2002a: 80). He argues that we should not assume that wherever a contentful state is present, “there is an accurate and exhaustive propositional description of the content of that state”(Clark, 2002a: 80). An example of “non-propositional aboutness” would be a cognitive operation that gives “something about redheads”, which although contentful, should not be treated as implicit beliefs or anything that can be “linguified”, propositionalised or sententially captured (2002a: 80).

Kentridge’s position on such content is clear as he regularly questions the ability of language and logic as the primary medium to arrive at meaning. As the 2011-2012 recipient of the Charles Eliot Norton Professorship of Poetry, Kentridge makes this bold statement in his series of lectures delivered to the Harvard audience: “Argument and logic [become] something on top of the world, hovering over its surface rather than embedded in it” (Kentridge, 2012). To assert his belief in the primacy of visual knowledge Kentridge approached his series of lectures as an artist rather than a scholar. He called the lectures “drawing lessons”. This notion that the image is fundamental to cognition can be interpreted as a subtle critique of the “privileged status of the more traditional, scholarly forms of knowledge in which much of Harvard’s community is engaged” (Scopa, 2012). Kentridge argues that artistic practice is a mode of generating knowledge that “shouldn’t be viewed simply as a form of supplement or afterthought that takes place once the important work of, say, philosophy, or some other discipline has been done” (Scopa, 2012).

Guercio (2008: 55) identifies “coevolutive coorigination” as an important aspect of Kentridge’s understanding of drawing, where “seemingly independent realms – such as those of subject and object, individual and signs, energy and matter, seeing and knowing – are revealed as co-dependent by the very coupling through which they both arise”.

Kentridge (1999: 30) alludes to the dynamics of co-origination, co-dependence, and co-arising in his appreciation of the fluidity of drawing and his interest in a “multi-layered highway of consciousness, where one lane has one thought but driving up behind and overtaking it is a completely different thought”.

Kentridge’s understanding of drawing as a “kind of model of how we live our lives” indicates his intuition that creativity is a “generic activity” which cannot be tied solely to particular areas of competence, nor accounted for according to fixed formal, linguistic or conceptual classifications (Guercio, 2008: 54). Guercio perceives Kentridge’s emphasis on “generic” aspects of creativity as a revival of the early appreciation of *techné* as any form of human ability that brings something into being (Guercio, 2008:55). As a generic human attribute, creativity thus acts as “a sort of primary agency” which mediates between diverse and co-dependant reciprocal dimensions of events and experiences. Guercio (2008:55) regards both “generic creativity” and “creative coevolving” as key aspects if we wish to understand “drawing’s capacity to manifest to the senses the extrasensory agencies of the mind and the imagination.” In this way, drawing – as an example of florid representing – “augments awareness in its visual, emotional, cognitive, and existential components” (2008: 55).

Barbara Stafford (2008: 44) suggests that the various modes of art making could reveal something “about the intricate ways in which the frontal region of the brain dynamically and actively switches between functions – automatically scanning and then suddenly willing to pay attention – rather than statically performing preset tasks or obeying a linear logic.” Stafford (2008: 45) argues that art is a principle example of “willed perception imaginatively and publicly working on the world. This outward-directed attentiveness to the thereness of an object, not just to our private experience of it, captures aspects of high-level cognition such as intention, design, and selection, bringing them back into the circle of awareness”(45). Stafford (2008: 45) argues that “preattentive seeing, like the varieties of memory, the secondary consciousness, and other automatic physiological processes or bodily functions – taken together – becomes amplified by selective attention and conscious conceptualisation.” Kentridge’s (Kentridge and Breidbach, 2006: 71) expansive view of

drawing as “a diagram of the way we make sense of the world, constructing, filling in gaps, trying to find coherences” similarly recognises that the strategies and discoveries of artists are applicable beyond the sphere of art.

Such an understanding of drawing resonates with the notion of *disegno*, or drawing, found in writers and artists of the Italian Renaissance, as a medium that both brings about and surpasses the arts of architecture, painting and sculpture. For Vasari *disegno* basically amounts to the same as ‘idea’, meaning that “drawing produces not so much representation of a pre-existing reality but *events of consciousness* that are lived and reified in the signs jotted down on a sheet” (Guercio, 2009: 56). The notion of *disegno* ranked art and knowledge as equal in worth, “appreciating creativity as *lived experience* guided by mutual transmigrations of subjects and objects, images and existence” (Guercio, 2009: 56). *Disegno* demonstrates that the connection between the inventive performance of a technical know-how and the process of becoming human is not one-directional but is a matter of co-development between human being and environment, artificial and natural things (Guercio, 2009: 56). In this manner it offers a more tangible picture of Dennett’s (and Clark’s) emphasis on tools and skills – a picture that shifts the notion of cognition to embrace all the tools and strategies that support our adaptive success (Clark, 2002a: 20).

However, this still does not address outstanding questions regarding what opened the door or primed our human brain to create and use these powerful external symbol systems (Clark, 2002a: 20/28). As a model of generic creativity and an event which envelops all the conscious and unconscious, imaginary and perceptive dynamics by which images come into existence through embodied experience, drawing could help provide such insight.

## Conclusion

The overarching aim of the research for this thesis was to investigate the extent to which theories of embodied thinking and extended mind can help us to understand the act of drawing. To do this I consulted a wide variety of theoretical and empirical studies of drawing, dispersed across a variety of disciplines, and tried to relate them to such theories of “embodied” or “extended” cognition. From all this emerged an integrated picture of drawing as a constructive thinking act. Such a picture challenges the notion of drawing as “expression” – the idea that a drawing is nothing but a *post hoc* exteriorisation of a prior interior mental process.

A second, related, aim of my research was to investigate whether drawing can contribute to a better grasp of what Clark (2002a: 29) calls “the range and variety of cognitive scaffolding, and the different ways in which non-biological scaffoldings can augment (or impair) performance on a task”. My conclusion is that it can indeed, as the many scenarios of drawing (e.g. fine art, mathematics, science) can be said to augment performance in a variety of different ways. This conclusion leads to insights into cognition, representation and creativity broadly construed.

The dominant – computational – approach in cognitive science runs into serious difficulties when it tries to account for the fluidity and flexibility of the cognitive processes involved in more open-ended cognitive domains such as planning, design and the arts. It is the multidimensional, imprecise, ambiguous, amorphous and indeterminate nature of conceptual innovation in these domains that poses a challenge to the restrictive structural properties of traditional computationalism. From my research I conclude that by viewing the external drawing processes as tightly coupled parts of a cognitive system, the extended mind theory offers a powerful conceptual tool to not only re-think these domains of human cognition, but also to understand, order, formulate and revise how drawing practice functions within these domains. The evidence regarding drawing, in turn, supports the Extended Mind argument that processes occurring outside of the brain, and at times outside the body, can form part of cognitive processes.



In order to approach the larger questions just outlined, this thesis is ultimately about smaller, more circumscribed questions. An important matter that required attention is to establish what the role of drawing is in the cognitive process: what does the physical process of drawing enable in a subject that would otherwise be impossible or unlikely? Along the way more specific questions were addressed, regarding how thinking with images is different to thinking with words and symbols, what sketching can do that cannot be done internally by mental imagery, which modes of cognition are facilitated by drawing, and how and when contemporary practitioners use drawing as thinking.

The extended mind hypothesis, with its emphasis on complementarity, offers a framework to identify the many quite different roles that drawing can play in the cognitive process. A key role that drawing is found to play in multiple contexts is to *draw* to the surface implicit, previously unavailable information, so as to make it available to other procedures and to the cognitive system as a whole. Clark and Karmiloff-Smith's Representational Re-description model of cognitive development helps us appreciate how drawing can serve such a wide variety of ends. According to their model, the constructive facilities of drawing are partly the result of its ability to generate "representational change whereby the mind enriches itself from within by re-representing the knowledge that it has already represented" (Clark and Karmiloff-Smith, 1993: 495). The Representational Re-description suggestion that these further representations "allow us to manipulate and exploit our knowledge in increasingly flexible, and mutually independent, ways" (Clark and Karmiloff-Smith, 1994: 494-495) is found to be applicable to a range of drawing scenarios.

The above-mentioned roles are closely related to the conceptualisation of drawing as a complex space where tacit knowledge co-exists and co-evolves with explicit knowledge, in a way that does not assume a clear distinction between doing and knowing. While this distinction has been questioned by many thinkers before, the Representational Re-description claim that explicit re-representation plays an important role in enabling knowing-how to *become* knowing-that has significant implications for appreciating drawing as a constructive thinking act. It makes the physical processing and manipulation of the environment a crucial extension of our minds.

A challenging property of this kind of know-how is the inherent tension between its value on the one hand and its elusiveness on the other. While doing the research for this thesis, I was struck by how often the act of drawing is to be found at this elusive junction between

doing and knowing, and in how wide a variety of contexts, for instance mathematics, cognitive science, design and the arts. Different fields approach the issue through different questions. In cognitive science, for instance, the issue is addressed by asking questions about representation. In those studying mathematics, the question asked is how mathematicians in fact arrive at their results. The emerging consensus across such diverse fields seems to be that the messy process of doing is much more important than the traditional focus on explicit knowing would ever have made us suspect. In the traditional view practical doing was taken to be dependent on theoretical knowing. Thinkers like Merleau-Ponty, Dewey, Heidegger, Wheeler and Dennett allow us to show instead how dependent theoretical knowing is on practical doing – a complete reversal of emphasis.

Drawing is shown to function as a mechanism through which disparate zones of experience are mediated and forced into a productive exchange with each other. I argue that this mediating role explains *why* drawing is found at the intersection of other related dichotomies encountered along the way. At each encounter drawing straddles the dichotomies between image and word, theory and skill, science and technology, knowing-how and knowing-that, body and mind, public and private.

In drawing one engages simultaneously with what is drawn and the process of producing the physical drawing. The drawing act entails a complex procedure in which perception, action, and conceptual processing are inextricably integrated and intertwined.

Neurophysiological and behavioural evidence indicate that in utilising the skills required for drawing, specific spatial schemata and interrelated motor procedures are developed to direct attention and augment perception. It can thus be argued that a range of cognitive properties unique to artists is not the result of an innate talent but rather the manifestation of the discerning utilisation of acquired perceptual strategies originating from, and dedicated to, activities like drawing. The act of drawing filters or guides perceptual, affective and cognitive attention and behaviour in ways that are peculiar to brains coupled with pencils and other drawing materials.

Chapter 2 attended to the theoretical difficulty of explaining how the complex range of physical and mental skills involved in drawing should be conceptualised. Taking Sutton's views on the development of skills as my point of departure I extended my argument that a sharp separation between doing and knowing is inappropriate for the domain of drawing, arguing that in this domain the intelligence of the body and a deliberate mental focus need

to reinforce each other if the person drawing is to shape the physical and mental skills referred to above. Clark proposes that we broaden the notion of internal representations so that they become much more action orientated. Such a broadening helps us to understand that the function of the internal representations involved in drawing is not to passively encode information, but rather to actively control and structure this dual engagement viz. doing and thinking. Clark argues that while such complex embodied skills are better conceived as dynamic, active and context sensitive, an appeal to inner and outer representations is still necessary to explain how mental techniques are used to influence ourselves in action.

Wheeler proposes that a Heideggerian approach to understanding representation could be beneficial. Using his mapping of different Heideggerian modes of encounter, we can position drawing as a mode of encounter which covers a broad spectrum of cases intermediate between doing and knowing. While smooth coping (doing) and the theoretical attitude (knowing) are distinct modes of encounter with the world, drawing is better perceived as falling in the complex intermediate domain of the 'un-ready-to-hand'. As a kind of practical thinking, drawing may sometimes approximate theoretical reasoning. Heidegger's claim that we come to know the world theoretically only once we have come to know it through handling is a theme that re-emerges throughout this thesis. Heidegger describes such action-orientated knowledge as producing its "own kind of sight". Wheeler proposes that the spectrum of modes of knowing identified above could establish a counterpart in the range and character of explanations in cognitive science. Smooth coping will accordingly invite more action orientated and non-representational dynamical system explanations while more theoretical encounters in the present-at-hand will invite explanations that are more computational in nature.

Empirical evidence that skills from more open-ended domains such as visual art are transferable to other contexts supports Sutton's view that to develop and enact high levels of skill does not require the intellect to be isolated from our accomplished embodied performances. It suggests instead that achieved fluency in such skills can give access to extraordinary flexibility in connecting thought and action, knowledge and procedural memory. In the light of this flexibility, strikingly evidenced in the drawings of children once they achieve drawing proficiency, Karmiloff-Smith argues that the mind is "endogenously driven to go beyond behavioural mastery" and to re-describe, or re-represent, its knowledge to itself. Our increasing cognitive flexibility is thus the result of getting better at

accessing the information and abilities that we could not access before. Through practice or re-representation such information, which previously may have been available in principle, but was still only implicit, becomes explicit. Through successive re-descriptions of pre-existing knowledge (in the system), this knowledge becomes more open to insightful control and conscious and reflexive exploration (by the system).

The representational redescription model thus sheds some light on our ability to develop the capacity to reflect on our own thoughts and thought processes. Over time we begin to structure our external world in ways to promote better thinking. As result of repeated interaction with such elements of cultural structure our plastic brains factor in the functioning and information-bearing role of such external scaffolding into our cognitive routines. Chapter 3 briefly explored the role of drawing – as graphic image and visualisation – in such expanded cognition. Compatible with Heidegger’s ‘own kind of sight’ is Ihde’s account of inscriptions as a kind of technology-enhanced perception that makes the world accessible in ways impossible for naked perception. Once mastery of it is attained drawing, like any other skill, becomes transparent, in the sense that we henceforth experience and perceive through it. Drawing serves as an example of a hermeneutic technological relation, which presents a special interpretative action through which all sorts of rich imaginative and perceptual phenomena can be seen and experienced. As a readable technology it ‘upgrades equipment’ to extend hermeneutic capacities through a kind of ‘seeing as’. While it mimics sensory perception, it is instead a referential seeing. As a technological prop in which our biological brain learns, matures and operates, it unmistakably falls in the domain of what Clark calls “cognitive technology”.

The historiography of science has traditionally given little consideration to the epistemological importance of producing images because the image was never conceived of as a resource for meaning. Peter Galison’s investigation of the role of drawing in the work of the physicist Paul Dirac reveals for instance that even though drawing had a “profound influence” on the production of his results, Dirac chose to hide this fact. That he hid the role of his drawings is indicative of a longstanding status hierarchy where skills and image are perceived to be of a lower order. Part of the reason the cognitive functions of drawing have up till recently been so neglected and undervalued would then lie in its association with know-how, skill and image.

More recent attempts to get closer to the technical contents of discovery, experimentation and representation in knowledge production show that the visual image often accompanies – and is probably often even constitutive of – productive intellectual work. Whereas the results of a mathematician are expected to take an explicit formalised form, the actual process which leads to these distilled results often involves a lot of open-ended inscriptions. As a source of intuition and a means to promote modelling, analogising, pattern completing, approximating, extrapolating and imagining, such imagery has an important place in mathematical and scientific practice. I briefly rehearsed a number of arguments, some of them referring to historical and other empirical evidence, for the indispensability of images to our own ability to understand a myriad of processes or phenomena. It is argued that the apparently mutually exclusive poles of putative dichotomies such as doing and knowing, skill versus theory, words versus image and science versus technology or art are better viewed as overlapping actions, intersections and collaborations, which are critical to advancements in human cognition.

When Latour claims that attention to the “humble practice of re-representation” shifts the locus of science and manages to “eat up” the two extremes of the “representing mind” and the “represented world”, he comes close to the extended mind theorists’ insistence that such practice is part of a cognitive system. By extending cognition beyond the brain and into the world, we get to appreciate drawing as not merely “what is in between” – not simply the resource for a mind to gain access to the world – but rather *that by which mind emerges*.

Neuro-scientific evidence as well as observations of theory and practice in the domains of mathematics and science indicate that the capacity for scientific and mathematical intuition and reasoning depends on the interplay between multiple mental representations. Studies of the use of images, models and inscriptions suggest that drawing, in tandem with other linguistic and symbolic representations, interacts with, mediates between, and co-ordinates a variety of content-relevant internal representations. By facilitating perceptual inferences and simulation processes, drawing bypasses constraints in existing propositional and formulaic representations, and utilises different abilities and memory stores. Drawing is better understood as a *component* of reasoning processes, rather than as a *mere aid* to such processes, since it helps scientists and other scholars to “control and guide the shape and contents” of their thinking in Clarkian (2008: 44) terms.

From science, with its propensity to ‘hide and filter out its mediators’, our study of drawing moved to the domain of design and the arts, where the process of mediation is better acknowledged. The historic and contemporary literature on drawing frequently acknowledges the sketch as a strategy to stretch mental capabilities rather than being a process which merely expresses pre-thought ideas or imitates the visible world. I review various attempts to understand the diverse mechanisms by which the sketch serves to stretch mental capabilities and stimulate (visual) invention. Several thinkers reject an instrumentalist view of the drawing act and celebrate this kind of drawing for its ability to produce a particular form of knowledge, differing from that typically validated in academia. Terry Rosenberg (2008) argues that, due to its potency in the process of innovative thought, such drawing needs to be viewed as an epistemological object. As an epistemic act the sketch is built into the very heart of the designer’s and artist’s cognitive routines. Clark (2008: 75) proposes that such repeated problem-solving routines should be thought of in terms of meta-cognitive commitments – where the availability of useful information or procedures on which certain cognitive routines depend need nowhere be represented in the brain. This rather radical approach holds the potential to explain why designers and their sketches are so enmeshed.

The ‘ideational drawing’ is also evidence of what Clark calls a certain species of thought where words or images are not always rooted in pre-existing thoughts – this being exactly part of what makes drawing such a fertile thinking space. The operation of such second order cognitive dynamics is likened to the mangrove swamp, where – against our preconceived expectations – the trees come first and the island second. This principle can be observed in the ideational sketch where a partial reversal occurs when it is the properties of marks that give rise to the thoughts that the sketch is finally taken to express. The notion of an ensemble is another conceptual tool used to describe the complex, nested and non-linear interaction between different dimensions and properties of the sketch. While recognising that the virtues of the ensemble cannot be reduced to the virtues of its distinctive parts, the discussion identifies and unpacks components of the ensemble for the purpose of discussion.

As a performance that “engages the body in a temporality that is rememorative, present and anticipatory all at once” (Noland, 2009: 17), gesture plays an important role in facilitating the complexity and simultaneity described above. Section 2 of Chapter 4 gathered a range of approaches which issue in the notion that gesture engages multiple

dimensions of mind. Noland (2009: 2) claims that gestures bring forth kinaesthetic sensations, which afford an opportunity for interoceptive awareness, and also that a field of reflexivity and the intervention of culture is opened up “at the very moment when the situated subject must make propositional sense (meaning) of what she feels” (2009: 10). At the moment when sensations become available to introspection they must be mediated by language or visual imagery to transform the inarticulate workings of the nervous system into the articulated experience of a particular subject. This idea resonates with Clark and Karmiloff-Smith’s (1993: 571) suggestion that knowledge stored in a particular representational format needs to be redescribed into a suitable format in order to become accessible to other processes and representations from other domains.

Gesture interacts productively with other information gathering processes provided by mind and body. While gesture in drawing is geared to accomplishing a task or leaving a mark, it involves a dialectical interplay and binding between elements trading in different kinds of encoding and information. In this dialectical interplay seeing, imagining, doing, theoretical reasoning and more are found to modify each other mutually and continuously, and to activate and harness each other to generate new representations. McNeill and Goldin-Meadow’s research on the cognitive role of gesture suggests that gestural and verbal thinking differ quite radically in the kinds of information they encode, and that the disparity between unlike modes of thinking acts as a fuel propelling thought and language. If the dialectic is the point at which the two dimensions intersect, as McNeill argues, this allows us to explain the generative role of gesture within the drawing act.

McNeill and Clark adopt Vygotsky’s notion of “material carrier” and expand it so as to make gesture the materialisation of imagery. The imagery referred to here is not of a photographic kind but rather a spatial-actional imagery in which form directly embodies meaning. McNeill’s research suggests that gesture expresses its own unique aspect of an underlying idea. Gesture can embody multifaceted loadings and meanings – semantic, pragmatic and poetic (expressive/communicative, operational/technical, and rhythmic/exploratory). It thereby expands the set of representational tools beyond the digital format of words. Because gesture adds nuances possible only through visual or motor formats, the act of drawing can be viewed as an organismically extended process of thought, not merely a motor-act that expresses some prior, already complete neurally realised, process of thought. Drawing as performative gesture thus accesses a dimension of thinking that the analysed and segregated semantic units of words cannot describe.

Shaun Gallagher draws on such research to support his account of consciousness and cognitive processes as being shaped and structured “pre-reflectively” by the fact that they are embodied. He uses the term pre-reflective to indicate how hidden these aspects of the structure of experience are to us, as they happen before we know it. As a pre-reflective performance, gesture orientates the body and paves the way for conscious acts of perception, memory, imagination and judgement in important ways. The act of drawing arguably shapes or structures experience in a way similar to gesture. Crucially, it also often involves gesture itself in order to accomplish thought.

The form-giving drawing act results in a stably present product – the drawing – which makes thought visible to the draftsman anew. Once the cognitive system has been extended through the creation of the inscriptions on paper, the trace left by gesture presents a condition of possibility for signification. An ever-present potentiality for meta-cognitive dynamics existing within any marked surface or image is repeatedly suggested by various theories covered in this thesis. Reinterpretation and emergence – new ways of seeing the drawn representation – constitute an important theme in this literature. The various manifestations of this phenomenon offer further empirical support to the earlier suggestion that information which may have been available in principle was previously so entangled and enfolded, and thus hidden, that it needed the sketch to become unfolded, laid open and revealed. It was striking how insistently this theme – the ability of the sketch to make manifest or explicit what was hidden or only implicit – recurs in the literature

Viewing the sketch as a dialectical situation is reinforced by the investigations of Goldschmidt. These suggest that sketching serves to *extend* imagery within a systematic dialectic, which involves a circular feedback loop between inner representation in (mental) imagery and external representation on paper. Extensive research suggests that the sketch performs as “interactive imagery” in which the sketch “talks back” to reflect the sketcher’s personal, tacit and other not yet used knowledge, preferences, concerns and needs. The drawing dialectic seems to generate and strengthen ideas by the propensity to read more information off the sketch than was presented in its making. Because an extended ‘ping-pong’ pattern between two modalities of visual reasoning – analogical reasoning and reflective observation – was detected only while sketching and nowhere else, sketching seems unique in its ability to induce this dialectical pattern.



To a large extent, design thinking and reasoning is found to be embedded in the act of drawing. Because designers' drawings play such a major role in guiding the shape and flow of their thinking, such drawings present an opportunity to account for the connection between external and internal mental structure. Clark's (2008: 59) observation that such cognitive relations "def[y] any simple logic of inner and outer" is found to be manifest in a process better described as a reliable problem-solving routine – "delicately geared to automatically factor in and exploit, on pretty much an equal footing, both internal and bio (external) forms of information storage" (2008: 41).

Designers often use the sketch together with words to facilitate finding superior solutions. It was found that there is no neat division between the roles that words and images play, as they are often used together to complement and broaden the knowledge base available. Nevertheless, investigations into the relationship between semantic and propositional knowledge on the one hand, and image-based knowledge on the other, indicate a very low proportion of common associations between semantic and imagery conditions. Words seem to help us retrieve more propositional or conceptual knowledge, whereas images help us retrieve more perceptually grounded knowledge. This would explain why designers, mathematicians, scientist and artists often use both word and image. This suggests that a subtle but dynamic interplay between different types of knowledge functions as a kind of hybrid representational vehicle to activate a variety of content-relevant internal representations.

Echoing suggestions from the domain of mathematics and science, empirical evidence from the domain of design suggests that the familiar ambiguous attributes of sketches contribute significantly to supporting and stimulating visual invention. Instead of assuming that these external formulations are mere recapitulations of a pre-existing inner code, this thesis endorses the Extended Mind view that these external formulations import their novelties, both *qua* structure and *qua* content, into our cognitive sphere. Such a view requires a more deliberate consideration of how and why the properties of sketches shift and productively reconfigure perception and cognition.

A broad range of contributions was identified which support Clark's theory that structural novelty allows an array of processes and manipulations that would not be naturally available to the naked brain. The designer uses and manipulates a series of representations to transform one set of knowledge about people, behaviour and goals into another set of

knowledge about artefacts, connections, structure and physical properties. It is argued that the nature of sketches is such that they promote this transformation in ways that finite and precise representations cannot. Analysis of the properties of sketches indicates that their characteristic syntactic and semantic density and ambiguity facilitate and amplify mental imagery. The sketch probably exploits innate mechanisms geared to pattern recognition so as to engender a flow of imagery conducive to invention. Because it manipulates the environment, the more accessible format of the sketch transforms the problem space so as to complement and exploit our natural abilities to recognise and match patterns, as well as to manipulate the environment.

While recognition and suggestion rather than prediction are what is operative in this domain, the importance of experience and skill in emergence should not be ignored. Research shows that the ability to interpret and take advantage of these representational characteristics depends on how rich the person's knowledge of the domain is. A sequence of marks on paper or physical gestures could never implement a cognitive process in their own right – their cognitive role emerges in synchrony with essential forms of neural activity.

Through a survey of findings from design research, section 4 and 5 of Chapter 4 established that in tandem with the benefits of productive dialectics and emergence as indicated in the preceding discussion, sketching plays a variety of additional roles to enable and promote the kinds of cognitive operations typical for design thinking. It not only allows us to compensate for limitations in human memory and information processing capacity, but also exploits our enormous capacity for pattern recognition, allows us to cope with large amounts of information and let them come into play, facilitates decomposition and sequential processing, reduces or simplifies complex information and preserves alternatives. Because things in the world act or function differently from things in the mind, the sketch – as an external representation – provides not only (external) storage, but also for new forms of (external) computation. External representations can be extended in space, rotated, manipulated, rearranged and interacted with in ways that internal representations cannot.

By providing a surrogate situation, the sketch relaxes constraints and counteracts premature commitment to ideas; it helps to identify aspects of concern, relationships and patterns, brings focus and generates new knowledge. It does this by accessing not only

information that is implicit in internal cognitive structures, but also knowledge that is implicit in external inscriptions. The complexity of many design endeavours would quickly overwhelm individual reason in the absence of environmental offloading. There is abundant evidence to suggest that the performance of what has been referred to as “a mental juggling act”, turns out to be the product not exclusively of mechanisms located in the designer’s brain, but rather of massively distributed mechanisms that extend across brain, body and environment.

Towards the end of the thesis the South African artist William Kentridge’s sophisticated and eloquent insight into his own working process is invoked for the rich and constructive support for the theory of extended mind which it provides. Kentridge’s non-heroic, non-individualist account of his work captures the active, generative spirit of creative cognition without prioritising a brain-bound vocabulary. Because drawing “insinuates itself into the way he thinks” (Auping, 2009: 228), Kentridge’s practice serves as a good illustration of the extension of a cognitive ability – when cultural practices and representations “get under the skin and transform the processing and representational structure of the cortical circuitry” (Menary, 2012: 152). His practice goes beyond a mere embedded and scaffolded account of cognitive abilities – the practice itself is part of the cycle of cognitive processing and not merely causally supportive of in-the-head processes.

With no reference to theories of cognition, Kentridge intuitively recognises the generative role of his process and medium. His *modus operandi* deliberately exploits what he considers the natural condition of “continuously trying to solve riddles, making predictions of order, trying to make things make sense” (Kentridge and Breidbach, 2006: 60). The myriad of activities and relations comprising drawing, remembering and imagining, searching and discovering, doing and recognising, looking and moving, studio, charcoal, found objects, intentionality and chance – and the leaps in between – exceeds that of a rational, linear train of thought. Kentridge’s commitment to the image and a less scholarly route to knowledge suggests that he is in active pursuit of forms of non-propositional knowledge that are not accessible through rational thinking. His claim that his process is not about an active intelligence, but rather about a category of recognition, suggests that our conventional conceptions of intelligence, creativity and agency need to be refashioned radically so as to do justice to the complexity of thinking.

Kentridge employs the general term Fortuna to describe a range of agencies which he exploits to find ideas and images, which otherwise “come so grudgingly”. Kentridge’s process deploys distributed cognition as a “dispersive agency” which suspends or delays the present to generate “an expanded presence”. Drawing thus expands his mental state by what Clark (2008: 74) would call its “delicate temporal integration of multiple participating elements and processes”. His studio presents a picture of human intentionality as a distributed, emergent and interactive phenomenon rather than a mental state situated exclusively within the subject.

The idea that drawing provides a search space and serves as a strategy to ‘find images’ adds a significant dimension to our appreciation of creativity-as-cognition as a transformative coupling to external conditions. Creative cognition is here embedded in exploring and transforming a self-generated search-space, rather than an *ex-nihilo* invention. The foregrounding of the role of extra-organismic representations alerts us to the materiality of the creative process. The materiality of creative practice is further underlined by the abundant evidence that artists and designers surround themselves with images, objects and displays which serve as potential sources of images, and that such displays increase the rated creativity of solutions. It suggests that creativity is not a special kind of brain state but is intimately related to the ability to search and find something for the neural system to work on.

The notion of found images raises questions that engage with broader theoretical and philosophical attempts to explain creativity. Daniel Dennett’s (2004) attempt at a Darwinian explanation of creativity chimes with insights from the domains of art and design practice. They all concur that on closer inspection, the notion of creative genius is less mysterious than often suggested and that genius instead is itself a product of the taking and seizing of chance. In the picture emerging from this approach artistic originality and scientific discovery share an underlying pattern which essentially involves processes of trial and error and leaps into the dark.

Kentridge has made the suggestion that drawing, as a slow motion form of thinking, is in effect a paradigm for illuminating thinking in general. Bold as this may seem, my research for this thesis has convinced me that drawing indeed has a lot of merit as a model of how we construct meaning in general. As a paradigmatic example of how quite inert information bearers are given roles in larger systems (Clark 2002a: 68), where “you start

with a scratch and a line and a muddle and you try to find clarity” (Kentridge in Auping 2009: 238), drawing was shown to be extremely instructive for cognitive science. Drawing displays cognition as a dynamic, multidimensional phenomenon “in which no mind-tool or class of mind-tools is essentially privileged in an explanation of thought and understanding” (Clark, 2002a: 89). Dennett’s assertion that our minds have the ability to recognize or discover tools when familiarizing themselves with found objects is strikingly played out in the sketching act. What emerges is a view of how explicit, implicit and tacit information all put each other to work, with “real understanding” emerging as a result.

The cognition enacted in drawing proves to be a good context in which to explore questions about where cognitive processes reside. It demonstrates that cognitive activity can be distributed across bodily repertoires and rituals, coupling and coalescing dynamically in real time within complex and variable physical, technological and social parameters. By extending cognition beyond the brain and into the world, we come to appreciate that external drawing processes in a cognitive system are as important as, and sometimes even indistinguishable from, “internal” ones. We arrive at a conception in which the marks on paper are viewed as part of the apparatus responsible for the shape and flow of thoughts and ideas. It is shown that drawing is in several respects indeed best viewed as an active, tightly coupled part of a cognitive system, which not only supports cognition, but also “drives cognitive processes” (Clark 2008: 220). The varieties of memory, tacit knowledge and skills become amplified as drawing mediates between diverse, co-dependent and interacting perceptual, conceptual, physical and computational dimensions. Drawing thus illuminates how representational re-description has the capacity to elicit a sort of primary agency, which is not uni-directional but co-evolves between “internal and external forms of representation and computation, epistemically potent forms of bodily action, and the canny exploitation of a variety of extra-bodily props, aids and scaffolding” (Clark, 2008: 219).

The research gathered in this thesis has borne out not only that the extended mind thesis can illuminate drawing, but also that a consideration of drawing in turn enriches the extended mind thesis. While the extended mind view helps us to understand the enduring value of the generative capacities of drawing, the domain of drawing in turn provides abundant evidence to support the extended mind claim that some processes occurring outside the brain and body deserve the name “cognitive processes” as much as those occurring in the brain or body. The practice of drawing furthermore provides rich and

convincing evidence to support the idea that (and demonstrate how) mental processes are indeed embodied, embedded, enacted and extended.

Clark proposes that real understanding *depends on* making our skill-based, non-propositional mind tools into objects suitable for other, propositional and non-propositional, skills. I argue that the non-propositional nature of the sketch accordingly makes it particularly suitable to function as a clue to how “real understanding” emerges from the re-representational act. A bolder claim would be that drawing illuminates *par excellence* the first moment when the human mind begins to understand the nature of representation. Because drawing is an activity which emphasises ‘generic’ aspects of creativity, the strategies of drawing can be extended and applied to other contexts of human endeavour.

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