

The Ontology of Cognitive Systems

John Ravenscroft



Ph.D.

University of Edinburgh

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Abstract:

In this thesis, I shall explore the theoretical and empirical expositions regarding the causal mechanisms of cognitive growth. I shall do this in order to determine if biological epistemic theories of cognitive systems can be justified.

It will be necessary in this thesis for me to adopt a multidisciplinary stance from Philosophy and Psychology. It will try to investigate from these two perspectives what it means to be a cognitive creature. However, I shall argue, if taken singularly, each standpoint fails to provide an adequate account of cognition that is necessarily based on adaptive, evolutionary constructs.

During this thesis I will primarily focus on the major arguments in Philosophy that show a tight coupling between language, cognition and rationality. More specifically I will examine in detail Donald Davidson's holistic account of what it is to be a rational, cognitive creature. I will show in the thesis, through comparative experimental evidence, that the causal mechanisms of cognitive growth, and thus thought may not be language. Consequently, Philosophical arguments that are based on tight relationships of thought and language will not be able to deliver a true account of cognition. I will demonstrate that Davidson's philosophy has suffered from not being able to ground his philosophical perspectives on the relationship of language, cognition and rationality within an empirical programme and consequently it makes fundamental errors. Davidson's account does not take on board the recent (and not so recent) empirical based work on primates which show the possible mechanisms of cognitive growth, which are independent of language.

Similarly, I will also show that Psychology, which does provide us with the means to deliver an empirical account of cognition, due to its history based on Behaviourism, does not have the right causal mechanisms nor language to talk about the nature of complex cognition. I will show how Associationistic Psychology mischaracterises what it is to be cognitive and consequently, like philosophy, cannot deliver an accurate ontology of cognition.

I intend in this thesis to provide a bridge between the two schools by adopting a comparative psychological approach. By using this comparative perspective, a more accurate theory of cognition may be possible and one that is not contaminated by language or any other cultural symbolic systems. I aim by the end of the thesis to be in a position which will hopefully allow modification of Davidson's condition on possessing beliefs, a creature must have beliefs about beliefs. This modification will be based on an evolutionary account of what may or may not eventually turn out to be the precursors of higher cognitive states.

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Declaration

I hereby declare that this thesis was composed by myself and the work presented herein is my own.

John Ravenscroft
Edinburgh
Wednesday, 21 March 2007

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Appendix

Published Works: Poster Presentation International Conference

McGonigle B., Ravenscroft, J., & Chalmers, M. (2001) Self organised memory strategies during unsupervised visuo-spatial search tasks by monkeys (*cebus apella*) and very young children. *8th European workshop on memory and cognition, St Malo, april 1-3.*

1. The Problem of Cognition

Aims

Chapter 1 introduces some of the main themes that will be explored throughout the thesis. Such that

- a) Why we should accept an evolutionary continuity view of cognition*
- b) Why modification of Davidson's position must be made because*
- c) the causal mechanisms of cognitive growth are not language dependent*

This chapter briefly introduces the claim made by Donald Davidson that knowledge of other minds is basic to any creature that has thought. Davidson argues that this knowledge can only be obtained if one is in communication with others. Thought is something that only language using creatures have. This Davidson's claims is the bar that has to be reached in order to be a rational animal, an animal that is a thinking rational creature, an animal that has thought. But is this view correct? This chapter will begin to explore other possibilities such as looking for and defining what are the criteria for awarding certain sorts of cognitive states to certain kinds of creatures? To investigate the possibility that to have sophisticated thought may not depend on being a language user at all and to start to determine what 'states' can legitimately be given to non-linguistic creatures. This chapter details how through Darwin and the theory of natural selection, 'Psychological Behaviourists' took up the Darwinian notion that showed that there was a continuity of mentality between man and other animals and developed an empirical paradigm that became the initial foundation of objective psychology itself. Chomsky and others soon saw significant difficulties with the behaviourist approach to the adaptive learning of linguistic man and non-linguistic creature and as a result this approach mischaracterises what it is to be cognitive and consequently cannot deliver an accurate account.

1.1. Introduction

We know that all sorts of creatures display rational behaviour, for example we see squirrels store nuts for the winter, a cat will avoid going into the neighbour's garden when the neighbour's dog is around. However, every action that provides a useful function cannot stake a claim to be a rational, cognitive action. What we need to know is whether these 'rational' actions and many more like them are performed merely out of instinct or by some acquired habit or are they a result of some other causal mechanism(s), which ends in a planned and intentional cognitive act.

I, like Descartes and Donald Davidson "*know for certain that thought exists*" (Davidson, 2004, p5) for if we doubt the existence of thought, surely that doubt is a thought. What I am not sure about, which is what I will try and answer in this thesis, is what creatures have it, what are the indicants of thought and is thought wholly dependant on some other feature, namely language. In answering this, it will be necessary for me to examine whether it is possible for a creature just to have a single thought or does a creature need to have many? If so, just how many thoughts are necessary if a creature is to have thought and can there be a graded scale of thought?

It has been claimed that in order to identify a rational cognitive agent, one that has thoughts, one must in part observe rational behaviour (Davidson, 1963). However, it does not necessarily follow that what underpinned the rational action is a rational architecture, for we could observe and interpret the behaviour of others through descriptions that are not psychologically or physically real. For example, we could say that X performed that rational action Y because the homunculi inside that creature's head had a series of look-up tables (Searle, 1972, 1997, 2001). This is not the way to proceed. Therefore, what I will try and do in this thesis is to examine the work of Davidson and apply his theories to recent comparative evolutionary empirical findings to determine if Davidson's position that thought is *something that only communicators have* applies. From the comparative evidence presented I will argue in this thesis that we should accept an evolutionary continuous account of cognition and therefore modification of Davidson's stance should take place.

1.1.1. Is a cognitive creature *only* a creature that has language?

This thesis will try to explore is something that is fundamental to Psychology and Philosophy. It will try to investigate from a philosophical and psychological stance what it means to be a cognitive creature, to be a rational thinking agent. Key issues in this investigation will be discussions relating to the position that human beings, by virtue of being language using creatures, are the only creatures that have the ability to reason about others mental states? However as Povinelli and Vonk (2004) state there are a whole range of other logical possibilities that will need to be reviewed. These are;

- a) the capacity to reason about mental states may be shared by many species
- b) that it may be unique to primates
- c) that it may be unique to some primates
- d) that it may be unique to humans alone
- e) different aspects of the cognitive system may be present in different species.

Povinelli and Vonk, (2004) and Povinelli and Eddy, (1996)

Is, Davidson correct when he states, that only a creature that is the interpreter of another is a cognitive rational creature. (Davidson, 2004). Davidson's claims this is the *bar* that has to be reached in order to be a rational animal. But is this view correct? Surely there are other possibilities, for example, should we not be thinking more epistemologically, and

- i) look for and define what are the criteria for awarding certain sorts of cognitive states to certain kinds of creatures,
- ii) investigate the possibility that to have sophisticated thought does not depend on being a language user,
- iii) to determine what cognitive states can legitimately be given to non-linguistic creatures.

Thinking more epistemologically several questions arise, one is, are there other creatures who are as complex as us but just do not have language or is it that they do not need to be **that sophisticated** to be thinkers and that Davidson is wrong to put so much into thinking and language

In order to answer these questions we need to understand what cognition is; and what it is used for, and what are its components? For example, is being able to reason, a rational adaptive feature of cognitive intelligent systems. This view suggests that cognition stems from an evolutionary history and is not a ‘knee-jerk’, hard-wired reactive system. We must also consider the evolutionary path that leads to rational creatures for Alasdair MacIntyre (1999) suggests that

“...it is of the first importance that what we thereby become are redirected and remade animals and not something else. Our second culturally formed language-using nature is a set of partial, but only partial, transformations of our first animal nature. We remain animal selves with animal identities.
(MacIntyre, 1999, p49)

MacIntyre views rational non-human agents not as agents that only have behaviour that is produced by biological forces, but as rational, active, explorative and capable of detecting relations in their environment. That is, he sees animals¹ as being able to engage with the environment, act upon it without prompting and detect relationships that exists between categories and act upon that relationship.

“The causal relationships between animals and their environment are thus of a number of different kinds and the explanation of animal behaviour is at different points in the scale, as more and more weight is given in those explanations to the ways in which different species take account of features of their environment in developing complex forms of purposeful behaviour.
(MacIntyre, 1999, p59)

MacIntyre opens a possible way to look at how creatures may have sophisticated thought but does not require the necessary condition of language. The ability for a non-linguistic creature to develop reasoning competences would for MacIntyre be a sure sign that that creature would be a cognitive agent. It would be an animal that can utilise the relationships that exists both internally and externally and use those relationships for purposeful goal directed behaviour.

However, in order to understand how agents can utilise relationships it will be necessary to look at the qualitative and quantitative aspects of cognition, and the evolutionary aspects of cognition with respect the Davidson’s arguments as to the legitimacy of requiring language in order to be a sophisticated cognitive creature. Darwin sums up the qualitative and quantitative argument between man and animal

¹ Mainly primates and dolphins.

argument nicely; those that hold to the qualitative argument would agree with the following “*the difference in mind between man and the higher animals, great as it is, certainly is one of degree, and not of kind* (Descent of Man, p193), and those that hold with the quantitative argument would posit “ *the lower animals differ from man solely in his almost infinite larger power of associating together the most diversified sounds and ideas*’ (Descent of Man, p 131).

To study ‘minds’ through the notion of a linguistic representation, as does Davidson among others, one essential question is: what are the early forms of representation that deserve to be called ‘*mental*’? And how, through evolution or through other processes do these representational structures scale up to higher cognitive and/or linguistic functions?

Is a necessary condition for developing a thought having/sharing the characteristics of creativity and of systematicity that many such as Fodor, (1975) claim underlay human thought. Is that capacity restricted to external language users as Davidson would claim?

I agree with Heyes, (2000) that descriptions of cognitive states and processes are ‘theoretical identities’, which provide a functional characterisations of operations within the central nervous system. That is, I am materialist about cognitive states, but I want to stress that I do not see cognition as a one to one mapping with neural states and processes. You cannot directly observe a cognitive state, therefore only by developing a hypothesis relating to cognition and testing the effects of manipulating the external environment on behaviour through experimental paradigms, can one deliver an account of cognitive states. I also acknowledge that cognition may or may not be part of consciousness awareness. This thesis will not be concerned about the role consciousness plays in the cognitive process, that is, I am not tying cognition to consciousness. I also see cognitive processes receiving inputs from other cognitive states and processes and from perception, and have outputs to other cognitive states and processes and of course to behaviour. How exactly these inputs and outputs work will also not be the subject of this thesis.

1.1.2. What is the role of Ontology?

The word *ontology*² has created a lot of discussion in many disciplines, Philosophy, Psychology, Artificial Intelligence (AI), and Computer Science. Philosophical accounts in the past have focused on the subject of existence, where ontology is a systematic account of existence. But now ontologies are seen and used in a variety of means. Not only are they common place in AI and Engineering, but ontologies are now often seen on the World Wide Web. One of the best known definitions of what ontology is Gruber's (1993) where "*an ontology is an explicit specification of a conceptualization*". Gruber claims an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. An ontology, he further suggests is the statement of a logical theory and is often equated with taxonomic hierarchies of classes. Ontologies are also not limited to conservative definitions, that is, definitions in the traditional logic sense that only introduce terminology and do not add any knowledge about the world. He claims that to specify a conceptualisation one needs to state axioms that do constrain the possible interpretations for the defined terms.

However, this definition has been criticised by Guarino (1995, 1999) she writes that the main problem with such an interpretation is that it is based on a notion of conceptualisation which does not fit our 'intuitions'. According to Genesereth and Nilsson, (1987) a conceptualisation is a set of *extensional* relations describing a particular *state of affairs*, while the notion we have in mind is an *intensional* one, namely something like a conceptual grid which we superimpose to various possible state of affairs, rather like a Kantian notion of thought.

In the simplest case, an ontology describes a hierarchy of concepts related by subsumption relationships; in more sophisticated cases, suitable axioms are added in order to express other relationships between concepts and to constrain their intended interpretation.

Blazquez *et al* (1998) states that the ontological development process has to be done in four distinct phases.

² (Its history stems from works such as Plato's *Sophist*, (Heudegger, Rojcewicz, and Schuwer 1997)

- The first phase he calls ‘Specification’ and in this stage the ontology needs to be explicit about why the ontology is being built and who are the end users that are going to be using the ontology.
- The second phase is called “Conceptualization” and leads to a structured domain knowledge.
- The third phase is called the “Formalization phase” – this is really the process that the conceptual model transforms its self to a more formal model which could be machine understandable.
- Finally, the “Implementation” phase sees the formal model developed in the last phase turn into a computational or cognitive model.

This methodology has been used widely in AI and can be seen commonly in the cognitive science community and in cognitive vision based systems. (Maillot, Thonnat and Boucher (2004). Ontologies, therefore can said to provide a rich conceptualisation of the working domain of an organisation, which represent the main concepts and relationships of the activities involved. (Middleton, Shadbolt and De Roure, 2004) Ontologies provide us with a classification structure and instances within a knowledge base. As such, ontologies can provide a *theory of content*, made up of statements that are falsifiable, statements that attempts to describe concepts and relationships within systems.

However, after more than a decade of discussion, the AI community, in particular, still has not reached complete consensus on what precisely an ontology is (Musen, 2004; Ellman, 2004) and I do not aim in this thesis to add to that debate. But I would like to view ontology as the heart of knowledge description. As such I will adopt Bachimont (1995) perspective that the aim of ontologies is to define which primitives, with their associated semantics, are necessary for knowledge representation. That is ontology can be composed of several entities such as (a) set of concepts, (b) set of relations, (c) set of axioms.. This is a more neutral way of defining ontology and is more akin to ‘theory’ than other previous commentators have used ontology, but by using the word in this way I will be able to examine other ontologies/theories of cognition from a perspective that treats these ontologies as *theories of cognition*. Adopting this approach to ‘ontology’ will enable me to explore biological causal cognitive mechanisms and to examine how these ontologies or theories perform over

ontogenesis. Therefore, through out this thesis the term ‘ontology’ and ‘theory’ may be intermixed but will refer to the same meaning unless otherwise stated.

1.2. A Changing Landscape

It is interesting to see how the landscape has changed over the past few years. We see a considerable rise in interest in looking for an evolutionary programme that looks at defining what it is to be a cognitive agent (See Hauser, Chomsky and Fitch, 2002).

This hunt for the evolutionary antecedents of cognition has broad church appeal and thus my aim in this thesis is to explore by utilising a philosophical and psychological empirical stance, to determine whether Davidson’s position – *only language using creatures have thought* is still a valid position to hold with new paradigms and empirical methodology recently being developed.

I am interested in exploring what are the meaningful criteria to what constitutes rational behaviour. Is the criterion embedded in language, such that there is a tight coupling of language and thought. However one legacy of adopting this Cartesian description of rationally is that we are providing an argument for a cognitive *discontinuity* view of cognition. One which I do not support. Can this relationship of language and thought be separated? Surely it must, as there is *no* appeal to some evolutionary antecedence. It is this appeal that will be the primary focus of the thesis and I shall put forward arguments asserting that we should instead accept an evolutionary cognitive *continuity* view point of cognition.

I shall explore, other, cognitive mechanisms that are none linguistically based that appear to be ‘*necessary*’ if an animal is to be a rational creature. I will examine the evidence that suggests these mechanisms are distributed and shared through out the animal/human kingdom. Consequently identification of these mechanisms would falsify any appeal to a Cartesian description.

We will see in my thesis that there has been a paradigm and measurement revolution which has recently enabled the development of concurrent testing of relational codes. (McGonigle and Jones, 1971, 1975; McGonigle and Chalmers, 1977, 1998, 2001, 2003).

If it is the case there are now significant experimental paradigms which empirically show non-linguistic animals have sophisticated cognitive competences, how far can non-linguistic animals climb up the “cognitive ladder.” For example can non-linguistic creatures achieve the kind of representational cognitive states that Davidson claims are necessary for ‘true’ rational behaviour? That is, can these non-linguistic creatures have beliefs about beliefs? Or is there a state (for example; beliefs about beliefs) in which non-linguistic creatures, by virtue of their non-linguistic ability, never obtain? We take it for granted that language using creatures have thought and that language is either the expression of thought or it is the actual articulation of thought. But what kind of thinking creature would you have to be to have language? Is it, to be an interpreter of others or are there other creatures who are as complex as us but just do not have language?³

In order to try and answer these questions it will be necessary for me to explore,

- the indicants of thought without language.
- What underlies higher order representational constructs.
- Can non-linguistic agents achieve higher-order cognitive competences?
- If so, what (non-linguistic) behaviour would demonstrate the existence of higher-order competence?
- Can that behaviour be demonstrated empirically

I hope by answering these questions I will be able to

- (b) modify Davidson’s account of rational animal thought for he sets the level too high in demanding that in order to have thought one needs to have thoughts about thoughts
- (c) this modification will be based on highlighting examples of empirical comparative evidence which show sophisticated cognitive reasoning through organisation in non-human animals and this organisation appears not to be dependent upon the coupling of language to thought.
- (d) the empirical evidence will show that some non-linguistic creatures, through recursion will meet the systematicity challenge and
- (e) finally this thesis will discuss how these non-linguistic sophisticated cognitive mechanisms may be precursors to our human ability to have beliefs about beliefs.

³ For they may have no language faculty or even a vocal tract for example.

1.3. What Should an Account of Cognitive Systems Tell Us?

Part of this thesis will be to review and examine different theories of cognitive systems, focusing specifically on the development of biological causal cognitive mechanisms. In developing accounts of cognitive systems, I believe that the first criteria for any true characterisation of cognitive systems is to identify the causal indicants of cognition. The ontological floor, as McGonigle and Chalmers (1998) describe it. I propose that any descriptions of cognitive systems must answer a range of fundamental questions, although these questions in turn ask many more⁴. If answers to these questions can be found based on an evolutionary, empirical and scientific method of investigation, then these answers will have significantly contributed to the development of a characterisation of the cognitive agent, and will also have identified the core cognitive ‘ontological floor’ of cognition. As we shall soon see, learning across the animal kingdom cannot be reduced to the operation of a base of optimised associationistic principles but that many species possess a range of specific learning mechanisms, as Gazzaniga, Ivry, Mangun, (1998) put it, “.... *when one is trying to understand how the brain enables learning, one must realise that there may be several mechanisms, not just one*” (Gazzaniga *et al.*, 1998, p521), and what that means is that not all animals are equal, rather they possess different adaptive specialisations. There are important species differences (Herrnstein, 1989) so any account of cognitive systems and of the ‘ontological floor’ must reflect this difference. As van Geert, (1994) suggests, ‘

the problem is one of novelty, the construction of new developmental forms out of existing ones. One of the fundamental limitations of a growth model is that it does not explain where growers come from. (van Geert 1994 p.275).

Detailing the indicants of thought without language is not an easy thing to do. How does one deliver it? How does one go about developing tasks that establish not only a common currency of comparative measurement (species fractionation) but reflect homologous cognitive processes in humans and non-human animals (McGonigle and Chalmers 1977, 1986; McGonigle, Ravenscroft and Chalmers, 2000; Conway and Christiansen, 2001; Hauser Chomsky and Fitch, 2003)? One possible way of answering this is to examine non-linguistic, non-human behaviour but that leads us to asking, are the non-verbal behaviours in non-linguistic creatures that mirror those

⁴ which shall be asked and answered throughout this thesis

cognitive functions that are the same behaviours that are demonstrated in language-based tasks (McGonigle and Chalmers, 2002)? If any appeal is to be made to an evolutionary account of non-linguistic cognition over and above of any Cartesian account, it is important that the experimental evidence is equal to or matches that shown in standardised language based tasks. As I aim to contribute in this thesis an evolutionary perspective in determining *the degrees of thought* without language it is essential that any description of the indications of cognitive growth must take into account the causal role (or even non-role) of evolution.

1.4. The Role of Evolution: Continuity, Discontinuity, and Salutatory Evolution

Before we begin to discuss the work of Davidson and others it is important to examine the role evolution has played in the development of cognition. Darwin published several famous works on the theory of natural selection and the process of evolution (1859, 1871, 1872). Darwin brought something new to the old philosophy of Descartes, Locke and Kant, and that was a continuity mechanism of evolution called "*natural selection*." According to the theory of natural selection, differing traits within species will occur because of random genetic variation, providing the individual with a characteristic that is outside the normal distribution. This new characteristic will propagate itself amongst a species if it increases the creature's ability to reproduce, and thus this characteristic will increase in density throughout the population (Gaulin, 1995). Evolutionary theory thus suggests that life did not emerge by chance but by the slow and gradual steps of cumulative natural selection and by the non-purposive, non-random, differential selection of traits that confer on the animal a survival and reproductive capacity in its adopted ecological niche (Neilsen & Day 1999).

As mentioned above Darwin believed that you could not compare one species in terms of degree of evolution to others and certainly by 1880 there was an acceptance that life had evolved, but differences in the processes of evolution had begun to concern the philosophers of the time Wallace (1889). However, there were proponents that suggest cognition may not have stemmed from some gradual evolutionary continuous roots but from some form of salutatory evolution. This view suggests cognition may have occurred by some form of marked variations or *intervention*. This sudden change in the evolutionary process many have claimed, is language.

Macphail (2000) asserts that

“there is a major shift between humans and non-humans, namely, language”
(Macphail 2000, p258),

and that “

there is currently little evidence of differences, (and so no shifts in cognitive capacity) in what might be called general intelligence among non-human species” (Macphail, 2000 p257).

Macphail (1985, 1987, 2000) further suggests that there are *no* empirical paradigms that can discriminate cognitive ability amongst species, thus we should view all non-linguistic animals as the same,

“there are no tasks that differentiate among species as a consequence of differences in capacity rather than differences in such factors as motivation and perceptual or motor capacity. I have, accordingly suggested that we should adopt the “null hypothesis” – namely, that all non-human vertebrates are of comparable intelligence. (Macphail, 2000, p258).

As we shall see, I strongly disagree with Macphail’s position, however, the issue of empirical task differences and appropriateness is a valid one, and this theme of task design will be recurring throughout this thesis.

By examining philosophical and psychological accounts of the indicants of the causal mechanisms of cognitive growth from a broad-church and evolutionary perspective, will allow me to sample best methods and practices that psychologists and philosophers have used in order to deliver theory(ies) of cognition. The language of higher order cognitive representation has historically been based within the camp of Philosophers. Davidson (1982) suggests that there exists a necessarily tight coupling between language and rational creatures. However, I feel that these arguments are circular and I believe many of them are not empirically grounded and therefore need to be approached from a different perspective. Psychology, through its Behaviourist programme does provide us with the means to deliver an empirical account of cognition, an account that suggests that there is no dividing line between linguistic man and non-linguistic animals. So this looks like a good place to start.

1.5 Behaviourism: Evolutionary Continuity

Behaviourism, gave rise to the empirical experimental method of Psychology for it oversaw the transition from anecdotal methods to scientific observation in comparative psychology. Morgan's Canon featured heavily in this and also in comparative psychology around the time of the rise of behaviourism in the early 20th Century (Roberts, 1998). In Behaviourism, there is the view that there is continuity between man and beast.

“[Psychology] as the behaviourist views it is a purely objective branch of natural science. Its theoretical goal is the control and prediction of behaviour [it] recognises no dividing line between man and brute.” (Watson 1913, Abstract)

Watson (1913), Jennings (1907) and other behaviourists took the view that *“the ideal of most scientific men is to explain behaviour in terms of matter and energy, so that the introduction of psychic implications is considered superfluous”* (Jennings 1906). They believed that behaviour should be the only subject matter of Psychology, concepts of the mind, imagery and other mental events are inaccessible and had no place in objective science. This notion that we should exclude mental events as they are unobservable have been developed further by other associationistic approaches such as Skinner, (1945); Hull, (1934, 1945, 1952), and Spence, (1936). Watson himself thought that concepts of beliefs and desire were ‘heritages of a timid savage past’; *“medieval conceptions with magic and voodoo”* (Watson, 1913)

Since no dividing line was drawn between man and brute, Behaviourists believed that if laws, which governed learning, were discovered then these ‘generalised’ laws had to be applicable to all species. Due to this basic tenet, Behaviourist investigation looked at simple reflexive systems. It was a belief of Behaviourism that all instances of intelligent behaviour in animals would be explained on the bases of learned responses. That is, all learning and behaviour could be mapped out in terms of stimulus response or operant associations and of associative learning. The greater the number of pairings between stimulus and response and the greater the capacity for their acquisition the more complex the creature is, such that the differences between species could now for the first time be detailed quantitatively (Dickinson, 1980).

1.5.1. Empirical Darwinism – Argument for Continuity

It could be claimed that it was Thorndike who established the notion of laboratory experiments within comparative psychology with his twelve cats and puzzle box experiments.⁵ Briefly, the cats were placed into small crates, which were 20 inches by 15 inches in plan and 12 inches high. The cats were young, roughly between five and eight months old. Thorndike describes the cats as being in a state of “utter hunger”. The cats could escape the boxes and eat the piece of fish which was placed just outside the crate if they pulled on a piece of string or by pushing on a lever, depending on which crate they were placed in. During a series of trials, the cats gradually learned how to escape more quickly from the box, and this gradual reduction in time led Thorndike to conclude that what was going on was an unthinking, automatic improvement in the efficiency of the cats’ escape response. The theory posited by Thorndike is that there is a connection between the direct stimulus of being in the box and the response of pulling the string rather than any association of pulling the string and getting out. By 1910 Thorndike had formalised this notion into the "*Law of Effect*," which essentially states that responses that are accompanied or followed by satisfaction (i.e., a reward, or what was later to be termed a reinforcement) will be more likely to reoccur, and those which are accompanied by discomfort (i.e. a punishment) will be less likely to reoccur. When in the presence of a particular stimulus a response occurred that was followed by a reward, an association between the stimulus and the response was thus strengthened. The stronger the association between the stimulus and the response the more rapidly the response could be elicited by the stimulus. Thus, the beginnings of Stimulus-Response (S-R) learning theory were born. Two laws of association are important to S-R associations. A stimulus and response should occur in close contiguity and should be repeated frequently for their connection to be strengthened.

Thorndike extrapolated his finding to humans and subsequently maintained that, in combination with the "*Law of Exercise*" (which states that associations are strengthened by use and weakened by disuse) and the concept of instinct. The Law of Effect could explain all of human behaviour in terms of the development of a myriad of stimulus-response associations. Thorndike believed that animals had no mental life that was not concerned with the mediation between stimulus and response, (Thorndike,

⁵ Before him, all other animal experiments were naturalistic, in so far that the animals that were observed were free-range and were kept in open air conditions.

1898) and that as a result they fundamentally differ to language using creatures, which had ideas and impulses that were decoupled from reflex-like responses to stimuli. It is interesting to note that Thorndike saw mental evolution to the development of rational agents, as one from not 'little and simple' to 'big and complicated' but from 'direct connections' to 'indirect connections.' (Walker, 1983) which is a concept that has received a lot of attention in recent years (McGonigle and Chalmers, 2002, 2003; Glover, 2003 Arbib, 2003 amongst others).

Thorndike, his laws, and trial-and-error learning became the foundation for behavioural psychology, and the behaviourist position that *all* human behaviour could be explained entirely in terms of stimulus-response associations and the effects of reinforcers upon them. By explaining human behaviour in this way there was no need to interpret behaviour by referring to terms such as representation or transformations of representations for all human and non-human behaviour was elicited directly by stimuli.

Shuttleworth, (1998) points out there are four reasons as to why any account of animal cognition needs to consider the role of classical conditioning as outlined by Pavlov and then latterly by Watson. The first she calls is a quantity argument. Classical conditioning has been one of the most studied forms of learning in Psychology. Pavlovian experimental design has produced models for how other learning phenomena can be studied (Rescorla, 1988). It is through using conditioning as a base the issue of how to distinguish between different kinds of learning or cognitive modules becomes possible (Shuttleworth 1988). The second reason as to why one should examine Pavlovian conditioning is although it is viewed as a stimulus-reaction account of learning, there have been many examples of conditioning that have turned out to have complex and interesting cognitive content (Rescorla, 1998). The third is what I shall call the Canon or to use Bermudez's (2003) term the 0-level hypothesis. This is, when we need to ask the question "Can this behaviour be explained in only terms of as associative learning and nothing more?" when we observe any example of learning or complex behaviour. To answer this question we need to need to be familiar with the properties of associative learning in order to either confirm or reject the 0-level interpretation. Finally the fourth reason why Pavlovian conditioning is important to animal cognition is that the basic phenomenon of conditioning is phylogenetically widespread, (Macphail, 1996) and a creature's ability to acquire these Pavlovian

associations enable it to adjust to foraging, to fight or flee, and learn social relations such as dominance within a animal group (Clutton-Brock & Parker, (1995).

An early attempt at accounting for the behaviour of complex as well as simple creatures was made by Pavlov (1927) where he introduced the notion of operant and classical conditioning. The "classic" classical conditioning experiment conducted by Pavlov is as follows: A dog is hooked to a mechanism that measures the amount that the dog salivates. A tone is sounded just before a dog is given meat powder. This occurs several times. Eventually, conditioning occurs in that the dog salivates just to the bell alone. Pavlov used this relatively simple experiment as a model for describing much of the automatic/non-conscious learning that occurs in everyday life. A basic characteristic of classical conditioning, in comparison to, operant conditioning, is that the learning is automatic and non-conscious. Pavlov identified four basic components in this classical conditioning model. The unconditioned stimulus (US) is the stimulus that naturally and instinctively elicits the target response, which, in the case of his classic experiment is the meat powder. The conditioned stimulus (CS) is the stimulus that comes to elicit the target response, which was the tone in Pavlov's experiment. The unconditioned and conditioned responses (UR & CR respectively) are a little trickier to identify in that they are often the exact same behaviour. For example in Pavlov's experiment they are both salivation. The fundamental difference is that the unconditioned response occurs as a result of the unconditioned stimulus, and the conditioned response occurs in response to the conditioned stimulus. In the Pavlov experiment, the unconditioned response is salivation in response to the meat powder, and the conditioned response is salivation in response to the tone. Since Pavlov's seminal experiment there have been a variety of other conditioned responses studied, most of these follow the same design as Pavlov experimental procedure in that the CS is followed by a US which in turn elicits a UR (Revusky, 1968; Brown & Jenkins. 1968).

Using these methods Pavlov showed how non-human animals can make fine discriminations (something that Thorndike rejected) and he empirically demonstrated how higher order conditioning could be made. In one experiment Pavlov conditioned a dog to salivate whenever it heard the sound of a metronome. This sound then became the CR and once this CR was well established Pavlov introduced a second CS which has the sighting of a black square. The second CS was presented to the dog for ten

seconds, fifteen seconds later the original CS, the metronome was again presented to the dog. Eventually, after several presentations the dog began to salivate at the presence of the second CS. So what happened, according to Pavlov (1927) is that the metronome became the UR, allowing the secondary CS to become conditioned.

Pavlov (1909) suggested two mechanisms that lay at the heart of all behaviour. The first mechanism is the formation of temporary connections, and this is the mechanism that can explain how arbitrary stimuli are able to function as signals, although exactly how this happens Pavlov did not describe in detail (Pavlov 1955). The second mechanism, which is distinct from the first sort of association, is how the creature is able to perceive, classify and analyse the world.

“An analyzer is a complex nervous mechanism which begins with an external receiving apparatus and ends in the brain..” (Pavlov, 1955, p.215)

The Pavlovian view of learning and behaviour is that all activities (human and non-human) are reflexive and are produced by external stimuli in a mechanical base manor. Pavlov, though, did make a distinction between humans and non-human creatures. In the case of humans Pavlov saw speech as the diving line between the two (1927, 1955) for

speech is an expression of the fundamental signalling characteristic of cerebral cortex, but is also at the same time a second signalling system, which is language, which is self-contained and independent of the first signalling system, which is of non-verbal perceptions, which is shared by man and other creatures (Pavlov, 1955, p537).

The minimalist view of cognition was firmly entrenched into Psychology by Watson, for he in fact coined the term Behaviourism (Watson, 1913, 1925 1929). A key feature of Watson’s behaviourism was that there was a denial that mental events should be viewed as causes of overt acts and that any behaviour should be simplified to the types of conditioning as outline by Pavlov. However, Watson went further than Pavlov, by specifically excluding the possibility of any association other than S-R associations (Macphail, 1996). Watson did not allow for an association to be formed between two stimuli (S-S associations) only the strength of associations between responses accounted for all learning. Watson saw human rationality as the operation of stimulus and response habits. It is interesting to note that language for Watson were words, that equalled or had the same status as responses, that were uttered vocally or sub-vocally,

which were elicited by external stimuli. His belief was that human/animal behaviour was the result of ‘millions of conditionings’ during life and is not affected by any inherited predispositions.

Finally, no account of the behaviourist tradition could be complete without detailing the work of Skinner (1938, 1953, 1957). He believed that all learning was the result of two types of responses; respondent and operant learning. He did not believe that respondent conditioning was that critical to learning for he viewed this type of learning as seated in reflexes, that is to say the dog salivated as a direct response to food. However, he viewed operant (instrumental) conditioning as the critical element to learning and rational behaviour. Like other behaviourists before him he was also strongly opposed to the existence of any mental events. One of Skinner’s main assumptions is that we cannot directly observe mental phenomena and as a result they are "inferential." And thus should not be subject to scientific explanations.

"any mental event which is unconscious is necessarily inferential, and the explanation [which makes use of it] is therefore not based upon independent observations of a valid cause" (Skinner 1980 p39).

Skinner claimed that any scientific theory should not make use of inferred entities or phenomena at all. He does so not because he believes that the danger of “*inferential*” states is that theories that make use of them may not be falsifiable as Popper (1962) does but because mentalistic accounts are not genuinely explanatory and are typically redundant. Skinner suggested that mentalistic explanations really just restate the facts of behaviour in more obscure language and since mental states which are supposed to explain behaviour are themselves determined by external stimuli, they can safely be ignored. In other words Skinner believes that we should simply study the relations between stimuli and behaviour.

"Unless there is a weak spot in our causal chain so that the second link is not lawfully determined by the first, or the third by the second, then the first and third links must be lawfully related. If we must always go back beyond the second link for prediction and control, we may avoid many tiresome and exhausting digressions by examining the third link as a function of the first" (Skinner 1980 p42).

Skinner suggested that mentalistic explanations are also homuncular. He believes that when mentalistic explanations are applied they invoke a homunculus interpretation

with the same abilities as the creature/person has. Dennett (1978) has a similar argument regarding the explanation of rational action.

“Since psychology's task is to account for the intelligence or rationality of men and animals, it cannot fulfil its task if anywhere along the line it presupposes intelligence or rationality” (Dennett, 1978, p58).

However, even if we must explain rationality in terms that do not presuppose intelligence or rationality, it does not necessarily follow that intelligence and rationality should not be appealed to at all, or that they are ultimately unreal.

Skinner's theories on behaviour stemmed from, at that time, new experimental techniques and experimental findings concerning the behaviour of laboratory animals. The most famous of course is the Skinner Box, which is in a way an extension of Thorndike's puzzle box described earlier. His whole scientific programme was to uncover events that modified the probability of operants and to explain all behaviour, simple and complex, as a history of reinforcement (Macphail, 1982). In order to explain how complex behaviour can be described as a history of reinforcement, it will be necessary to relate one of Skinner's most impressive experiments. This experiment relies on the chaining of various responses as changes to response strength occur. Skinner trained a rat, not only to pull a piece of string, but also to pull a piece of string, which released a marble from an overhead track and into the box. The rat, seeing the marble would then pick the marble up with its two front paws and carry the marble to a tube, in which the opening was approximately two inches above the floor of the box. Once the marble was dropped into the opening of the tube, it released a food pellet and the rat was fed (Skinner, 1938). Skinner claimed that this complex sequence of behaviour is nothing but automatic responding in the sequence chain and thus no mentalistic description needs to be applied and that all behaviour should be reported as such.

1.5.2 Behaviourism and Language

As we have seen above the behaviourist program aims, via the study of animals, to identifying laws of generality, applicable not only to specific animals within an experimental setting but also applicable to all species in all environments. If this were so, such an analysis would be able to identify the differences between language using

creatures and non-language using creatures. Behaviourists viewed language in terms of an extended pattern of stimuli and responses, dispositions to verbal behaviour.

In *Verbal Behavior* (1957), Skinner argued that speech sounds are emitted and reinforced just like any other operant response. Some speech utterances make demands on the hearer and are reinforced as the hearer complies. For example, the child says "milk please", and is reinforced for that utterance when the parent provides the milk (for milk becomes the reinforcer). This function, called the "*mand*", appears early in the life of the child. Skinner based this idea on '*com-Mand*' and '*de-Mand*'.

A second function is related to a child's reference to non-verbal objects and the use of naming. It is called "*the tact*". For example, a parent may say, when in the presence of a cat, "cat". The child says "cat" in the presence of a cat (can be the same or different cat) and the parent would then say something like "good, that is a cat". A negative reinforcement would be for example when the child may say "dog" in the presence of a cat and the parent would correct the child and say "no, that is not a dog, but a cat". Tact is thus a verbal response occasioned by a nonverbal stimulus and reinforcement occurs through the praise for correct naming.

Skinner suggests that the acquisition of tact involves discriminative conditioning, whereby the same tact is reinforced in the presence of the "relevant" features despite variations in the irrelevant features.

A third term used by Skinner was what he called "*Autoclitic Behaviour*". This is verbal behaviour which is a comment or observation upon our behaviour by ourselves. An example of autoclitic behaviour may serve to illustrate the point. The primary [verbal] operant is the tact 'John is in Montreal'. If the speaker says "I hear that John is in Montreal" we have an example of autoclitic words in which 'I hear that' is a comment on a primary [verbal] operant that is presumably an echoic (that is, the speaker heard that someone say that John is in Montreal') (Paivio & Begg 1981).

The speaker talks about his role when he says things like "I was about to say... I hesitate to say... I am afraid to believe". Such autoclitic behaviours were assumed to comment upon other verbal response, designate their strength or allude to the effect on the speaker of the fact stated. Autoclitic processes were also assumed to apply to

verbal behaviour conditional upon other verbal behaviour. Given that you have learned the possessive, e.g., Fred's cat, John's home, etc., the sight of a cat with John is held to result in the tacting of John's cat. According to Skinner, similar word-position frames apply to the ordering of tacting adjective-noun and actor-action relations. Correct verbal operant and autoclitic comment will be positively reinforced by praise and said again, whereas incorrect grammar will be negatively reinforced.

1.5.3 Chomsky's Attack on Skinner:

Chomsky, in his now famous 1959 review of Skinner's verbal behaviour provided a stinging attack on the behaviourist account of language acquisition and showed comprehensively how any behaviourist account could not possibly scale up to cover the complexities of language, grammar and its acquisition. Chomsky's attack on Skinner has three approaches. The first of these deals with the problem of scaling up from simple to complex behaviour, the other "Stimulus Free" argument relates to the complexity of internal mental structures found within language using creatures in that knowledge acquired in language acquisition outstrips the information that is available in the environment. In other words, the output is underdetermined by the input. His third attack on Skinner is concerned with the way Skinner uses crude "behavioural" classifications of types of utterances, and their manifest inferiority to traditional linguistic classifications. For example, Skinner talks about "*mands*" where linguists differentiate between questions, requests, or commands — and so forth. Consequently, Chomsky claimed that there is more to language learning than imitation and reinforcement

Chomsky highlights the fact that there are a possible infinite number of sentences in any language (although this can be debated); and we know that it is impossible to learn all possible sentences through imitation and reinforcement and this fact is a significant problem for a behaviourist account of language. Behaviourism cannot account for the acquisition of all sentences in all languages, in other words if any behaviourist theory is true, then adults must be constantly training young children: differentially 'reinforcing' their correct and incorrect pronunciation, their correct and incorrect word usage — and their correct and incorrect grammar. However, as Chomsky highlights, this behaviourist contention is false.

"It seems quite beyond question that children acquire a good deal of their verbal and nonverbal behavior by casual observation and imitation of adults and other children. It is simply not true that children can learn language only through 'meticulous care' on the part of adults who shape their verbal repertoire through careful differential reinforcement, though it may be that such care is often the custom in academic families. It is a common observation that a young child of immigrant parents may learn a second language in the streets, from other children, with amazing rapidity, and that his speech may be completely fluent and correct down to the last allophone, while the subtleties that become second nature to the child may elude his parents despite high motivation and continued practice." (Chomsky, 1959, p. 42)

Chomsky noted that children acquire language quickly and effortlessly, and at roughly identical stages across cultures. This indicates that there is some internal structure at work, and that this structure is not a simple behaviouristic one that Skinner proposes where changes in the operant strength is brought about by reinforcement. This, for Chomsky shows that Behaviourism cannot account for all behaviour. Chomsky asserted that children learn the rules of language, and not just specific responses, as Skinner had proposed. This point is also emphasised in the example of rule learning given by Chomsky (1959). Semantic tokens like *goed*, *thinked*, and *eated* are not spoken by parents but are common over-generalisations made by young children when learning language rules, in this case the past-tense rule.

1.5.4 The Poverty of Stimulus Argument

But one of the most damaging criticism of the empiricist account of language acquisition is the "Poverty of Stimulus argument" or sometimes known as the "Stimulus Free Argument". Very briefly, the argument that Chomsky puts forward is that children's linguistic environments are too information-poor to sustain the developments of grammars, which are, by anyone's measure, information rich. The information deficit, suggests Chomsky, must therefore be provided by the child's innate endowment. There are two basically two versions of the poverty of stimulus argument. The first one concentrates on the very particular and specific grammatical constructions, for instance, Chomsky would claim that children can easily perform the following transformation of sentence *A* into the question *B* (see below) but almost certainly have not been exposed to even a single instance. (Chomsky, 1975, p31-32).

- A) *The man who is drinking is happy*
into
B) *Is the man who is happy drinking?*

However, this type of example has been criticised by Pullum (1996) by showing many examples of this transformation in conventional text. The other version of the argument has recently concentrated on conversions of pidgin languages to Creoles. Pidgins are largely a grammatical mixtures of languages/words all thrown together when speakers of Pidgins try to communicate. Creoles are fully grammatical languages which spontaneously emerge in the children of pidgin speakers. So, the argument goes, the stimulus – the pidgin, is information poor relative to the final production – the Creole. (Ravenscroft, 2004).

Chomsky believed that language-using creatures are biologically equipped to learn language, through the Language Acquisition Device (LAD) – which is an innate mechanism or process that facilitates the learning of language. This nativist theory, suggests that humans are born with the ability to discriminate among phonemes, to fast-map morphemes, and to acquire the rules of syntax, and more, thus revealing a complex internal structure – directly opposing the simple structures as outlined by Skinner and other behaviourists.

Not only was Chomsky's attack on Behaviourism significant other criticisms soon became apparent and I shall briefly discuss these now.

1.6 Other Difficulties of the Behaviourist Approach

Behaviourism as an empirical study into the behaviour of language and non-language using creatures has at its core the main underlying assumption that the same learning mechanism underlies all forms of learning at all levels of complexity in all creatures. This assumption was reached because of the experimental approach used. The behaviourist experimental paradigm showed that there was no fractionation between simple and complex behaviours. By showing that no distinction could be made between these behaviours reinforced the fundamental behaviourist belief that associationistic principles governed all forms of behaviour. However, the assumption of equivalence of association underlying behaviourist research has been conclusively

demonstrated to be false. Associations which are in accord with species-species defence mechanisms, or relate to innate fixed action patterns are much easier to learn than those which are not (Garcia, Ervin & Koelling, 1966; Bolles, 1970; Seligman, 1970).

- **Expected Associations**

It is also assumed by Associationists that when a creature learns the association between the CS and the representation of the US, that the strength of this association grows over repeated conditioning trials and that this is reflected in the strength of the CR (Roberts 1988). However, as we have seen, one of the main stock experimental paradigms of Behaviourism is the Thorndike and Skinner box type experiments which force the animal into making a binary choice between pressing a lever/pulling a string or not. What this does to the animal is that it makes the creature find the solution accidentally due to the fact that the creature does not have any kind of representation of the working functions of the apparatus. This is important because Rescorla & Wagner, (1972) have shown that conditioning proceeds only to the extent the US is unexpected or surprising to the creature. If the creature has no expectation that the US will occur, its presentation will lead to considerable associative learning. However, if the US becomes more and more expected, the CS-US association becomes less and less until eventually no learning can take place. Not only that but they have also shown that a previous CS can block the conditioning of a new CS and thus no associations can be made to the new CS.

- **Optimal Learning Times**

Another criticism of the behaviourist account of learning is related to when a creature itself learns. It has been suggested that learning has a cost implication compared to the alternative of relying on pre-programmed responses (Johnston, 1982). The cost to the creature could be in the guise of neural or genetic hardware in less than optimal behaviour (Thrun & Sullivan, 1988). Therefore, is there an optimal time for when animals should learn, or should learning take place in all situations and in all times Suttleworth (1994). Stephens (1991) has suggested that what is needed for learning to evolve is predictability within generations and variability between generations. There are occasions when the cost of learning to the creature is greater than the benefits of learning, and therefore the creature does not learn. An example of this is the

recognition of failure in the recognising of eggs and offspring by birds that have been subjected to nest parasitism as in the Cuckoo. A host bird does not associate that it is time to build a new nest when it sees that its nest has been invaded by another's egg (Lotem, 1993). One reason is that the cost of offspring recognition may be greater to the bird than raising the occasional parasite (Lotem, 1993).

We also know that when a creature is presented with stimuli, that stimuli does not always elicit the same identical response in all occasions, for responses to stimuli can vary depending on the internal factors such as the endocrine state and memory. There are many internal and external constraining factors including both learning and the control of behaviour (Hinde & Stevenson-Hinde, 1973). There is also a growing body of evidence which suggests that there are biological determinants in a creature's capacity to learn (Lorenz, 1935, Bateson & Klopfer, 1982, Hinde, 1982).

- **A Single Learning Mechanism – Universal Learning Mechanism**

As stated Behaviourism denies the existence of the vast range of different types of leaning or competences across species. The same learning mechanism is used to explain all learning for all species. However, it is quite clear in the literature that *“...when one is trying to understand how the brain enables learning, one must realise that there may be several mechanisms, not just one”* Gazzaniga, Ivry & Mangun (1998), p521. Behaviourism only focused on an associative learning mechanism which it appears only forms part of an adaptive mechanisms which complex creatures use (McGonigle and Chambers 2003; Gazzaniga *et al* 1998; MacIntyre, 1999).

Behaviourism states that biological agents can regulate their affairs by a tight coupling of input and output, between the stimulus and the response made. Indeed, tightly coupled behaviours are very useful and can be used in a wide variety of events, however, what we shall see is that this tight coupling is not the building blocks of behaviour but more like a “first strike” (McGonigle, 1990) behaviours.

- **Weak to Strong**

The model of learning as produced by the Behaviourist paradigm is based on the repeated connections of particular objects and events (McGonigle & Chalmers, 1998), however, Fodor & Pylyshyn, (1988) claim that from this there is little possibility of the acquisition of systematic knowledge, a view supported by Smith, (1986) and thus

behaviourists relying only on sensorimotor association couplings find it difficult to fully characterise the causes of complex behaviour in language and non-language using creatures. As Fodor (1983) McFarland (1999) McGonigle & Chalmers (, 1986, 2002) have shown behaviourism cannot provide the link necessary that will enable a creature to make the transition from simple to complex, inductively weak to strong, through associationistic mechanisms. Behaviourism fails to account for complex rational behaviour that has been transformed from simple, weak systems.

To recall Chomsky, (1959) suggested that these associationistic approaches could not explain the full complexity of human behaviour especially language. Chomsky and others argue that human verbal behaviour exhibits variability, but most importantly of all, temporal organisation. Grammar, argues Chomsky are properties of linguistic performance that are beyond, at least in principle, the realm of behaviouristic enquiry for they require the operation of creative mental structures and processes. He further claims that language can best be described as a set of rules, and that the child's task is to discover what the rules are. He suggested that the child is able to do this by generating his or her own rules as a result of listening to and analysing the speech he/she hears around him. The child thus tests out these rules, by producing his or their own sentences. As a result the behaviourist paradigm is fundamentally unsuited to the study of complex creatures that demonstrate rational behaviour, for there is no convincing evidence that reflexive learning competences, which stem from within the nervous system, are extendible to more complex, especially epistemic forms of adaptation (McGonigle & Chalmers 1998). In fact, McGonigle and Chalmers argue that "*such models do not appear to deliver explanations of where higher level of cognition comes from*" (McGonigle and Chalmers, 1988).

1.7 Behaviour Based – Task Achieving Models of cognition

What is interesting is how some of the criticisms of behaviourism and the failure to 'scale' cognition up can also be applied to behaviour based modelling. In its attempt to model cognition, intelligence, and rationality AI has undergone a shift from what has been called good old fashioned AI (Brooks (1997) or Classic AI to Behaviour based approaches. Brooks (1986) introduced the concept of *subsumption architecture* not only as an example of behaviour based approach to building robots that could operate in the real world but as an explicit rejection of the symbolic approach of classical AI.

(Brooks 1991). Subsumption approaches adopt an explicit anti-symbolic situated agent stance. Intelligence behaviour is viewed as the outcome of the internal interaction of multiple concurrent units together with interaction between the agent and its environment and is therefore characterised as *emergent*. In introducing this approach, three key ideas were important in the development of the transfer of learning in task achieving architectures. The first of these key ideas was the attempt to recapitulate evolution as a design methodology. A major part of this methodology is that improvements in performance come about by incrementally adding more situation specific layers whilst leaving the old layer in place, able to operate when the new layer fails. When a new layer is added it will produce some new observable behaviour in the system when it interacts with the environment. When a new layer is added into the system, it is important in this approach, that each layer is kept as short as connection between perception and actuation, and that the designer should try and minimize interaction between the layers. (Brooks (1997) Behaviour based architectures support system behaviour which is an immediate, and generally stereotypical, response to a given sensed situation. No planning stage intervenes between sensing and acting. Behaviours operate concurrently with inhibitory connections between them allowing higher level behaviours to subsume or (take control of the system). In other words using the behaviour based approach there are often specific actions represented, coupled to other actions of perceptual condition. But, importantly the specific overall goals of the system are never explicitly represented, nor are there any plans. The goals of the system are implicit in the coupling of actions to perceptual conditions. The subsumption architecture of these layers supports a single task achieving behaviour in order to optimise computation. Each layer of the architecture is designed to be continuously and asynchronously active, and the system scales up through the addition of new layers which can suppress their predecessors.

When the design principles of behaviour based task achieving architectures was introduced it was initially seen as a ground-breaking but there are many now that see this approach failing and does not actually capture what it is to be a cognitive creature. Nor is it too clear how cognition really emerges from such systems. Brooks (1991a) states that intelligence should emerge from the situated interaction of the system and the environment. The two levels of interaction, interlayer and system environment are supposed to give rise to emergent intelligence, however, it does appear in reality that

such systems does not truly emerge through system environment interaction but is actually written into the system by the designer itself. The two following quotations from Brooks (1991*b,c*) support this claim.

When speaking about the inter-layer interactions within the system Brooks says

“Note carefully that we are not claiming that chaos is a necessary ingredient of intelligent behaviour. Indeed we advocate careful engineering of all the interactions within the system. Evolution had the luxury of incredibly long time scales and enormous numbers of individual experiments and thus perhaps was able to do without this careful engineering.” (Brooks (1991*b*, p345 my underlining)

And even more explicitly Brooks suggests that when the designer looks at the system-environment interactions;

“as each layer is built it must be tested extensively in the real world. The system must interact with the real world over extended periods. Its behaviour must be observed and be carefully and thoroughly debugged.” (Brooks, 1991*c*, my italics and underlining)

It appears that the functionality of this type of task- achieving architecture is not a property of emergence but is installed by the designer. This is a series constraint of scaling up, for emergence of behaviour really occurs through handcrafting and interactions between the layers are unpredictable (Brooks, 1991) thus making it very difficult to scale the system. On top of this, behaviour based systems appear to have a lack of scope for progressive adaptation and learning over the life span of the system, which as we shall see later is a very critical aspect of cognitive animals.

Brooks himself (1997, 2001) has admitted that Behaviour based AI and building intelligent systems may *‘just completely be off-base* and that AI has missed some overall organising principle of biological systems. Brooks calls this the *“elixir or juice of life”* (1997, p304); or even *“new stuff”* (2001, p411). What could be this organising principle and how has it evolved will be some of the issues that shall be addressed in this thesis. But certainly economic constraint and adaptation over ontogenesis is a clue.

1.8. Spatial Representations

Research that investigates the causal mechanisms that govern behaviour is fraught with problems because, the causal mechanism of behaviour in humans and in non-humans

and can be explained in a variety of ways, each explanation of course has very real implications for the theories of cognition. For instance, we know that when items are presented in a connecting sequence, and the relational direction is the same across the whole series such as $A > B > C > D$, known as an isotropic series (James, 1981), is easier to choose and require less reaction times (RT) than either an heterotropic series, one where the items presented $B > C$, $A > B$ or when the logical relations are relationally inconsistent ($A > B$, $C < B$). Interestingly enough, McGonigle and Chalmers, (1986) have shown that when presented with a heterotropic series, subjects convert, and transform the series so that it ends an isotropic series, that is; behaviour is canonical (McGonigle and Chalmers, 1986, 2001; McGonigle, 2004). Indeed it is often assumed that the independently stated premises have been integrated into an ordered series (an isotropic one) of a linear spatial representation. However, this view causes a chicken/egg dilemma.

The problem of linear spatial representational accounts has been raised by McGoingle and Chalmers (1986, 2001). Their argument questions whether privileged spatial vectors are the necessary features in the development and evolution of cognition or have they developed later, that is, have they occurred, through the culturalisation of humans, based on what Popper has called the “*third world of books*”, the product of a “*society of mind*”, rather than the product of an individual one. For example, we as a literate society, might use, as an ‘*optional but convenient tool*’ to represent relational terms as objects in a linear array (McGonigle, 2000). But what this suggests is that spatial schemas may have emerged from what were once separable components.

The role of language and even spatial representations are extremely difficult to separate from cognition, however I believe that this must be done in order to accept evolutionary continuity accounts of cognitive animals.

1.9 Summary

Davidson stakes the claim that knowledge of other minds is basic to all thought, and that this knowledge is accessible only to those creatures that are in communication with others. Davidson argues that it is only a creature that is the interpreter of another, which has thoughts. Only language using creatures have thoughts about thoughts,

beliefs about beliefs. Only these creatures are cognitive rational creatures Davidson (2004).

Quite clearly Davidson has set out his stall. He has stated what it is to be a rational creature, and that if you are not in communication with others you have no access to other minds. Rational thought is something that only communicators have. This is the *bar* (for Davidson) that has to be reached in order to be a rational cognitive animal. Philosophy and Psychology has tried throughout the centuries to investigate what thought is and which kind of creatures have it and whether sophisticated thought depends or does not depend upon being a language user. It was not until Darwin that we see the real first evolutionary adaptive approach to cognition. Darwin's theory was extremely important for it showed that there were *no differences* of kind between the species, there was a continuity of mentality between man and other animals.

Once Darwin provided a plausible scientific evolutionary hypothesis that showed that there was a continuation of mentality between the linguistic man and non-linguistic animal, this opened up the door to a non dualist approaches to study the behaviour of both human and non-human creatures. Hence giving rise to an empirical behaviourist account of cognition and learning. This school of psychological thought developed so that reference to a psychological notion of consciousness could finally be dealt with and dismissed.

From the many criticisms of Behaviourism it is clear that reflexive behaviour is not cognition. Conceptually and methodologically Behaviourism and Behaviour-based modelling accounts do not get at the causal roots of cognitive behaviour and thus cannot answer the possibility that a creature could have sophisticated thought but does not depend on being a language user. Any appeal to the mentality of animals based on a Behaviourist's account will be an inaccurate description. Behaviourism and Behaviour –Based AI cannot tell us whether the capacity to reason about mental states is shared by many species (Povinelli and Vonk 2004).

If, as it is my intention, to modify Davidson's argument on the nature thought and rationality through the investigation of comparative evolutionary empirical methods, Behaviourism, as we have seen is not going to do it for us. Although working

backwards from behaviour, in a range of purely behaviour based tasks that employ a long-term evolutionary approach looks like a good way to proceed. It is also clear that these behaviour based tasks must be developed in such a way that they require no linguistic instruction from the experimenter to the subject. If these non-linguistic behaviour based tasks are developed then it would deliver us with the means to develop a common currency of comparative measurement and would also start to identify the homologous cognitive processes that are apparent in both humans and non-linguistic animals (Conway & Christiansen 2001; Hauser, Chomsky and Fitch, (2002) and McGonigle, Ravenscroft & Chalmers, (2002). Only by doing comparative empirical research in this way are we at last able to mount a challenge to view that a rational animal is a language using animal.

Consequently, by the time this thesis is completed, I hope to have shown

- a) Why we should accept an evolutionary continuity view of cognition
 - b) Why modification of Davidson's position must be made
- because
- c) the causal mechanisms of cognitive growth are not language dependent

Finally in this chapter I would like to present two quotes by Watson.

“Psychology, as the behaviourist views it, is a purely objective, experimental branch of natural science which needs introspection as little as do the sciences of chemistry and physics....The position taken here is that the behaviour of man and the behaviour of animals must be considered on the same plane; as being equally essential to a general understanding of behaviour.”

John Watson, *Behaviour: An introduction Comparative Psychology* (1914).

“From our point of view, it can readily be understood that the search for reasoning, imagery, etc in animals must forever remain futile, since such processes are dependent upon language or upon a set of similarly functioning bodily habits put on after language habits.”

John Watson, *Psychology Review 20* (1913).

2. Systematicity, Language of (and) for Thought and Relational Competence

2.0 Aims

The aim of this chapter is to introduce some other core concepts that need to be addressed if one is to support ontologies of cognition that are evolutionary continuously based. More specially this chapter will introduce the notion of a Language of Thought and show how the systematicity challenge must be met, both for humans, and if we are to accept cognition non-linguistic animals, then for these creatures too. One possible way of meeting the systematicity challenge is through the identification and exploration of lower ontological bounds – and the existence of specific design primitives. I suggest in this chapter that relational competence may be a way of not only meeting the demands of the systematicity challenge but may also provide a necessary tool or hook into eventually delivering a modification of Davidson’s account of rational animals. As such this chapter will start to examine in detail exactly what Davidson’s position is which can be characterised as an argument of Language for Thought.

2.1. The Systematicity Challenge. (Humans)

Linguistic agents are capable of entertaining an infinite number of thoughts, indeed it does appear that humans have unbounded competence in entertaining different thoughts. It is not difficult to think of many new thoughts that I have never had and never will again. I am also going to take it as read that we do not store each and every individual thought as a discrete entity in our heads, thus this unbounded competence is achieved by finite means. How? How can we produce an infinite number of thoughts/beliefs etc from a finite base?

According to Fodor and Pylyshyn, (1998) there are intrinsic connections between certain thoughts and certain other thoughts. That is, if a cognitive agent were to lack some thoughts that cognitive agent would also lack certain other thoughts. Fodor and Pylyshyn claim that the systematicity of cognitive representations is a psychological fact, and one that is in need of an explanation. One of the crucial components that lie at the heart of discovering what types of mental states linguistic and non-linguistic

creatures have, is to discover, the intrinsic connections, (if any) between thoughts and other thoughts and to determine why there are these intrinsic connections.

Cognition for Fodor is realised as syntactic operations defined over representations. The core of Fodor's argument is that (1) processes of cognition consist of computational processes, and (2) computation requires a language over which the computations are performed. The basic units of this language are conceived of as symbols: entities which of themselves are content-less or arbitrary. It is by virtue of their structural relationships and the structural transformations which are possible that these symbols can serve as the vehicles of cognition. Fodor, in essence, is placing highly non-trivial restrictions on what the internal constitution of a thinking organism must be like: 'if a thing does not possess an internal system of representation, a mentalese that shares certain essential features with natural language, then it cannot be a thinker'

Fodor raises some critical points that must be discussed within any account of the mental states of non linguistic creatures and to any discussion as to the theory of where cognition comes from.

Fodor and Pylyshyn (1988) state that there are two/three principles of structure, and they are, productivity, systematicity and compositionality, although compositionality can be seen as part of the systematicity structure. These, they suggest are indeed necessary functions of cognitive creatures. Productivity is the property is the product of producing potentially infinite diversity from a finite set of elements.

Fodor (1987) and Fodor and Pylyshyn (1988) developed the concept of systematicity to make arguments about models of the cognitive architecture, which can apply to human and non-humans. Systematicity is when the agent is capable of representing the state of aRb , then it is necessarily capable of representing the state of bRa . The representation of aRb or bRa has constituent structure, that is, the representation has parts, subparts and goals that are composed according to specific recursive syntactic rules. It is important to note that they specifically exclude representations that are 'unordered' or are 'unstructured collections'.

Systematicity thus has a constituent structure which involves “*combinatorial syntax and semantics for mental representations*” and “*structure sensitivity of processes*” (Fodor and Pylyshyn 1988 p12, 13). Fodor and Pylyshyn note that you can always apply particular relational operators to sentences in a language and obtain additional sentences in that language. For example “John loves Mary” is a statement which is meaningful however we can apply the relational operator “loves” to give us a new sentence “Mary loves John”. So in general Fodor and Pylyshyn claim that, if ‘*aRb*’ is meaningful, so is ‘*bRa*’.

Part of the systematicity argument is the ability to combine structures through a relational chain. When Fodor and Pylyshyn state that;

- (a) *Turtles are slower than rabbits,*
- (b) *Rabbits are slower than Ferraris*
- (c) *Therefore turtles are slower than Ferraris.*

Fodor and Pylyshyn (1988, p33)

they argue that there has to be ‘*understanding*’ of ‘*slower than*’ where ever it appears. Secondly this relationship ‘*slower than*’ must also be seen as transitive, therefore, from two contextually independent situations related only by the fact that they share an ‘*abstract*’ relationship, we can infer a new third situation “*turtles are slower than Ferraris*” based on those relationships. Fodor and Pylyshyn conclude from these considerations that the language of thought is the ‘*correct*’ way to explain the systematicity challenge. (Fodor, 1975, 1987).

Having a thought is being related to a structured array of representations; and presumably, to have the thought that ‘John loves Mary’ is ipso facto to have access to the same representations, and the same representational structures, that you need to have the thought that Mary loves John. [A]nybody who is in a position to have one of these thoughts is ipso facto in a position to have the other. The Language of Thought explains the systematicity of thought. (Fodor, 1987, p151).

A semantically and syntactically combinatorial language of thought is one possible theory that thoughts involve mental representations that are made up of meaningful parts. Cognitive agents have explicit representational systems; to think a thought with a given content is to be appropriately related to a representation with the right (true) meaning.

A brief summary of this position is given below;

1. Thoughts have the same semantic like properties of sentences of human languages.

- Thoughts have referential relations with the world.

(The thought John loves Guinness refers to Guinness and the love of it in just the same way as the speaker's sentence "John loves Guinness")

- Beliefs, thoughts, like assertions are true or false.
- Thoughts, like sentences can cope with inferential relations.

(John thinks that all lager drinkers are mad, Peter is a lager drinker, and therefore Peter is mad.)

2. Thoughts have the syntax of sentences

- a. From the above example of lager drinkers we see that

All Fs are G

A is F

So, A is G

What this shows is that John's inference regarding lager drinkers has a particular form, or syntactic structure to it, and that these syntactic structures of beliefs share the same syntax of sentences.

- b. Thought, like language is productive

People can entertain an infinite number of thoughts as well as speaking an infinite number of sentences. The capacity that enables the person to do this requires that thought have syntactic structures.

3. Thoughts like sentences are abstract in character.

The sentence that "John's cat is 8 kilograms" tells you nothing more about John's cat except its mass, which is the same as the thought John's cat is 8 kilograms. Thought and talk are abstract in nature.

Conclusions: The language of thought is one way (and Fodor would claim the only way) to explain the systematicity of thought.

2.2 The Systematicity Challenge (Animals): Are animal thoughts systematic?

Fodor and Pylyshyn (1988) consider this about the systematicity of animal's thoughts;

"It is not, however, plausible that only the minds of verbal organisms are systematic. Think what it would mean for this to be the case. It would have to

be quite usual to find, for example, animals capable of representing the state of affairs 'bRa' but incapable of representing the state of affairs 'aRb' ... (So that you could teach the creature to choose the picture with the square larger than the triangle, but you couldn't for the life of you teach it to choose the picture with the triangle larger than the square.)" (P.41)

This relationship of representing 'aRb' and 'bRa' is critical to developing an ontology of cognition. I think the important question here is not what form this representation takes, this comes later, but rather do all or some animal thoughts/concepts or propositional attitudes exhibit such systematicity of content. An example for clarity is offered. A dog may be able to represent that there is no cat in the tree, and the fact that there are no humans in the garden, but, (and this the crux of the matter) the dog may not be able to represent there are no humans in the tree. The systematicity challenge before us is to provide comparative empirical evidence 'of pervasiveness' (Kaye, 1995), that demonstrates the true complexity of systematic non-linguistic thought.

The systematicity challenge raises some very important issues for any investigation into evolutionary antecedents of cognition. Being able to produce an 'infinite' set of behaviours from a finite set of structures appears at first glance something that we would want to put within the realm of rationality. I agree with Fodor (2000) on two fronts at least that some cognitive competences that are later expressed in advanced stages of human development and those animal thoughts are indeed systematic. An argument though can be made that cognitive thought is not solely the product of language-like operations in the brain. There may be different types of cognitive thoughts that are complex and are sophisticated, yet this competence, however represented in an agent's head, may not be the product of a language of thought. There are other explanations that exist, that also stem from an evolutionary perspective that can account for such behaviours. They may be, for example, as McGonigle and Chalmers (1989) suggest be products of lower design relational primitive operators and that cognitive growth as a whole stems from these lower design relational primitives and not from a Language of Thought. So can these lower design relational primitives be part of a story about the systematicity of thought?

2.3. Lower Ontological Bounds

I agree with McGonigle and Chalmers (1995) that what is critical to any theoretical landscape of cognitive systems is the existence of lower bounds competences. These lower bound competences constrain the development trajectories that are open to the system, through both the system itself and system-environment interactions.

McGonigle and Chalmers (1995) for example suggest that the more complex the species the richer and more resourceful are its lower ontological bounds. In Behaviourism we see how evolution has evolved certain constraints keeps the inductive space as small as possible, but with their focus on tightly coupled easily modified input to output stimulus response behaviours, meant that this approach just could simply not capture the richness of lower bound competences. This is why Vygotski (1927) suggested there is a levelling effect, and more recently McPhail (1982) developed the ‘null’ hypothesis theory. Modern day versions of bottom up approaches to learning such as connectionism also fail on similar grounds, learning cannot be reduced to the operation of a small number of highly optimised associationistic principles, but rather species possess a range of ‘*problem specific learning mechanisms*’ (Marler, 1991). It is also the case that the richness of these lower bounds must also reflect the differing evolutionary histories of the species, and must not be accountable to some ‘celestial’ intervention.

2.3.1. Relational Competences: A possible way of meeting the challenges

I believe a way of answering, in part, the systematicity challenge is by discovering the behavioural indicants of rational cognition. We can achieve this by looking at how certain ‘thoughts’ have relational, systematic (rather than associative) properties about them (Fodor & Pylyshyn 1988). This is the correct approach to adopt, for as we have seen in the systematicity challenge relational operators provide a significant component of being able to provide ‘unlimited’ productive output. The challenge that meets us now is not necessarily finding all possible solutions to meet the systematicity challenge but to investigate and to deliver an existence proof of relational structures in non-linguistic creatures that might eventually provide us with an alternative route into meeting the systematicity challenge rather than rely solely on a Language of Thought.

We see in James, (1891) the power and primacy of relations between man and beast and that the mind is a "*teeming multiplicity of objects and relations*" (James, 1891) We also see how in the science of Gestalt psychology they have argued against behaviourist ideals in which relations between parts are independent of the parts themselves; but rather argued for relations among parts are determined by the properties of the parts. The relational experiments of Kohler (1929) and others that specifically focused on the relations between objects and insight were unclear at defining what role relations actually played for many Gestalt experimental methodologies could be replicated by a behaviourist one. We see no increase in task difficulty, and Kohler's experimental paradigm could really be described at the one trial level. This methodology is not going to provide us with the means and ends to meet the challenges before us.

Behaviourism and further associationistic ideas studied not the internal aspect of relations but rather the relationship that a stimulus could have on the response being made. Any scientific theory, suggests the radical behaviourist approach should not make use of inferred entities, internal relational structures or phenomena at all. Mentalistic explanations, according to the radical behaviourist, really just restate the facts of behaviour in more obscure language and since mental states which are supposed to explain behaviour are themselves determined by external stimuli, they can safely be ignored.

A significant move away from arbitrary associationism has been through language and symbolic representation where investigations have looked at the acquisition of comparative terms such as 'bigger' and 'smaller' (Kuenne, 1946; Reese, 1968; Bryant, 1974). But these verbal mediation accounts fail to deliver an accurate ontology of cognition due to their reliance upon language. In order to break the link away from language and verbal mediation theories it is necessary to study relational competences using creatures that are not influenced by some symbolic internal representational code that is, we need to get out of the cultural confines of language and into the non-linguistic world of animals.

Relational structures are a key element in any theoretical account of cognition and as such will provide a significant clue into determine what constitutes rational behaviour. Relational structures may also provide a hook in to not only meeting the systematicity

challenge but also to meeting Davidson's 'bar', - *only those animals that have language have thought.*

In order to explore these issues I suggest that we need to investigate several factors.

- The degree of interaction between internal relational states of a creature without language and other internal relational states.
- How these relational states are represented, spatially or temporally, for they cannot be represented in language as they are non-linguistic creatures.
- How much is interaction and manipulation of objects with the environment a necessary condition for the development of these relational states to occur and develop.

Behaviour, by itself, is not the key ingredient to focus on any study of cognition.

What is critical is the basic and core causal mechanisms that lie behind the behaviour.

Here I agree with MacIntyre (2002) who suggests that,

“The principle by which we “solve the other mind problems for animals” is not that intelligent behaviour is proof of consciousness but rather the principle is that if the animal has the [same[causally relevant structure[as] to our own, then it is likely to produce similar mental events in response to similar stimuli.” (MacIntyre, 2001, p74)

The key phrase in this quote is “*the [same[causally relevant structure [as]]*”, that is if we can identify the same causally relevant structures in humans and non-human animals then an argument can easily be made that these causally relevant structures will produce the same or similar behavioural effects in both humans and non-humans. This is why when we talk about cognition we do not say that thermostats or radios or watches have cognitive states because they do not have the necessary causal structures for cognitive states to appear. The challenge that lies before us now is to examine what are the causal structures, how creatures utilise these causal structures, are they part of an evolutionary history, and are they powerful enough to not only meet the systematicity challenge but also to meet Davidson's as well?

The issue that is at stake here is very simple, what exactly are the mechanisms of cognitive states, how did they arise, develop, and evolve, and how are they or are they sustained in both humans and non-human animals?

These are the fundamental questions of any evolutionary theory or ontology of cognition, and I suggest that the best way of answering these questions is to approach it from an empirical comparative perspective, that is to do specific work on specific mechanisms, and to do so by using the best technology, tools, paradigms that are available at the time of scientific enquiry.

2.3.2. Existence Proof

We know there are species differences in animals Herrnstein, (1989) highlights that

“abstract relations differentiate most sharply among animals. It has been noted that we see the largest gaps in comparative performance at the level of abstract relations. It may not be surprising that the means for dealing with just the transient contingencies of reinforcement has had lower evolutionary priority than the means for the enduring ones represented by concepts or by open ended categories. But once a species has a foot hold at the level of abstract relations the possibilities are unbounded.” (Herrnstein, 1989)

and there have been many approaches to provide the existence of proof of relational competences in animals and one such experimental paradigm has been developed by Hauser (1997). He explores relational concept learning in cotton-top tamarins (*Saguinus oedipus oedipus*). The experimental paradigm makes use of the functional properties of tool use by presenting them with a means to end task design. The experimental methodology is as follows;

Nine cotton-top tamarins were used and were individually placed at testing time into a test box that consisted of a wire mesh platform and a V-shaped back that centred the animal to the transparent Plexiglas front panel. The front panel had two slits in it so that the monkey could reach through and manipulate the test materials. Importantly, the slits were too narrow so that they could not reach across and grab both test objects at the same time forcing the monkey to select one test object at a time.

When the animal was ready in the test box, a stand was placed in front of it and a light blue tray divided by a partition with the test items on each side of the partition s placed in front of the animal for three to five seconds then raised up onto the stand so that the test items were now in reach.

One the first series of experiments the task involved pulling a blue and white cane to gain access to a pellet. Each trial involved a choice between two identical canes, one with a pellet inside the hook and one on the outside. As Hauser points out, the optimal choice is to pull the hook with the food pellet in side of the hook, as the other hook requires manipulation by the animals of lifting the cane, rotating it, putting back onto the tray in the appropriate place and then pulling back on it, whereas the success with the food inside of the hook requires a simple pulling back of the hook. Hauser believes that this task tests whether the tamarins have access to abstract relational concepts.

“It is abstract because it is not tied to a particular type of object or objects. It is relational because an object that is tagged as ‘inside’ holds a certain spatiotemporal relation to another object.” (Hauser, 1997 p 294)

Although the tamarins quickly reached criterion on the task that is they favoured the cane with the food pellet inside the hook, there is no evidence that the tamarins were using the concept of ‘inside’ to guide their choice of canes. It is possible that they solved the task by focusing on more concrete perceptual factors. For example, the tamarins could have solved the task by always picking the side where the white pellet is closest to the concave in bit portion of the blue curve. Here operant conditioning can easily be used to explain how the monkeys solved the task. Hauser also reports that when the cane was chosen with the food pellet outside of the hook, the monkeys did not attempt in anyway to try and manipulate the cane so that they get the food pellet. They just pulled the cane back and missed the food altogether.

In the next series experiments (two to four) Hauser altered four physical features of the cane to determine which of these features the tamarins were affected by. The features altered were colour, size, texture and shape. (It is important to note that in these later experiments the food pellet was inside of the hook which now negated any simple algorithm “go to pellet on the inside bit of the cane”.) Hauser found that the tamarins were basically tolerant of all the property changes of the cane’s tool use. However there were preferences observed. For example, the animals preferred tools with colour or texture changes than tools with shape or size change, due to the fact that the former features do not affect the tool’s functionality. In the final series of experiments Hauser introduced both novel (triangles and spiky objects) and familiar objects to the tamarins which were classified as ‘being ready for tool’ use or required some ‘manipulation’ or conversion to tool use. The monkeys preferred the ‘ready for tool’ use objects to those

that required some manipulations, even when the possible tool was novel and the convertible tool was familiar. When presented with a choice of two objects that required manipulation we see the tamarins choosing the object that requires the least amount of physical manipulations to get the food pellet.

2.3.3. Causal Features

Based on their overall performance and speed to reach criterion, Hauser claims the tamarins do not form a simple one-to-one mapping between a single object and a single function, for the same tool whether ready or convertible had a significant effect on its chances of being chosen. Hauser suggests the over all results indicate that the tamarins do have a full understanding of the means-end/cause effect relationship and must have some relational conceptual representation of the tasks in hand and how to solve them. However, it may be the case that the experimental procedures here developed by Hauser do in part demonstrate that the monkeys have developed some conceptual representation, but it is not clear from this methodology where these relational constructs have come from, nor how they have developed. All Hauser has really shown is that they may be able to utilise these structures. Surely, to return to MacIntyre, (1999) what we need to get at is *the causal features* of behaviour and not the behaviour itself. We need to get at the level of basic design, or as McGonigle and Chalmers call it “*the ontological floor*” of the creature. (McGonigle and Chalmers, 1992, 1996, 1998). This is what I shall discuss next.

The Ontological Floor. A Study

McGonigle and others originally began their work began in 1969 and now over three decades at the University of Edinburgh, has provided a characterisation of cognitive systems that has been developed from both an evolutionary comparative and developmental perspective. Their work has focused on the dynamic mechanisms of self-organisation as well as identifying various self-selection pressures which then in turn provide the agent with “*progressively enhanced adaptive power with greater economy of resource*” (McGonigle and Chalmers 1996, p289). Their work starts from the premise that relationally based organisation is key to supporting complex structural properties. As such I think that this approach may provide some ideal starting points to look at some of the issues and questions highlighted above and in the previous chapter.

McGonigle and Jones (1975, 1978) began work on relational design primitives when they investigated the learning of size and brightness relations, compared to the learning of single absolute values in squirrel monkeys (*Saimiri sciureus*). This research tried to identify if relational encoding is governed by some complex mediational or rule-based system, where some additional primary form of encoding may 'superimpose' itself on top, or that relational encoding is based in relational perception itself (McGonigle and Jones, 1978).

Unlike previous experiments in animal discrimination tasks, where animals are first trained to discriminate a single pair of stimuli and then are tested for preferences when the training 'positive' stimulus is re-paired with a novel one differing, they found that this method was far too limiting in evaluating those subjects that might respond primarily to a set of relational cues compared to those that may respond to absolute one. McGonigle and Jones, instead, developed a range of training and tests episodes, and varied the task requirements from subject to subject.

2.4.1. Experimental Design and Methodology

In more detail, McGonigle and Jones developed a series of tests using the Wisconsin general testing apparatus (WGTA) with a red stimulus tray and with white stimulus cubes made out of polystyrene, which differed in size from each other by roughly 1cm² placed onto the stimulus tray. The three cubes were presented as the pairs, BC and CD. By doing this we get a serial order of size for B is the largest, C, the middle size and D the smallest. (B>C>D).

Five monkeys were randomly placed in group R, the relational group, choosing B over C in BC and C in CD. The monkeys in this group were rewarded with a half-shelled peanut. Six other monkeys were allocated to the absolute (SS) group where C was always rewarded with a half-shelled peanut.

Group R was rewarded for their choice of size selection (the largest in every case) Group SS was rewarded for always choosing the block that was designated as C.

Experimental Procedure

The monkeys in each condition R and SS were given five seconds to view the stimulus tray before the tray was moved within their reach. A response was defined as any movement of the stimulus items upon the tray. Each inter-trial interval lasted for approximately fifteen seconds. If an incorrect response was given the tray was withdrawn and the monkey was allowed to observe the error for a further five seconds.

2.4.2. (Initial) Results

Both groups of monkeys learnt rapidly on the various tasks. However, differences soon began to emerge. In the simple relational task ($B > C$, $C > D$), the R group outperformed those who had to learn the absolute rule 'C' rule. It was found that the absolute SS group did not have as stable retention as those monkeys within the R group. In fact the performance of the R group was so robust that it was not affected by a change of stimulus transformations which included painting the cubes with luminous paint and presenting them in the dark. Monkeys in the R group were able to use a relational code to transfer both from dark to light and light to dark, where these transfer conditions perturbed the SS absolute group.

2.4.3. What a Micro Level of Analysis Can Tell Us

What is important to note about this experiment, apart from the overall result, is the fact that the monkeys in R, before even taking a single cube, were predicting right from the start – trial 1, which cube to take, where as the SS group were forming non-specific learning sets, and thus were making errors on first trials but not necessarily on the second. Only a detailed level of micro analysis could have picked this critical result up. To be clear, the monkeys were not at the start of each trial phase, choosing the wrong stimulus to touch, and then by the second trial learnt which cube to aim for. The monkeys assigned to R were immediately choosing the right test cube, right from trial 1. This was not the case for those monkeys in the SS condition. Choosing the correct stimuli right from trial 1 test 1, does seem to indicate some kind of normative relational competence at work.

This type of micro analysis, trial by trial, subject by subject, is critical in determining the real behaviour of the subjects. In traditional associationistic learning paradigms where a macro level of analysis is sometimes reported, results like this where there is

just one trial difference could go unnoticed and as a result the true behavioural performance is not acutely identified and therefore not reported. Increasing the task difficulty over extended periods for the subject has also been out of bounds for some associationistic design, but not in this case. McGonigle and Jones wanted to increase the task difficulty from choosing between two items to three.

In a similar procedure to that describe above, McGonigle and Jones increased the task difficulty by adding a third item A to the BC set making ABC and E to the CD set making CDE. Again those monkeys assigned to R had to select the largest stimuli out of the triadic sets presented, which they duly did, and those in SS had to choose the stimuli C. The monkeys in SS found it very difficult to maintain the choice C across the set. The contrast between to two results again shows how perceptual relational encoding can be utilized by the money.

2.4.4. Conclusion of Study

Monkeys in the R group significantly outperformed those in the ‘absolute group’ and in a wide range of conditions All in all so robust was the monkeys’ performance not only on size but also on brightness conditions on various contextual relational codes that McGonigle and Jones were left with no other conclusion but to claim that that perceptual relational encoding was irreducible to any lower level of competence and that the relational code was a *design primitive*. Not derived from associative, absolute learning, and of course non-linguistically based. McGonigle and Jones discovered that relational encoding is less demanding than the absolute one, and consequently encoding is prior (as it is a design primitive) to an absolute code contrary to the ontological order proposed by Piaget (1963). The design primitive should therefore be seen as robust and economic in respect to the allocation and management of cognitive resources.

Although this level of cognitive ability, does not match that demanded by Davidson to be a rational creature, it is clear that there is significant evidence for the existence of design primitives. However, the role of learning through these primitives need to be clarified. As does learning through self regulation or supervised learning, or even learning in a social encounter. For example, it is interesting to compare this result with Piagetian conventional tasks. For example Piaget believed that logic is recovered

through the active discovery from the relation between objects. That is the child, had to actively reach out and discover the relations between objects. Piaget thought that significant advances in cognitive structures came about in the course of being used, that is both the organism and the environment were necessarily involved in this process of change. The child had to disturb the world, change the environment it was living in. On this particular paradigm we see the primates during training touching and manipulating the test objects. We shall see later through the advancements of touch screen technology how manipulation in training is not a necessary feature of learning at all. McGonigle and Jones' work does, though, confirm Kohler's (1969) hypothesis that our perceptual and cognitive apparatus is not a passive receptor of sensory stimuli, but asserts a shaping in the sense data.

2.4.5. Where Does the Existence of a Relational Encoding Design Primitive Lead to?

It does appear that relational competence may be the first clue in an evolutionary continuous account of cognition. To be able to select bigger over smaller, is fundamental to any rational cognitive agent. It appears it may be core key feature of cognition. In philosopher speak, it may not be a sufficient condition of cognition, but it might be a necessary condition, which means that in order to be a cognitive agent, the agent may necessarily have, some relational competence. This view is opposed to Spence (1949), Ingelder & Piaget (1964), Bryant & Tabasso (1971) which strongly coupled relational ability with linguistic ability. A view of course which Davidson would support.

If '*relational competence*' is a necessary condition there are some questions we need to ask; can a relational competence support later more advanced cognitive competences (McGonigle and Chalmers, 1996, 2002)? Can these competences be found in non-linguistic creatures as they are found in speaking ones? How do we further demonstrate their existence and how do these competences unfurl?

At first glance it does appear that McGonigle and Jones have found a set of precursors to what could be linguistic comparatives, but as McGonigle and Chalmers (2002) ask themselves, "but what sort of precursors?" (p293). Could the existence of relational design primitives be a key development in supporting a type of learning mechanisms

that have been taken seriously as a possible basis for language and high-level cognitive capabilities in humans (McGonigle and Chalmers, 1996, 1998)? If so how does cognitive growth emerge and what are the ontological implications of order of such emerging cognitive competences? Relational competence therefore may have provided us with a way of meeting the challenges set before us. Relational competence looks a likely candidate for us to start an investigation into the cognitive structures of non-linguistic creatures and to finally confront Davidson's stance.

However, it is important before we proceed to examine in detail an evolutionary account of a theory of cognition based on the existence of relational design primitives that we fully understand what exactly Davidson's position is. As I am ultimately aiming to mount a serious challenge to what Davidson constitutes to be rational thought, we do need to be clear what his position is and why he places *the bar of rational thought* at such a high level; where only language using creatures can reach this level. Consequently, the next section of this chapter will give a Davidsonian overview.

2.5. A Davidson Overview.

2.5.1. Anomalous Monism

Davidson calls his position *Anomalous Monism*. His monism is, that each token mental state or event is simply a physical state or event. The difficult part of Davidson's theory is the anomalousness of the mental. This is, the denial that there can be any psychological laws, (beliefs, desire, hopes fears) which are scientific kinds.

“There are no strict deterministic laws on the basis of which mental events can be predicted and explained” (Davidson, 1980 p208).

This view claims that there are no scientific laws linking the psychological to the physical. Davidson believes that psychological states are not natural kinds, and thus cannot be studied scientifically. Davidson holds that psychological explanation must be holistic (p.217) in the sense that it involves implicit reference to the agent's entire belief-desire system. Psychological phenomena do not constitute a closed system, and as a result there cannot be any psychological laws. To qualify as a law, Davidson thinks that generalisations must be precise, quantifiable and almost deterministic, and

these conditions are only met in a “comprehensive closed system” (p.219) and that psychological activity is not part of that system. For Davidson, only the laws of physics and physical chemistry are true laws; laws that appear to govern psychological explanation are not.

2.5.2 Principle of Charity

An important part of Davidson’s theories is the principle of charity component. When people ascribe beliefs or desires to other agents, we, according to Davidson, have to be charitable, we have to see people as rational and as believers of the truth.

“...in inferring this system [of beliefs and desires] from the evidence, we necessarily impose conditions of coherence, rationality and consistency. These conditions have no echo in physical theory, which is why we can look for no more than rough correlations between psychological and psychical phenomenon” (Davidson 1980: p231).

Although this principle of charity is often viewed by Davidson and other such as Dennett (1978) as a single element, it can in fact be broken down and examined separately. For the purposes of this overview I will concentrate on three kinds of topic; true belief, rational belief and rational action.

(i) *Charity – as true belief.* This element assumes that most of the beliefs that an intentional system has must be true. Davidson assumes that there are very few false beliefs, and when they do occur they require an additional explanation.

“It cannot be assumed that speakers never have false beliefs. Error is what gives belief its point. We can, however, take it as given that most beliefs are correct” (1984, p168).

If we are then to attribute to another intentional system that they have true beliefs, then this really is the same as assigning truthfulness to our beliefs as well. (A sort of charity begins a home principle.) As Davidson says “a *good theory of interpretation maximizes agreement*” (p169).

(ii) *Charity – as rational belief.* Charity sometimes requires the rationality of beliefs given other beliefs. The fact that the belief system is inferential, these connections among beliefs must be rational. For example, if John believes that a silver bullet will kill a werewolf, and if John believes that Harry is a werewolf, then John

must believe that a silver bullet will kill Harry. It is important for Davidson that agents must apply good rules of induction.

(iii) *Charity – as rational action.* This aspect requires that the connections between the agent's beliefs and desires and its actions be rational.

“The belief and desire that explain an action must be such that anyone who had that belief and desire would have a reason to act in that way (1980 p.159).

In more simplistic terms this third principle can be described as the agent desires that p , believes that doing A will bring about that p , and so does A . Beliefs and desires are causal. John desires Harry to be dead, so shoots him with a silver bullet.

2.6 Davidson's Ontology of Rational Animals

Given this very brief introduction to the philosophy of Davidson, I would now like to turn my attention to his writings on “Rational Animals” (1982) and “Thought and Talk” (1975). In doing so I will go into greater detail into Davidson's writing and will concentrate on why he feels possession of language may be an indicator of what it is to be a rational animal. *"A creature cannot have thought unless it has language"* (Davidson, 1982; p322).

We know that through the principle of charity, Davidson holds the view that if we are to ascribe propositional attitudes such as beliefs and desires to humans, we are committed to finding them to be rational (Jackman 1998).

“ Since this "constitutive ideal of rationality" controls our interpretations, "we must stand prepared, as the evidence accumulates, to adjust our theory in the light of considerations of overall cogency," and in doing so we "necessarily impose conditions of coherence, rationality, and consistency" on the beliefs ascribed.” (Davidson, 1970)

The constitutive ideal will thus affect which mental predicates we *actually* attribute. There is, however, no corresponding pressure upon our attribution of physical predicates. This is why, suggests Davidson, we cannot expect there to be any law-like connections between the two types of predicates, even if the two happen to occur together.

Central to understanding Davidson's notion of cognitive rational thought is the claim that thoughts require a background of beliefs. The reason being is that Davidson belongs to the school of thought that posits the holistic rather than systematic character of the mental. In both "Thought and Talk" and "Rational Animals" Davidson gives the example of a dog and a cat running up a tree, of which he has adapted from Malcolm (1973). The example is as follows,

"Suppose our dog is chasing the neighbour's cat. The latter runs full tilt toward the oak tree, but suddenly swerves at the last moment and disappears up a nearby maple. The dog doesn't see this manoeuvre and on arriving at the oak tree he rears up on his hind feet, paws at the trunk as if trying to scale it, and barks excitedly into the branches above. We who observe this whole episode from a window say "He thinks that the cat went up the oak tree" (Davidson, 1973, p13).

Davidson and Malcolm differ in their view about the usefulness of language employed to describe this scene and what we think the dog is "thinking". Malcolm, appears to be happy with the folk psychological view that dogs think. However, Davidson claims that this ordinary use of language takes us down an incorrect path in developing an accurate theory of cognitive agents.

The reasons for Davidson's unhappiness regarding this scene is related to the issue that if the dog has a belief, then that belief must have some specific content and referent. The question that Davidson wants us to ask is, '*what precisely is this content*'?

We cannot intelligibly attribute the thought that a piece of ice is melting to someone who does not have many true beliefs about the nature of ice, its physical properties connected with water, cold, solidity, and so forth. One attribution rests on the supposition of many more." (Davidson, 1982, p302).

Whilst we are asked to infer from the example that the dog wishes to catch the cat, and that the dog goes to the tree, because of his belief and desire about where the cat has gone, there are many expressions that we could use to refer to the oak tree that the cat was supposed to have run up. As Davidson says, the "*oak tree happens to be the oldest oak tree in sight*", or we could say 'that oak tree came from the smallest of acorns', or 'that oak tree was planted by my great grandmother'. Davidson would then claim, and rightly, that the dog believes that the cat ran up the oldest oak tree in sight is not the same belief as the cat ran up the tree planted by my great grandmother. In general, it

seems that two sentences may describe different beliefs, even if those two sentences differ only in having different ways of picking out the same referents.

It certainly begins to look difficult to actually state what belief the dog has about where the cat has gone. It is definitely not the case that the dog believes that the cat has gone up the oldest tree in sight, since I know of no research that has demonstrated a dog's ability to tell how old a tree is. Nor could we say that the dog believed that the cat went up the tree that was planted by my great grandmother. This problem extends to whether the dog believes the cat went up a tree at all? What do dogs know about trees? Davidson holds that in order to have the belief that the cat went up the tree, the dog must be able to believe of objects that they are trees. As Davidson says

“The dog must believe, under some description of the tree, that the cat went up the tree. But what kind of description would suit the dog? For example, can the dog believe of an object that it is a tree? This would seem impossible, unless we suppose the dog has many general beliefs about trees: that they are growing things, that they need soil and water, that they have leaves or needles, that they burn. There is no fixed list about things, someone with the concept of a tree must believe, but without many general beliefs, there would be no reason to identify a belief as a belief about a tree, much less an oak tree. Similar considerations apply, to the dog's supposed thinking about the cat.”
(Davidson 1982, p475)

Davidson's argument in a nutshell is this. If we wish to intelligibly to ascribe a belief to a dog, (or any other animal for that matter), we must first decide exactly, what belief to ascribe. But to determine what exactly the first belief to ascribe to the dog is appropriate, we need to take into account a whole range of beliefs that the dog might have. And if we do that then we seem to be on the slippery slope that forces us to make decisions that the dog has beliefs about such as soil and things that burn for example.

These are decisions that Davidson claims that we have no rational grounds to make. Without language, Davidson thinks, a creature's behaviour cannot have the complexity necessary to support any belief attributions. There would be no way of telling which set of sentences would said to have accurately have described the creature's belief.

2.6.1. Implications

The implications for animal rationality are devastating if one accepts the view that a single belief requires a network of further beliefs. Another example, may illustrate the how condemning this stance is. Take Fodor's 'intelligent' cat, Greycat.

"In the morning, at his usual feeding time, Greycat prowls the area of the kitchen near his food bowl...When the house is cold, Greycat often sleeps before the fire place. But only does this if there is a fire on the hearth...[Greycat] maintains an appreciable distance between himself and the nearest aggressive dog... Greycat - unlike rocks, worms, nebulae...acts out of, beliefs and desires. The reason for example, that Greycat patrols his food bowl in the morning is that he wants food and believes - has come to believe on the basis of earlier feedings - that his bowl is the place to find it. The reason that Greycat avoids aggressive dogs is that he is afraid of them." (Fodor, 1987; Preface to Psychosemantics)

Most pet owners will recognise the story Fodor is telling about his cat and some may even believe that Greycat does have beliefs and desires about where to find his breakfast. But could there ever be such a single description of the cat's behaviour that could enable us to justify the inference that Greycat had rational beliefs or desires about breakfast time?

This point is made clearer when we start examine just what kind of rational beliefs we could actually attribute to Greycat. It seems from the example that one possible rational belief we could attribute to Greycat is the rational belief that *"it's morning time and it just so happens that every morning there is food for me to eat at this particular bowl in the kitchen"*. However, it is unlikely that we would seriously attribute to Greycat the above belief because it requires Greycat to have, and to understand the concept of 'kitchen', 'morning time', and 'bowl'. Greycat, as far as we know, does not represent these concepts. As Davidson suggests it is difficult to make sense of questions that ask us to define, precisely, the content of a creature's rational belief. Perhaps an answer to the problem is to attribute the most 'rational' belief to Greycat, say, *"the cat believes that by patrolling around the food bowl, food will appear."*

But this rational belief is, just as are all the others, impossible for Greycat to have, unless of course Greycat has many other beliefs about his bowl, such as the belief that this bowl has depth so that it is capable of holding substances. And the belief,

substances put in this bowl are good to eat. Similarly, Greycat would have to entertain the belief that this bowl is in the kitchen and not in the bedroom. This bowl is not the same bowl as one finds in the kitchen sink and so forth.

It appears then, there is not one single description we could use of Greycat's behaviour in order for us to warrant the attribution of a single belief, for if we are to intelligibly ascribe a rational belief to Greycat we must also ascribe other beliefs to him in order to '*support*' the first. It may appear that our first belief ascription is appropriately and correctly attributable to Greycat but we soon end up unable to decide whether Greycat has any other beliefs that are necessary to back up the first, and if we are not confident that the creature has these other beliefs or fears then our first rational belief we attributed to Greycat begins to look very much in doubt and in fact it soon becomes clear that was always impossible for Greycat ever to have entertained the belief in the first place.

From the above examples we have seen the philosophical position that suggests if a creature has thought, believes, or desires or hopes, or even fears, the ontology of this would necessitate that all these propositional attitudes would require a network of true beliefs that are logically coherent. Thus, this is why Davidson suggests that if we cannot decide which other rational beliefs an animal has apart from the first we cannot assume that the animal has thought. In fact Davidson goes further and would claim that the animal is not a rational creature for rationality is the constitutive feature of the Davidson view, which posits the holism of the mental.

Of course not all philosophers are committed to the holistic picture. Dummett (1975) provides two arguments against Davidson's commitment to holism. The first of these concerns, how a language can be learnt, for if one accepts Davidson's picture learning a language seems to require that one comes to understand the whole of the language at one go, whereas learning is a gradual process. The other fallacy that holism commits, suggests Dummett, is that it also restricts Davidson from being able to give a comprehensive account of the nature of linguistic understanding, since Davidson cannot separate fully the semantic from the non-semantic. Other critics of the holistic approach have come from Fodor, amongst others, whose own modularity thesis of the mind is in direct opposition to Davidson's approach (Fodor and LePore, 1992).

However, for the purpose of this thesis, I believe that Davidson sets out a very interesting challenge and therefore I shall not debate Dummetts concerns.

2.6.2. Radical Interpretation and Radical Translator

Part of Davidson's view of what it is to be a rational animal, is to be a *Radical interpreter*. This is when a person interprets the behaviour of a speaker 'from scratch' and does so without reliance on any prior knowledge either of the speaker's beliefs or the meanings of the speaker's utterances. Davidson's thesis of radical interpretation is to attempt to give an account of linguistic meaning, which is based on;

- (a) providing an interpretation of all utterances, actual or potential, of a speaker or group of speakers;
- (b) being verifiable without knowledge of the detailed propositional attitudes of the speaker.

Davidson's Radical Interpreter stems from Quine's notion of the radical translator which he introduced in *Word and Object* (Quine, 1960). It is important to look at this notion of radical translator for it highlights the errors which are made when one tries to ascribe a set of beliefs or ideas to non-linguistic animals that are bound in the language we use to ascribe those beliefs.

A radical translator is a person who has the task of discovering and understanding the language that is spoken by some group of unknown speakers amongst whom he finds himself. The radical part of this situation is that the translator is completely unfamiliar with the language about whose syntax and semantics he has to translate and he has no additional information on hand to help him such as a translation dictionary or any other aid. It is only the use of the native's discourse which provides clues for the translation to occur.

The translator, Quine (1960) suggests, starts with the sentences that seem to correlate closely with factual events in his environment.

“The sentences first and most surely translated in such a case are ones keyed to present events that are conspicuous to the linguist and his informant. A

rabbit scurries by, the native says 'Gavagai', and the linguist notes down the sentence 'Rabbit' (or 'Lo, a rabbit') as tentative translation, subject to testing in further cases." (Quine 1960, 29)

Quine, makes the distinction between *affirmative stimulus meaning* of a sentence and the *negative stimulus meaning* of a sentence. The former is a set of all stimulations that confirm to that sentence. The latter, negative stimulus meaning, of a sentence is the class of all stimulations that prompt dissent to that sentence. The *stimulus meaning* of a sentence is the *ordered pair* of the affirmative and negative stimulus meanings. So argues Quine, the translator would choose 'Rabbit' as the translation of 'Gavagai' if 'Rabbit' and 'Gavagai' are *stimulus synonymous*. They equal each other (Bermudez, 2003).

However, the following English sentences are also stimulus synonymous, and can easily have been used by the translator and are therefore equally acceptable as translations of 'Gavagai':

- (a) 'Lo, a rabbit';
- (b) 'Lo, a bit of rabbit-part';
- (c) 'Lo, an example of the universal concept of *rabbithood*';
- (d) 'Lo, a temporal stage of a rabbit'.

All of these translations would preserve the empirical observations that are necessary by Quine. Although the sentences are stimulus synonymous, the terms 'rabbit', 'a bit of rabbit-part' etc. are not. It is quite clear that we are able to choose any of (a) to (d) as translations of the term 'gavagai'. However, the problem is that each choice will have different consequences as used by the translator and this is a critical feature of Quine's argument. Quine in fact calls this problem the "*indeterminacy of translation*."

"The general law for which he is assembling instances is roughly that the native will assent to 'Gavagai?' under just those stimulations under which we, if asked, would assent to 'Rabbit?'; and correspondingly for dissent." (Quine 1960, 30)

Quine is concerned with the extent to which dispositions to verbal behaviour uniquely fix the meaning to native remarks; Quine claimed they do not, as we have seen in the translation of 'Gavigai' speakers sharing identical dispositions may say things that might nevertheless not mean the same by their remarks.

Quine, used the notion of indeterminacy of translation to establish the conclusion that two different translators could properly come to assign quite different meanings to the sentences of the natives they observe.

“For, consider 'Gavagai'. Who knows but what the objects to which this term applies are not rabbits after all, but mere stages, or brief temporal segments, of rabbits? In either event the stimulus situations that prompt assent to 'Gavagai' would be the same as for 'Rabbit'. Or perhaps the objects to which 'gavagai' applies are all and sundry undetached parts of rabbits: again the stimulus meaning would register no difference. When from the sameness of stimulus meanings of 'Gavagai' and 'Rabbit' the linguist leaps to the conclusion that a gavagai is a whole enduring rabbit, he is just taking for granted that the native is enough like us to have a brief general term for rabbits and no brief general term for rabbit stages or parts.” (Quine 1960, p51-52)

The problem of the field linguist is the problem of the comparative psychologist, and those wishing to produce any theory of cognitive systems. There can be many ways in which to describe the behaviour of a given act, and each description of that behaviour can give satisfactory accounts of that creature's behaviour, so how can the comparative psychologist/cognitive ontologist give a true account of how an animal carves up its perceptual world?

What Quine is getting at is that there is no way of determining how to move beyond the general, and advance to the specific. Quine himself takes the view, that this ontological indeterminacy cannot be resolved.

There are of course serious questions to be asked about whether radical translation could possibly be subject to an ontological indeterminacy as radical as Quine suggests. But what Quine has raised for us, through his analogy of the radical translator, has serious implications for any theory of cognitive rational animals. Is the case that when we come to observe the behaviour of non-linguistic creatures, we all are confined to play the role of the radical interpreter? And if this is so, then is there any way of getting past the problem of indeterminacy of translation?

Bermudez (2003) also highlights this problem and suggests that unlike the radical interpreter, animals or very young children do not use language, thus making the task of translation even more difficult and even more susceptible to indeterminacy.

Quine, 1995, suggests that systems carve up the world via a process of reification⁶ and reification plays an important role in the notion of what it is to be a rational animal. Strawson (1959) and now taken up by Bermudez (2003). makes a distinction between two types of experience. He calls them the feature-placing level of experience, and the particular-level of experience.

At the feature-placing level of experience, a creature lives and moves around in an environment which contains food, shelter, weather. The creature comes to know that these items can be found not only at different places, but also at different times and in different combinations. The creature may also come to understand that some encounters of food, shelters etc are predictable, and some are not. Those creatures that is best able to make these predictions will have the highest fitness and thus will reproduce more. However, regularities at this level are based simply conjunctions of features. (Bermudez 2003).

In contrast, the creature that operates at the particular-involving level is able to detect regularities and relations of a completely different order — regularities that govern the behaviour of persisting bodies. Many of these regularities will be causal, governing the interactions between persisting bodies. Others can be kinematic, governing the possible movements and behaviour of any given body. In order to move to the particular-involving level agents will need to make full use of observational categories (Bermudez, 2003).

Observation categories can occur according to Quine at any of the two levels of experience, however, the generalisations of categories at the feature-placing level can be wholly associative driven and are the basic kind of learning (Quine 1995). But particular-involving generalisations are of a qualitative different level of description. Reification then is the move from feature placing-to a particular-involving level of experience and to move from the general to the specific level. Quine suggests, that this

⁶ Reification is an operation by which something that was previously implicit, unexpressed and possibly inexpressible is explicitly formulated and made available to conceptual (logical or computational) manipulation.

move is done by language – or more specifically by having the linguistic tools that will permit the agent to combine these features together.

What Bermudez suggests is that the theorist of non-linguistic thought needs at the very least to show that reification can take place in the absence of the linguistic machinery associated with pronominal reference and quantification. He quantifies this by stating that “*the outcome of reification is the perception of an articulated and structured world*” (Bermudez, 2003, p74).

It appears then that Bermudez is laying down another challenge to the comparative psychologists, that is to produce evidence that a non-linguistic agent is capable of perceiving a structured world which is not dependent upon some linguistic mechanism. A structured world where the agent can grasp an objective truth.

Rationally, in Quine’s ontology then, is when an agent can exhibit reification and move from a feature level of abstraction to a particular-involving level, and Quine claims that language is the only tool that can provide behavioural evidence for this move to have occurred.

To recap, Quine posed the problem of the radical translator, where this person must discover the meanings of the sentences another group of speakers are using to communicate in. In order to solve this problem, Quine suggested that the radical translator must solve the problem of indeterminacy of translation, where the translator cannot finely tune the proposition of the native speakers he/she is trying to understand. Gavigi, for example, can mean many things about rabbit-hood, and Quine came to the conclusion that two different translators could properly come to assign quite different meanings to the sentences of the natives they observe.

To solve the problem of indeterminacy of translation Quine puts forward the view that an agent must move from a feature-placing level of experience, to a particular-level of experience. This move to a particular-level of experience is, I suggest, the same move to a subject/object contrast. That is to say in order to be a rational animal, an agent must move to the particular level of experience.

2.7. Design Primitives and Reification

A simple questions now confronts us, if relational encoding and other design primitives are something which cognitive growth can stem from as McGonigle and Jones (1975, 1978) and McGonigle (1987) and McGonigle and Chalmers (1977, 1992, 1996, 2003) suggest, can these same design primitives provide the necessary growth for a creature to move from a “feature-placing” level of experience to a “particular-level” of experience. Can design primitives ultimately provide non-linguistic creatures with the ability to go through the process of reification and is this process a gradual unfolding of cognition or is it dependant upon other factors?

One way suggest McGonigle and Chalmers (1977, 1992) to answer these questions is to develop paradigms based on the notion of concurrency.

2.7.1. Concurrency and Size Seriation: An Example of Reification?

Davidson claims that there “*is no distinction to be made between having concepts and having propositional attitudes*”, (Davidson, 2004, p137). In order that ladybirds and roses do not become part of a class of things that have concepts Davidson further makes the distinction that the agent must “judge” or “believe” that certain items fall into the category of the concept under review. This perspective of what Davidson believes thought requires is especially interesting from the view point of the comparative psychologist. The fact that Davidson’s relies on *judgement* to be an element of what is required for thought, has implications for those investigating the work of seriation. The ability to order items in a monotonic sequence, (depending on size) either ascending or descending is known as size seriation. As we have seen in the basic triadic size set seriation tasks described at the beginning of this chapter there is a judgement to be made with the three items such as which is the biggest, which is the smallest and indeed which is the middle item. But other immediate questions need to be answered if we are able to determine if non-linguistic animals can move to reification. They are as follows.

- What is the order, if any, of a size acquisition relational competence?
 - Is bigger than, more fundamental than its reverse, as Clark (1969), Clark, Carpenter and Just (1973) suggest in lexical marking effects?
- Is the middle rule learnt only after all the comparatives had been learnt? And

- Once this middle rule had been learnt, how far could that take a non-linguistic creature into seriation compared to children (Inherlder and Piaget (1964). Finally
- What is the maximum number of items a monkey, for example could seriate?

In order to answer these questions we need to look at further empirical work of McGonigle and others to determine if there is sufficient empirical evidence that suggests the primates have moved through a process of reification.

2.7.2. Block Size Seriation (2 Concurrent Relational Codes)

The Paradigm

Experimental Design and Methodology

McGonigle (1987), McGonigle and Chalmers (1980, 1986, 2002) used four squirrel monkeys that were previously tested in the McGonigle and Jones (1978) study. Using the same WGTA as before they were re-trained on pair wise size discriminations using a colour conditional code.

The stimuli were 5 different wooden blocks, except they ranged in different sizes from the smallest 1.2cm to the largest 6.2cm and there were two sets. One set was painted white and the other black. For two of the four monkeys when all the blocks presented were all white it meant ‘take larger’ or ‘take the largest of the two blocks’ and when presented with all black blocks it meant ‘take smaller’. or ‘take the smallest of the two blocks” It was simply reversed for the other two monkeys so all black equalled ‘take larger’ and all white, ‘take smaller’. Table 1 shows the two conditional codes being used .

	Set Colour	1st Conditional Rule	Set Colour	2nd Conditional Rule
Monkey 1	White Set	Take Larger Block	Black Set	Take Smaller Block
Monkey 2	Black Set	Take Smaller Block	White Set	Take Lager Block
Monkey 3	White Set	Take Smaller Block	Black Set	Take Lager Block
Monkey 4	Black Set	Take Larger Block	White Set	Take Smaller Block

Table 1: Two colour conditional rules used in a five term size seriation task. (McGonigle and Chalmers, 1980)

The monkeys as before were presented with four adjacent pairs of AB, BC, CD, DE on a tray, in randomly presented trial blocks of initially five trials then ten until the subjects had reached a successful 80% correct choice on one of the conditional rules. Once this had been completed, in the next phase all possible ten pairs from the set ‘ABCDE’ were presented⁷. Again, until an 80% successful criterion level was obtained. The other colour conditional was trained in exactly the same way. In the penultimate phase of the experiment trial blocks of 10 were given across all blocks again until high levels of accuracy (80% successful criterion) were achieved. The final test phase of this experiment included the randomization between trial blocks of all pairs and both conditional rules.

This paradigm can be seen in table 2 below.

	Conditional Rule	Pairs	Criterion Run
Training Phase 1	Training on 1st Conditional Rule	AB, BC, CD, DE	80% Successful Criterion
Training Phase 2	Training on 1st Conditional Rule	AC, AD, AE, BD, BE, CE	80% Successful Criterion
Training Phase 3	Training on 2nd Conditional Rule	AB, BC, CD, DE	80% Successful Criterion
Training Phase 4	Training on 2nd Conditional Rule	AC, AD, AE, BD, BE, CE	80% Successful Criterion
Test Phase 5	Randomisation of all pairs and conditional rules		

Table 2: Training and testing procedure for testing two conditional rules concurrently in Squirrel Monkeys. (McGonigle and Chalmers (1980, 1996).

2.7.3. Results

The Training Phases: Acquisition.

All monkeys completed all the training phases of the experiment. As the monkeys had previous exposure to the different size blocks re-training on the first conditional larger rule was quite rapid, taking only on averaging 98 trials per pair on the initial phase. Interestingly, on the second conditional rule, for example, the take 'smaller than' relation, this was learned even faster: taking only 39 trials on average. All the monkeys were able to maintain a stable performance involving performance on both of the conditional rules and few errors were seen to be observed. McGonigle and Chalmers report that over 90% accuracy for both rules and for all pairs was obtained.

Reaction Time Analysis

⁷ The ten pairs are as follows: AB, BC, CD, DE, AC, AD, AE, BD, BE, CE.

McGonigle and Chalmers used reaction time as a measure of speed and competence, as this measure is exactly the same approach as that of psychophysics which has shown that size discrimination can be measured using reaction time. Analysis was only conducted on correct choices only with a minimum of ten decision times recorded per instruction. As figure one below shows for the group as a whole that there was a significant marking effect between the size of the presented stimuli. In fact the data showed that there was a preference for the “unmarked” conditional block.

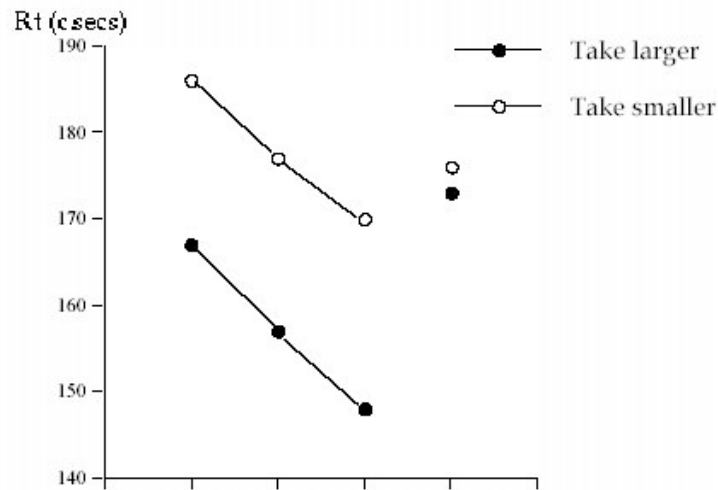


Figure 1: A marking effect in the reaction times (monkeys). (McGonigle and Chalmers, 2002)

McGonigle and Chalmers found there was an interaction between the instructions and the ‘ends’ of the set. Which can be seen in figure 2 below. What this interaction indicates is that there is a fundamental series asymmetry favouring the ‘big’ end, the larger of the cube of the presented pair set.

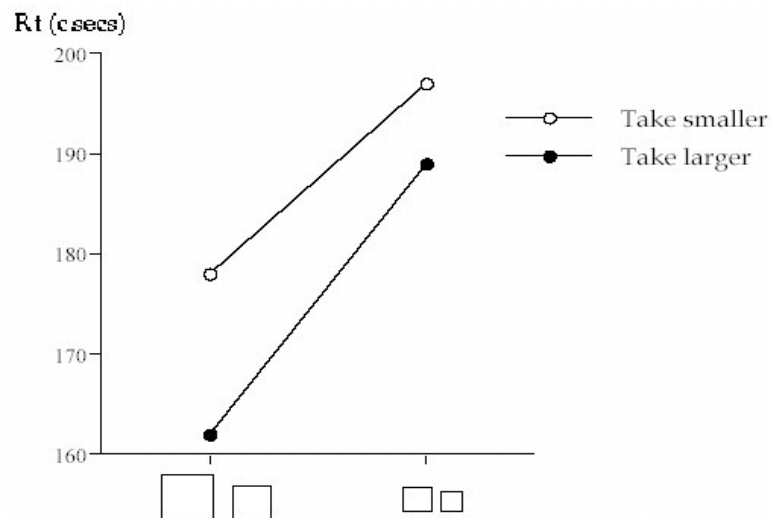


Figure 2: End of set asymmetry in reaction time data from Monkeys McGonigle and Chalmers, 2002)

This asymmetry is highlighted in figure 3 where we see group data for all of the individual pairs in both of the conditional rules. What we see is that the 'take larger' conditional rule appears to produce a pronounced greater distance effect when plotted from the small end. Conversely the smaller than instruction also produces a more marked distance effect from the small end, but not as great. The primates therefore show a marking favouring the 'big' end of size range.

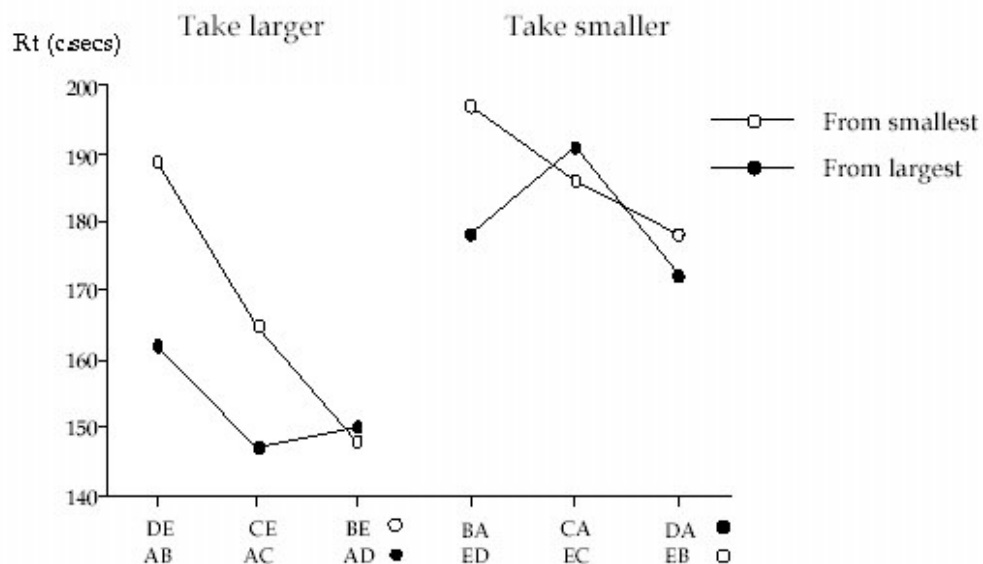


Figure 3: 'Favouring the Big End' – the interaction of the two conditional rules for all pairs presented.

The results therefore show that these squirrel monkeys can concurrently operate two rules of relation and that there is a dependency between the operation of one rule and the operation of its reverse. A systematic relationship. Again using a micro level of analysis McGonigle and Chalmers found that the one end of the series seems to anchor all decisions. That is they found that the further away the test stimuli are from the big end of the set the slower the choice is. (See figure 2). In other words the analysis tells us that big anchors all. What is interesting about this relational encoding paradigm is that the paradigm itself tests the cognitive structure of relational encoding and not the behaviour per se and does this by the increasing task difficulty such as adding in all the ten possible combinations of AB, BC, CD, DE.

Another important feature of their paradigm is they tested using a second conditional code *concurrently*. The full ontology of relational encoding cannot appear in paradigms (such as those used in Behaviourism) that just tested singular codes in isolation and independent of each other. Concurrent testing is a necessary feature.

Previous to this experimental paradigm very few researchers have tested for the existence of relational competences using a concurrent test design (McGonigle, 1987; McGonigle and Chalmers, 1980, 1986; McGonigle et al, 2003). However, it is key to the unambiguous identification of relational codes that a concurrent testing regime be employed. As McGonigle and Chalmers (1998) state, the condition of concurrent testing has to be met in order to evaluate the role of any one relational code in the operation of another. As there was a significant gain in information when more than one relation could be tested by deploying a concurrent procedure, McGonigle and Chalmers extended this basic paradigm to not only testing three conditional rules but so that five conditional rules could be tested concurrently. Before we get to five lets look at how McGonigle and Chalmers demonstrate that the primates can utilise three concurrent codes.

2.7.4. The Middle Size: (3 Concurrent Relational Codes)

In the above experiment we saw how two concurrent relational codes were tested at the same time, however in order to show if some non-linguistic animals are capable of moving to a processes of reification, we need to know how many relational codes can a non-human agent cope with, especially since given these non-linguistic agents are receiving the linguistic equivalent of “if all black choose bigger”, and the inverse (whilst still retaining the original rule), “if all white choose smaller”. Therefore we need to know what happens when a third code is introduced – that is the middle size. Table 3 shows how this third rule can be introduced.

	Set Colour	1st Conditional Rule	Set Colour	2nd Conditional Rule	Set Colour	3rd Conditional Rule
Monkey	White Set	Take Larger Block	Black Set	Take Smaller Block	Red Set	Take Middle Block

Table 3: The Introduction of a third conditional rule through the red blocks meaning “Take Middle Size”

Methodology

The same stimuli and monkeys were used as in the previous experiment. However, as the 2 conditional rule experiment used blocks presented in pairs it was necessary that if a ‘take middle size’ was to be introduced that a third block should be added. As such, this was done but initially still keeping the first two conditional rules. That is when the triads were presented at first the monkeys were still tested on bigger/biggest;

smaller/smallest⁸. When the criterion level of 80% was reached for both of the first two conditional rules the third conditional was then introduced by a red colour block. (Table 3). Consequently, the test phase of the experiment all three conditional rules were being tested concurrently and all being presented in a random sequence to control any learning effects.

2.7.5. Results

McGonigle and Chalmers noted training on this rule was found to be lengthy, and costly for the monkey to learn. In fact on average the monkeys took around 100 trials per triad before reaching the standard 80% correct criterion. Compare this to the learning of the take smaller' relation of 39 trials per pair. Importantly, even though the learning was costly all monkeys did manage to achieve in learning this third concurrent rule to the imposed criterion level. Although, this is an achievement in itself what was interesting was how the middle size affected the other two rules. McGonigle and Chalmers showed that the marking effect increased. This was manifested by the 'big' end of the continuum played an ever-increasing role to anchor the choice behaviour and as a result there was an increase in reaction times between the 'take middle' and 'take smallest'. This can be seen in figure 4 where we see the comparison of reaction times against the two conditional rule experiment.

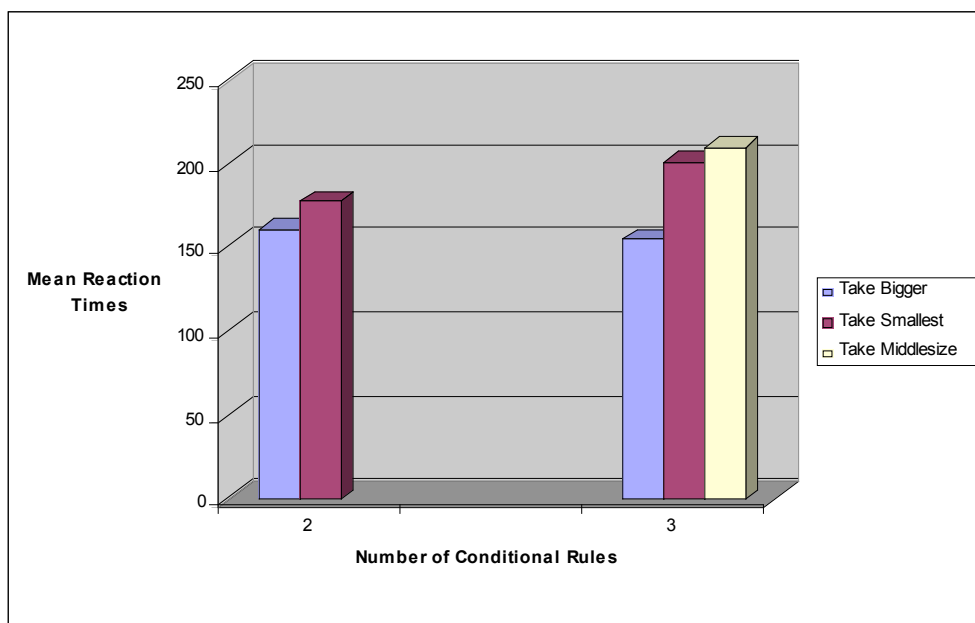


Figure 4: Mean reaction times for monkeys as a function of conditional rules.

⁸ It is interesting to note that when the triadic block was introduced the primates found no difficulty in choosing the "take larger" or the "take smallest" block. This result alone confirmed an earlier result from McGonigle and Jones (1978) that primates have a basic understanding of perceptual transitivity.

We can see from figure 4 when the third conditional rule was introduced it had a significant effect on the mean reaction times of the ‘take smallest’ and of the ‘take middle size’ rule. In the case of the ‘take smallest’ rule we see an overall increase in the reaction time. Consistent with the learning the third rule, the reaction time of the monkeys to respond to this was the greatest of all.

McGonigle and Chalmers, (2002) not only found that the found that the ‘bigger than’ judgments were faster than any of the other two rule judgements but that they were fastest when made with the biggest stimuli of the set, that is, the bigger of the big stimuli was faster than the bigger of the small stimuli of the set. But this congruity effect was asymmetrical. The smaller of the big items in the set was still faster than the smaller judgments of the small items, which indicated that some derivation of the inverse from the end point of the series representing ‘big’ (McGonigle and Chalmers, 1980, 1986). This result could explain the asymmetries reported earlier by McGonigle and Chalmers (1984), which showed the same directional asymmetries when asking children to compare the size of two animals from memory, found that denying an animal was big took less time than to confirm its smallness.

2.7.6. Direction

These results are consistent with results from human studies on memory, for reaction times are commonly recorded as being faster within a given size range for the large end of the sets even when the differences of the items are less psychophysically salient than at the smaller end of the set (Moyer and Bayer, 1970). Parkman, (1971) model of digit size comparisons suggests that when an asked to compare two digits say 10 and 37, what the person does is that they scan from 0, until they come to the first of the two digits, 10 and then stop, the larger digit is then by default the ‘other one’ and is subsequently retrieved. What is interesting about this model is the next stage of acquisition; say smaller than, this secondary process is only completed once the forward scan has been executed. As a consequence of this model all ‘smaller than’ scans will take longer than ‘larger than’ comparisons, as the scan goes up to the larger one first, anchors there and then locates the smaller one in a downward manner. So in our example we scan all the way to 37, stop, scan back down to 10, and then make the choice.

This processing model can be tested in the paradigms developed by McGonigle and Chalmers, 1980, 1996, 2002) for certain predictions based on reaction times between the size of items can be made from it. This obviously has specific cognitive growth implications, for it does appear that multiple relational codes are being derived from a set of design primitives, but how many relational codes can a non-linguistic creature concurrently use? And in what order does the non-linguistic animal acquire these relational codes. It does not seem to be an all at once (holistic) model of acquisition so what is the order and can the methodological paradigm bring out' the direction of acquisition of relational codes

2.7.7. Multiple Testing: (5 Concurrent Relational Codes)

We have seen one then two and now three relational codes being concurrently tested using this WGTA block world paradigm. But what of five rules? Could the monkeys identify and correctly choose the objects on the basis of a five rule set?

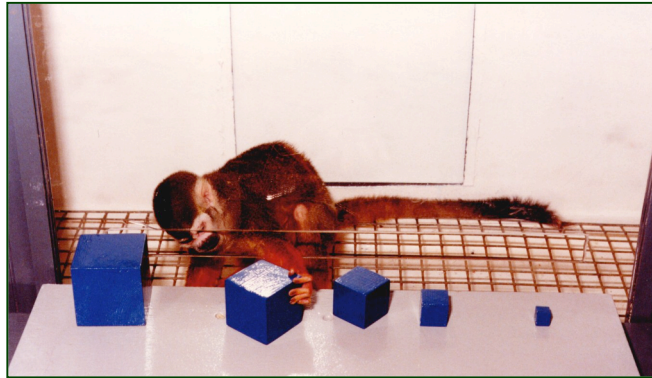
Experimental Design and Methodology

McGonigle and Chalmers used a large WGTA so that the monkey could view the five objects simultaneously. Each of the sets, consisted of five different colours and of five different sizes. (Chalmers, 1994; McGonigle & Chalmers, 1996) Along with the three already existing conditional rules two other conditional rules were introduced. Below is the full list of all the five rules, along with an example of a colour block identifying that rule.

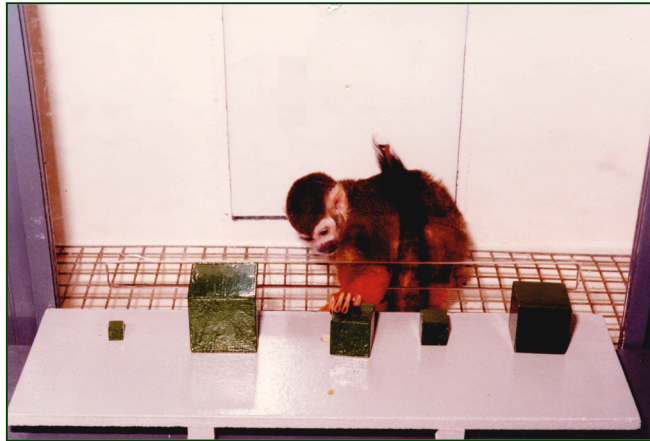
- If all the blocks are Black choose **biggest**
- If all the blocks are Yellow choose **second biggest** (new rule)
- If all the blocks are Red choose **middle**
- If all the blocks are green choose **second smallest** (new rule)
- If all the blocks are White choose **smallest**

As a control McGonigle and Chalmers mixed the colours and rules across all monkeys so that no one particular colour could have effect. On any one trial, all stimuli were of one colour, and only one size rule was rewarded, Again as with the previous experiment the spatial layout of the five blocks were presented randomly for each trial. The following photographs (photographs 1 and 2) shows the monkey working in this paradigm. Here you can quite see the monkey reaching out and touching the block.

The monkey is very keen to participate and is not held in an environment that causes the animal stress.



Photograph 1. A Squirrel monkey at work on a blue five item size seriation task
Photograph 2. A Squirrel monkey at work on a green five item size seriation task



In order for the monkey to complete the task a demanding training procedure was developed. Initially the monkey was presented randomly with interleaving trial blocks of five trials per rule, then two trial blocks and then in keeping with the control methodology described above, one, (critically no rule was then repeated until all the rules were exhausted). During the training phase an 80% correct training criterion was established across fifty trials and no rule could be less than 60% correct. When eventually the five colours were presented in single random alternation across trials, again no colour was repeated. In order to ensure that the monkeys were learning to make set-referenced ordinal judgments rather than just ones based on absolute size, McGonigle and Chalmers introduced a second set size which overlapped with the first and tested the size rule transfer.

2.7.8. Results

To begin with all monkeys learnt the five rules being taught and did so in a concurrent fashion. However, differences in the data profiles of the monkeys occurred compared to the previous binary and triadic conditions. The data showed both (rather than one) end points of the set superior to the learning of codes, suggesting some internal set values at operation. So the biggest and smallest end points of the sets transferred well, with the 'smallest' having the most accurate choices and the least number of errors. Next in the acquisition sequence came 'take biggest' again with high percentage correct levels but more errors occurred with this rule than the 'smallest' one. What about the middle rules. Was the middle rule next to be acquired? No, In fact the 'take second smallest' was the next rule to be acquired followed by the acquisition of second biggest and then middle So the cognitive profile of the five rules being concurrently tested can be seen in figure 5

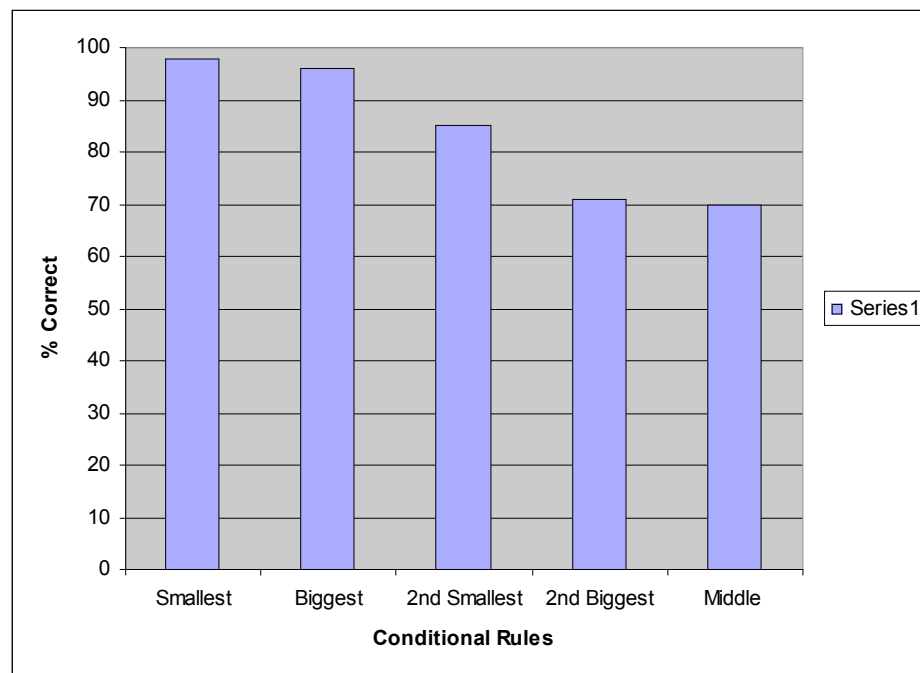


Figure 5. The syntax of acquisition of five concurrently tested size rules on non-linguistic creatures. (McGonigle and Chalmers 1996)

This profile can be directly compared to the results found in linguistic agents, Chalmers and McGonigle (1995) when testing children showed that in a five stimuli set middle size is not the next rule to learn after the two end points. Instead an end-inwards calibration of the series occurs. When McGonigle and Chalmers looked at the reaction time distribution once acquisition of the five rules had been sufficiently demonstrated, they found that the big end of the series has primacy over the other

rules. That is, it is quicker for the primate to judge something is biggest than any of the other rule. Next came smallest, second biggest, second smallest and therefore it took the primate longer to determine something is the middle size of a set than anything else.

These results not only show how non-linguistic creatures utilise multiple concurrent conditional rules, (certainly at least four⁹) but that that seriation and relational competences are causal and that there is an acquisition lag in their development. (McGonigle and Chalmers, 1996).

2.8 Implications

This relational ability is clearly at the door of perception. Although these series of experiments demonstrated significant advances in the abilities of non-linguistic creatures, this level of perceptual systematicity is at the perceptual level of functioning. The paradigms and methodology used in these series of experiments do not test the primate's relational ability without perceptual correlates. Piaget and others including Davidson would suggest that for a creature to be cognitive it must move beyond the level of mere perceptual functioning. Cognition is more than that; a cognitive creature must be able to manipulate 'symbols' in the absence of their referents themselves. That is they must do it 'in the mind's eye'. Although the evidence above indicates sophisticated strategies, this is as yet, in my opinion, no threat to Davidson's position. What is necessary is for experimental evidence to show if (and how) non-linguistic creatures can manipulate these relations in the head. The results of these experiments have answered some theoretical questions, such as the richness of the ontological floor, the syntax of pre-linguistic relation size learning for example, but they ask many more.

2.8.1 Fodor Revisited

Not all, though, believe that design primitives are necessary criteria to cognition. Fodor (1983, 1985, 1992) claims that "higher" cognitive functions do not interact with low-level functions like perceptual design primitives. He suggests that cognition is independent of low-level functions. Fodor claims that the necessary components of

⁹ It is not clear from these results if the fifth relational code is actually being learnt or is just operating out of default.

psychological processing can be divided into a three-part functional taxonomy of transducers, modules (input systems) and a central system (Fodor, 1983; 1985). Modules for Fodor are rigidly specialized, domain specific, innately specified, autonomous, unassembled input systems that are encapsulated. Encapsulation entails that the inference producing mechanisms have general features of their architecture that constrain both their access to background information and the information that they output. Thus modules are structures so that: *i*) minimally some information that is accessible to the cognitive process is unavailable to the module and *ii*) the operation the module performs has access to only the information in the database of that module and the retransmitted stimulus. Finally, central systems globally and isotropically access information. This is typical unencapsulated behavior — and it is holistic and ‘Quinian’ (Fodor, 1983, p. 117). Cognition for Fodor as we have seen in the beginning of this chapter is realised as a language, or, more specifically, as syntactic operations defined over representations. The core of Fodor’s argument is that the (1) processes of cognition consist of computational processes, and (2) computation requires a language over which the computations are performed. The basic units of this language are conceived of as symbols: entities which of themselves are content-less or arbitrary. It is by virtue of their structural relationships (their systematicity) and the structural transformations which are possible that these symbols can serve as the vehicles of cognition. Fodor in essence is placing *highly non-trivial restrictions* on what the internal constitution of a thinking organism must be like: ‘*if a thing does not possess, a mentalese that shares certain essential features with natural language, then it cannot be a thinker*’. However as we have just seen in the above paradigm how reasoning competences have derived from very ‘base’ ontological beginning such as design primitives and that these reasoning processes appear not to unfurl all at once within some kind of Language of Thought.

2.8.2 The Move to Reification Revisited

To recall, the process of reification is the process of moving from the feature-placing level of experience, to the particular-level of experience. Those agents that can operate in the particular level of experience, are able to detect regularities and relations of *a completely different order*. Regularities that can be causal, governing the interactions between bodies. Others, governing the possible movements and behaviour of any other given body. In other words we are looking at are creatures that can ‘*make full use of*

inductive learning' (Quine 1995). As we have seen this move for Quine from feature to particular is done through the acquisition of language or more specifically by having the linguistic tools that will permit the agent to combine these features together.

Rationally, in Quine's ontology, is when an agent can exhibit reification and move from a feature level of abstraction to a particular-involving level, and that language is the only tool that can provide *the behavioural evidence* for this move to have occurred.

Language may not be the only tool that can provide evidence for this move to have occurred. The experimental paradigms designed by McGonigle, McGonigle and Jones, and McGonigle and Chalmers suggest that careful comparative methodology can deliver a way of demonstrating the move to the particular level, to demonstrate the existence of inductive thinking creatures without language. The methodology is not quite there yet as we are still based with the perceptual level of reasoning and we need to show, how these relations in the mind's eye can be performed, However, through the work of McGonigle and others the evidence showing the order of size acquisition, the role of the bigger, smaller and middle in variable size sets does indicate that possibility that the primate may be able to behaviourally demonstrate reification after all.

2.8.3 What Does This Relational Competence Mean?

What is important is that we get at the causal mechanisms of cognitive growth and what does this relational competence mean to a non-linguistic creature that has this ability, what is its utility to it, and how far can this competence take the non-linguistic creature up the ladder of cognitive skills. Does successful performance on relational competence tasks mean that at some level the primate has a meta representation of the relations it sees? However, this does not seem right as design primitives do not appear to be the stuff meta-representations are made off. Or does it mean that these primates, at some level, just move through the relational transitions it sees. If the latter, which the results seem to suggest, then it would be wholly appropriate to see these design primitives more of a mechanism that is "*likely to be the engine of cognitive growth, [rather] than its product*"? (McGonigle and Chalmers, 1992, p228). If so, and design primitives are seen as the engine of cognitive growth then it is legitimate to ask the following;

- what cognitive growth do they support?
- Is it the same engine in humans as it is in primates?
- if it is the same engine, does it support any other shared cognitive features?
- if so is cognitive growth a serial unfolding of development or is it dependent upon the degree and number? of hard wired design primitives?
- will design primitive eventually support beliefs about beliefs?
- can design primitives meet the systematicity challenge?
- is this engine related to the development of language in any way?

I hope to explore answers to these questions in the remaining chapters of this thesis.

2.8.4 Davidson Revisited

To summarise the position so far, Davidson claims that thoughts/propositional attitudes depend upon a network of mostly ‘*true*’ beliefs, where one belief is dependent upon many others, which in turn are also dependent upon other propositional attitudes as well. This means that having a concept of belief is having a state which is being capable of being true or in contrast to an *objective truth* (false). What this means to an animal that possess all of these qualities is that it is surely a “Rational Animal”. It would be capable of ‘*intelligibly attributing any propositional attitude to an agent within the framework of a viable theory of his beliefs, desires, intentions, and decisions*’ (Davidson, 1970). This then for Davidson is rationality. To have propositional attitudes is to be a rational creature and to be a rational creature one must have language in which all the distinctions in language are used in the attributions of beliefs, desires and intentions to each other. It is a creature that when it matches its own beliefs with how things are in the objective world it, will have beliefs that are true, or otherwise false.

Davidson’s position is grounded in an argument whose outcome “*suggests that the attribution of thoughts to others must go hand in hand with the interpretation of speech*” (Davidson, 1984, p163). We can only know why a person has chosen something¹⁰ if we assign the relevant set of beliefs to that person. For example:

¹⁰ For instance, (largest banana , smallest banana, middle size banana, second biggest banana and so on

“A man who takes an apple rather than a pear when offered both may be expressing a preference for what is in his left hand, rather than what is on his right, what is red rather than yellow, what is seen first, or judged more expensive [and] if we think of all the choices as revealing a preference that one sentence rather than other be true” (Davidson, 1984 p163)

Thus, Davidson claims, we must accept the fact that we have to recognise that the interpretation of what the other means by spoken sentences are correct and true but are also inseparable tasks. He claims it will be an impossible task for those that do not have the capacity for uttering sentences, to have *sufficient* grounds for ascribing any beliefs thoughts, desires to that creature. And if we cannot ascribe a particular thought to that creature, due to the holistic nature of the mental, we cannot ascribe any thoughts to that creature.

McGonigle *et al* shows the primate can learn multiple conditional rules and is making a choice based on size. But are the primates making a choice that is solely based on a response to making an error or are they making the choice as a result of comparing possible different states of affairs? The latter is something that would look like thought in a Davidsonian sense. Is the behaviour of the primates sufficient enough for us to determine that they are moving to *‘thinking about different possible states of affairs dependent upon objective truth?’* It may well, be for the controls on the experimental design show that the monkey is not learning to switch to a new relational state just because it failed on the previous trial, and therefore is learning to learn to switch¹¹. The non-linguistic agent appears to demonstrate that it does have an understanding of concurrent conditional relation codes, so much so that for one paradigm it is correctly choosing on the 1st trial of the test phase. If the primate has an understanding of relations amongst items does it also therefore by necessity have an elementary grasp of an objective truth? If so what could this mean?

It can mean one of two things. Either the monkey demonstrating an elementary but non linguistic distinction between determining truth and falsity and that this non linguistic ability is completely separate to human ability. Or is it something that is wholly related to the linguistic skill but is simply PRE-linguistic. If the latter, then this would certainly fit well with an evolutionary account of cognition that I am trying to pursue,

¹¹ Therefore the primates behaviour can be explained away by some simplistic and not so simplistic associationistic route.

for on this account there would be no saltatory jump when language appears, which is suggested by accepting the first theory.

Before we explore the answers to that, it is necessary to go explore further Davidson's work and examine why he places so much emphasis on the ability to have beliefs about beliefs, to have second order representations, to be the reader of minds. The issue of language and representation is an important one and hence will be detailed in the next chapter.

3. The Interference of Language and Surprise in Discovering Ontologies of Cognitive Creatures:

3.0 Aims

The aim of this chapter is to explore why Davidson explicitly requires beliefs about beliefs to be the main core factor of thought. For an explanation of this, he turns to the notion of surprise and highlights why if a creature has surprise then by definition it must have thought. The idea of surprise is based around the concept of not just updating our view of the world but also having the concept of being able to compare our thoughts with an 'objective truth'. I will also examine one of the weakest positions of Davidson's argument and that is his notion of the emergence of thought. I will show how a simple monotonic experiment can cause problems for Davidson. I will also explore how theory of mind experiments in non-linguistics animals also pose a problem for Davidson, however I will also show how support for his position can come from an unexpected place. Finally I will show how other theories from the language for thought camp suffer from the problem of original meaning and that we should get back to our original aim of discovering evolutionary continuous ontologies of cognition.

3.1. Davidson and Second-order Representation: Beliefs about Beliefs

As we have seen in the last chapter Davidson has provided us with a strong case for accepting the holistic nature of the mental and how all-propositional attitudes require a networking of 'true' beliefs Davidson is also happy to claim that animals show by their behaviour that they can make fine distinctions too, and can discriminate many of the same things that language speaking animals do. However, Davidson would assert that these creatures do not have beliefs, desires, and intentions.

"Dumb beasts see and hear and smell all sorts of things, but they do not perceive that anything is the case. Some non-human animals can learn a great deal, but they do not learn that something is true" (Davidson, 2004, 136).

But is this sufficient in addressing those conditions that are necessary for a creature to be a rational cognitive one. It is this part of Davidson's philosophy that I will now critically examine.

He outlines two premises that, by necessity, must be fulfilled in order to become a rational animal. They are;

(Premise one.) In order to have a belief, it is necessary to have the concept of belief.

(Premise two.) In order to have the concept of belief one must have language.

(Conclusion one.) Therefore, belief is not possible without language

(Conclusion two.) No language, no rational animal

(Davidson, 1982; p324-327)

Again, I think it will be useful to clarify some of the terminology Davidson uses here. Both of the premises are based around the '*concept of belief*.' What does Davidson, mean when he talks about the necessity of having this 'concept of belief?' In "Rational Animals", Davidson is quite clear, he equates having the concept of belief, with having a belief about a belief (1982, p326). To explain this concept further I would like to make a distinction between a first-order intentional system (Dennett 1987) and a second order one. A first-order intentional system has beliefs and desires but no beliefs and desires about beliefs and desires. That is we could only attribute to an animal that we knew was a first-order intentional system limited propositions such of the form;

(1) x believes that p;

(2) x wants that q;

or more neutrally;

(3) x has the information that p;

As Dennett (1987) has highlighted, second-order intentional systems are a lot more complex than first-order systems for they can have beliefs and desires of others as its own. Hence we could attribute to second-order systems propositions such as;

(4) x wants y to believe that x is injured;

(5) x believes that y expects x to lie still;

(6) x desires that y will follow x the nest;

A third-order system becomes very sophisticated indeed for it would be possible for the system to have such states as;

(7) x wants y to believe that x wants y to jump into the river.

One can even make a case for fourth/fifth and sixth order intentional systems but as this begins to stretch the limits of our psychological processing I will leave it to the reader to determine what kind of description we would have of the creature's mental states.

What is important to note about these differing kinds of intentional systems is that as soon as one passes the first-order description it becomes necessary for the creature, if it is to be a rational agent, to have second-order representations. This is why many philosophers believe that the critical step of this move is the one from first to second-order intentions.

"Once one has the principle of 'embedding' in one's repertoire, the complexity of what one can then in some sense entertain seems plausibly more a limitation of a memory or attention span ..[rather]..than a fundamental measure of system sophistication."
(Dennett, 1987; p244)

This principle of *embedding* is not only a critical feature in the nature of second-order representation but as I will demonstrate later, it is perhaps the mark of cognition itself (Hauser, Chomsky, Fitch 2002; McGonigle and Chalmers (2003).

As a result Davidson holds that in order to be a rational animal, *where one is an interpreter of themselves*, a creature must be capable of representing a belief about a belief, it must be capable of a second-order representation.

One reason why Davidson wants the requirement that a rational animal must be able to have second-order representations is that he specifically wants to make clear that having language does not draw a line between creatures that merely think and creatures that have the concept of thought. For example, imagine Greycat chases a mouse into a hole somewhere along the kitchen wall. Some may claim, as does Malcolm, (1975), that Greycat can have the belief that the mouse went in the hole, but not have the thought that the mouse has gone into the hole. Recall that the latter, according to Malcolm, requires language as well as second order representations.

Davidson suggests that this is not the case for in order to think one must have the concept of thought, and so language is required in both cases.

3.2. Surprise and the Objective Subjective Contrast

In order to convince us that to be a rational animal one needs to have a belief requires us to have the concept of belief, Davidson turns to the phenomenon of *surprise*. The reason being is that if one is surprised one must have various beliefs, which need, in order to be surprised, a concept of belief. Please forgive the long quotation from Davidson which details his rationale of what surprise is. I think that there are many important issues raised in it.

"Suppose I believe there is a coin in my pocket. I empty my pocket and find no coin. I am surprised. Clearly enough I could not be surprised (though I could be startled) if I did not have beliefs in the first place. And perhaps it is equally clear that having a belief, at least one of the sort I have taken for my example, entails the possibility of surprise. If I believe that I have a coin in my pocket, something might happen that would change my mind. But surprise involves a further step. It is not enough that I first believe that I have a coin in my pocket, and after emptying my pocket I no longer have this belief. Surprise requires that I become aware of a contrast between what I did believe and what I come to believe. Such awareness is a belief about a belief: if I am surprised, then among other things I come to believe that my original belief was false."
(Davidson, 1982; p326)

In this passage we see a number of points that Davidson suggests is critical to any theory of cognitive systems. The first, we already know, is that any animal that demonstrates behaviour sufficient for us to attribute surprise, that animal must be capable of having second-order representations. The second, and one of the most important points in all of Davidson's work concerning animal rationality, is the claim that the creature must have the ability to recognise that a belief may be false. And to have this ability the creature must be aware of an '*objective/subjective contrast*', which is the idea of an "*objective reality, which is independent of our belief*" (1982, p326).

Davidson stresses that if a creature can demonstrate surprise, then it has command of this objective/subjective contrast, a contrast that is necessary for a rational system. Therefore if a creature does not have command of this contrast then it will not develop the ability to recognise a belief may be false, and it will therefore not be a rational animal.

A useful way of understanding what this objective/subjective contrast entails has been suggested by Campbell (1993). He gets us to imagine a collection a green bottles and

comments that, it is not sufficient for us to perceive that the bottles are green, what matters is that we can get ourselves in the '*right enabling conditions*' for us to perceive that the bottles are green. (Campbell, 1993). Although initially this seems useful all Campbell is saying is that a creature just needs to be able to recognise the task domain to the expertise the creature has, a feature that has been demonstrated in AI for decades (Newell, Shaw and Simon 1962).

Being able to demonstrate surprise is of course an example of being able to update ourselves, by comparing what was, with what is. For example, I believe that there are monsters hiding under my bed. When I go and look under the bed I am surprised to find that there are no monsters hiding there. This is not what I expected. I expected to see a monster – therefore I am surprised. I have updated my view of the world by comparing what I believed with what I am seeing now. Notice how surprise is much more than just updating our view of the world.

Compare this example with a squirrel running up a tree and a cat waiting at the bottom to chase it. I call to the cat to draw its attention to the fact that the squirrel has jumped down from the tree onto the garden fence. The cat sees the squirrel and begins to chase it again. The dilemma we are faced with, although it is no dilemma for Davidson, is, does the cat think something akin to 'my goodness that squirrel, is no longer up that tree I am sitting under, but it has jumped down from the tree and is now on the fence' or does it, and more likely think, 'easier squirrel hunt'. The cat accepts the new situation. There is no surprise in the second interpretation of what the cat thinks. It sees a squirrel so chases it. It has only up dated its view of the world.

Davidson says that this is why the cat is not a believer. A believer is someone who is in the market for error. Getting it right, getting it wrong, and you can not get it right or wrong unless you have a way of comparing how you thought it was, how you think it is, and how it is or how someone else thinks it is. Therefore you have got beliefs about beliefs.

At last we are beginning to get to know the criterion Davidson imposes on any theory of cognition if it is to be a cognitive animal. The creature must show command of this objective/subjective contrast. If this is so, then one more question needs to be asked;

what behavioural evidence would show command of this subjective/objective contrast?

The answer Davidson gives is: Linguistic communication.

“Why?, because "communication depends on each communicant having, and correctly thinking that the other has, the concept of a shared world, an intersubjective world. [Where] the concept of an intersubjective world is the concept of an objective world, a world about which each communicant can have beliefs”

(Davidson, 1982. p327)

But surely a claim can be made that non-linguistic creatures can tell the difference between true and false beliefs? We know that a creature's mental state is based within a network of perceptions and actions which are the biological primary forms of cognitive states, and we know that perception fixes belief, and belief then determines actions, if this is true, (philosophically and empirically) then the argument, developed from MacIntyre (2001) would go like this. A dog stops chasing the cat because it saw the cat leave the garden, is one where the dog has to correct a 'state of affairs', (p68) in order to stop chasing the cat. It has distinguished a true belief, *the cat has left the garden*, from a false one - *the cat is in the garden* - and it is satisfied that this true belief – *the cat has left the garden* is true. The same is true, suggests Macintyre, for desires. As a result he claims that:

“For neither beliefs or desires does the animal require language; rather what it requires is some device for recognizing the world is the way it seemed to be (belief) and whether the world is the way the animal wants it to be (desire)”
(MacIntyre 2001, p69).

3.2.1. Triangulation

Davidson, as we know, claims that one cannot be a rational animal unless one has language, because language offers the only way into the necessary component of an objective/subjective contrast. But in defence of his claim, Davidson admits that he can only offer an analogy;

“If I were bolted to the earth I would have no way of determining the distance from me of many objects...I might interact successfully with objects, but I could have no way of giving content to the question where they were. Not being bolted down, I am free to triangulate. Our sense of objectivity is the consequence of another sort of triangulation, one that requires two creatures. Each interacts with an object but what gives each the concept of the way things are objectively is the base line formed between the creatures by language. The

fact that they share a concept of truth alone makes sense of the claim that they have beliefs, that they are able to assign objects a place in the public world.” (Davidson, 1982, p.327)

What this passage implies is that attitudes can be attributed, and so attitudinal content determined, only on the basis of a triangular structure that requires interaction between at least two creatures as well as interaction between each creature and a set of common objects in the world. The objects of propositional attitudes are fixed by looking to find objects that are the common causes, and so the common objects, of the attitudes of two or more speakers who are capable of observing and responding to one another's behaviour. Davidson holds that language is necessary for triangulation because we could not come to understand another's beliefs without simultaneously understanding language (Davidson, 1974, 1984). *Without this sharing of reactions to common stimuli, thought and speech would have no particular content—that is, no content at all”* (Davidson, 1991, p159). Both speakers in the triangle must utilise the *Principle of Charity*, by attributing rationality as well as meaningful thoughts to one another. Davidson's triangulation analogy and Davidson's account of radical interpretation shows how the attribution of propositional attitudes must always proceed in tandem with the interpretation of utterances. Notice that this process of triangulation is critical for the emergence of thought.

3.2.2. Surprise and the Role of Surprise in Modelling Emergence of Discontinuities from Continuous Systems

It is interesting to see how the role of surprise is also being investigated in other academic areas. For example in the field of AI 'surprise' or the concept of surprise has also been under the microscope in models of emergent systems. As Arkin (1998) suggested.

Emergence is often invoked in an almost mystical sense regarding the capabilities of behaviour based systems. Emergent behaviour implies a holistic capacity where the sum is considerably greater than its parts. It is true that what occurs in a behaviour-based system is often a surprise to the system's designer, but does the surprise come because of a shortcoming of the analysis of the constituent behavioural building blocks and their coordination, or because of something else.(Arkin, 1998, p. 105).

Models of emergent thought and how agents (creatures/robots/humans) are capable of emergent processes are becoming more and more apparent in accounts of cognitive systems and how cognition can grow from 'weak to strong' (Fodor & Pylyshyn,

(1988). In AI for example a lot of work has already been done on this very issue using various modelling techniques. We see in emergent systems, that it is emergent if the ultimate behaviour of which is discontinuous with the behaviour observed at lower levels (Polack and Stepney (2005). For example in AI when describing an emergent system, low level components or parts of the system have certain behaviours and certain interactions, possibly with each other, and possibly with the environment or both. This interaction can be described or expressed in some language C . This agent or system also demonstrates high level behaviour, for Davidson this may be language, or having a belief about a belief, and this high level behaviour can be expressed in some language A . So a system displays emergence if there is a fundamental discontinuity between the languages of A and C . It is important though to bear in mind that emergence is not a specific thing, nor is emergence not one specific behaviour, which is known to occur at some moment in time. Surprise enters the scene when the observer sees emergent discontinuity behaviour from the lower described continuous system. Some examples taken from Ronald, Sipper and Caparrere (1999) will clarify the point being made here. That is, it is the observer/interpreter that becomes the arbitrator of whether a system has demonstrated emergent behaviour and this arbitration may be done through surprise.

Modelling example #1

The emergence of a nest structure in a simulated wasp colony from the interactions of taking place between individual wasps. (Theraulaz & Bobabeau 1995).

In the modelling design phase of this system the language L_1 is of local wasps interactions, including the movement on a three dimensional cubic lattice and placement of bricks. The actions the wasps takes are pre-wired under the form of a very simple look up table with as many entries as there are stimulating configurations. The observation that we can see in L_2 is that of large-scale geometry, as employed to describe nest architectures. So, suggest Ronald *et al*, surprise occurs from the observer fully aware of the underlying wasp interaction rules, “*nevertheless marvels at the sophistication of the construction*” (Ronald *et al* 1999 p229).

Modelling example #2

The emergence of a “Highway” created by the Artificial Langton Ant, from Simple Movement Rules (Stewart, 1994).

We see in this model that the design language L_1 is that of single moves of a simple, myopic ant. The ant starts out on the central cell of a two dimensional, rectangular lattice, heading in some selected direction. It moves one cell in that direction and looks at the colour of the cell it has moved on whether black or white. If it is a black cell, it paints it white and turns 90 degrees left; but if it has landed on a white cell it does the opposite and paints it black, and turns 90 degrees to the right. This rule is reiterated for as long as the model has power. The observation language of L_2 is of tens of thousands single ant moves, spanning thousands and thousand of cells. However, what we specially observe is the ant constructs a ‘highway’ that is a repeating pattern of fixed width that extends ‘indefinitely’ in specific direction. Again, although we are very aware of the very simple ant rule “*the observer is nevertheless surprised by the construction of the highway*” (p 229). The emergent behaviour is displayed by the behaviour of the artificial Langton ant.

In AI artificial systems are constructed to be observed. The researcher(s) or constructor closely observe and interpret the behaviour of such models, and this fact has not gone unnoticed amongst the AI community. As Cariani (1992) suggests;

“The interesting emergent events that involve artificial life simulations reside not in the simulations themselves, but in ways that they change the way we think and interact with the world.....computer simulations are catalysts for emergent processes in our own minds.....” (Cariani, 1992, p790).

Several authors have even suggested that emergence is “*in the eye of the beholder*” (Emmeche, 1994 p145); “*But for whom has the emergence occurred, More particularly, to whom are the emergent features new?.....The newness in both cases is in the eye of the observer....*”(Crutchfield, 1994, p517.)

It looks that even the concepts of surprise and the observer’s role in interpreting behavior play an important function not only in philosophy but also in such computational studies as AI.

3.3. Davidson’s Theory of the Emergence of Thought

In order to understand Davidson’s account of how thoughts emerge we must return back to Davidson’s notion of holism, and specifically the idea that in order to have any concepts, thoughts “*then, one must have a quite fully developed set of basic*

concepts” (Davidson, 1997/ 2001 p123). His account of the emergence of thought is a direct appeal to the holism of the mental. As he has argued he believes that there are no beliefs without many other related beliefs, no beliefs without desires and no desires without beliefs, and no intentions without both desires and beliefs. (Davidson, 2001). As he says himself;

“You will see my strategy. I am enlarging the field of the mental aspects of life all of which must emerge together. Intentional action cannot emerge before belief and desire, for an intentional action is one explained by beliefs and desires that caused it; beliefs can't emerge one at a time, since the content of each belief depends on its place in the nexus of further beliefs; and so on.” (Davidson, 2001, p127).

A consequence of this approach is that there cannot be a sequence of emerging features of the mental. This as we have seen, in chapter 2 (2.7) and we will see in below, the comparative empirical evidence does not support. However, and very interestingly, Davidson insists that there is a *precognitive, prelinguistic* situation necessary for thought and language and that this situation can exist independent of language and as such precedes it. Davidson says this precognitive situation is the process of triangulation. (3.3). As described, triangulation is the interaction between two agents and the world. These agents can be non-human animals and small children. The triangulation works for each creature as it learns to correlate the reactions of other creatures with changes or objects in the world to which it also reacts. The triangular relationship, suggests Davidson is something that is essential to the existence, and to the emergence, of thought. Without this triangle we cannot have the objectivity of thought and the empirical content of thoughts about the external world.

As such once these correlations are in place, each creature is in a position to expect how external phenomenon behaves when it perceives the associated reaction of the other. Notice this is how the possibility of error occurs, for what introduces the possibility of error is the occasional failure of the expectation; that is to say the reactions do not match.

As we have seen Davidson believes this triangular relationship between agents and an environment to which they mutually react is, a **necessary** condition to thought. Importantly though, it is not a **sufficient** condition. This is because he believes that we

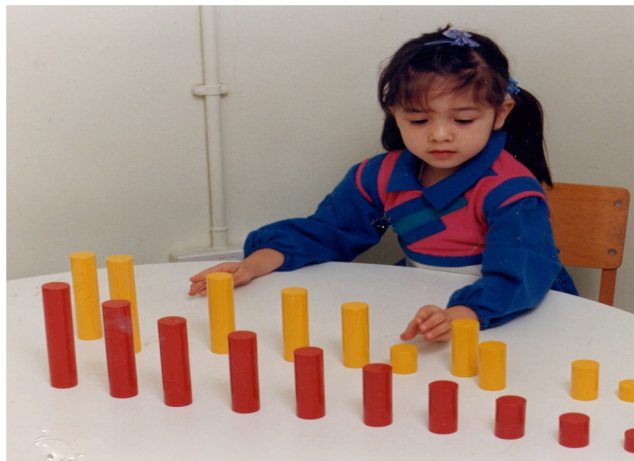
cannot credit non-linguistic animals with judgement. So how do thoughts emerge well, Davidson says “*we can say that a certain kind of primitive social interaction is part of the story of how thought emerged. What more is needed for thought? I think the answer is language.*” (Davidson, 2001, p130)

3.4 Monotonic Ordering: A Problem for Davidson

One way of determining whether Davidson is right regarding his belief in the unfurling of the mental and the reliance of language as the scaffold of thought is to look at human tasks which have been used as an index of human cognitive growth. Piaget (1963, 1971) thought that knowledge consists of cognitive structures/concepts, which ranged in degrees of complexity. Therefore one way of looking for answers is to use Piaget’s own paradigms as a possible starting point. One such task is the classic size seriation task developed by Piaget and Szeminska, in Inhelder & Piaget, (1964).

3.4.1 The Classic Size Seriation Task.

This task requires children to re-organise a jumble set of rods, which can vary in size up to ten rods in total. The child has to then manipulate the rods so that he/she can create a linear arrangement on the table in either ascending or descending dependent upon instruction. See photograph 3 below.



Photograph 3. A young girl tries to copy the example red set in a typical Piagetian size seriation task. (McGonigle, 2004).

There has been a wealth of studies in developmental psychology that shows that around six or seven the child solves the task in a principled selection procedure, based around the rule of ‘take biggest, then biggest’ and so on until the linear arrangement is

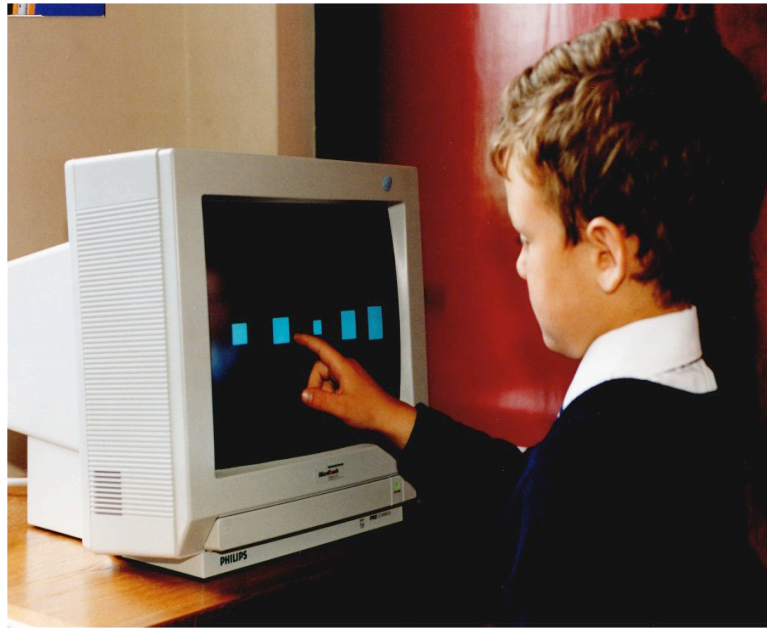
complete. Although the task itself is particularly simple, the actually possible combinations as reported by McGonigle and Chalmers (2001) is a ‘substantial search problem’, (p264).¹² They reported that in a ten item set, the actually possible number of sequence that can be made is 3628800. This expansion, from binary sorting, demands effective on line serial control, because of this massive combinatorial problem. This then requires that the subject takes advantage of inherent monotonic features within the set, monotonic ordering of all ten items is demanded. Inhelder and Piaget, (1964), have suggested that this competence is solved by developing conceptual *insight* into the logical structure of relations such that if $A < B$, then $B > A$. If true then the implications of this are that seriation of the items is actually independent of the set size or indeed the differences in size between the items (Inhelder and Piaget, 1964). In other words, the child should be able to seriate a set no matter how large it is and no matter how big or small the differences are between the items of the set. This, however has recently been disproved by a series of experiments by McGonigle and Chalmers, (1993).

3.4.2 Experimental Design and Methodology

McGonigle and Chalmers, (1993) moved away from the classic experimental approach of examining seriation, so instead of laying out items on a table as in photograph 3 where the subject has to reach, then physically manipulate the objects in front of them, they devised a touch screen methodology where the children were required to learn to touch differing size items on the screen in a given monotonic ascending or descending sequential order. By turning to touch screen and computer based technology, the computer could display icons (instead of rods) varying in size and linear arrays. The child had to simply touch, once only, each icon on the screen according to the instructed presented, for example biggest to smallest (Chalmers and McGonigle, 1997, McGonigle and Chalmers, 1996,1998, 2001). The photograph (4) below shows this experimental set up in operation. It is important to note that these touch screen seriation tasks presented the different size icons on the screen in random spatial layouts that changed trial after trial.

¹² Notice, that in language production too, there is also pressure to organize because of this combinatorial explosion.

This was to ensure that solutions of the seriation task were done cognitively and not perceptually which may have been arrived at by spatial layout factors.



Photograph 4. A young boy at the monotonic size seriation task. (McGonigle and Chalmers, 1996).

Two experimental phases were developed. In the first of these 12 five and 12 seven year old children were presented with random arrays of five items, (as pictured above). In the second experiment another 24 five and seven year old children were presented with seven items set arrays. To control for absolute size learning two non-overlapping and randomly interleaved size ranges were presented

All of the children were trained by a series of feedback systems delivered by the computer. Every time the child made a correct touch, in either ascending or descending order of size the computer would beep. If however the child made an incorrect touch the computer would buzz. McGonigle and Chalmers placed a learning criterion of 8/10 sequences executed without any errors.

3.4.3 Results

McGonigle and Chalmers, (1993,) demonstrated that performance on tasks requiring non-arbitrary monotonic size ordering is far superior to that on those demanding non-monotonic size, or arbitrary connectives, as indexed by both acquisition measures and error profiles, see figure 6 below.

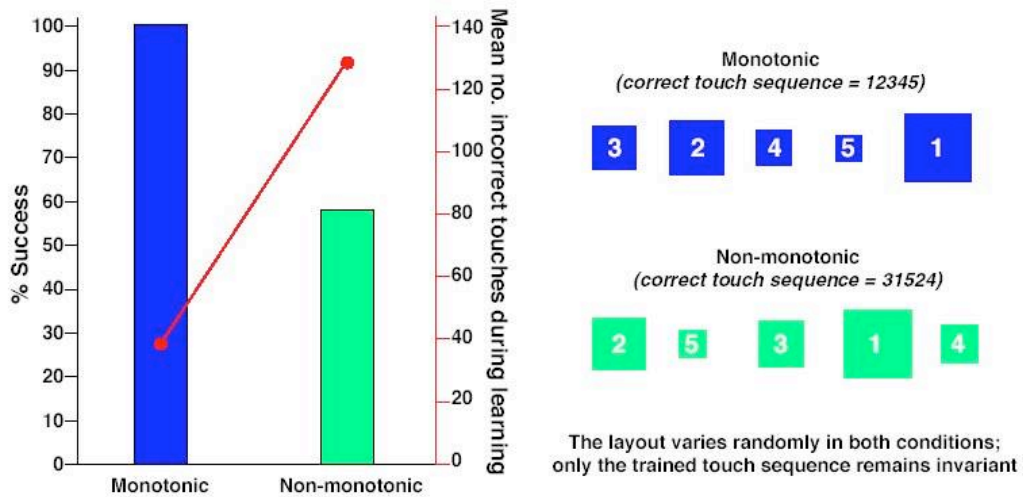


Figure 6.: A graph showing the ease of monotonic ordering in children. (McGonigle and Chalmers, 1993).

However, the results do indicate some significant implications for Davidson. Children at the age of five, can seriate 5 items monotonically over non-monotonic sequences, but they failed to transfer to 7 items, which they found more difficult to complete. As figure 7 shows, it took more than double the number of trial runs to criterion on seven items than on 5 for the five year olds.

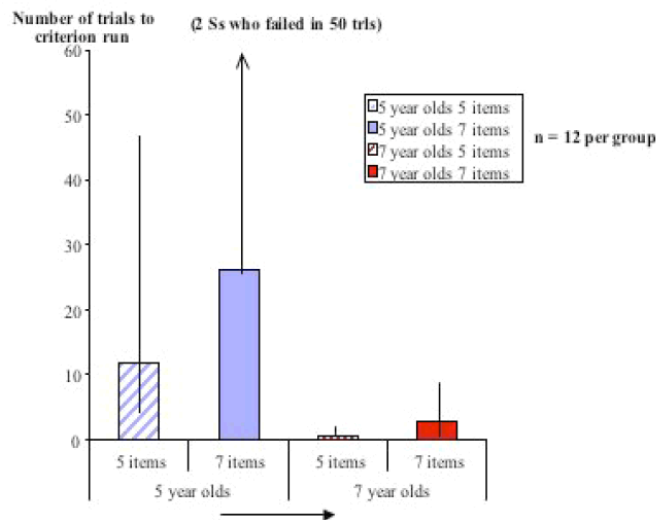


Figure 7 Acquisition profiles from five and seven year olds on 5 and 7 item set. Taken from McGonigle and Chalmers, (2005).

The seven year olds found both 5 and 7 monotonic items easy to seriate. Therefore the size of the set (5 items or 7) had an impact on the younger child (McGonigle and Chalmers 2005). One potential theoretical implication of this is that solutions to complex tasks involve trying to obtain success through low computational demands.

However, obtaining these economic preserving procedures appears to emerge over time. As children get older, they get better, and they get better because they make the task easier, they become more efficient.

3.4.4. Implications for Davidson

In order to solve the combinatorial problem that this task generates, the child can either rely on some costly brute force memory, or the child could opt for a '*simpler*' option of reducing cognitive load. One way to reduce to cognitive load with the classic test is to manipulate the objects and spatially lay them out in a row so the system can see what they are doing. However, with the touch screen this option is not available. Once again notice how the relational primitive becomes critical to the solution of the task. The child utilises the monotonic constraint present in the data set, and arrives at success by iteration of a single relational code, take biggest, take biggest, and so on until the set is exhausted. It is clear that utilisation of monotonicity does not require spatial vectors to solve the problem. Nor can the solution be afforded by a quick fix associationist response as the task, due to the combinatorial problem, the task clearly fits outside the narrow inductive space that associationist response lends to creatures for no association between spatio – temporal contiguity can take place. (McGonigle and Chalmers, 1998). The fact that the child utilises the monotonic constraint in the data, shows how there must be different learning mechanisms present, for the results cannot be reduced to the operation of a base of optimised associationistic principles. The ontology suggested from the results of McGonigle and Chalmers' study that core cognitive precursors to abstract high level thought, do not derive from some external communication system, or even from an internal symbolic representation, spatial or linguistic in origin, but are derived from "honest toil" (Hanard, 1987) and hard work. By doing it, the competences emerges, (iff it is supported by rich set of design primitives hard wired into the system).

It is difficult to determine what kind of response Davidson would make to this empirical finding. Five year old children find it extremely difficult to transfer to the larger seven item set size, where as the seven year old children had no problems. I believe that those that adopt a Davidsonian position have to say some kind of story about seven year olds that make monotonic seriation on a seven item set possible but not for five year olds! I assume that one response a Davidsonian could make is about

the difference in language between the two groups. However, this would be a weak defence; most children actively use language by the age of three, and certainly by the age of five. Also a number of developmental psychologists have shown that children around the age of four developed competence on the standard false belief task and have an understanding of objective truth. (Perner, 1991, Flavell, Green, and Flavell, 1986). This is also consistent with the view that human cognition does not arrive all in one go. Vygotsky, (1962), and Inhelder and Piaget, (1964). have shown that children begin to classify and order items at a younger age that approximates their later and more refined cognitive competence. We know that Davidson believes that one cannot understand objective truth and have the notion of a false belief until one has language. But is Davidson committed to the reverse that in order to have speech, you are required to have an understanding of false beliefs, objective truth, and so forth. It does appear so, Davidson states that “ *the dependence of speaking on thought is evident, for to speak is to express thought*”, (Davidson, 1975, p155). So if speech requires belief and belief requires the ability to recognise that a belief may be false and to have an understanding of the objective-subjective contrast then speech it seems also requires this. But as already noted language develops in child prior to second order representation, and consequently there is a contradiction if he genuinely accepts this position.

Another possibility is that Davidson could deny that the seven item seriation task is a behavioural manifestation of thought, and therefore there would be no problem in explaining away the results. If the seven item seriation task is not a genuine marker of thought, the fact that five years cannot do it, compared to seven year olds, does not matter, its neither thought in both cases. Again I think that, claiming competence in the seriation task in not an example of thought would be a weak defence. At the earlier stages of cognitive growth it is clear that the children can seriate only a small number of items, and that the children may be selecting items on a trial and error basis or “gropings and fumbings” as Piaget described it (Piaget and Szeminska, 1952). But in the ‘*operational*’ stage of development around six years of age onwards we see performance that is based on selected procedures, and are measured. Davidson needs to account for the qualitative and quantitative changes in cognitive development. Davidson believes that there cannot be a sequence of emerging features of the mental,

but instead there is some pre-cognitive, pre-linguistic situation of triangulation. This looks incorrect.

The experiments of both young children and the squirrel monkey by McGonigle and Chalmers, 1977, 1992, 2001, (See chapter 2) show that 'by doing it' we become efficient at it and as such more complex cognitive states emerge out of old ones. We shall see in chapter four how the theme of complex cognitive states emerge out of simpler ones is a significant theme and one which poses difficulty for Davidson, and one which theories of cognition need to take seriously.

Before we proceed, I think it is necessary to review Davidson's stance.

3.5. Summary of Davidson's stance.

Essentially, Davidson's position can be summarised in two statements supported by two main arguments.

(A) All speakers must be interpreters of other speakers

(B) All those that have beliefs must be speakers

Main Argument (1) (Radical Interpretation)

1. All speakers have beliefs
2. In order to have a belief you must have the concept of belief
3. In order to have the concept of belief, you need to also have the concept of a false belief
4. If you have a concept of a false belief, then you must be an interpreter of other speakers (triangulation)
5. All speakers are interpreters of other speakers

Main Argument (2) (No rational animals)

1. In order to have a belief, you need the concept of a false belief
2. In order to have the concept of a false belief, you must be an interpreter of other speakers
3. In order to interpret the utterances of others, you must be a speaker
4. In order to have a belief, you must be a speaker

If one accepts these arguments then we are forced to concede to Davidson's stance that a creature that we cannot interpret as capable of meaningful speech will as a result also be a creature that we cannot interpret as capable of possessing contentful attitudes. These then are the reasons why Davidson suggests that to be a cognitive animal is just to have propositional attitudes. Part of what it is to be a rational animal, above all things, is to be able to interpret the speech and thoughts of others and only those that communicate in this way have rationality. Cognition for Davidson is something that "*Only communicators have it*" (Davidson, 1982; p327).

3.6. A Theory of Mind?

It appears that part of Davidson's account looks very much like a theory of mind account of cognition. A 'theory of mind' refers to the capacity to interpret, predict and explain behaviours of others in terms of their underlying mental states. Scholl and Leslie (1999) believe that this capacity is "*inherently metarepresentational*" in that it requires not only to have propositional attitudes, but also to employ them about propositional attitudes. In other words to have beliefs about beliefs, to have beliefs about other beliefs. (Leslie, 1987; Perner, 1991; Pylyshyn, 1978). Davidson, (1984), as we know sees this ability as intrinsically dependent upon our linguistic abilities. When an agent has a theory of mind, that agent will understand others may have thoughts different to that of their own, and like Davidson agents that have a theory of mind must have a holistic understanding of how beliefs, desires and other propositional attitudes are related to each other in order to cause the agent to act, and that the other agent they are interpreting, are fundamentally rational.

There has been over the last two decades considerable work looking at 'theory of mind' and the claim that language users have a theory of mind is something that has been empirically tested, for it appears that until the age of around four, children seem to have difficulty in realising the representational nature of other minds. (Wellman, 1990). Young children do not understand that people who have had different experiences can believe different things. The standard empirical test which investigates theory of mind in child is known as the false belief task, which was initially developed by Wimmer and Perner (1983) and later modified by Baron-Cohen *et al*, 1985). Briefly the false belief task is as follows;

The subject, a young child, is told a small story about a girl, called Jane, and Jane, places a bar of chocolate in a basket and leaves the room. Anne now comes into the empty room and puts the bar of chocolate into a box, and then also leaves. Jane comes back into the room and the subject is asked where will Jane look for the bar of chocolate?

Generally, children under the age of four will claim that Jane will look in the box, where as older children will state that Jane will look in the basket. The failure of very young children to correctly identify that Jane will look in the basket, is thought to indicate that they lack a theory of mind.

To study ‘*minds*’ through the notion of a linguistic representation, as does Davidson, suggests that a theory of mind can only be found in those creatures that have language. However, a major challenge to this view came from comparative psychology studies. If the presence of such a capacity was found in non-human, non-linguistic animals then, as the argument goes, it could be possible to investigate theory of mind as a biological endowment (module) independent of language.

In their now famous 1978 paper, “Does the chimpanzee have a theory of mind?” Premack and Woodruff have argued that experimental evidence of chimpanzee’s understanding of human behaviour can be interpreted as an ability to detect intentions. This view that theory of mind could have had a slightly different evolution history to that of language would pose a significant threat to Davidson’s position. In order to examine theory of mind in non-linguistic animals I will briefly use Bermudez’s (2003) levels of Rationality to clearly exclude what should not be considered as non-human theory of mind behaviour.

3.6.1. Non-Linguistic Rationality: Level 0

Bermudez starts his three level theory of rationality at level 0, where behaviours such as reflexes, innate releasing mechanisms or typical classical conditioning behaviours are observed. At this level there is no decoupling of the input to the behavioural output. A relevant stimulus will produce the same response in all cases. Behaviours in level-0 rationality can be explained in fixed law-like connections. “*We do not need to postulate intermediary representational states between sensory inducers and behavioural outputs*” (Bermudez, 2003 p116). He outlines two characteristic features of level-0 rationality. A) It is not grounded in any process of decision making, B) It is not

applicable to particular behaviours, but to the presence of a particular tendency or disposition.

What is critical to his three levels of non-linguistic rationality is the space of alternative behaviours that a creature could perform when presented with a stimulus or range of stimuli. That is, the degree of rationality a creature can have is dependent upon how much decoupling there is between sensory input and output behaviour. But why does Bermudez call reflexive behaviours and other associationistic outputs examples of rational behaviour, for they are still within his three level classifications? Surely, behaviours of this type should be seen as simply that – fixed associationistic responses to set stimuli input? Not so, he claims, although behaviours at the level-0 rationality will most often be hard-wired they are properly described as rational because there is a normative theory, which the animal uses to determine the best response among the range of alternatives available at that time. This range of responses can have evolved over a period of time, and thus, this gives Bermudez the grounds to make the claim that there exists a level-0 non-linguistic rationality. Evolution, he claims, has developed this normative sense of level-0 rationality. A good example of this type of behaviour would be optimal foraging where a creature may forage for a particular type of prey when food is in short supply but then will switch behaviour and forage for other kinds of prey when plentiful (Stephen and Krebs, 1986). Although there can be room for disagreement over the degree of associationistic response, it is clear that no theory of mind inference is being made at this level of rationality.

3.6.2. Non-Linguistic Rationality: Level 1

As we have seen in level-0 rationality this is the preserve of behaviour types and not behaviour tokens. Behaviour cannot be selected from a range of alternatives because it cannot be involved in a process of decision-making. Behaviour selection comes from a very limited set within its own contrast space and is usually evolutionary hard-wired. However, Bermudez claims, that there are behaviours that can be selected from a range of possibilities within its contrast space that is open to the creature at that specific time. The behaviour is not evolutionary hard-wired but is available to selection. Behavioural tokens which are a feature of level-1 rationality are more likely to be described as level-1 rationality than behavioural types.

Using Gibson's (1979) theory of affordances that is perception is not neutral but rather it involves 'seeing' possible alternatives, Bermudez gives an example of where an animal confronted with an attacker may fight or flee the scene. If the possible outcomes are perceived by the animal to stay and challenge the oncoming attacker or to run to safety then this choice of possible outcomes, afforded to the creature there and then and not evolutionary hard-wired, is what he calls level-1 rationality.

"A given behaviour may be selected from a range of alternatives in a way that does not involve a process of decision making and yet that seems to be accessible according to criteria of rationality" Let us call this the sphere of level-1 rationality" (Bermudez, 2003, p121.)

So rather than the behaviour being selected by evolution, in the flight or flee example the behaviour is one of choice and that choice, although not determined by a decision-making process is one available to the creature in that particular state. Bermudez, states this scene is rather an example of 'selection' than decision-making. The selection the creature needs to make is either to engage in violent activity or to run away to safety and in order to be able to select one of the two behaviours the creature must be able to compare the action of fighting and the action of fleeing. This comparison though does require a representation of action (Gibson, 1979). Again no theory of mind inference is being made by the languageless creature in this level of rationality. Whether or not there is such a significant distinction between level-0 rationality and level-1 rationality as Bermudez suggests, one can surely see how a normative flight or flee response can be hard-wired into a creature and that evolution can determine which range of alternative behaviours within a contrast space to select. The distinction between level 0 and level 1 is not important. What is important is the distinction between level-1 rationality and level 2 rationality.

3.6.3. Non-Linguistic Rationality: Level 2

The key feature of this level of rationality is the creature's own ability to make decisions. Any agent that is in possession of level-2 rationality would be a decision-making agent. At the very least a decision-making agent is one where the selection of a particular behaviour is made upon the grounded assessment of the likely consequences that different possible courses of action will have. This ontology would demand that *"Deciding is not simply selecting. It is a selection for a reason"* Bermudez (2003 p124). As a result Bermudez claims that decision-making only takes place where

instrumental beliefs are available. He states rationality of an action will depend upon the match between action and the background beliefs of the agent. In other words, level-2 rationality can be measured as a function of the following criteria;

- the accuracy of the instrumental belief
- the extent to which the action in question is a suitable implementation of the instrumental belief. (Bermudez, 2003 pp 125)
-

If this is the criteria in which to measure level-2 rationality, what evidence is there that the creature is at that particular time representing the consequences of two or more different actions, rather than the just the actions themselves, for the actions themselves are (if this is correct) being grounded on representations of contingencies? In other words, are the actions being made, in part being driven by a theory of mind inference?

In order to explore these different levels of rationality, I would like to examine evidence from comparative deceptive behaviour studies that may identify behaviour that shows a creature representing not only the consequences of two or more different actions but also may be representing a sophisticated theory of mind.

3.6.4. Deceptive Behaviour

But in order to do this I would like to first give a definition of what deceptive behaviour is, for a distinction has to be made between two types of deceptive behaviour that occurs in the animal world. Only one of these has a significant consequence for any theory of level-2 rationality or theory of mind. The type of deceptive behaviour which may pass Bermudez's criteria for level-2 rationality, and thus may be in the realm of 'theory of mind' I shall call 'intent' deception and the other, which are examples of level-0 & 1 rationality I shall call 'innate dispositional' deception. To be clear Levels 0 and 1 cannot support the kind of behaviour comparative psychologists would demand for theory of mind ascription.

Deceptive behaviour of the first kind (intent) can be defined as;

- (i) a behavioural act that is not part of the animal's everyday behavioural repertoire,
- (ii) when used, it is used, at low frequency and in situations that are different from those in which the animal uses a high frequency version of the act,
- (iii) so that another individual,

- (iv) is likely to respond in such a way to the act,
- (v) that the actor has a greater advantage over the recipient than if the act was never initiated.

Deceptive behaviour of the second kind (innate dispositional) is;

- (i) a behavioural act that is part of the animal's normal behavioural repertoire,
- (ii) The act is a high frequency act and occurs in the same conditions across time,
- (iii) such that another creature,
- (iv) is likely to respond in such a way,
- (v) that the actor significantly benefits in use of the act than if the act was not initiated.

The distinction is seen at its best when we consider the deceptive behaviour of the Ringed Plover (*Charadrius hiaticula*). One-way of dealing with predators is to divert their attention and hence probability of attack away from vital areas such as nesting sites. The plover, when it sees a predator approaching its nest engages in a complex distraction/diversion display. The bird will adopt a tilted, sagging posture, as if to feign a broken wing, and move slowly away from the nest. The predator follows this 'injured' bird, perceiving it as an 'easy meal' only to see it fly away once a safe distance has been gained between the predator and the bird's nest. However, this behaviour is restricted to protection of its young. The plover does not use this display to lead other competitors away from food sites or potential mates. It is a fixed innate disposition and is an example of level-0 rationality. Interestingly enough, the plover's behaviour can be modified to such a degree that the bird can learn to distinguish between those predators that head directly to the nest and those that merely by-pass the nest and so not waste energy in performing the display. This, though, is not an example of a creature being a complex decision-making machine as some have suggested. It is merely an example of conditioned modified learning (Ristau, 1983, 1988). No theory of mind.

We still need is clear examples of intent deception behaviour and to complicate matters even more I will distinguish between two types of intent deception. Full-fledged Deception, which involves one animal misleading another by communicating the false location of a genuine object, and Precursor Deception, which involves hiding and distraction behaviour. Although this latter form of deception is not as sophisticated as the first it is still claimed that it involves the animal representing a theory of mind of

the other creature. The first piece of evidence that indicates chimpanzees are capable of intent, precursor deception comes from a series of experiments by Menzel (1974).

In an enclosure Menzel and his co-workers had hidden various food sources but only one out of a group of chimpanzees (*Belle*) knew where to find the food. Initially when the group were let into the enclosure *Belle* would, in Menzel's terms, "*invariably give the game away*" by showing a "*nervous increase in movement every time Rock, a dominant male, came near to the location of the food source*" (Menzel, 1974; p135).

If it is true that *Belle* became nervous because she observed that another animal, would get to the food and eat it then her behaviour, would seem to indicate that she has some theory of <seeing>. However we can explain this behaviour in a simple reflexive 'anxiety' interpretation. We do not have to attribute anything as complex as a theory of mind to the chimpanzee?

I would agree but this was not the end of the experiment as Menzel reports;

"However on a few trials she actually started off a trial by leading the group in the opposite direction from the food, and then, while Rock was engaged in his search, she doubled back rapidly and got the food." (Menzel, 1974, p136)

In terms of Dennett's (1987) intentional gradings a second order representation would be one where an animal has the capacity to '*work out*' the probabilities that another animal would reach the food before it does. It would have a mental representation of a mental representation. (A belief about a belief) This is also true for Bermudez's second-level of rationality. Is *Belle* acting in such a way that she has this belief about a belief? The fact that *Belle* only rushed back to the true source of food when Rock was engaged in his search does suggest an interpretation that what *Belle* was actually doing was judging the likelihood of trio finding the food. That is, she had to be aware of the fact that if Rock was looking at her, then the probability of him finding the food, by following her, would be greatly increased. It therefore seems to suggest that *Belle* may have the capacity to have a sophisticated theory of <seeing>. Menzel further writes;

"In other trials when we hid an extra piece of food about 10ft away from the large pile, Belle led Rock to the single piece, and while he took it she raced for the big pile. When Rock started to ignore the single piece of food to keep his watch on Belle, Belle had temper tantrums."

A case could therefore be made about the abilities of *Belle* as a sophisticated intentional system, a creature at level-2 rationality. However, there are serious methodological questions concerning this study which call into question *Belle's* abilities, but there are further examples I wish to outline specifically the work by Premack on theories of <seeing>¹³. Premack (1988) suggests that for a chimpanzee to be able to compute the caretaker's line of vision, the chimpanzee must be aware of the fact that there is a relationship between 'seeing' and 'knowing' (Premack, 1988).

In a series of well-designed experiments Premack used four 6-7 year old domestic born chimpanzees in which the chimpanzee has to solicit the advice of a 'seeing' trainer in order to gain access to a baited container that it could not see. The experiments required three stages. The first was just a pre-training stage where the chimpanzees became familiar with two opaque containers, one of which was baited, and they were left to choose between containers. Stage two required the containers to be baited from view of the chimpanzees. This was done by placing an upright box before the animals and putting the containers in the box. Again the animal was left to choose at chance level. The third and most critical stage involved a screen being placed perpendicular to the animal's cage. On each trial two trainers positioned themselves on opposite sides of the cage. One trainer could clearly see the containers being baited and the other had her view impaired by the screen, as was the chimpanzee's. The chimpanzee of course had a clear view as to which trainer had clear visual access to the containers and which trainer did not.

¹³ Let me explain this term by using an example

Tom and Greycat

Greycat and Tom are chasing Jerry the mouse. Jerry runs under the table and positions himself behind a table leg in such a way that Greycat can now no longer see him. Jerry's behaviour can be explained at the zero order level and therefore we do not have to attribute a naive theory of perspective to him. However, Tom ran round the table in the opposite direction to Greycat and can easily see Jerry. Consequently, Tom eats Jerry. Fortunately for Tom (unfortunately for Jerry), the mouse was not capable of getting in to the right conditions to perceive that Tom was the threat and not Greycat and hence this is why some creatures are more amenable to re-description at the higher, intentional level while others are not. That is, the behaviour of those creatures that do not have this ability can be interpreted at a zero-order description, however, those that do, lend themselves to higher-order descriptions of level-2 rationality and possible a theory of mind interpretation.

After the baiting the box was removed revealing the two containers and the screen was taken away. The two trainers then moved forward and stood equidistant behind the two containers. Each trainer was attached to a piece of string enabling the chimpanzee to choose between the trainers (the chimpanzees were accustomed to this method of choosing between trainers). When a trainer was chosen she then tapped one of the containers. However, Premack designed the experiment in such a way that when the 'seeing' trainer was chosen she always tapped the wrong container. Thus, this enabled Premack to determine whether the chimpanzee would follow her advice or whether the animal would perform at chance level.

Premack found that three of the four animals significantly chose the 'seeing' trainer thus solving part one of the problem. He also found that one of the three animals did not consistently follow the trainer's advice, although she did perform above chance ($P < 0.05$). In all, it was found that two of the four animals (50%) solved the task. That is, they not only chose the correct trainer but they also followed her advice in picking the incorrectly tapped container.

Cheney and Seyforth, 1990 & Povinelli Parks and Novak (1991) investigated perspective taking in monkeys, but reported a failure to find evidence that the subjects understood the relationship between seeing and knowing, or had the 'theory of mind' concept of *see*. There are many examples of primate perspective taking experiments both from the perspective of the animal guessing the perspective of the human experimenter (Povinelli and Eddy 1996a 1996b; Povinelli and Vonk 2003), and those from the visual perspective of its own conspecifics (Hare, Call and Tomasello, 2001; Hare, Call, Agnetta, Tomasello, 2000). But all of the examples that I have given above are examples of what I have been calling intent precursor deception behaviour. But humans engage in more complex kinds of deceptive behaviour where:

U expects - but does not expect A to realise that U expects - to get A to falsely believe, that P.

This is an example of intent full deceptive behaviour, a case where a human utterer, U, communicates in the full Grice (1957) sense, linguistically or non-linguistically, a false belief to the audience, A. Can chimpanzees engage in similar deceptive behaviour?

Examples of precursor deceptive behaviour are rare (Griffin, 1981, 1984, 1992; Whiten and Byrne 1988), examples of full deceptive behaviour are virtually nonexistent (Griffin, 1992), however, there is one experiment which suggests that this complex behaviour may be possible.

The experiment is similar to that described in detail above except this time the chimpanzee had to indicate to a human participant in which container the food was hidden. Two trainers were used and they were distinguished by the fact that the friendly trainer wore standard laboratory clothes and gave the food to the chimpanzee if she indicated correctly. The other the hostile trainer wore dark glasses and had a 'bandit's' mask on and always kept the food to himself, if the chimpanzee communicated correctly. The trainers on each trial did not know in which container the food was baited.

Over the course of a hundred trials *Sadie* the chimpanzee, had learnt to use her feet to point to the wrong container and consequently misdirect the hostile trainer and to point to the correct position of the baited container when the friendly trainer was the human participant. Thus leading the researchers to claim that *Sadie* had "*developed an entirely new way of directing the trainers, pointing to tell the truth to the friendly trainer and to lie to the unfriendly one*" (Premack and Premack, 1983; p57).

Although Premack and Premack (1983) state this is an example of fully-fledged lying, this experiment out of all the others I have cited can easily be explained in terms of an associationistic response. The fact that *Sadie* repressed her response or pointing to the correct container in the presence of the hostile trainer can be explained by simple habituation theories, and her response of misdirecting the hostile trainer can be explained by conditioning theories. Alas *Sadie* does not lie.

Many of the examples of what has become *tactical deception* (Byrne, 1995) can be understood as the manipulation of not another's propositional attitudes but simply their visual perspective. There is no theory of mind here.

Povinelli, (1996) has distinguished between three different types of knowledge about the visual perception and its mechanism,

- 1) Simple sensitivity to the eyes and to eye like stimuli
- 2) Perception as a cognitive connection between organisms and the world.
- 3) The “*understanding that in addition to linking an individual’s mental state of attention to the external world, visual perception also alters one’s internal experiences, states of knowledge and belief*”. (Povinelli, 1996, p313).

and whilst a debate can be made to place non-human deceptive behaviour either at Bermudez’s (2003) level 1 or 2 (a level in which would support ‘a theory of mind), I believe that we should view the above behaviours as examples of a form of understanding, reliant on the use about vision and goal directed action, rather than the attribution of beliefs, desires and other propositional attitudes. A more neutral approach given the criticism of the experimental evidence (to follow) when looking at the existence of ‘theory of mind’ in languageless creatures.

3.7 Theory of Mind and Experimental Evidence

To recall, finding evidence of a ‘theory of mind’ in non-human, non-linguistic creatures would place Davidson’s argument under considerable review for if found there would be the ability to attribute second order beliefs about another’s behaviour, but without the use of language. The experimental methodology therefore, is critical in determining whether non-linguistic creatures have a theory of mind. Critical for Davidson and critical for any evolutionary account of the development of cognition. How good is the experimental evidence in determining whether non-linguistic creatures, like humans, can reason about unobservable mental events?. The research quoted above suggests that the evidence does not look too convincing which is a view supported by Povinelli and Vonk (2004).

In a pair of recent papers Povinelli and Vonk (2003, 2004) provide a model in which calls into question the current research paradigms being used to investigate ‘theory of mind’.¹⁴

They claim that;

¹⁴ They specially look at research into Chimpanzee theory of mind experiments, but their critique is extendable to all non-human research into the detection of a ‘theory of mind’.

“the research paradigms that have been heralded as providing evidence that [chimpanzees] do reason about such mental states, do not, in principle, have the ability to provide evidence that uniquely supports that hypothesis”.
(Povinelli and Vonk, 2004, p2).

To support this argument Povinelli and Vonk introduce two possible psychological systems. They do this to demonstrate that the performance of chimpanzees can be fully explained even if the chimps have no mentalistic understanding or theory of mind.

The first psychological system is dedicated to social cognition but is limited to reason about behaviour. It is a non-mentalistic system, which they call S_b . The second system, which is meant to replicate the use of a theory of mind, is the same as S_b except they add the ability to reason about mental states. It is called S_{b+ms} . Povinelli and Vonk say that it is essential that this second system be built on top of the behaviour of the reasoning system.

“[M]aking inferences about mental states does not allow the organism to skip the step of having to detect the abstract categories of behaviour and to compute the regularities among them” (Povinelli and Vonk, 2004, p7).

In detail the S_b system consists of

- (1) A database of representations both specific behaviours and statistical invariants which are abstracted across multiple instances of specific behaviours; (representations that may be formed either by direct experience with the world, or may be epigenetically canalized);
- (2) A network of statistical relationships that adhere between and among the specific behaviours and invariants in the database;
- (3) An ability to use the statistical regularities to compute the likelihood of the specific future actions of others. (Povinelli and Vonk, 2004, p6).

And using Andrews (2005) interpretation for S_{b+ms} it works in the following ways

- (1) Observe behaviour and categorise it
- (2) Refer to the database to match the category of behaviour and environmental features with another behaviour
- (3) Infer the mental state associated with the behaviour

- (4) Use the ability to compute statistical regularities and the mental state attribution to make a prediction of behaviour. (Andrews, 2005, p524).

The question remains can the research paradigms that have been used in non-linguistic creatures to determine the existence of a ‘theory of mind’ distinguish between the operation or the functioning of S_b or S_{b+ms} ? Povinelli and Vonk (2004) clearly state that they cannot. (p7.)

In order to substantiate their claim they detail a study by Hare *et al* (2000) in which a subordinate and dominant chimpanzee are placed in a separate enclosure. The two creatures are facing each other, and there is an area which is between them. In this area are placed two pieces of food – one on the left and one on the right. However only one of the pieces is available by sight to the subordinate as it is behind a small barrier. The experimental theory of the design of this study is to determine whether the subordinate can reason about which piece of food the dominant animal is able to see. This is recorded by measuring where the subordinate animal goes when first released into the area. Simply, the theory goes if the subordinate heads towards the food that the dominant cannot not see, the subordinate has a theory of <seeing> for it makes an inference based on a representation that ‘the dominant was able <to see> the open food and thus will not try to take it. (Povinelli and Vonk, 2004). But as they suggest one can also explain this behaviour of moving away from the dual observable food by the subordinate having a simple notion regarding the statistical invariants that exist in head/eye/body orientation towards the food, and future behaviour (S_b) or the chimpanzee does all this and then has a mental representation of the mental state of the other chimpanzee as well (S_{b+ms}). This experimental paradigm which as we have seen above is common in deception or theory of mind studies in non-linguistic creatures but cannot distinguish between the two competing theories.

To conclude, Povinelli and Vonk based on the above reasoning state categorically that there is no evidence whatsoever to conclude that chimpanzees have a theory of mind.

“The problem we face with is not primarily an empirical one. Instead, the most pressing problem is to come to grips with the fact that experimental results form the kinds of techniques that are currently in vogue cannot add a single bit of evidence in unique support of the conclusion that chimpanzees reason about mental states – any mental states.” (Povinelli and Vonk, 2004, p11).

3.7.1. Implications for Davidson

Davidson states that in order to be a rational animal, where one is an interpreter of themselves, a creature must be capable of representing a belief about a belief, it must be capable of a second-order representation. That creature must be a language using creature. A creature that has a theory of mind has a specific cognitive ability to understand others as intentional states, such as having beliefs and desire. Davidson would claim that this ability is intrinsically dependent upon that creature’s linguistic ability. If the empirical evidence demonstrated that that a theory of mind capacity was present in a non-linguistic creature, that creature could represent beliefs about beliefs, language therefore is not the key having beliefs about beliefs, to have thought and therefore Davidson would be wrong.

3.7.2. To Davidson’s Rescue

Povinelli and Vonk, (2003, 2004) in an unexpected way have come to Davidson’s rescue. They have produced two models, one which does not reason about the mental states of others but uses forms and concepts about behaviours which can only be observed and action is applied through the use of a database of representations of specific behaviours and statistical relationships. The other model, uses the database to generate inferences about the likely mental states of others, and thus reasons about the mental states of others. What is interesting about these two models is that if you applied them to not only the above examples of deception behaviour but to other experimental paradigms investigating ‘theory of mind’ in non speaking creatures, it is impossible to determine which model the creature is using. Consequently, using the principle of Occam’s razor, we are left in a position to support their claim that there has to date been no clear decisive evidence to suggest that languageless creatures have a ‘theory of mind’, for there have been no experimental techniques that can distinguish between the operations of S_b and S_{b+ms} .

Davidson’s position therefore still remains. This view is correct if and only if you concur with Davidson’s notion of what it is to be a rational creature, however if

methodological paradigms allow, (with respect to Povinelli and Vonk, 2003, 2004), could we empirically discover languageless creatures who are as complex as us but just do not have language or is it that they do not need to be **that sophisticated** to be thinkers and that Davidson is wrong to put so much into thinking and language?. I shall examine some answers to these questions in the following sections.

3.8. A Range of Possible Outcomes

Although I have said that I have some concerns over the direct interpretation of the three levels of non-linguistic rational action proposed by Bermudez, especially the difference between level 0 and level 1, I do hold that what is a key feature of rational action is that a creature has a variety of choices to make when faced with a diversity of situations. Not only do I think that this is a key feature of rational action but at the very least it is a sufficient condition of rational action. That is to say any rational creature, linguistic or non-linguistic must be able to decouple the direct output behaviour from the sensory input and select the appropriate response in a multiplicity of circumstances. Stalnaker suggests that

"[a] creature has "attitudes", pro and con, towards the different possible outcomes, and beliefs about the contribution which the alternative action would make to determining the outcome. One explains why an agent tends to act in the way he does in terms of such beliefs and attitudes. And according to this picture, our conceptions of belief and of attitudes pro and con are conceptions of states which explain why a rational agent does what he does." (Stalnaker 1984; p4)

I am sympathetic to Stalnaker's point of view, that our perception of whether a non-linguistic creature is a rational one is really our perception of whether that creature can conceive itself of being in various different states, states that the creature is comparing what was with what is. I am also supportive of his position because it does not focus upon the need for language to be a key element in order for that creature to select the appropriate behaviour, as opposed to Maphail (1998, 2002) who does view language as 'the magic bullet' for cognition.

There is a problem though in supporting fully Stalnaker's idea and this can best be described by relating to the example of the dog chasing the cat up the tree. Is the dog able, when it chases the cat up the tree, to get itself into the right conditions so that

when it sees a cat on the fence, it can successfully determine that the same cat has jumped down from the tree, and not just an '*easier hunt*' cat?

3.8.1 Other Ontological and Epistemic Problems

To be clear, I am not suggesting that when a creature adjusts beliefs in the light of experience (squirrel on the fence) this amounts to meta cognition, something more is needed. It is also more than just selecting normative behaviour for we know from the work by Newell, Shaw and Simon (1962) that very simple systems can select the appropriate 'normative' behaviour and can recognise tasks to match the expertise the system has.

Quine and Davidson suggest that language is the only way to determine cognitive rational creatures and any ontology that does not include language as a primary driver of rationality would be wrong. These philosophical concepts all appear to support Macphail's (1982, 2002) "*null*" hypothesis where there are no qualitative changes in the adaptive competences of non-linguistic creatures.¹⁵

I have to agree here entirely with MacIntyre (2001) that what this argument is saying is that there are some 'cognitive' states that animals cannot have but this does not show that animals have no cognitive states. Similarly the fact that we cannot give a precise, correct and detailed account of the dog's mental representation in chasing the cat up a tree does not show at all that the dog has no mental representations, or cognitive states that we are trying to interpret.

Philosophers though are not the only ones that fall into the trap in thinking that language is a prerequisite for rationality. Many Psychologists have also gone down this route and the major premise of these philosophical and psychological arguments appear to be that human possession of language makes 'thought' possible and the absence of language in animals makes animal thought impossible

¹⁵ Although Bermudez is willing to concede slightly more than Macphail

3.9. Language as causal mechanism of Cognition.

In the theoretical dispositions of Davidson we have seen just how important language is to his account of cognition. Language has also played a significant part in testing theory of mind capabilities in children, although in primates, this role of language has been eliminated, but these particular paradigms have then been open to a Povinelli and Vonk style of criticism. The use of language to test high level cognitive functions in adults and children has also widely been seen as the best tool (Inhelder and Piaget, 1964). There is a history of experimental paradigms that require not only instructions to be given in the symbolic code but the results are also reported through language using agents. Why?, because there are many that see language itself as providing the bridge or the mediating device that enabled creatures that use it to reach various cognitive achievements (Kunne, 1946). Language, therefore for some is the causal mechanism of cognition and this particular biological empirical approach to the study of cognition is what I shall explore now.

Many people think that they think ‘*in language*’ and so in reverse if they do not have language they would be without thought (Gleitman and Papafragou, 2004). This view has also been reflected by many commentators such as Wittgenstein (1922), where he wrote

“The limits of my language are the limits of my world” and also by Sapir (1941), where he suggested that *“the fact of the matter is that the real world is to a large extent unconsciously built upon the language habit of the group”*.

In one sense though it is a trivial to ask if language influences thought, for after all it is true and not very interesting to say that language has a powerful and specific effect on thought. For example, advertisers use slogans and language all the time to influence our thoughts as to whether ‘*Guinness is good for you*’ or not. But this is not what I am arguing here, what the debate is that some have claimed that natural languages provide the format in which cognition is necessary. That is, there are aspects of a particular language system that organise the thoughts of its users. In other words language is the mechanism of cognition. One of the main holders of this view was Whorf (1956).

“We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can in some way be collaborated” (Whorf, 1956, p214).

Proponents of this view claim that linguistic categories will be the “*programme and guide*” (ibid, p212) for cognition.

3.9.1 Sapir-Whorf Hypothesis

This approach has become known as the Sapir-Whorf hypothesis and can be broken down into two basic principles. The first of these is the view of linguistic determinism, which refers to the idea that the language we use to some extent determines the way in which we view and think about the world around us. The concept has generally been divided into two separate groups - 'strong' determinism and 'weak' determinism. Strong determinism is the extreme version of the theory, stating that language actually *determines* thought, that language and thought are identical.

“Instead of language merely reflecting the cognitive development which permits and constrains its acquisition, language is thought of as a potentially catalytic and transformative of cognition” (Bowerman & Levinson, 2001, p13).

Weak determinism, however, holds that thought is merely affected by or influenced by our language, whatever that language may be.

“We surmise that language structure...provides the individual with a system of representation, some isomorphic version of which becomes highly available for the incorporation as a default conceptual representation. Far more than developing simple habituation, use of the linguistic system, we suggest, actually forces the speaker to make computations he or she might otherwise not make.” (Pederson, Danziger, Wilkins, Levinson, Kita & Senft, 1998, p586)

The second basic principle of the Sapir-Whorf hypothesis is that of linguistic relativity. Linguistic relativity states distinctions encoded in one language are unique to that language alone, and that “*there is no limit to the structural diversity of languages*”. If one imagines the colour spectrum, it is a continuum, each colour gradually blending into the next; there are no sharp boundaries. But *we impose boundaries*; we talk of red, orange, yellow, green, blue, indigo, and violet. It takes little thought to realise that these discriminations are arbitrary - and indeed in other languages the boundaries are different. In neither Spanish, Italian nor Russian is there a word that corresponds to the English meaning of 'blue', and likewise in Spanish there are two words 'esquina' and 'rincon', meaning an inside and an outside corner, which necessitate the use of more than one word in English to convey the same concept. These examples show that the language we use, whichever it happens to be, divides not only the colour spectrum, but

indeed our whole reality, which is a 'kaleidoscopic flux of impressions', into completely arbitrary compartments.

What this suggests with respect to an evolutionary continuity theory of cognition is language is the vehicle for growth of new concepts. It is only through the intervention of language that new concepts can be placed in '*the mind*'. A very much discontinuity view. But Sapir and Whorf are placing too much significance on the role that natural language plays in thought for cognition does exist independently from natural language and that linguistic determinism is a "*conventional absurdity*" and that thought *is* different from natural language (Pinker 1994: pg 67).

3.9.2 The Problem of Original Meaning

The existence of a public language system acting as an internal mediating device has been suggested by behaviourists such as Kuenne (1946). The basic premise of the mediation theory is that the linguistic token itself could eventually become to act as an internal conditioned response, which then in turn then acts as a mediating stimulus for the end response, and so the linguistic token is the stimulus S becomes Rmed to Smed to R (McGonigle and Chalmers 2002). There are several criticisms of the verbal mediation hypothesis, it is not clear whether it is the language itself that changes the stimulus type, or it is something else but more significantly Bryant (1974) when reviewing Kuenne's hypothesis called upon the tautology of original meaning noted by Lashley (1929).

“The main trouble with the hypothesis that children begin to take in and use relations to help them solve problems because they learn the appropriate comparative terms like ‘larger’ is that it leaves unanswered the very awkward question of how they learned the meaning of these words in the first place” Lashley (1929 p42)

The problem of original meaning is not only relevant to such theories as the Sapir-Whorf hypothesis and to verbal mediation theories but for other theories of cognition such as connectionism (Fodor and Pylyshyn, 1988) and Piaget's top down developmental approach (Chalmers and McGonigle, 1997, McGonigle and Chalmers 1998). If one cannot resolve the problem of original meaning then the ontology describing such systems must be false. Any theoretical account must deal with the problem of original meaning. I shall now briefly review some attempts to solve the problem of original meaning.

On attempt to answer the problem of original meaning has been provided by Haugeland (1985). He uses the distinction between *semantically active* and *semantically inert* to solve the task. Haugeland suggests that symbols are active, but that their activity is directly related to their meanings; the changes and interactions among thought symbols are *semantically appropriate* Haugeland (1985). An example of this can be seen using the same two propositions demonstrated below:

- a) All cats chase birds
- b) Tabby is a cat.

If each semantic token of the above two propositions were written on small pieces of paper and then stuck to the back of 'busy' ants, the tokens would be active, and indeed complex interactions between each of the tokens would ensue. But

“the behaviour of such symbols is quite unrelated to what they mean. By contrast, if we got those premises into somebody’s head (for example, a belief that p), then a new complex symbol would more than likely appear and not just any new symbol, but specifically a valid conclusion” (Haugeland, (1985, p120)

about Tabby and bird chasing that is;

- c) Tabby chases birds

This then is how thought symbols are semantically active. Haugeland goes on to suggest that semantically active symbols are the only candidates for original meaning. The interactions that take place within the agent do so without any 'outside interference' and the interactions continuously remain constant appropriate to what they mean. This he claims indicates that “the meanings are somehow “there” in the active symbol system itself regardless of whether or what anyone else takes them to be”. Active symbols for Haugeland are interpreted states or part of an integrated system that are manipulated automatically and are only semantically active if the system as a whole manipulates the tokens in ways appropriate to what they mean.

However, this does not really solve the problem of original meaning; it is not clear if all semantic activity has original meaning, or only some certain sophisticated kinds, or those that have distinctive characteristics can be a marker for original meaning. There are still too many unanswered questions regarding this analysis. Haugeland (1985) admits himself, in order to fully solve this problem we would need to know what are

all the characteristics semantic activity and what is it about them that gives them special original meaning status.

The problem of original meaning leads to the conclusion that language is not the medium researchers can use to explore causal mechanisms of cognition. We need to try and deliver an account that breaks away from the symbolic world, to not get trapped into an account that has been intertwined with culturally expressed conventions of what Popper has called a product of a “society of mind”. We need to deliver an empirical account, yes, but not one based on a symbolic, linguistic cultural world. Such theories must get around the symbol grounding problem of original meaning – for if we search for meaning in symbol systems, the results can only lead us to an infinite regress through layers of meaningless syntactically related symbols (Harnard 1990).

3.9.3 Implications

There are just too many problems and difficulties with any theory of cognition that is based from this symbolic perspective. What is needed is an approach that disassociates itself from a collective interpretative system. We need to look at the organism itself, and not the cultural systems the creature belongs to. It is necessary that we develop biological and evolutionary insights into cognition, and are not falsely led by our cultural expertise in communication and interpretation. Surely, by doing this can get at the causal mechanisms of these mental states, what causes them and what in turn, they cause.

Although based on different reasons I support the philosophical work of MacIntyre and the psychological empirical based studies of McGonigle and others in suggesting that accounts of cognitive systems needs to be derived from an empirical, evolutionary biological perspective. In delivering any theory of cognition I have suggested that we must satisfy the metaphysical question and explain how cognition is possible, where it comes from, how does it emerge and how does it scale up from simple systems to complex ones.

Language, is not the medium for us to use to answer this metaphysical question. We cannot use it to ask questions of non-linguistic creatures, and very young children..

Such ontologies of cognition that have been developed from this approach must therefore be rejected. However *empirical epistemic biological ontologies* are what we are after and one such account took hold of psychology and for a while became the main psychological account of cognition and of cognitive growth and is reviewed in the following chapter. What is very interesting in this account is that rather than look for surprise, the real marker of thought is being able to *Reason*.

4. 'Surprise': Looking In the Wrong Place

4.0. Aims

One possible way to deliver evolutionary continuous accounts of cognition is to focus rather than on Surprise, as Davidson does but on 'Reasoning Competences' and the architecture of relational structures. We know that evolutionary ontological accounts of cognition are not very easy to arrive at, however in saying this differing accounts do exist and one such account is by Piaget. This chapter looks at his account but will detail due to several methodological reasons as to why his account should be rejected. As language has previously been the medium in which to investigate this architecture, this chapter will examine work which has taken language out of the equation all together, by examining competences such as transitivity in non-linguistic agents. The implications of this approach are discussed towards the end of this chapter with specific reference to systematicity and to Davidson.

4.1. Why Davidson is Looking in the Wrong Place

In the last chapter we saw Davidson detail that in order to demonstrate that one has grasped the notion of truth and falsity he used the concept of surprise. "*Surprise requires that I be aware of a contrast between what I did believe and what I came to believe*" (Davidson, 1982, p104). This is because surprise requires the concept of error. Language-using creatures can grasp the distinction between objective and subjective realities (the notion of error), suggests Davidson once they've been engaged in the process of triangulation. Consequently, one of the reasons Davidson suggests that animals do not have thoughts is that they are incapable of surprise. For there to be a belief is to know that you thought the world was a certain way and information comes to light that goes against that and you have to revise your belief rather than change it. The world has changed and there is recognition that you had things wrong. So there is this concept of error and understanding that if you cannot get it right you get it wrong.

However, I would like to suggest that surprise is NOT the right kind of place to be looking for sophisticated cognitive states, not only is it extremely difficult to say what is surprising but we should focus on the key issue of identifying the causal

mechanisms of thought and what thought really allows you to do. What is common to both Davidson's holistic approach and to the systematicity challenge is that genuine thought allows you to make connections between thoughts. One way of making connections between thoughts is through reasoning. Reasoning is an ordering of thought and is a relation of thought. Reasoning about something can give us single states and how they change under environmental pressure. Reasoning therefore, I would suggest is a key component of thought, and instead of looking at the concept of surprise we should look at the process of reasoning and determine how far non-linguistic creatures can reason.

Reasoning also carries with it one very important concept that both Davidson and I suggest is a necessary criterion of thought. If one, either a language user or a languageless creature is guided by reasoning, then one must be guided by some kind of normative element. We talk as if someone who believes p and that if p then q , ought to believe q . In talking about reasoning we make both evaluative and normative judgements. Rationality and the governing normative principles suggest Davidson is essential characteristics of the mental.

In one sense in which the mental is normative is that to say someone believes that p rules out certain patterns of thought. If I believe that p then I cannot (unless contradiction is involved) believe that *not* p . Likewise, doing x will probably cause it be the case that q given that p (all else being equal). The mental is therefore normative suggests Davidson in so far as the basic principles of logic and inductive reasoning define the structures of a person's attitudes and actions and what it is to have a thought. (Joseph 2004). In this sense we see that rational norms are constitutive principles of the mental. It makes that *belief* that *attitude* with that *content*.

“relations amongst beliefs; amongst beliefs, desires and intentions, [and] between beliefs and the world, [and these relations] make beliefs the beliefs they are; therefore they cannot in general lose these relations and remain the same beliefs. Such relations are constitutive of the propositional attitudes”.
(Davidson, 1985, p351-2)

Normativity is said to enter Davidson's account of the mental life of creatures through the method of *interpretationism*. We have seen which propositional attitudes an organism has depends upon what the best interpretation of it is. Davidson states that the best interpretation that one can give is being one that is constrained to make the

organism “*like ourselves*” (Davidson 1980, p 239). Any creature that we can interpret as being like ourselves is therefore rational. We are rational creatures, and anything that we can interpret as being like ourselves must also therefore be rational. Since rationality is an evaluative standard, Davidson’s theory of mind invokes a norm¹⁶. Seeing someone as rational is an essential condition for finding his behaviour intelligible, and “*to the extent that we fail to discover a coherent and plausible pattern in the attitudes and actions of others we simply forgo the chance of treating them as persons*. Davidson, 1980, p222).

Consequently, Davidson is happy to agree that reasoning about mental states answers to strong constitutive normative principles, in fact Davidson would go on and say something further like “*reasoning does not comes in strips*.” Our next task surely then, is to explore whether we can capture, through experimental paradigms tasks, this strong constitutive principle of the mental, and to determine whether if non-linguistic cognition , if discovered is ‘*strip*’ based or is part of strong constitutive principles?

One attempt at looking at reasoning competences as the true indicator of thought, rather than surprise has been suggested by the work of Piaget. However as we shall see, although he has developed a genetic epistemological account, his methodology is considerably lacking for the task.

4.2. Piaget’s Ontology of Cognition.

Davidson we know has a problem in accounting for the emergence of thought. This I feel is a real weakness in his stance. It is important for if we are to accept an evolutionary continuous account of cognition that we need be in a position to fully detail how thought emerges and develops, both in humans and non-humans. One possible way is to suggest that cognitive structures are patterns of physical or mental action that not only underlie acts of intelligence but also correspond to various stages of development. These cognitive structures change through a process of adaptation, assimilation and accommodation, and cognitive developments consists of a constant effort to adapt to the every changing environment in terms of assimilation and

¹⁶ Although not all Philosophers think Davidson’s account of the mental is a normative account – See Schroeder, 2003).

accommodation. This approach is known as a *genetic epistemology* and has been developed by Piaget (1963, 1971, 1983).

Piaget's *genetic epistemological* narrative, believed that we cannot understand what knowledge is unless we understand how it is acquired, and that we cannot understand how knowledge is acquired unless we carry out psychological (empirical) and historical investigations. The development of knowledge for Piaget is a biological process, a matter of adaptation by an organism to its environment. Piaget is centrally concerned with the development of such categories as space, time, number, and causality - *the Kantian categories of knowledge*.

In essence his ontological perspective of cognitive systems can be described in the following five points.

- i. knowledge has a biological function, and arises out of action (change of perceptual input)
- ii. knowledge is basically "operative" - it is about change and transformation
- iii. knowledge consists of cognitive structures or schema
- iv. development proceeds by the assimilation of the environment to these structures/schemata, and the accommodation of these structures/schemata to the environment
- v. movement to higher levels of development depends on "reflecting abstraction," which means coming to know properties of one's own actions, or coming to know the ways in which they are coordinated

His early work focused on language¹⁷, the use of language by children, and on their reasoning about classes, relations, physical causality and also responses children gave to various clinical interviews. Notice in this early state that 'language' was at the heart of his empirical technique. However, he did eventually become concerned about his own use of language in the interviews and developed a series of concrete tasks for children to perform. However, these concrete tasks were of course entrenched in linguistic instruction on how to perform the task, and part of Piaget's analysis was to again interview the child and ask 'follow-up' style of questions.

¹⁷ It is interesting to note though that Piaget had very little to say about the development of language after 1930.

Piaget saw young children, even as young as six, as being *egocentric*, that is they could not perceive what another person's point of view could be. They had no theory of mind. For instance, in a typical language based task young children are presented with models of three mountains, where there is a big one and two smaller ones. The child is then presented with a series of photographs from different perspectives and the child is asked to pick out what photograph is the same as another child's view sitting in a different location around the table (Piaget and Inhelder,1948).

Piaget thought that knowledge consists of cognitive structures, which ranged in degrees of complexity. One of the simplest forms of cognitive structures was that of sensory motor action schemes, where a child as young as three months old, after trial and error, could learn basic specific motor action schemes (Piaget, 1963). Complex cognitive structures for example, dealt with hierarchical systems of seriation and classification (Inhelder & Piaget, 1965). But what was important for Piaget was operative knowledge, and knowing how things changed in the biological landscape of the child.

Piaget thus thought that cognition is the development of operative cognitive structures. Cognitive structures are not static, tightly coupled stimulus response behaviours; they provide the child with a means of interacting with the environment.

Piaget's stance is that humans are not born with a fixed set of cognitive structures which are '*primed*' and are ready to slowly evolve throughout childhood, nor are they already contained within the child and are released when the child has reached some physical stage of maturation. Piaget also did not think that significant advances come about because of the affordances that exist in the environment. His view was that cognitive structures naturally change in the course of being used, and both the organism and the environment are involved in this process of change (Piaget, 1963, 1983).

The construction of knowledge by the child is an *active process*. At the beginning, the action is purely physical - then, through a process of *internalisation*, the actions become mental. Ideas are not given in the perceptive features of the brain, or encoded in language - that is, ideas are neither thoroughly mentalistic nor cultural - but are arrived at through the child's physical interaction with the world.

I think that one of the most important accomplishments of Piaget, is impressing on psychologists that cognition arises from action and fulfils a biological function serving adaptation. This role of cognition must feature in any successful ontological/theoretical account of cognition. What also must feature is the Piagetian notion that there are qualitative and quantitative differences in cognition. For example, cognition in the early development of systems is different in kind from cognition at later stages. All animals are not equal, rather they possess different adaptive specialisations (Gazzaniga *et al.*, 1998). Qualitative differences do exist between different species of the animal kingdom and this is reflected in their varying evolutionary histories. As such, the epistemic approach that Piaget takes is a correct one. As McGonigle and Chalmers (1998) say empirical programmes that try to trace the competences of the epistemic subject to its ontogenetic antecedents are rare.

Piaget had a reversal of views regarding the relationship of language and thought and eventually was not committed to the symbol world,

“It took me some time to see, it is true, that the roots of logical operation lie deeper than the linguistic connections, and that my early study of thinking was centred too much on its linguistic aspects.” (Piaget, 1962, p5.)

and

“Some forty years ago, during my first studies.....I believed in the close relation between language and thought....”
(Piaget, 1973, p109.)

He therefore was not caught in the cultural trap of language (see Sapir-Whorf hypothesis chapter 3.9.1). Thus Piaget’s attempt at delivering a biological ontological account of necessary knowledge must be applauded. However, this is not the end of the story there are some significant difficulties with Piaget’s account, some of which I shall detail now.

4.3. Methodological Problems

Piaget’s account of the causal mechanisms of cognition has left him with a problem. It is not clear how the agent can move within his ontological framework, from ‘habit of mind’ arbitrary to non-arbitrary and necessary knowledge, because his work has failed to identify any lower bound primitives of the system. This has serious implications for

any theory that maps with in an ontogeny programme the relation between a set of basic design primitives and the epigenetic growth of these structures to high level cognitive competences.

Piaget also made the mistaken assumption that an adequate description of the accomplishments of which we are capable of is also an adequate description of the processes by which we produce those accomplishments. Piaget sought ‘mother-structures’ in order to explain how scientific, and mathematical principles could be learnt. Out of the three ‘mother-structures’ Piaget had identified, two had a common theme of relational reversibility, a systematicity. An example will help to clarify this. Piaget observed that children from the age of six become adept at making related inferences about sets of classes, so that if all cats are animals, then not all animals are cats, but if tabby is a cat then tabby is an animal; if tabby is an animal, tabby could be any kind of animal in the world, including cats and so forth. The idea behind relational reversibility is that it ‘frees’ up the subject from the ties of immediate time and space. Relational reversibility allows the child to develop a new world of schematic combinations (Inhelder and Piaget, 1964), so that the subject may perceive that A is larger than B, but will also know at the same time that B is smaller than A. (This occurs around the age of seven or eight the operational stage.) If the child has developed this structure then the child can go onto grasp that A is bigger than B, and B is bigger than C and C is bigger than D, ($A > B > C > D$ etc.) and this structure also enables the child to develop transitive inferences so that $A > C$, $B > D$. Mobility within these structures is the key to cognitive equilibrium (Inhelder and Piaget (1964). Piaget presented cognition as having specific ontological order such that absolute encoding occurred before relational encoding, seriation of items occurred before transitive inferences could be made and class inclusion occurred after disjoint classification.

However, the development of these structures was characterised by a slow and gradual differentiation of behaviours. What Piaget measured was only the significant *landmark behaviours* that emerged over time, in addition to verbal responses. So those behaviours or responses that were ‘devoid of logical necessity’ (Piaget, 1928 p234) were those that were found in the pre-operational child, but when the child had entered the formal operational stage and had access to the ‘*logic of propositions*’ (Piaget, 1971,

p39) then the child could be explicit about the solutions to task.. Cognitive performance is thus mapped onto the ‘*relevant*’ stage of development.

This may sound like a good empirical programme, where tasks were designed and developed to match the various cognitive growth structures that Piaget had outlined. Indeed there are numerous paradigms, developed as such through the work stemming from the Genevan laboratory (Chalmers and McGonigle, 1997), but is it good science? Does it deliver an accurate theory of cognition? Unfortunately it does not.

As Chalmers and McGonigle (1997), and McGonigle and Chalmers (1998) claim these motivating structures were always there at the outset, they were never up for refutation. It was an empirical paradigm that took a hypothesis regarding the growth structure of children and then developed paradigms to match onto those growth structures, there was never any possibility of denying the structure was there in the first place - there was an incorrect theory of measurement. As Inhelder and de Caprona (1987) state ‘*Genetic Psychology is adult centred, indeed scientist centred. It starts from the end, the final stage, and reconstructs its construction*’ (Introduction to B. Inhelder, D. de Caprona and A. Cornu-Wells), and as Chalmers and McGonigle, (1998) claim “*the interactive dynamics postulated by Piaget have never been used to discover what the structures might be*” (p187).

4.4. A Way to Solve the Mystery

Relying on language as the medium of experimentation as a way of investigating the evolutionary identification of cognition is not going to provide a solution as to where cognition comes from, and as to what kinds of creatures have cognitive states.

Therefore, what is needed is a range of purely behaviour based tasks which require no linguistic instruction given from the experimenter to the subject, that can also be given to both the language and non-language using agent. If these non-linguistic tasks are developed it would deliver us with the means to develop a common currency of comparative measurement that would also identify the homologous cognitive processes in humans and nonhumans (Conway & Christiansen 2001, Hauser, Chomsky and Fitch, (2002) and McGonigle, Ravenscroft & Chalmers, (2002).

As we saw in chapter two, McGonigle and Jones (1969, 1977) and McGonigle (1987), McGonigle and Chalmers (1977, 1980, 1986, 1992) have devised perceptual non-

linguistic based tasks to explore and examine the range of relational design primitives in monkeys. These experimental paradigms may provide the evidence proof to demonstrate that primates can move through the process of reification and that we can legitimately assign sophisticated cognitive thought to these creatures. These tasks had no linguistic instruction and no linguistic response was demanded. These purely behaviourally based tasks exploring the range and depth of design primitives are surely the way forward to investigate reasoning competences and the growth of cognition in non-linguistic animals.

4.5. The Architecture of Relational Structures

As suggested there are alternative approaches to the understanding of cognition that do not rely on the logical/language like-symbolic perspective. The view held here is that reasoning and cognition have little or almost nothing to do with the sentential-inferential paradigm but rather may develop out of a product of a relational engine. (See chapter 2)

If relational structures can provide a way in which the systematicity challenge can be met without a language of thought, we need to be able to provide, if an evolutionary continuous ontology of cognition is to be successful, the architecture supporting these relational states; how these states are internally utilised, whether they adhere to some normative principles and to give an account of the evolutionary genesis of their organisation. Otherwise, any account that has no basic design primitives and no organisational constraints built in to the system's functional architecture, may be open to the criticism that if the system's growth trajectories, which leads to novel behaviours at a later stage of development, cannot be specified in advance, only *a posteriori* explanations develop can develop.

4.5.1. Qualitative Changes

Before I detail further experimental work in exploring the lower bound competences of cognitive systems we must ensure that in doing so any theory of cognition must account for qualitative changes in the system lower bounds rather than detail some progressive growth of some biological component – neurons, synapses and the like. Just because a brain may get bigger does not necessarily follow that the creature will become more complex. What I am getting at is which differences in ontological lower

bounds allow for some creatures, agents/systems to become increasingly more adaptive over ontogenesis, resulting in higher cognition, whilst others remain limited to the confines of tight sensory motor couplings.

By identifying the behaviours from non-linguistic agents that can be mapped onto those that have been produced by standard linguistic tasks, it is also possible to deflect the criticism that the behaviours demonstrated do not truly reflect those cognitive processes that underpin ascriptions of cognition. It is necessary that these behaviours are demonstrated empirically, through scientific investigation so that direct comparisons with human laboratory learning based work can be made.

4.6. Transitivity with No Perceptual Correlates. A Reasoning Competence

By investigating cognition from the relational encoding perspective, and not from a symbolic perspective we saw the evidence, in chapter 2, (2.4.) for design primitives, but now we need to examine the closer role of learning itself. We need to examine how learning through reasoning competences can scaffolded the development of cognitive systems. A way of exploring these issues is through studying transitive inference.

Transitivity according to Evans (1983) is a property of any scale or dimension on which objects can be compared and ordered and transitive inference describes one of the most fundamental processes in reasoning (Schnall and Gattis, 1998). Such scales are usually defined by their opposite poles for example big – small, tall – short. A transitive relation therefore is, in general, one where given that $A \succ B$, and $B \succ C$, it follows that $A \succ C$. A classic transitive linguistic inference would be one where, *John is taller than Bob, Bob is taller than Jim, therefore, John is taller than Jim*. Such transitive inference tests require the subject to go beyond the information that has been presented, there are no explicit relations in the external world and therefore it is generally thought that some reasoning, 'inside the agents head' must occur in order to solve the transitive task (Davis, 1992). This principle is only one form of law, according to James (1890) which holds in many series of homogeneously related terms, the law that *skipping intermediary terms leaves relations the same*. This axiom of skipped intermediaries or of transferred relations occurs, as we soon shall see, as a fundamental principle of inference. For James, he thought that that the transitive

competence “*seems to be on the whole the broadest and deepest law of man's thought*” James (1890). I would also suggest that Davidson (1976) would agree that if an agent is to have thought, that agent must at least be able to successfully solve transitive inference tasks. Transitivity is for some, the marker of cognition.

We see the transitive task has been widely accepted as the understanding of logical necessity (Piaget 1954, 1963*a,b*,) through the logical coordination of internal ‘symbolic’ representations. The transitive reasoning tests have been used as a Piagetian test of the level of the child’s state of operational thought. Piaget (1954) claimed that any child using transitive inference would be using formal operational thought and would highlight the child’s awareness of logical necessity. That is, Piaget (1970) restricts transitive reasoning to those in or beyond the concrete operational stage. According to this view children below seven or thereabouts were unable to engage in this form of logical reasoning. Piaget attributed failure on his linguistics tasks (/John/ is /fairer/ than /Bob/ and so on) to the failure of children to be able to seriate mentally and to create the three ordinal positions ‘fairest – darkest’ together with the middle position which was indicated from the binary presentations. However, many studies over the past three decades have challenged this view and have shown that very young children, as young as four (Bryant and Trabasso 1971), Riley and Trabasso (1974), McGonigle and Chalmers (1994, 1998, 2000) are capable of transitive inferences on binary transitive tasks. What then are the causal mechanisms of transitive inferences, if children as young four as well as a broad range of non-linguistic creatures (monkeys, (see the work of McGonigle et al), chimpanzees (Gillan, 1981, 1982), pigeons (von Fersen, Wynne, Delius, & Staddon, 1991) and rats (Davis, 1992)) can perform successfully well on binary transitive tasks.

4.7. The Generic Paradigm

The generic paradigm to test the causal mechanisms of transitive competence in non-human species is to train an animal with two pairs of arbitrary named stimuli, A+B-, B+C-¹⁸. Then when the animal, is presented with an AC pair, the animal is likely to choose A over C. However, as A is always rewarded and C is never rewarded, selection of A can be determined through simple operant conditioning procedures.

¹⁸ The plus sign indicated that if chosen this stimulus would be rewarded and the minus signs indicated that the stimulus would not be rewarded upon selection,

Nothing about this design could tell us anything interesting about the mechanisms of transitive behaviour, although it does tell us something about operant conditioning. As such an extended paradigm developed where subjects are presented A+B-, B+C-, C+D-, and D+E-. The subjects then have to obtain a degree of criterion success before being presented with a novel stimuli of BD. (Note that BD has never been presented to the subject.) Here we see B in the training phase of the experiment being rewarded in equal amounts D, (B with C and D with E and never with A and C). This way any successful performance on this binary of choosing B over D cannot be explained by some historic reinforcement selection. Hence, Dusek and Eichenbaum (1997) claim, *"An appropriate choice between the two nonadjacent and nonend elements, B and D, provides unambiguous evidence for transitive inference"* ,(p.7109).

4.8. Transitivity in Monkeys: The first experimental proof. (McGonigle and Chalmers, 1977).

Using this type of paradigm McGonigle and Chalmers (1977) were the first to test transitive behaviour in non-linguistic animals and all the subjects showed high levels of transitive choice on these binary type tests, thus calling into question the competences that have been suggested from human studies as the causal mechanisms of transitive choice. Their experiment is detailed below

4.8.1. Experimental Design and Method

Eight Squirrel monkeys were tested using the Wisconsin General Testing Apparatus, again which the monkey once positioned in could see a tray bearing two cylindrical tin containers. Each tin was seven centimetres in diameter.. These tin containers were of equal size, but differed in weight and in colour.

Each monkey was given four pairs of colour discriminations which were learnt serially (not concurrently – see chapter 2). For four of the monkeys the reward stimulus was the heavier of the two tins, and for the other four the reward stimulus was the lighter of the two tins. See the photographs below as an example of how the squirrel monkey is tested.

In the experiment itself and not in the training phase, there were only two tins of two different weight values presented to the monkeys at any one time. One tin was filled

with lead shot – thus being the heavy tin, and the other tin, the light one, was empty. As a control no specific weight could be uniquely identified with stimuli B,C, and D. In an attempt to eliminate unforeseen colour preferences which might have affected the test choices by the monkeys they were assigned different colour pairings.

In the learning phase of the experiment the primates learnt in serial order the pairings of AB, BC, CD, DE, up to a successful criterion level of 18 out of 20 consecutive trials. This is an example of supervised learning, where the monkey is instructed in which order to learn.

The monkey was rewarded by having a peanut located in one of the two food wells underneath the ‘correct’ choice tin. If the monkey correctly indicated the appropriate tin on the binary test then it was rewarded with a peanut, however when there was an incorrect choice of tin, an error, no reward was given. When each trial was over the tray was withdrawn from the monkey’s sight for five seconds, during this time a screen was lowered blocking the monkey’s view as the experimenter changed the items on the tray. The screen was lifted, the tray placed was then placed in front of the monkey and the trial started again. It is important to note that the stimuli varied from left to right of the tray according to a random pattern again as another control

The subject learnt all four pairs and this procedure was repeated until there was the same level of performance criterion across all the pairs. Once this was obtained a reduction of the number of training trials took place, until finally five runs were given of one trial per problem in a random order of presentation. A total of fifty trials per day maximum were administered to the monkeys.

Critical Tests

Once the monkey had successfully completed the above phase to a successful 22 out of 24 correct criterion over the course of twenty four successive encounters then the critical test trials proceeded. The critical tests were a series of ten presentations against the B and D comparison. (The transitive comparison set). And not more than two transitive tests were administered per session. In this critical test phase *all* choices were rewarded. Once these B&D comparisons had been presented to the monkey, they were then presented, in a counterbalanced sequence, with the remaining AC, AD, AE,

CE and BE comparisons.¹⁹ See the photographs below as an example of the monkey at work.



Photographs 5: A Squirrel monkey at work taking B over A
Photograph 6: A Squirrel monkey at working taking E over D



4.8.2. Results

All but one of the eight monkeys learnt the series, and therefore the results are based on seven monkeys. McGonigle and Chalmers compared the results from the seven monkeys to a study of four year old children by Bryant and Trabasso, (1971) and found the data showed a choice profile consistent with the notion that monkeys are

¹⁹ These remaining stimuli pairs are regarded as less critical and they include A and E as E was always being seen as a reward item and A as always non rewarded item. (McGonigle and Chalmers, 1977).

transitive, and equal to the performance of four year old children, binomial test, 0.90, ($p < 0.001$) on the BD comparison. See table 4 below.

					Percentage Choice Bias on Test Pairs				
Monkey	B	C	D	E	Children	B	C	D	E
A	98%	100%	100%	100%	A	96%	96%	93%	98%
B		93%	90%	76%	B		92%	78%	92%
C			89%	87%	C			90%	94%
D				97%	D				91%
McGonigle and Chalmers (1977)					Bryant and Trabasso (1971):				
					Results from 4 year old Children				

Table 4: Transitive choice data for Squirrel monkeys compared with the profile reported for four year old children. (Taken from McGonigle and Chalmers, 1997, *Nature*, Vol. 267, p695).

The results do suggest that in order to solve the transitive BD problem the monkey is able to coordinate C is heavier than B and that D is heavier than C (McGonigle and Chalmers, 1977).

4.8.3 Possible Mechanisms

Are the monkeys solving this transitive problem by means of deductive inference reasoning, or are there other possible mechanisms for the solution of transitive tasks? One possibility is known coordination account: Basically, this is when training pairs are stored in memory so that when a test pair (e.g., BD) is presented, the subject recalls the relevant training pairs (B_C_ and C_D_) and coordinateds between them to determine which item to choose. However, McGonigle and Chalmers (1977,1984, 1992) have demonstrated quite convincingly that when testing transitive behaviour with monkeys, in a triadic phase of testing their successful performance dramatically decreases as compared to their successful performance on binary testing. This would not be predicted for the coordination model would suggest that since B, C, D are given explicitly, the subject should equally be able to decide them compared to the high performance binary co-ordination. An example of how this is can be tested is described below.

The seven monkeys, used in the above experiment, were also used in this part of the experiment, and they were presented with the ten remaining triplets of the ABCDE

sets²⁰. Each session of this triplet phase started with a ‘*performance criterion check*’ in that they were given twenty five (25) trials of the original AB, BC, CD, DE pair set presented in random order. If the monkey made less than two errors then they could move into the triplet phase.

In the triplet phase of the experiment the monkeys were presented this time with three tins to choose from, for another twenty five (25) trials, where each of the triplet sets were presented in a counterbalanced and not random order. This was to ensure that all of the triplet sets would be presented to the monkey. If the experiment had relied on pure randomisation then there would have been no guarantee that all the sets would have been presented in the twenty five trials. The position of the stimulus on the tray was also counterbalanced.

The training history of each animal was noted so that the stimuli were either all ‘heavy’ or all ‘light’ to match the animals training history. McGonigle and Chalmers (1977) note that all choices were rewarded, and the experiment ended when the monkey had made ten separate choices to each of the ten triplets presented.

Using a method of choice projection based on a binary choice model, and choice actually obtained, McGonigle and Chalmers found that the response distributions for the ten triadic sets are well predicted from this binary choice model and that the coordination account of transitivity does not support the actual choice data obtained.

Using this type of experimental procedure McGonigle and Chalmers state that

Whatever, the case for, or against, deductive reasoning, which may be fashioned from results such as those reported here, it is clear that some kind of ‘inference’ necessary to produce the appropriate ‘inferred’ set or absent referent is used by the monkey in tests of transitivity such as those described here. (McGonigle and Chalmers, 1977, p696).

²⁰ The ten triplet sets that are derived from A,B,C,D,E are; ABC, BCD, BDE, CDE, BCE, ABD, ACD, ADE, ABE, ACE.

4.9 Possible Mechanisms II – Spatial verses Design Primitives

Although this early experimental proof that non-human primates can solve transitive inference tasks suggests that some inductive reasoning may be used by these languageless creatures, this is not a possible threat to Davidson's position on the constitutive nature of the mental. I do think though, that the empirical evidence is nudging nearer to show that non-human animals have some kind of sophisticated thought. The reason why I believe this is the case is that other low cognitive demanding mechanisms, rather than 'language', such as the use of spatial vectors may be responsible for such behaviour. Therefore, what I would like to do now is to examine the role of spatial vectors to determine if they are in some way responsible for this kind of sophisticated non-linguistic thought that we appear to find in some languageless animals

It is often assumed that the independently stated premises such as those found in the transitive tasks have been integrated into an ordered series (an isotropic one) of mental representation (Halford, 1984, Van Elzakker, *et al* 2003). This order is cognitively efficient because it not only carries with it all the essential information from the training sets but it can also be used to answer questions about novel presentations that appear within from the set. What we see is the agent solves the task though they never have experienced the entire range of stimuli at the same time and thus must construct in '*representational form*' the whole series from the set. DeSoto, London and Handel (1965) and Huttenlocher (1968) suggest that spatial vectors can account for performance on such tasks and that the subject manipulates these analogue spatial representations to obtain the goal state. There are those such as Clark (1969) who suggest a language-like representational process accounts for the performance on transitive tasks. However, because of the comparative proof of non-linguistic animals solving transitive tasks these appeals to language have declined (McGonigle and Chalmers, 1977).

However, the appeal to some form of a spatial representational device has never left, for example Gattis (2003) more recently, has added her weight to the spatial representation argument by claiming that;

The finding that rats and young children perform better when external spatial cues are provided indicates that integrating pair-wise relations to form an

integrated array requires some additional step beyond simply learning the relations.”(Gattis, M. 2003)

There remains a serious philosophical question concerning the role of spatial representational accounts which has been raised by McGonigle and Chalmers (1986, 2001). Their argument questions whether privileged spatial vectors are the necessary features in the development and evolution of relational encoding or have they developed later, that is, have they occurred through the culturalisations of humans. The problem lies in “*how the private, salient adaptations of the individual become expressed as the public conventions of row, ruler and array*” McGonigle and Chalmers, 2001, p 251).

Nevertheless, Roberts and Phelps (1994) presented pairs of stimuli (e.g. $A > B$ or $C > D$) in either a linear or random spatial organisation until the rats performed to 80% successful criterion indicating they had learned the relations. In the transfer test a choice between B and D, rats that learned the paired relations from a linear arrangement performed transitively, while rats that learned the paired relations from a random spatial arrangement did not. Using a linear spatial representation order to arrive at a solution was also confirmed by Schnall and Gattis (1998) who reported the same pattern of results with six and seven year old children.

Davis (1992), though, does draw attention to some procedural issues in the testing of animals such as rats and pigeons. His argument highlights the need to ensure that we know what exactly we are testing and what are the causal mechanisms that lie behind the behaviour before assumptions are made. A position that McIntyre (2001) and myself would agree with. Results in transitive inference tests in animals such as rats or pigeons indicate that both rats and pigeons are indeed capable of complex transitive inference and if transitivity is a marker of cognition we must reassess the cognitive abilities of these animals. Or, if we are not willing to concede that, then the procedures that test for this in these species must be inadequate, because they have shown these animals wrongly to have this ability. Looking for the ability to do transitive inference tasks in these animals therefore is really about an assessment of the procedure and designs of the test rather than the test of the species cognitive capabilities itself (Davis, 1992). As Davis says we must be aware that we do not fall in to the trap of saying;

“If rats are de facto considered incapable of transitive inference and they perform poorly then the test must have been adequate. However, if the rats succeed, then by implication the test must have been flawed.” (Davis 1992, p417)

There is of course another interpretation that Davis misses. That is, linear ordering and comparative judgements are derived from core design primitives, which as we have seen are neither spatial nor linguistic and are evolved from effective inductive mechanisms (McGonigle and Chalmers, 2001). This view suggests that performance on binary transitive tasks can be equated with causal mechanisms that are *ontologically* lower down than once initially thought.

However, before we investigate this, it is necessary to back-track a little. In 1975, Trabasso *et al* (1975) developed a new way to evaluate choice transitivity in monkeys and in children based on reaction times (RT) rather than just choice. He found that transitive choices were faster than those recorded during retrieval of the training pairs. This is known as the *symbolic distance effect* (SDE) (Moyer, 1973) which stipulates that there is an inverse relationship between the ordinal separation between the two items and the time it takes to choose between them. In other words, it is easier to compare stimuli that are farther apart on the relational continuum²¹.

Trabasso and his colleagues proposed that the ‘human’ subjects he tested were enlisting a spatial internal device which represented the items within the series as a linear array, with the possibility that they were categorising the series as ‘*big ones*’ and ‘*short ones*’. They suggested that subjects were then embarking on a self-terminating search of the items which occurred in the ‘*minds eye*’ (Paivio, 1975). When asked the question “which is longer/biggest/brightest/etc” the subjects would begin from the ‘long/big/brightest’ end and stop when one of the two items in the question had been found.

As this model provided a testable causal mechanism of binary transitive behaviour, the implications for a theory of cognition were clear. Monkeys had to demonstrate high levels of a SDE when successfully performing binary transfer trials, in order to suggest that the mechanisms that are causal in humans were the same mechanisms in non-

²¹ It is easier to tell a very tall person is taller than a very short person, relative to a comparison between two people of similar heights.

humans. If however no SDE occurred then one would be left with having to accept that it may be the case that different causal mechanisms may be at work and no evolutionary, phylogenetic comparison about the causal mechanisms could be made between man and non-human man. Davidson of course would support the differing causal mechanisms argument.

So in order to proceed with my investigation it is necessary to examine the experimental proof which looks for SDE in non-linguistic animals and to determine if this effect is driven by some spatial search strategy or by some other cognitive mechanism.

4.10. The Search for the Symbolic Distance Effect in Monkeys.

McGonigle and Chalmers (1992) used a series of four experimental designs to search for the SDE in monkeys.²² Although similar in some respects to that of the 1977 study, in that they used colour tins and squirrel monkeys, there are significant differences in design which need to be highlighted. Consequently I shall detail the paradigms below.

Experiment 1 The relationship between (binary) transitive choice and the SDE

4.10.1. Experimental Design (1) and Methodology

Six of the eight squirrel monkeys that had taken part in the previous experiments were used.

The stimuli were five 7 centimetre diameter circular tins that were painted either red, green, blue, yellow or white. These colours represented the series ABCDE. Again the tins were either heavy or light.

As before (1977) the monkeys were placed in the Wisconsin General Testing Apparatus (WGTA) except this for this study there was a millisecond timer attached to the door of the WGTA which was manually button operated.

²² I shall detail the four experimental designs separately so that the reader can get a feel for not only an increase in task difficulty but also for the long term nature of conducting such experiments.

The different coloured tins were placed over food wells which were sunk into moveable trays, and each tray contained two food wells, six centimetres apart. These trays were available for all five different tin colour options.

(Stage 1)

So to be clear, we have five different coloured tins, which represent ABCDE²³ and in the first phase of this experiment the tins were presented in pairs in the following order, AB, BC, CD, DE. For example, a monkey may have been presented with the following series, AB (red/green); BC (green/blue); CD (blue/yellow) and DE (yellow/white). And during training in this phase the colour which represented B, (green in this example) was rewarded over the colour which was represented A (red). The colour which represented C was rewarded over B, D over C and E over D. As before (1977) the rewarded item was either 'heavy' or light' and for three of the monkeys the rewarded item was heavy and for the other three the rewarded item was light.

For control purposes the spatial location of the tins varied across trials, as determined by a pseudo-random sequence, and the monkeys were rewarded with a portion of a shelled peanut for a correct choice. When the monkeys however made an incorrect choice the tray was immediately withdrawn, but were, for five seconds allowed to see the tray, although they could not produce a second touch. When the monkey touched a tin, the experimenter operated the timer button and recorded the time. Approximately, the intertrial interval took twenty (20) seconds.

McGonigle and Chalmers demanded that the monkeys reached 90% accuracy on this first phase, and this was obtained through three different supervised learning training procedures. On the first training procedure, the pairs were introduced in a fixed serial order of AB, BC, CD, DE, using a fixed number of trials per pair.

On the next session the number of trials was reduced to five (5), however, a change was made on how the tray was presented to the monkey. Instead of pushing the tray to the monkeys as in the previous phase and in the 1977 experiment, the tray was static, and within each reach of the monkey. This was done so that accurate reaction time

²³ Each tin was a different colour which meant that you did not get an example of ABCDE being all red or all white.

measure could be taken. In the next sub phase the pairs were then presented in a pseudo random fashion, again using five trials per pair. Again no pair was repeated until all the pairs were presented. During this particular phase of the experiment a total of 120 trials were given.

On the final phase of this experiment the number of trials per pair of tins presented was reduced to just one (1). However, if two or more errors during a session then the remaining time of the session was dedicated to re-training the monkey back up to a criterion of 90%.

(Stage 2)

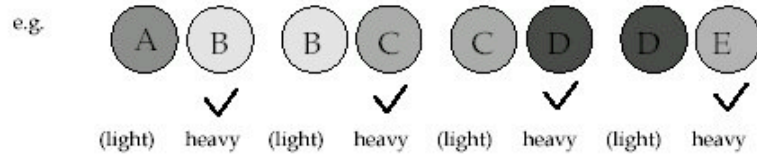
In the second test phase of experiment 1, the six novel, non-adjacent pairings of colours were given. These non-adjacent pairings are of course, AC, BD, CE, AD, BE, and AE. However one important difference was made. The tins were only distinguishable by colour this time and not by weight as all the tin weights were constant and respected the previous reward value for each specific monkey.

During this training stage the experimental procedures were the same as in the last phase of stage 1, until the monkey could sustain a 90% accuracy for each pair across a total of eighty (80) consecutive trials, which breaks down as twenty (20) per pair.

For clarity the whole paradigm used can be seen in figure 8 below.

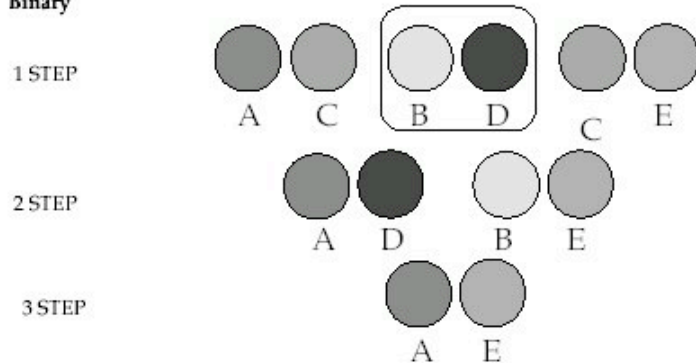
TRAINING PAIRS

Differential reinforcement is given within each pair as follows:
(This will be the heavy or the light one in each case)



TESTS Non-differential reinforcement is given (all choices are rewarded)
and all items will now be e.g. heavy as per training

Binary



Triadic

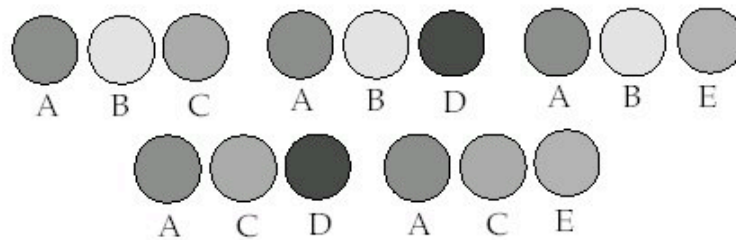


Figure 8. The transitivity paradigm used with monkeys by McGonigle and Chalmers (1977:1992) Taken with permission from McGonigle and Chalmers 2002.

The testing phase of experiment 1

Once trained on the connecting pairs, binary transitivity testing was introduced in blocks of ten observations per (test and training). This was done by having the four primary testing pairs (AB, BC, CD, DE) interweaved with the six non-adjacent pairs, making 10 pair sets in all. The ten pairs were presented in a pseudo random sequence, within a trial block, and as no pair was repeated until the full set of 10 have been exhausted. As a control the left right location of the tins on the tray were also counterbalanced across trials. In this test phase choice was always rewarded no matter if it was correct or not. McGonigle and Chalmers report that a typical test session consisted of two or possibly three trial blocks and that testing continued until all six monkeys had received ten (10) trial blocks.

4.10.2. Results

(Training)

In all, completion of the phases in stage one took on average 359 trials per monkey. In sub-stage three, where the monkey was presented with just one trial per pair, took, again on average, 159 trials. During stage two though one monkey had to withdraw, so results are for the remaining five monkeys. Throughout training the authors noted that performance was always better on the AB and DE pairs than the middle two pairs.

(Transitivity)

Not only could the monkey learn all the connectives between the stimulus set (ABCDE) but that choice transitivity including the non anchored set of B v D was highly significant for all monkeys. McGonigle and Chalmers showed that on all points of comparison, the monkeys demonstrated a very similar profile to that of six year-old children, as reported by Bryant and Trabasso (1971).

Using a micro level of analysis on reaction time data each individual monkey was examined for analysis of an SDE. All monkeys showed a significant inverse linear trend by the third block of test trials and this can be seen in figure 9 below²⁴

²⁴ The colours in figure 9 are the names of the monkeys.

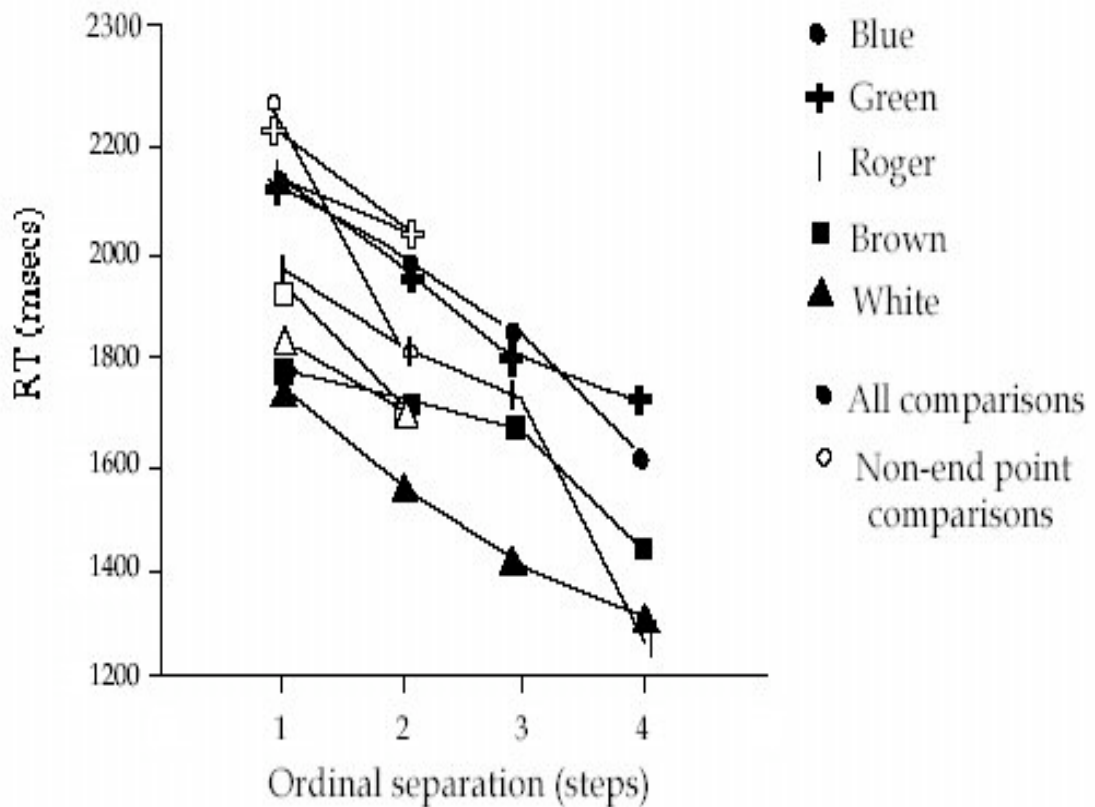


Figure 9. Symbolic Distance Effects obtained for individual monkeys. (McGonigle and Chalmers, 2002)

Consequently, the SDE had been reported for the very first time in non-human animals. The SDE had occurred in the binary testing of transitive trials in non-human species, therefore this indicates that similar causal mechanisms between humans and non-humans do in fact exist. But is De Soto and Handel right, claiming that a spatially based representation of the array occurs? Is Trabasso right, that successful performance is arrived by some scanning mechanism?

No, they were both wrong. Although reaction time data does show a SDE effect, what it does not show is that it is the product of a mental manipulable representation that is then scanned and then terminates once an item is found. McGonigle and Chalmers know this for they found asymmetries when the reaction time was computed for each end of the series. As they did with their relational data, (see chapter 2) they assessed the role each end of the series played in obtaining the SDE. They found that two kinds of results emerged. One set of results were uniformly fast – no distance

effect occurred – and the other which showed slower reaction times, were sensitive to distance effects. This result can be seen in figure 10 below.

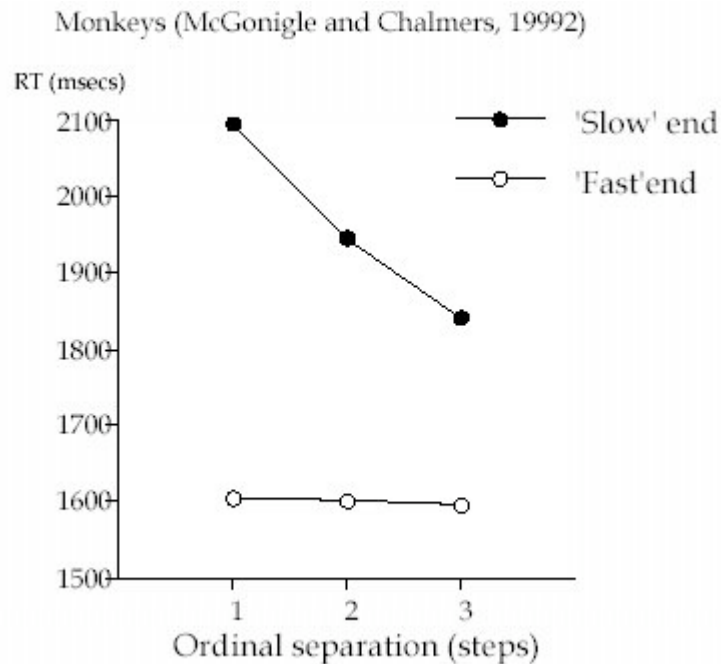


Figure 10. Decision times for squirrel monkeys as a function of ordinal distance. (McGonigle and Chalmers 1992; McGonigle 2004).

This result of course concurs with the results described above in chapter two regarding relational encoding, both in monkeys and children. This experiment provides an explanation of the asymmetries reported earlier in the relational encoding experiments which showed the same directional *asymmetries* in young children (Chalmers and McGonigle, 1994). The results do appear to indicate that subjects, human or non-human, do not use a ‘read-off’ scan mechanism based on some spatial vector.

“There is no evidence from any of the extensive analysis that we did, either on logical tasks or on the Moyer type mental comparison ones, that a spatial paralogical device is in operation in our subjects”. (McGonigle and Chalmers, 2001 p258)

The strong directional effects in performance on the five term series problems have shown that that the two end items possess privileged status. It seems that humans and non-humans do not construct a bidirectional manipulable representation of a known series but rather possess a ranking mechanism with unidirectional properties. It is encouraging that the same mechanisms responsible for this behaviour are both reported not only in humans but is also reported in non-humans. Thus strengthening the

position of an evolutionary continuous account of cognition, that is also not based upon some symbolic/linguistic feature.

4.11. Increasing Task Difficulty: Triads

When describing the transitive series of experiments, you may have notice that the binary testing condition has been emphasised. A possible argument could be made that there is something about supervised binary learning that shows this kind of sophisticated behaviour, however can this level of sophistication be maintained if there was an increase in task difficulty, for example, if triadic supervised learning took place? As such I would now like to turn the attention to the results of the triadic conditions that were also tested.

As suggested earlier, in order to fully develop an evolutionary comparative theory of cognition from an empirical perspective it is necessary to employ an increasing task difficulty protocol. Rather than demonstrate examples of binary choice in other non-linguistic species it is more important to manipulate the task with species being tested, for one may be able to arrive at an overall picture, rather than just part of one that is replicated across the animal kingdom. This task manipulation was conducted by McGonigle and Chalmers for they introduced a triadic testing phase to the experimental paradigm.

In order to tease apart different components of the SDE, they added two new procedures, (See figure 8 for graphical representation of the paradigm used), they did this to ensure that any performance deficit recorded the testing triadic transfer condition was not due simply because there was an increase in the number of tins on the tray. For the purposed of clarity I will describe the experiment below.

4.11.1. Experimental Design (2) and Methodology

The subjects were again the five monkeys that had completed the binary SDE experiment described above, and the apparatus and the stimuli remained the same, except instead of having two food wells the trays were replaced by ones that had three food wells.

(Training)

The monkeys transfer to the triadic training occurred immediately after the completion of the binary SDE experiment, and for consistency the monkeys were maintained on the same colour string, tray ‘colour and reward conditions’ as before. Although the training was similar to the previous experiment, the monkeys in this phase were trained using ‘pseudo-triadic’ sets in which one item of the set appeared twice. For example, one monkey may have been presented training stimuli in a triadic format such that each triples of stimuli contained a double positive such as AAB or a double negative ABB. Again this is an example of supervised learning. Thus the monkeys were trained using the training set of AAB, ABB, BBC, BCC, CCD, CDD, DDE, DEE. As before in order to control the spatial location of the items on the tray, the triadic configuration varied randomly between trial to trial. The intertrial interval as remained at twenty (20) seconds.

The monkeys were trained until they had reached a 90% level of accuracy which was recorded across forty consecutive trials, and sessions consisted of approximately forty trials each. The pseudo trials were presented once, in random order but within blocks of four trials. If the monkey recorded two successive errors on any one pseudo trial then that monkey went for a session of retraining of that particular triad, (not all of them just the one that the monkey found difficult to process), until a level of 90% accuracy, over a minimum of ten consecutive (10) trials was recorded.

This level of training was sustained until the monkey had acquired 90% percent correct level of accuracy over a minimum of forty (40) trials – 10 trials per triad.

The training phase of the pseudo trials lasted from one month to six.²⁵

(Triadic Testing)

The ten triads from the series of ABCDE, were given as tests. The ten triads are as follows; ABC, BCD, CDE, ABD, ACD, BCE, BDE, ABE, ACE, and ADE. However, these triadic tests were tested along with the above pseudo trials at a ratio of 5:24. All tins within these test triads were positively reinforced and were either all ‘heavy’ or all ‘light’ to match the subjects specific training history. Within each session, these test

²⁵ Again this emphasises the long term view one must take when examining ontological components of cognition. One trial procedures or one experimental paradigm is not enough to bring out, to tease, the necessary features of cognition.

triads were presented using an embedded methodology within six (6) blocks of four (4) trials. The first of these blocks was a ‘warm up’ block where no test triad was given. Of the remaining five blocks, a test triad was given either between the first two or last two training trials.

4.11.2. Results

The initial results from this extended experimental phase showed the monkeys were able to transfer from binary to triadic phases but all the monkeys failed to maintain their extremely high transitive choice performance on binary test trials. In fact, the primates on average dropped by 23%. The analysis of error, rather than analysis of correct performance was used to determine why such a drop had occurred. McGonigle and Chalmers found that the error profile was not a random phenomenon but one that could be accounted for by the individual bias towards certain items within the triadic set. Behaviour which indicated that they were trying to maximise their choices over these configurations. A critical question thus arose, are these primates ‘stuck’ at this triadic level, do they not have the competence to deal, in a fully principled way, with the demands of the triadic tests? If so then surely one could posit the claim that the causal mechanisms that underlie the behaviour of monkeys in such tests are different to those causal mechanisms that underlie the behaviour of humans, for as we know, humans can move beyond such triadic competences. And if the causal mechanisms of cognitive growth between humans and non humans are different, then are we at the beginning? Could the difference be attributed to language, could the difference be due to some salutatory intervention, or even could the difference be attributed to some paranormal essence?

In another two extended experimental phase of this paradigm, McGonigle and Chalmers tested to see if at all monkeys could achieve high level of performance on this difficult triadic test condition

They did this by concentrating on the triadic nature of the test itself and increasing the triadic test transitivity conditions through the experimental phase. If the monkey’s competence is set, then this increase in exposure and training should have no effect.

4.11.3. Competence in Triadic Transitivity Testing: Experimental Design (3) and Methodology

Again the five same monkeys were used, as was the same apparatus and stimuli tins. Same colour sting, tray colour and reward conditions for each monkey was also maintained.

Although the same test procedure as describe above for the triadic experiment was used the ratio of test to training pairs was changed. In the previous experiment the ration was of 5:24 test to training, the ratio now was changed dramatically to 10:4 test to training and four times as many test observations (240) per monkey were given. Testing was conducted across trial blocks of 14 trials and each trial block consisted of pseudo-randomly presenting one presentation of each of the pseudo-triad and every test triad. Note that this method allows for a free choice method that emphasises the nature of the triadic nature of the task.

4.11.4. Results

In the previous experiment the test triads were used sparingly but with this new procedure where the primates are presented with almost all test triads alone, all the monkeys registered significantly increased transitive choice levels on most of the individual test triad sets (84% correct score over the standard successful criterion measure.). One monkey, blue, even scored 98% correct on the test transitive triad conditions. The correct transitive choice for the group was 15% higher than that in the above experiment (experiment 2). The reaction times for the group also show that E attracted the fastest responses, followed by D and then C.

4.11.5 Competence Achieved: Experimental Design (4) and Methodology

In a final experiment, McGonigle and Chalmers were prepared to give specific training to individual monkeys if needed, to determine once and for all if the triadic task could be achieved. As blue had already scored over 90% correct on every triad without explicit feedback he was not party to this experimental procedure. Therefore, four monkeys were tested, although one monkey had to drop out due to illness and therefore the results are based on the scores of three monkeys. This experiment copied the procedure of the above, except the monkeys were rewarded *only* when a transitive response was made. The pseudo-triads were also completely dropped.

The test triads were presented pseudo-randomly within blocks of ten (10) trials and as before no triad was repeated until the full ten set had been presented. If two errors occurred on a specific triad, across two (2) trial blocks, McGonigle and Chalmers gave specific training on that triad until a criterion of 9/10 was reached. Counterbalancing of the spatial placements of the tins on the tray took place and every spatial configuration of every triad was also considered. Triadic training took place until the monkey had reached a criterion of 9/10 on every triad across 10 consecutive trial blocks.

4.11.6. Results

McGonigle and Chalmers found that training the monkeys to be fully transitive was actually achieved quickly. It took less than 13 trial blocks (four sessions) for the monkeys to start the run to criterion. They also discovered that what training was needed was specific to improve the behaviour of no more than three of the ten triads. The remaining seven were at criterion levels throughout. A summary of the overall results of these experimental phases can be seen in figure 11.

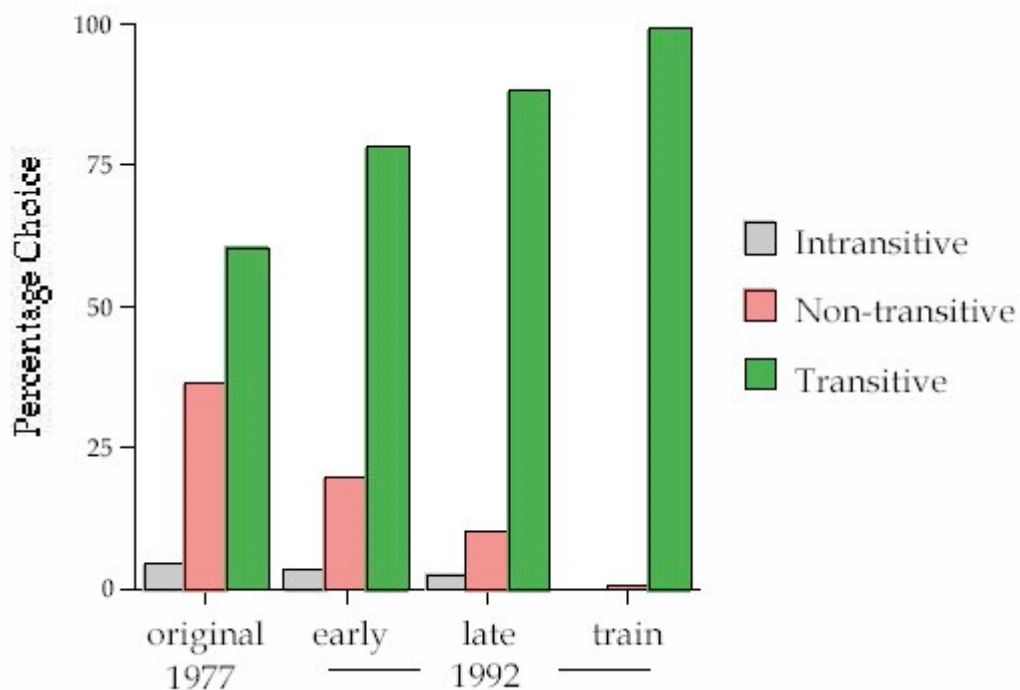


Figure 11: Triadic choice patterns by squirrel monkeys in transition (McGonigle and Chalmers, 1992)

We see from figure 11, that indeed over period of time and as a result of processing constraints these monkeys were able to reach extremely high performance scores on transitive test trials. The causal mechanisms of cognitive growth between man and beast may still yet be the same.

We can also now see the need for paradigms that employ a hierarchical series of task difficulty. For example, we know from the work by McGonigle *et al* that if the squirrel monkeys were presented with a triadic transitive task, without any prior training either on the binary or triadic condition, the monkeys fail. However, because McGonigle and Chalmers employed a series of increasingly difficult task paradigms, the true competences of the monkey were eventually drawn out. If one does employ a hierarchical series of task difficulty, then one needs to have subjects live long enough to complete the implementation of the increasingly difficult task paradigm. This is a factor that surprisingly has been overlooked by many in the field of comparative psychology. Paradigms need to have lengthy trials numbers, single one step examinations of cognitive behaviour, is not enough to capture the true nature of the creatures cognitive capabilities.

4.12. Implications

The results of transitivity testing certainly have serious implications for accepting an evolutionary ontology of cognition. Transitive choice, as demonstrated via the primate research in both binary and triadic tests, develops early within a trajectory of cognitive growth using such primitive forms of relational judgments. How early? It is clear from the empirical work with the primates that transitivity occurs before all of the logical relations within the set are learnt, thus meaning transitivity occurs before seriation. You do not need to be able to seriate all of the items within the set, in order to do transitive problem solving. Thus any theory of cognition that puts the transitive competence at a higher level, within the ontological framework, than a seriation competence must surely now be dismissed. This finding may be counter-intuitive perhaps, you may expect that the transitive competence would appear after the all the logical relations have been learnt, but clearly this is not the case. This finding is reinforced by a simple production model developed by Harris and McGonigle (1994).

Based on the monkey transitivity data given above they showed that their production system was capable of accounting for binary transitive choice tasks and also the SDE, without the full set of logical construction relations being logically connected. That is they could solve the transitive choice task, using a small subset of rules (16 out of a possible set of 1920) on a five term series. Each rule had a place in the overall stack of rules and thus as one particular rule was acted upon the next rule in the stack would come into play. An example of a rule is detailed below.

If E select E

If A avoid A

If D select D

If C select C

If transitive decision requires more processes and is of a higher cognitive level than decision about pairs that are adjacent to each other, a position that Halford, Wilson and Phillips (1998) take, then the Harris and McGonigle model should reflect this extra processing. However, what this model in fact does is it actually treats tasks on remote pairs, just as well as tasks on adjacent pairs without having to add any additional 'computational' features to the model. Consequently, this model supports the view from ontogeny that transitive choice occurs earlier in the developing cognitive competences of the system than acquiring the full set of logical coordinates.

Following this, the model was tested to accommodate the triadic data. It was necessary, by Harris and McGonigle in the transfer to triad condition, to frequently add further disambiguation rules. The 'rule stacks' had to be augmented to cope with this condition. In other words, transitivity from both an empirical and formal perspective is simpler than the explicit seriation of items derived from the same parental series, the greater the number, the more difficult such seriation becomes, a view well supported by the repeat findings of investigators using Piaget's classic stick seriation task.

.This formal model again suggests a non-spatial representational system in operation, for the model treats both kinds of pairs, adjacent and distant, the same. Agents make transitive choice decisions by utilising a unidirectional ranking rational mechanism using primitive forms of relational coding where the ranking of object codes is based

at best on their derived distance from one or two table reference markers and the search is non-exhaustive, terminating when the target is found (McGonigle and Chalmers, 1984).

Transitive data from both human and nonhuman primates indicates that operation of a relational primitive is fundamental. Systems appear to utilise a unidirectional ranking mechanism in order to construct a representation of the presented set. With this in mind and the finding that new competences can follow from old, the next question we need to ask is what would happen when task complexity is increased towards explicit seriation, hierarchical search and even categorisation?

In other words, if the causal mechanisms of these cognitive competences are replicated in humans and non-humans, just how far can they take the non-human agent, and what implications does this have for an evolutionary continuous ontology of cognition?

As we have seen, the results of these series of experiments have several key features which are also *ontologically* interesting. The first is that transitivity in binary conditions is less complex than explicit seriation. It enters in on our *ontological* framework much earlier, working up from an ontological bottom, than previously held theories such as Piaget. Transitive choice is a product of low level relational encoding that appears to be dominated from a salient reference point. The results of the formal and comparative investigations all appear to suggest there is within our '*ontological floor*' a core rational mechanism, which needs less ordinal computation and explicit search than once was thought.

To get back to our theoretical framework of cognition, what we do not see is the position posited by Piaget, (1970), and Karmilloff-Smith (1992), that the higher the level of abstraction, the higher the cognitive process. We have seen with Piaget that there is a serial unfolding of cognitive competences in the child and that these layers of cognitive competences are a derivation of the previous one. This position stems of the intertwining of evolution and development. To adopt this position, is to adopt the stance that cognitive competences begin to serially unfold in a specific order.

Rather, what we see in the theory of cognition proposed by McGonigle *et al*, is that the growth of cognitive competences depend on a co-present set of hardwired design primitives. These adaptive design primitives are not derived, for example, from one set to another, then to another, like a chaining mechanism. “*the less rich and diverse the design primitives, the more limited the system ontogenetically*” McGonigle and Chalmers (1996) but rather cognition appears from something else.

4.12.1. Three Barns on Fire

Perhaps a rather crude ‘gestalt’ analogy may help to explain this crucial and fundamental difference between these contrasting evolutionary theories of cognition.

Imagine three barns on fire, barn A, barn Bi and barn Bii. All three barns have a pond of water some arbitrary distance away from it, let’s say 100 metres. The distance from the pond to the fire, represents the systems evolutionary journey to the fire. The barn on fire represents an end state of higher cognition.

A serial unfolding ontological view of Barn A, is where there is a person standing next to the pond, 100 metres away, with a bucket in their hand. The person say, Mr Size competence has to manage his competence, (this is represented by the coordination of getting the water out of the pond, into the bucket and then throwing the water out of the bucket to the direction of the fire) before another competence arrives, Mr Shape. Mr Shape then has to also master this competence before Mr Colour arrives, and so on until Mr Seriation, Transitivity, and Classification and so forth are in standing right next to the fire and saves the barn.

In the opposing view (Bi) the difference is this, *surrounding the pond* a group of people who have already mastered the coordination of getting the water out of the pond, into the bucket and then throwing the water out of the bucket to the direction of the fire as it was already hard-wired, and by a processing of performing their competences, over and over and over and over, new competences (people) appear out of these old ones and thus they get closer to the fire. Cognition is obtained by having a greater diverse set of people round the pond “*as a necessary precondition for their expression in later cognitive life*” McGonigle and Chalmers (1996).

In Barn Bii there are very few people around the pond, and although they can master the competence they have, by virtue of having a limited number of people around the pond and as such very few competence grow out of old ones. As a result there is a limited number of people who can come to help, and thus they never are able to reach the fire.

A suggested, a crude analogy, but one which hopefully shows that cognition does not develop from linear fixed sequences of mastered competences. But rather it stems from a hard-wired, simplistic, series of design primitives, based initially at a level of perceptual encoding. Bi and Bii provide us with an evolutionary account of cognition for notice how Bi and Bii for it can easily account for species fractionation, which is also a necessary component of any theoretical account of cognition as well as showing how through evolution the number of primitives can increase within a species.

Significantly, though, another implication that we see from this series of experiments is that by simply doing it, over and over again, higher level of cognitive competences can be reached. We saw a drop in successful performance from the squirrel monkey when transferred to the triadic condition from the binary condition. However, by performing the task repeatedly, , triadic transitivity become almost automatic, and internalised which was seen in the monkeys' extremely high successful end performance scores. Only by repeatedly attempting the task could this competence have occurred, and only by having a stable relational encoding competence could this new competence of triadic transitivity unfold. What we see here is new competences emerging out of old. This is how systems scaffold, or as Fodor (1983) put it develop from 'weak to strong', something that behaviourism could not explain. The richness of the ontological floor allows for new emerging competences to appear, but only after a series of protracted and possibly not so protracted attempts. Only by trying to put the fire out over and over again in Bi can new competences emerge, thus the barn is saved – higher levels of cognition are reached. If new cognitive competences emerge out of old ones, through a process of doing it, (without the use of language), then Davidson's argument of how thoughts emerge, that is there can be no emerging sequence of mental thought, begins to look on very shaky ground.(See also chapter 5) What is important to note that McGonigle and Chalmers placed significant controls on the paradigms such as controlling for spatial locations, colour, distribution of items on the

tray and so forth, so the result do not appear to simply be a matter of associationistic response. This was experimentally controlled out of the paradigm.

4.12.2. Systematicity and Reification

Notice how we are also beginning to solve the systematicity challenge, being able to recognise that aRb and bRc means that we can solve aRc through a process of transitivity, without having to rely on some language of thought. The results and experimental procedures describe above is certainly moving in the right direction. McGonigle and Chalmers (1992) have satisfied Fodor's (1975) claim that the relationships between the parts must be transitive. The experimental work of McGonigle and Chalmers (1977, 1992, and 2002) do suggest that these competences have stemmed from much more simpler and non-representational engine, than from a language of thought. Meeting the systematicity challenge, is not as Fodor suggest achieved only by a language of thought, but may be able to also be met by other none mentalese structures.

Being able to solve transitive tasks such as the ones describe also appears to have satisfied Bermudez's (2003) and Quine's necessary criterion of the move of reification. A move from the feature-placing level of experience, to the particular-level of experience. In order to move to the particular-involving level agents will need to make full use of observational categories (Bermudez, 2003). I would suggest that being able to know that when a subject first learns the relationship between two stimuli a and b and then the relationship between b and c , and therefore bRc . And since the relationship between a and c has not been observed, arriving at the correct answer does seem to indicate that the creature has arrived at the particular-involving level. Within the binary and the triadic conditions, the primates were (eventually) capable of solving such transitive relationships. It seems to me that the monkey has moved to this particular level and has met the Bermudez's condition on what he wants to impose on the differences of animal thought.. Bermudez is left with having to face the empirical evidence that this is the case, and that the work of McGonigle and others have shown the beginnings exactly how creatures can "*carve up their perceptual world*" (Bermudez, 2003).

4.12.3. A Threat to Davidson?

Through the work of McGonigle and others it does appear that we are beginning to get a little bit closer to developing an empirical evolutionary account of cognition and through this we are beginning to meet the systematicity challenge as laid down by Fodor and Pylyshyn (1988). This account of cognition does not at its core stem from within a symbolic, language-like or language structure, therefore does it pose a significant threat to Davidson's account on cognition. Can at last Davidson's argument be refuted, has the squirrel monkey caused a radical rethink on Davidson's position on what it is to be rational?

At first glance it appears so, the ability to reason looks very much like the ability to have thought, and in fact we see how the transitive inference task, an internationally recognized feature of being able to reason about things can be solved to extremely high levels of correctness, by non-human animals. By creatures that do not have language. If this is so, then indeed Davidson, by looking at surprise, has been looking in the wrong place.

Unfortunately, I think that above experiments, as they stand, do not refute Davidson's position at all. First of all, the experiments describe above indeed show the animals moving to a new world view, the new transitive relation, but as we have seen in Davidson's theory this is not enough. Recall that not only is a move to a new world view necessary but also the ability to monitor this move and to compare the previous thought with the 'now' thought is vital. Tests of transitivity do not necessarily nor explicitly test for this comparison.

A second reason as to why we cannot as yet refute or modify Davidson's position stems from Davidson's holism argument. Part of Davidson's holistic argument is that;

“a creature with propositional attitudes is equipped to fit a new concept into a complex scheme in which concepts have a logical and other relations to one another. Speechless creatures lack the conceptual framework.” (Davidson 2004, p137).

Although the above experimental evidence that McGonigle and Chalmers have shown is an impressive demonstration confirming non-linguistic creatures can solve transitive inference tasks, it does not show that the monkeys can utilize this ability into a new framework or into a new structures. All it has shown is that over a sustained period,

the monkey is able to make certain transitive inferences about certain external objects in the world. What is needed therefore is experimental evidence which would show how the languageless creatures could use these organizing concepts in new structures and frameworks, and in new experimental settings. If this could be experimentally demonstrated, then Davidson's position would, in my opinion have to be seriously reassessed. Is this possible?, well, McGonigle and Chalmers hint that this is indeed a realistic possibility by suggesting that;

“the core decision mechanism (in human and non-human) is a general, abstract one, implementable in a variety of contexts where preference has to be expressed in a multi-alternative decision space. (McGonigle and Chalmers, 1992, p225).

The next chapter will therefore explores this possibility and will try and determine if comparative empirical experiments can show how some non-linguistic creatures can utilise various organising concepts into new structures and new framework, thus seriously undermining Davidson's position.

5 Concepts, Classification and the Emergence of Thought

5.0 Aims

The aims of this chapter are to not only review where we have arrived at in this thesis but also to actually provide very explicit empirical proof that Davidson's account of thought may need some modification to take into account the evidence set before us. We shall in this chapter look at how Davidson believes that if one has a concept of something then this must entail that you also have other concepts. However, there is clear empirical evidence that monkeys are able to classify a range of stimuli not only under the concept of colour but also under the concept of size and shape. However, no holistic account of concept understanding needs to be applied here. We will also look at the role and utility this classification competence has for non-linguistic creatures, for if classification has no utility for the creature then I believe that any appeal to adopt an evolutionary continuous ontology of cognition is considerably weakened. This chapter also looks at the role of recursion in classification, which some have said is only a marker of linguistic creatures, this as we shall see proves not to be the case.

5.1. Taking Stock

Before we proceed I think that it is necessary to take stock and review what has been proposed. I have been trying to examine from a continuing evolutionary perspective, using key concepts from both Philosophy and Psychology, what it means to be a cognitive creature, to be a rational thinking agent, and as such determine why we should accept a continuing evolutionary account of cognition.

One of the key concepts that have been proposed from both camps has been the theory that human beings, by virtue of being language using creatures, are the only creatures that have the ability to reason about others' mental states, to have thoughts about thoughts. As I believe that any theory of cognition must stem from an evolutionary perspective it has been necessary to detail whether non-linguistic animals have thoughts (to reason about mental states).

Thinking from a cognitive, evolutionary and epistemological stance I have begun to look for, and to use empirical evidence, to suggest that certain sorts of cognitive states can be awarded to non-human creatures that do not depend on the creature being a language user. As such it does appear that relational competence may be the first clue in an evolutionary account of a theory of cognition. For example, to have competence in transitive tasks appears to be fundamental to any intelligent, rational cognitive agent and this capacity appears not to be coupled with linguistic ability.

Relational competence therefore may provide us with a way of meeting the challenges set before us and it certainly looks a likely candidate for us to start an investigation into the cognitive structures of non-linguistic creatures. From the empirical evidence of non-linguistic creatures utilizing relational competences, we have seen how from a set of design primitives more complex forms of cognition appear. This does provide an account of the emergent of thought in creatures, and this is where I believe Davidson provides an extremely unsatisfactory account. However, it is not clear that is the behaviour of the primates so far is sufficient enough for us to determine they are capable of beliefs about beliefs, although the controls on the experimental designs suggest that the non-linguistic agent appears to demonstrate that it does have an elementary understanding of relations it sees before it and certainly has an understanding that if aRb the bRa . Thus, the research suggests, that the creature that has this understanding, has the ability to necessitate that if one element of a particular type, a makes sense in a particular production, (reaching out choosing which tin) then any other element of the same type b, c, d, e and so on, will make sense when substituted into that same production. (see later in this chapter arguments for meeting the systematicity challenge as set down by Fodor and by Davidson)

We have also seen how through the problem of original meaning leads to the conclusion that language is not the medium researchers can use to explore causal mechanisms of cognition. I have suggested therefore that we do need to deliver an empirical account, but not one based on a symbolic, linguistic cultural world for if we do the results can only lead us to an infinite regress through layers of meaningless syntactically related symbols.

What of Davidson's work? We have seen that he has at least in essence two arguments for thinking that non-linguistic beings are incapable of thought, and therefore one would have to modify an evolutionary theory of cognition, to ensure the sufficient and necessary role of language. His first argument stems from his belief about the holistic nature of the mental, and the kind of evidence available for the attribution of attitudes in the absence of any verbal behaviour.

- Thoughts can only be ascribable only in dense networks of other propositional attitudes.
- In order to attribute a complex network of propositional attitudes to another requires, in order for us to support this attribution, a rich pattern of behaviour.
- The pattern of behaviour required cannot be demonstrated unless that creature is capable of speech acts.
- Therefore, only linguistic animals can have thoughts

His other argument for language being essential to thought hangs on what is required to have beliefs. Namely, the concept of belief, and, in order to have a concept of beliefs we need other concepts of truth and falsity. Consequently we see

- One can have propositional attitudes (thoughts) only if one has beliefs.
- One can have beliefs only if one has the concept of belief
- One can have the concept of belief only if one has a language
- Therefore, one can have propositional attitudes (thoughts) only if one has a language.

And to get to that stage we need

- One must have the ability to recognise that a belief may be false
- One must have an understanding that there is an objective-subjective contrast.

It is clear in Davidson's work that having a concept of belief is having a state which is being capable of being true or in contrast to an objective truth (false) and that what this means to an animal that possess all of these qualities is that it is a *Rational Animal*. It is

a creature that when it matches its own beliefs with how things are in the objective world, it is a creature that will mainly have true beliefs.

As a result of Davidson's conditions on what it is to be a rational animal, I believe that, so far, I am not in a position to refute Davidson's over all theory of cognition, although I do feel that there is significant evidence to mount a serious debate over his description of how thought emerges. Where are we then? It brings us back to the nature of relational competence and the discovery of design primitives which may be the "*engine of cognitive growth*" (McGonigle and Chalmers, 1992). We have seen how through, a sustained effort and through innovative experimental controlled paradigms, the languageless squirrel monkey has achieved an serial ordering of five items, using multi-concurrent relational codes, as well as being able to demonstrate the accepted mark of reason – to solve transitive inference tasks. However, as noted in chapter 4 what is needed for a stronger attack on Davidson's position is an experimental paradigm that will show how non-linguistic creatures can utilise new concepts into new structures and new frameworks. Has there been any experimental evidence showing this? Yes, a significant attempt at demonstrating this has been again through the work of McGonigle and others and I will in the remaining space of this chapter detail new experimental paradigms and highlight how these experimental paradigms may pose a threat to Davidson's account of being a rational animal. Before I do so, it is necessary to examine closely Davidson's account of having and using concepts that ultimately will need to fit into new structural frameworks.

5.2. Davidson on Concepts

Concepts provide an efficient way of organising experience. They also serve as an important function for a wide range of cognitive tasks such as identifying objects in the world, forming analogies, making inferences and also they can be used to convey elements of a theory. As such many view concepts as the building blocks of more complex skills. Davidson claims that there is no distinction to be made between having concepts and having propositional attitudes or thoughts. To have a concept of something suggests Davidson, is to order or class things under it. (Davidson, 2001). He makes it clear that to have a concept is not just simply having learnt it in some behaviourist way or being able to respond to stimuli from that particular concept in a certain way, but to 'judge' or 'believe' that certain items come under this concept

heading. This additional step of ‘believing’ or ‘judging’ is the crucial step for Davidson.

If we do not make this a condition on having a concept, we will have to treat simple tendencies to eat berries, or to seek warmth, and to avoid cold, as having the concepts of a berry, or of warm or of cold. I assume we don't want to view earthworms and sunflowers as having concepts. This would be a terminological mistake, for it would be to lose track of the fundamental distinction between a mindless disposition to respond differentially to the members of a class of stimuli, and a disposition to respond to those items as members of that class. (Davidson, 2004, pp137-138).

Another example modified from Joseph (2004) of what it means to have a concept for Davidson may make the picture clearer. To have a concept of something suggests the capacity to have some ability or abilities. For example, to have the concept of ‘wasabi’, is to have beliefs about what *wasabi* is, and to be able to classify selectively that some plants satisfy the sentence “*x is a wasabi*” and others are not. However, it could be the case that we could train up systems to identify *wasabi* every time it sees it; in fact we could train it up so that it could correctly identify *wasabi* one hundred percent of the time, and only to say *wasabi* when it sees *wasabi*. But, this system would say ‘wasabi’ without knowing what *wasabi* is, without knowing that *wasabi* is a type of horseradish. In this case Davidson would say that we ought not to say that ‘this system’ knows what *wasabi* is. There are many other things that we could know about *wasabi*, that it is grown in Japan, the chemicals in *wasabi* that provide its unique flavor are the isothiocyanates, but possessing a sortal concept entails an understanding and being able to use a corresponding expression and some fragment of theory in which it occurs (Joseph, 2004).

Davidson would further argue that a concept is defined by its typical cause only within the framework of a system of concepts. “[*T*]he sentences and thoughts that employ them, are in part individuated by their causal relations to the world and in part by their relations to each other.” (Davidson, 2004, p138).

The question now that confronts us is, can some non-linguistic creatures, who Davidson claims do not have the conceptual framework, demonstrate, through tightly controlled empirical means, behaviour sufficient for us to state that that creature knows what it is to have *that* concept? The empirical evidence needs to be over and above the

system being able to just correctly identify every time it sees *that* concept, as being an example of *that* concept, as in the *wasabi* example. The non-linguistic creature needs to be able to fit new concepts into complex schemes which have logical and other relations to each other. (Davidson, 2001). Being able though to experimentally prove this, is only part of the story. We saw in the experiment detailed in Chapter 4, (4.8) that through a process of honest toil the monkeys were able to solve the transitive inference task. One consequence was the primates became more efficient at the task and ‘*relaxed*’ into the problem. If it is the case that by doing it we become more efficient at it, which the empirical results suggest is something we do, and if the emergence of efficiency is part of a story about evolutionary cognitive growth and cognitive thought. It is then important that we can not only to ensure we can capture the utilisation of ‘*concept*’ but also to truly measure efficiency. So how does one do this? I will start with efficiency first.

5.3. The Measurement of Efficiency

The first experiment I wish to briefly review was devised by McGonigle, de Lillo and Dickenson, (1994), and was simple in its design. All the subjects; in this case *children* and *Cebus Apella* had to do was to touch all the dots, in any order that appeared on a computer touch screen. However, there was no material difference between the dots. There was no reinforcement during the subject’s production, although at the end of each trial a small reward, a peanut from a dispenser for the monkey and an animated man with a balloon on a ladder appeared for the children²⁶. After each trial a new array of dots appeared. The dots did not move around the screen after each touch but remained stationary until all of them had been touched. Measures of time to complete the task and the total number of touches were taken. The task also increased progressively in difficulty from originally two dots to nine. Figure 12 is an example of the touch screen paradigm used.

²⁶ This was for motivational reasons alone.

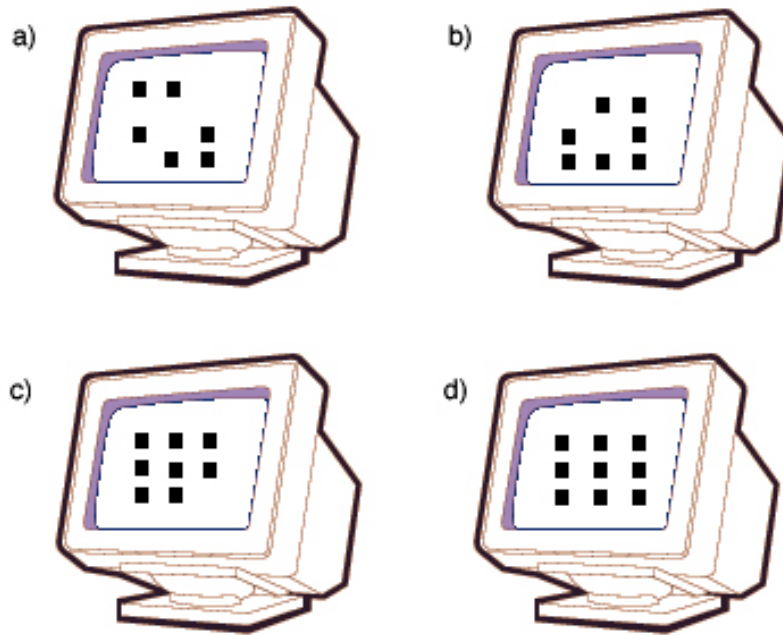


Figure 12: Some examples of the touch screen configurations. (Taken from de Lillo, 1994).

a) An example of configuration with 6 stimuli. b) An example of configuration with 7 stimuli c) An example of configuration with 8 stimuli. d) An example of configuration with 9 stimuli.

Recall that the combinatorial explosion problem really gets going after five items thus, with this task, the task difficulty going up to nine items, seriously places a massive load on memory, in keeping track of icons already touched. Unless of course an economic principled search metric can be applied. If no economic search principle is adopted as the number of dots increased, random unprincipled searches would show a high number of reiterations and an increased length of time to complete the task.

Several issues arise. The first is a production one. It was not known at the time if the *Cebus* could actually search for more than five and up to nine items displayed on a computer touch screen. The second, an ontological one, is related to the actual search strategy the monkey/children adopt. Is the search random, or is it strategic and principled, it is efficient, and if so how do the subjects utilize a spatial layout, and if so what form does it take? Based on McGonigle's *et al* theoretical position, the monkeys should, when successful, 'relax' into a more efficient search strategy over time, that is complex competences emerge from previous ones.

To answer the first question, the results below demonstrate that the monkeys were able to search all nine items, and to answer the second, the primates demonstrated effective search procedures, based on linear rather than a spatial geometric vectors. The monkeys initially were poor especially for the larger sets of 5 to 9 icons, they behaviour was uneconomic and costly. However, after a period of months their behaviour performance changed, and became very principled and efficient in their search procedures, thus indicating ability to self regulate other than responding to an arbitrary external stimulus. The monkeys were able to solve the task through a process of linear rather than some spatial geometric function. Again we see conformation of the theory that in non-linguistic creatures, complex cognitive competences can emerge out of old competences without the need or Davidson's sufficient condition of language.

We see in figure 13 that as the number of stimuli increases on the screen the younger children were becoming less efficient in their search strategy. The efficiency of a search pattern can be measurement by an *Efficient Ratio score*, (ER) devised McGonigle. 1993, 2001; See McGonigle and Chalmers (2003).

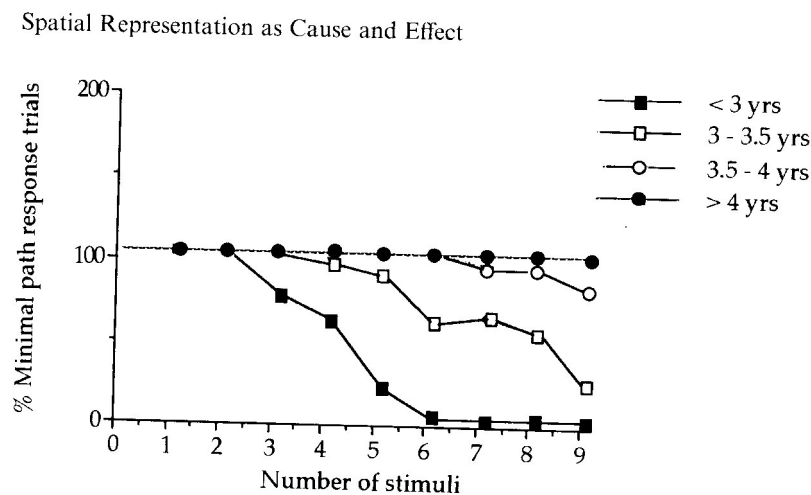


Figure 13 Search paths for children between 3 and 4 years as a function of the number of icons to be touched. (Taken from McGonigle and Chalmers, 2001)

The ER measure is a quantitative measure of sequencing efficiency. For example, on this particular experiment we see that if two dots are presented and the subject (child or monkey) touches the two dots, without any additional touches that would be reflect a maximum efficient search. A *minimal path search*. However, if the subject on a six dot presentation records a score of eight touches for the six items then this would

record a score of 2 additional touches. This then reflects a search that is *inefficient*. It is costly, and not economic. Although this looks like a simple measure it is in fact extremely powerful as we shall see later, it enables the experimenter to determine how efficient and economic the subject really is on a given task.

Efficiency scores can thus be given as a ratio for example, if six touches were made on six items this would equal a ratio 6:6 which gives a *unity* measure of 1. However if eight touches were made then a unity score of .75 (min path = 6 touches/maximum touches 8) would be recorded, reflecting the difference in the economy of search. This ratio can also be adjusted for set size, giving an *AER* score. This is important because a measure is needed to reflect the increasing difficulty of search through an increased set. So on our example if the subject searched six items presented in a maximum efficient way they would record an ER of 1. As there are six items this can simply be multiplied $1*6$, giving a AER score of 6. However the inefficient subject would score .75 (ER score) multiplied by 6 (number of dots) which is an AER score of 4.75 which is of course lower as the search was less efficient.

The less efficient searches for the children were thus costly and expensive, or simply they adopted arbitrary paths through the space, such as touch all the outside ones, but neglect the centre ones. Figure 13 above clearly shows that the degree of efficiency is correlated with age and success for the older children were much more efficient than the younger ones. Would Davidson claim that this difference of competence as seen in the transition between three and four years of age is due to language, which is of course a similar claim supporters of Davidson may have stated as an explanation when seven year olds out seriate five year olds on a seven item seriation task (McGonigle and Chalmers, 1992)? Or, and more likely, is this difference and the utilization of specific sequential control, stem from non-linguistic roots.

Now that we have a measure for economy and efficiency is it now possible to empirically provide evidence for Davidson, that non-linguistic creatures can be equipped to fit new concepts into other complex schemes? Will this evidence show an evolutionary continuity view point – or will it show an evolutionary saltatory perspective akin to Davidson's account, that through a process of triangulation plus the addition of language, higher cognitive thought, beliefs about beliefs, desires about

beliefs occur? What I am getting at is to determine whether there is sufficient empirical evidence which suggests that languageless creatures can '*respond to items as members of a class*' as opposed to *responding differently to different members of the class*.

One way of helping to proceed with this evolutionary empirical investigation is to turn the question around back on its head and look at it from a different perspective. We know that Davidson and others believe that the single distinctive feature that separates humans from non-human animals is language. Yet we also know from the empirical evidence reported throughout this thesis, that the indicators of complex rational cognitive agents, such as transitivity and seriation, are not uniquely human. So what is it then about language that makes it such a single distinctive feature? Recall the systematicity argument (chapter 2, 2.1) that is we need to account for the productivity of language. We as humans have an unbounded competence to entertain a possible unlimited number of thoughts. We have a limited capacity system; yet we can generate an infinite number of sentences, we exploit this limited system by recursion, feeding its output back as input. The mechanism of recursion allows us to do this. It allows the creation of limitless combinations from a finite set (vocabulary). Recursion in any systematicity must be distinguished from reiteration. Reiteration is doing the same thing over and over again, where as recursion is a procedure which is (partially) defined in terms of itself. Memory is needed for recursion but not for reiteration. (Hurford, 2004). Any creature that performs a recursive task will need to keep track of each successive layer of nesting. Recursion therefore is the mechanism that allows us to express, amongst other things complex thoughts, and create an 'infinite' opened pattern, such as John, thinks that Mary thinks that, John thinks that Mary thinks that and so on. Recursion allows us to move beyond the here and now level, beyond the observational and affordance level and with each step of recursion, we see an increase in complexity.

In a recent article Hauser, Chomsky and Fitch (2002) claim that recursion, is uniquely human. In essence their argument is '*No languageless creatures have it*'. If this claim is right then theoretical accounts of cognition must then detail how this uniqueness emerged in biological systems through evolution, and map relations in the ontology

between cognitive competences such as recursion and other competences that are shared across species, human and non-human such as transitivity and seriation.

There is of course another option and that is to deny the premise. Hauser *et al* have set up an empirical rather than philosophical position such that if cognitive mechanisms that lie behind recursion can be found in non-human subjects then modification not only of their original position must take place but also Davidson's position will need to be re-examined. For if one can demonstrate recursion in non-linguistic animals, a claim can be made that one has also demonstrated that languageless creatures may have met some of Davidson's conditions. I will however come to that later in this chapter, but first it will be necessary to detail why Hauser *et al* see recursion as a unique human competence.

5.4. The Human Uniqueness of 'Recursion?'

Hauser *et al*, are right in suggesting that if an animal shares an element of the language system then it is reasonable to assume that its ancestors shared that element too, however, if it is discovered that an element of the language system is found unique to humans, and cannot be discovered in animals then that too can be inferred as being uniquely human. This I think is straight forward enough. They are also right to highlight that some ontological accounts of animal communication systems lack the power and rich expressiveness of the human language system. They simply cannot scale up to the vast productiveness of human language. As Hauser *et al*, state, the question is "*how did we get from there, to here, given this apparent discontinuity*" (p1570). Again, sentiments that I agree with here.

5.4.1 Narrow verses Broad

In order to solve some of the questions they raise Hauser *et al*, make a definite distinction between human and non human animals by suggesting a two-part model of language, and its evolution. The two constituent parts of the model are the Broad Faculty of language (FLB) and the Narrow Faculty of Language, (FLN).

The human non-human distinction becomes clear as they propose that the FLB is the part that consists of features that we share with other animals for this is made up of

motor-sensory systems, organs, muscles and other physical elements that enable us to see hear, hear and touch objects in the environment around us. The claim being made here is that the actual physical characteristics that are used in humans for producing, interpreting, and listening to speech does has at least some representation in non-human animals. Not only this, but that the FLB is made up of a creatures knowledge of the world and its ability or capacity to use that knowledge which is then acted upon as intention actions. This correctly negates any Cartesian hypothesis. Animals, though, for Hauser *et al*, are more than nerves and muscles, and are not unthinking agents.

Although as the name implies, the FLB is general, it is broad and found in a lot of species, and it is just an empirical question, rather than a philosophical one to determine in which animals possess the FLB.

5.4.2. The Faculty of Language (Narrow): “Recursion is the sole sign of man”.

The FLN though, according to Hauser *et al* is unique. It is only found in humans. No other creatures have it. The FLN is a component of the FLB and some mechanisms that serve the FLB also serve the FLN. However, when stripped down to its barest form the FLN consists of only one mechanism - *recursion*. In fact one might be tempted to modify Descartes famous quote and say that ‘*recursion is the sole sign of man.*’

To support their claims Hauser *et al*, cite a number of comparative studies which consider the uniqueness or non-uniqueness of components of the language faculty depending on which aspect, narrow or broad they are referring to. Citing work in perception, they highlight how many species have an ability to discriminate and generalise human speech sounds (Khul & Miller, 1975; Kluender, Diehl & Killeen 1987) as well as primates using rhythm to discriminate between two different languages. (Ramus, Hauser & Miller, 2000). This ability to discriminate the sounds indicates, at least for Hauser *et al*, that the ability to perceive speech was present before the onset of language. An important ontological consideration if true, however, there is contrary research which shows that when non-human animals discriminate human speech sounds they do so in a qualitively different way. Kojima & Kiritani, 1989 have shown that chimpanzees discrimination for vowels differ to that of humans. Similarly, research using human speech sounds on quail (Trout, 2003) and budgerigars

(Dooling & Brown, 1990) show different patterns of sound discrimination from those that are found in humans. It may therefore be the case that when non-human animals do discriminate human speech sounds, they may so do in a dissimilar way to humans and consequently the link may be weaker than initially thought.

Hierarchical organisation is also a necessary feature that makes human language possible (Conway and Christiansen 2001; Hauser, Chomsky and Fitch 2002; Premack, 2004).

“The grammar or syntax or syntax of human language is certainly unique. Like and onion or Russian Doll it is recursive.” Premack (2004) p318.

To demonstrate the point that only humans have this ability, Fitch and Hauser (2004) investigated whether such processes as hierarchical processing (recursion), is or is not one of the pre-existing abilities, that has evolved to solve non-communicative functions such as motor control, number of social cognition (McGonigle & Chalmers 2003; Byrne & Russon 1998).

5.4.3. Experimental Design and Methodology

Fitch and Hauser (2004) developed two aural tests on cotton-top Tamarin monkeys in which sequences of one-syllable words were called out by human voices. All monkeys were exposed to a twenty minute repeated play back of sixty different, but grammatically consistent strings. In all sixty four strings were generated and sixty were used for exposure, however, only four testing strings per condition were used as test purposes.

These four (X 2) test strings can be seen in table 5 below.

Finite State Grammar Stimuli: (AB)n

Audio 5	la li ba pa
Audio 6	di mo yo pa
Audio 7	di pa wu bi tu nu
Audio 8	ba nu di do mi ka

Phrase Structure Grammar (A^nB^n)

Audio 1	di yo gu do
Audio 2	yo no mo li
Audio 3	la no yo mo bi gu
Audio 4	no tu wu ka mo gu

(Female voice strings in bold and male voice strings in plain text)

Table 5. Test strings presented to Tamarin monkeys. (Fitch and Hauser 2004).

In the first test, random strings were called out in a strictly alternating pattern of male followed by female voices. The monkeys responded to breaks in the male-female rule, by looking at the loudspeaker, thus noting a violation on the simple finite state grammar rule $(AB)^n$ rule. This showed that they were able to recognise this simple rule, and is in fact consistent with various findings that monkeys can discover and are able to learn the rules governing sequential patterns. (McGonigle and Chalmers, 1977, 1996, 1998, 2001, 2002; Hauser, Newport & Aslin, 2001; Hauser, Weiss and Marcus, 2002).

In the next recursive hierarchical test, the grammatical phrase structure rule (A^nB^n) dictated that the male voice could call out one, two or three words, followed by a similar pattern by the female voice. So a hierarchical structure could form along the lines of $(AA - BB, AAA - BBB)$, where the male vocalisation appears twice or three times followed by the female vocalisation and so on. This then could in theory lead to an infinite number of strings with an infinite number of string lengths, but as Hauser, Dehaene, Dehaene-Lambertz, and Patalano (2002) have shown that tamarins are capable of only processing strings up to three syllables in length, Fitch and Hauser only used strings up to a maximum of three syllables.

5.4.4 Results and Implications

In this second phrase structure test, the monkeys were unable to recognise any breaks in the pattern. But a human control group had no such difficulty, although most were unable to explain what the rule actually was. Fitch and Hauser explain their results by suggesting that the tamarins were attempting to parse the phrase structure strings by

building a finite state structure and may be stuck trying to interpret phrase structures at this more simple finite state level.

Fitch and Hauser claimed that their experiment showed that while tamarins are able to understand basic rules about word patterns, they are not able to follow more complex rules that underpin the crucial next stage of language structures that is tamarins could not learn the simple recursive language $A^n B^n$ ²⁷

“tamarins suffer from a specific and fundamental computational limitation on their ability to spontaneously recognise or remember organised acoustic structures.” (Fitch and Hauser, 2004, p380).

As a result of this finding they conclude that tamarins are not capable of complex hierarchical processing and this is the *“critical juncture in the evolution of the human language capacity”* (Fitch and Hauser, 2004, p380).

Being able to classify is a highly complex cognitive skill, but is it a skill that is only found in the FLN and are Hauser *et al* right claiming there exists *cognitive discontinuity* in hierarchical competences between linguistic man and non linguistic animal? MacIntyre (2002) suggests that that the ability to classify objects over ontogenesis would for be a sure sign that a creature, human or non-human would be a cognitive rational animal. But if classification is a sign of cognition how could this be, from a continuity perspective that MacIntyre suggests, empirically demonstrated. One cannot use the Piagetian classic task for non-linguistic creatures such as monkeys do not have the necessary manipulative skills to perform such class inclusion tasks.

However, I will in the following section, in order to demonstrate the existence of complex cognitive continuity of classification, describe the development of further paradigms and procedures that have been employed by McGonigle and co-workers to investigate linear and hierarchical control in non human agents, the categorical competences of non-humans which have been undermined by conventional testing techniques and which interestingly enough have been largely by passed by philosophers and psychologists alike. (McGonigle & Chalmers, 2001, 2002, 2003; McGonigle, Chalmers and Ravenscroft, 2001)

²⁷ All sequences consisting of n instances of the symbol A followed by n instances of the symbol B).

5.5. Evidence of Cognitive Continuity in Hierarchical and Linear processing: Classification in Languageless Creatures and the argument for Recursion

In order to investigate the classification skills of non linguistic primates McGonigle, Chalmers and Dickinson, (2003) developed a longitudinal approach and devised various paradigms to assess classification competence. The duration of the study took four years to complete and their experimental paradigms employed a rich set of design procedures using touch screen methodology. As such the investigation was divided into several parts.

5.5.1. Overall Experimental Aim (Part One)

In part one of the investigations the monkeys were first required to order up to 9 icons by shape, using three different shape classes. In the early stages of this paradigm the exemplars were all identical within the class, later they began to vary within the class by size and colour. So that by the end of this particular phase the icons had to be ordered within classes using not only the size variation rule but also a colour variation rule as well. Thus McGonigle et al looked at not only disjoint classification (all exemplars being the equivalent within the classes) but also reciprocal classification as well. (Size and colour) The increasing task difficulty can be seen in the figure 14 below

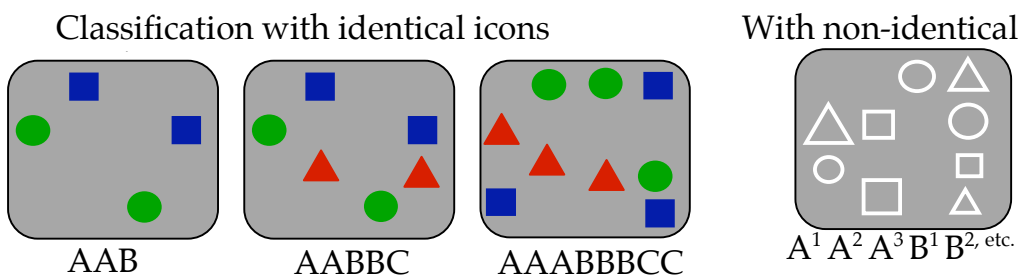


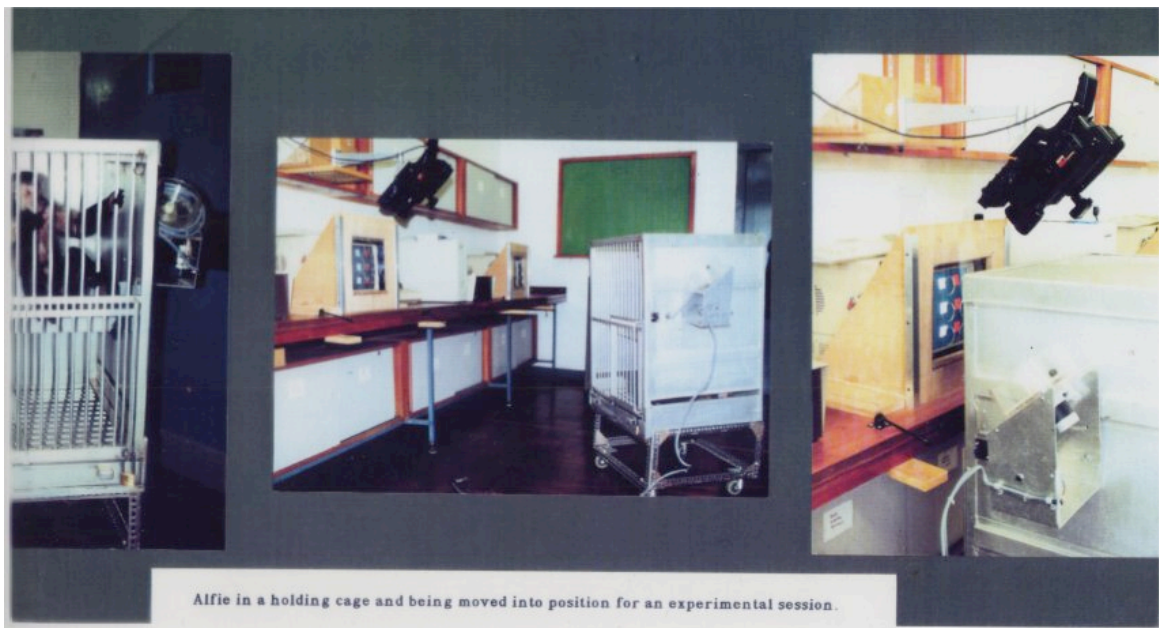
Figure 14. An overview of the classification paradigm with *Cebus apella*. (McGonigle, Chalmers and Dickinson, 2003).

5.5.2 Disjoint Classification (Part One)

The first part of the experimental design was to measure disjoint classification, where classifications of the objects within the class are identical.

5.5.3 Experimental Design and Methodology Part 1

In this first part of the experimental paradigm the subjects were seven (*Cebus apella*) monkeys which were all touch screen naive and were tested in a large room on a standard PC computer and monitor. Over the monitor was placed a Perspex screen with 16 holes large enough for the monkey's hand to reach through and touch the monitor. This grid aligned the monkey's touches with a 4X4 'imposed' computer driven grid.. This experimental set up can be seen in photograph 7 below where we see the monkey is taken from its 'home' cage into a holding cage, then placed into the testing cage, which is then placed in front of the computer ready for testing.



Photograph 7. The testing set up for *Cebus Apella*.

Stimuli for Part 1

The stimuli for the experiment were generated from eight shapes, the 'parent set'. *Circle, Square, Triangle, Star, Cross, I Bar, Hexagon, and Egg Cup.*

Each monkey was randomly allocated three different shapes from this parent set. The shapes initially were coloured in with one of three colours, *Red, Green or Blue*, and each shape was randomly assigned one of these colours. So for example, a monkey may have been presented with three green squares, (all identical) three red triangles (all identical and three blue hexagons all identical)

For the final part of this section, sub-phase 6, had the colour fill removed so they became white and contoured based only, but the stimuli within the classes all remained identical to each other.

Procedure (Part-one)

The animals entered the testing cages of their own accord, and were tested in the test room for on average 50 trials per day. The rewards for the Cebus were always peanuts. When testing started, on the computer, trials were cued up by a large white rectangle that appeared for a few seconds on the centre of the screen. Then the icons were displayed on the touch screen. The monkey then had to sequence between classes only by remembering the position of each (identical) exemplar.

Although this becomes a serial task, for example A1 to A2, to A3 to B1 to B2 etc the use of identical icons creates what McGonigle et al call a '*branching structure*', (p191), where the same stimulus calls for a different response in different times in the sequence. As part of the semi- supervised procedure the monkeys were not allowed to reiterate any icon, if this did occur the screen would go immediately go blank for an extended period of time. (30 seconds) Repeat touches were allowed. A random spatial array was generated for every trial

The acquisition task of the monkeys was to develop seriation from a small sequence to a long nine item sequence through sub-phases until ultimately the monkeys if possible, could seriate three classes and three exemplars per category²⁸. In order to build up this profile addition sequences were added in lengths so that undue weight could not be given when new items were added to the set. So in order for AAABBBCCC to be obtained the monkeys were trained through sub-phases of ABC, (sub-phase 1-3 which included training of sequences like ABB to AABB, BBCC, and AACC) to sub-phase 4 where two classes were presented with their full sequence length, AAABBB, AAABBB, BBCCCC, and eventually AAACCC along with AABBBCC, to subphase 5 where the nine item three classes was presented, AAABBBCCC). In sub-phase 6 the monkeys were presented the monochrome transfer condition.

²⁸ For example, Square, Square, Square, Triangle, Triangle, Triangle, Hexagon, Hexagon Hexagon.

Controls

All sequences within each phase were presented in a controlled pseudo-random fashion such that every sequence was presented equally often within a session. A criterion of 75% successfully correct trials across 20 consecutive trials was demanded by McGonigle *et al* as a measure of performance competence.²⁹ There were 16 possible places the icons could be presented on the screen (a maximum of 9 used in any one trial), and these were presented randomly after every trial. There was also no long lasting indication that the icon had been touched so the monkey had to keep track of which ones it had completed and which ones were still left to do. All conditions within each phase were presented concurrently .

5.5.4. Results and Implications

All monkeys were able to reach the 75% completely correct criterion of success imposed on all conditions. Table 6 shows the mean number of trials and the mean number of errors made in phase 2, 4 and 5.

Sequence Condition	Mean Errors	Mean Trials
ABC	245.9	522.29
AAABBB	223.7	321.6
AAACCC	115.4	165.9
AAABBBCCC	602	1816

Table 6: Mean acquisition performance for all monkeys expressed as mean number of trials and errors, leading to the acquisition of 9-item sequencing with three disjoint classes. (McGonigle *et al*, 2003)

The monkeys transferred to the monochromatic condition with actually fewer number of errors made when learning the original 9 item sequence. As seen in table 7.

	Sequence Condition	Mean Errors	Mean Trials
Colour/ original	AAABBBCCC	602	1816
Monochrome/Transfer	AAABBBCCC	276	353.6

Table 7: Mean acquisition performance for all monkeys during transfer of a 9 item sequencing to a monochromatic condition with three disjoint classes. (McGonigle *et al*, 2003)

²⁹ Although ABC was trained to 75% correct across 120 trials to ensure stable performance.

It appears that, in this simplest form of classification all monkeys were able to classify the three disjoint categories, providing evidence for a cognitive continuity argument of the utilisation of concepts. McGonigle *et al* reported that the monkeys first learnt to classify two items per class then moved to complete the set. (McGonigle and Chalmers 2005).

This experiment showed that monkeys have the ability to order a set of icons even when the icons within the class category are identical. Figure 15 shows an example of the linear array produces by the monkeys on this particular task.

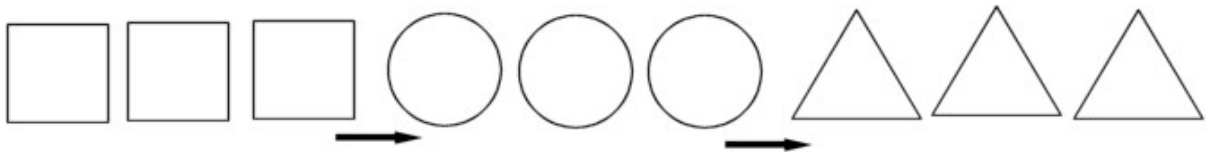


Figure 15. An example of disjoint classification success achieved by all seven monkeys. (McGonigle, Chalmers and Dickinson, (2001)

However, could these results have been obtained by simple associative conditioning responses? If so, then the claim that these results show the utilisation of hierarchical organisation as Langer (1994) suggests, would have to be dismissed and an argument for cognitive continuity would be considerably weakened.

These results though could not have been explained by any associative Markovian chains, because no associated response can be made to the first item within the ‘first’ position within the category as all exemplars within the category are of the same type. Markovian chains therefore do not explain the success of the monkeys. The evidence is stacking up that indeed the subjects are searching and classifying hierarchically to compensate for the increasingly cognitive load demand by having to order progressively longer and longer sequences.

McGonigle *et al* also report how the learning profiles show that the task did not increase in subjective difficulty, although it did increase in ‘real’ difficulty as when the monkey went through the various phases, i.e. the additional number of icons to search significantly increased. This indicates that early learning has a significant ‘utility’ for later problems of the same type. The pattern of acquisition suggests that organisational

constraints materially reduced the costs of dealing with novel sequences of higher levels of difficulty.

This is also suggested by the result displayed in figure 16, which shows the error profile of three subjects.

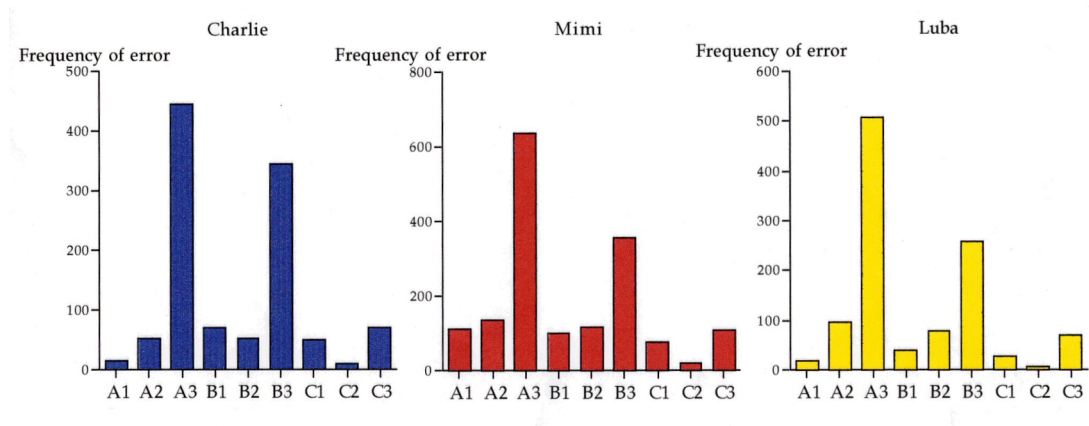


Figure 16: Error distributions during concurrent disjoint classification. (McGonigle, Chalmers and Dickinson 2001).

The errors initially are high but decrease monotonically through out the sequence, which suggests that early exemplars within the task are all competing against each other but as the monkey proceeds through the task, he/she is discounting the exemplars already chosen, and thus do they not cause interference with the ones left to be searched. A very economic way to proceed through the task. Figure 16 also shows errors are at the end of each class boundary, again this result suggests that the monkeys are not solving the classification task by Markovian chains for if they were, there would be no difference in the number of errors made between items within the ‘chain’. This is clearly not happening. The results indicate that if the monkey was turning the task into one long linear sequence there would be no categorical boundary effects at all. The fact that the monkeys can classify the items without a Markovian confirms position that a public language system, nor indeed a culture of mapping is not needed to be successful in concurrent disjoint classification.

5.5.5. Reciprocal Classification (Part Two)

This next part of the experiment examined the *Cebus*'s competence on a reciprocal classification task. This is where classification of the stimuli is dependent upon size

5.5.6. Experimental Design and Methodology: Phases A' and A (Part Two)

Subjects

In this experimental phase four monkeys that were involved in part 1 of the experiment were used.

Stimuli (Phase A' and Phase A (Recursion))

In the second part of their experimental design the same shapes were used except the exemplars now varied in size. There were three size shapes per class, small medium and large. The difference between the stimuli was 2 cm in diameter.³⁰ Instead of using colour this time the shapes were differentiated by a white line contour. In order to seriate the items successfully, the monkey has to collate class with range of size stimuli.

Procedure A'

However a different experimental procedure operated to that of part one. In A' the primates were allowed to touch the icons *within any order*, they could touch small star, then large star followed by little star and then move on to the next class. The only rule that McGonigle *et al* imposed on the subjects was that they had to exhaust all the class categories and no reiteration was allowed. Once a class category was chosen the monkey had to seriate all the items in that class. Size, could therefore be selected in any order. Again the monkeys were trained to their previous criterion levels of 75% complete correct across 20 consecutive trials.

Procedure A (Recursion)

In the second phase of part two the monkeys were tested with a strict ordering rule. Using the same stimuli as in A' of Part two, (size and shape), the monkeys were trained to order each shape monotonically by size in ascending order; small to large. Again the 75% complete correct criterion was imposed across 20 consecutive trials. Notice that in this procedure we see a recursive rule being imposed. An example of this recursive rule would be to touch in order the following

Class (A) small, middle large, (B) small, middle, large (C) small middle large

³⁰ So now we have; small star, medium star, large star, small circle, medium circle, large circle, small square, medium square and large square.

5.5.7. Results and Implications

The monkeys found it initially difficult to learn in both A' and A condition to a 75% correct criterion, eventually, after a large number of trials and errors three monkeys successfully reached this level in both A' and A. Table 8 highlights this difficulty

		Sequence Condition	Mean Errors	Mean Trials
Free Search	A'	AAABBBCCC	1512.3	1462.1
Fixed Search/Supervised	A'	AAABBBCCC	2528	2848.7

Table 8. Mean acquisition performance for all subjects, expressed as trials and errors to criterion during a hierarchical condition where three sizes had to be selected within each of the three classes (McGonigle *et al.*, 2003).

The fact that eventually the subjects reach criterion suggests again that the primates '*can organise multiple classes hierarchically*'. (McGonigle *et al*, p193). There were interesting differences in the results between A' and A. The free choice condition A' proved much easier for the monkeys than the strict supervised one. Charlie one of the four *Cebus* for example reached criterion on A' in only 470 trials, however, in A took over 2231 trials. On average the four monkeys took 1462 trials to reach the 75% correct criterion level in A' and 2829 in A. However in say this, the monkeys were still able to reached the criterion level and thus demonstrate recursive competence in non-linguistic primates. To be clear the results show that recursion itself may not necessarily be a unique feature of the NFL. (McGonigle and Chalmers, 2005).

When the monkeys were allowed to impose their own order on the items to be classified, they performed significantly better than when they were forced to learn an order. This self ordering is very interesting indeed as it does seem to indicate that the monkeys might be using their own set of beliefs and thoughts to order the icons before them. This will be discussed in depth later.

Although the monkeys did take a long time to reach the nested recursive level, they did succeed. Again, we see another demonstration of how new competences emerge out of old, without the scaffold of language. As shape information could only support three ordinal positions, and size likewise could only support three, in order to reach a nine item sequence the monkeys must have had to combine shape AND size information

which were nested hierarchically so that shape provided the ordinal segment which was then in turn individuated by size seriation. In other words the monkeys had developed a classificatory nested procedure that shape of the exemplar was positioned along an axis and the size of the exemplar was then positioned within that axis under its respected shape category. This surely is an example of hierarchical nested control, empirical evidence against those claims that suggest mechanisms for hierarchical control have evolved for communication purposes. (Pinker, 2003, Hauser, Chomsky and Fitch, (2001). This evidence of hierarchical classification does indicated that the primates are using new concepts into different frameworks. We see how being able to classify each member of the class of icons, say, *all stars* before classifying *all squares* shows how the primate is able to utilise the concept of ‘shape’ and the concept of ‘size’ in a recursive structured framework. It does not confirm however Davidson’s holistic picture where if one has a concept of shape or size, then one can have other propositional attitudes.

By using a micro level of analyses, McGonigle and Chalmers, (1998, 2001) investigated the degree of planning the monkeys were able to utilise. The degree of planning can be seen in figure 17 below,

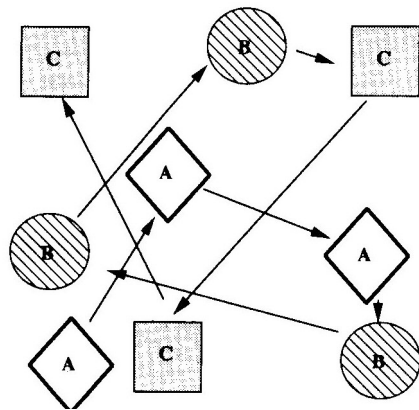


Figure 17: Planning a route through a three class three items set (McGonigle and Chalmers 1998)

Figure 17 above shows how the monkey has to plan its route through the classification task from A to A to A then to B to B to B and then to C to C to C. Recall that part of the paradigm procedure both in Part One and Part Two of the experiment was that after every trial the spatial array of the task moved. Figure 18 below shows the reaction time

measures from children and the Cebus and indicate clearly how planning was indeed a factor in the search strategies used.

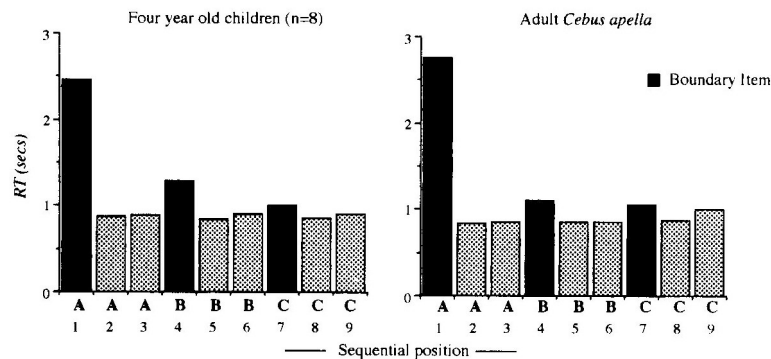


Figure 18: Reaction Time measures during successful sequencing of three categories, each with three exemplars. (McGonigle and Chalmers, 1998)

We can see from figure 18 the monkeys (and children) take longer to touch the ordinal position of each item within the class than the following two items. Thus strong boundary position effects are seen. A1, B1 and C1 take longer to touch than A2 and A3, B2, B3, C2, C3 respectively. This indicates that the subject is planning its route through the spatial representation on the touch screen. Notice how the first ordinal position has the longest reaction time of all, (both in children and especially in the monkeys). A1 took almost twice as long as the other two boundary items, again giving support that the monkey plans its route through the task before any touches commence and once started it becomes then a task of implementing the planned route. The pattern of results produces by the reaction times thus suggests not only a planning characterisation but also an economic one, for the results show that the primates are chunking the class items together, to off set memory cost. Here a simple measure of reaction dwell times clearly indicates that the subjects are not only planning the route through but the measures also show strong classification behaviour. Second and third items within the category are much quicker class boundary ones.

5.6 Emergent Growth – Long Term Dependencies

Davidson's holistic account of cognition implies that there is no sequence of emergence of the mental; however the comparative empirical evidence suggests that this is not the case and in fact there is a specific ontological emergence of cognitive

growth that Davidson misses. On such example is the finding that long term dependencies emerge before short term ones. This can be explained by examining the training sub-phase conditions in Part One that McGonigle *et al* (2003) undertook in the four year study described above.

McGonigle et al found that in the training sequences that featured longer term dependencies such as AACC than those which trained local ones such as BBCC or AABB, the *Cebus* learnt the ordering of non-ordinally adjacent items far easier than ordinally adjacent items in the training series see Table 9 below.

Condition	Mean Number of Errors	Mean Number of Trials
AABB (Short-term)	63.9	124.1
BBCC (Short-term)	83.3	139.0
AACC (Long-term)	28.6	63.3

Table 9. Long term dependencies were acquired more easily than short term ones. Demonstrated through mean number of trials and mean errors made. (McGonigle *et al*, 2003)

This finding, they suggest, shows that “*the primary mechanism which supports the acquisition of long term dependencies then enables the acquisition of local or short term dependencies and not visa versa*” McGonigle et al, (2003 p192).

Ontologically speaking this is counterintuitive for one would assume that in a cognitive ontological framework the mechanism that govern such acquisitions would start with short term dependencies first then migrate to long term ones. One would not expect to see a system develop from long term first and then fill in to short term acquisitions.

However, in a study designed by McGonigle, which is I conducted (McGonigle and Ravenscroft, 2004), this finding was replicated. I shall briefly detail it here, for it also confirms the position that transitivity occurs before seriation, indicating that there is a clear pattern of cognitive emergence that develops without being forced to be a language user.

5.7. Emergent Transitivity – My own empirical investigation

5.7.1. Experimental Design and Methodology

This study took place over a twelve-month period. The aim of the study was to examine the emergence of transitivity over seriation. Trabasso (1977), and Halford *et al* (1998) claimed that transitive choice decisions requires a higher order complex representation mechanism than the mechanisms of seriation. According to this position the logical coordination of the set needs to be acquired before transitivity occurs, this finding though was questioned by the ‘tin’ transitive experiment we saw in chapter four where through a series of weighted tins binary transitivity occurred before the seriation of three tin items.

Subjects: This study used four juvenile *Cebus apella*. The monkeys were randomly allocated into two groups, two were placed in the “Relational Size *R*” condition and two were allocated in the “Arbitrary Same Size *SS*” condition.

Stimuli: A five item set was used for both conditions and they were derived from a parent set of five arbitrarily chosen black and white stimuli. The stimuli set composed of a circle with a black and white ying/yang pattern inside of it, a black and white square maze pattern, a black and white menorah, a white star of David on a black background and a white triangle on a black background. In the *R* condition two monkeys were presented with a set of 5 relational stimuli, ABCDE with A being the smallest icon and E the largest. The increase in size between each icon was consistent at .05cm² in diameter

The other two monkeys were presented with a set (ABCDE) of non-connective arbitrary same size stimuli, in this case the middle size stimuli were used. So for example, the monkey in condition *R* was presented with five different sizes of the menorah stimuli whilst a monkey in *SS* was presented five icons of the same (middle size icon) white triangle stimuli. The stimuli were presented on a touch screen using a DELL computer.

Procedure

In all, there were twenty different conditions set within the three categories of testing which built up the experimental paradigm. The paradigm, which can be seen in figure 19 below, consisted of three distinct sections; *Training Pairs*, *Binary Transitive* and a *Triadic condition*. The 20 different conditions were presented to each of the four subjects concurrently.

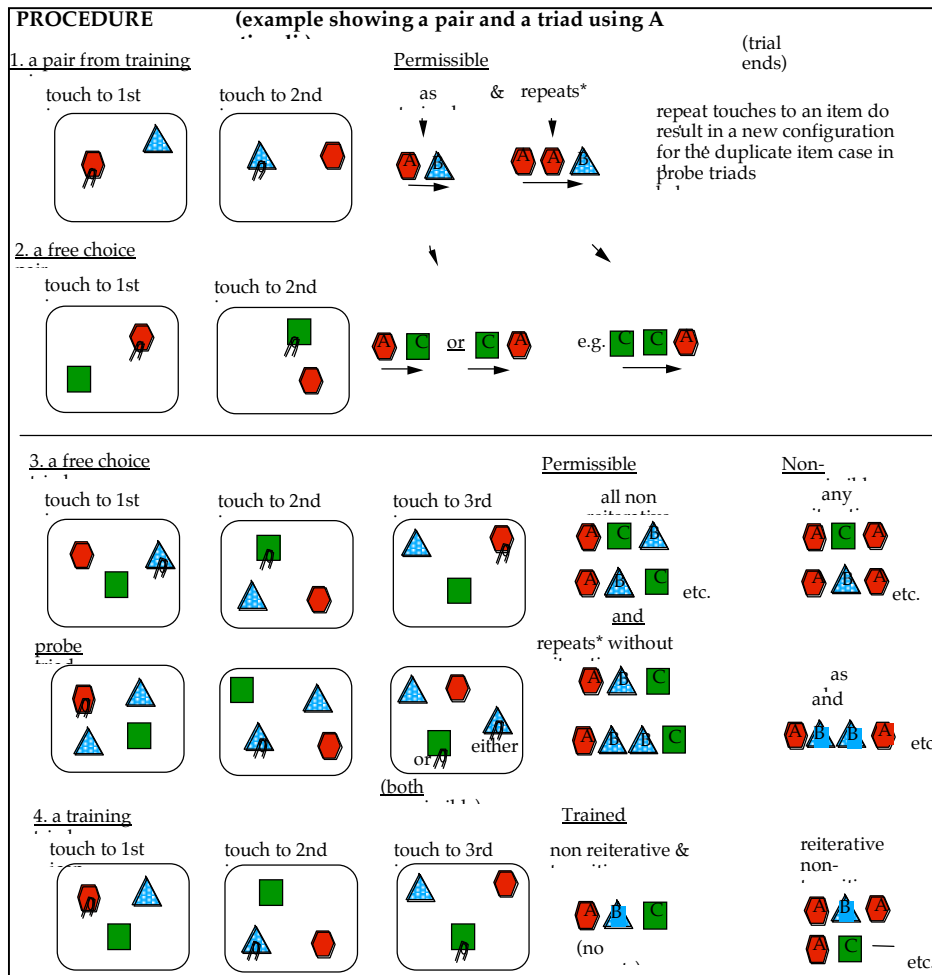


Figure 19: The emergent transitivity paradigm (From McGonigle, Chalmers and Dickenson 2001.)

Binary Pairs

There were differing restrictions placed upon the behaviour of the subject for each of the conditions. When presented with the training set, (AB, BC, CD, DE) the subject was strictly supervised such that he must always press A > B and B > C and C > D and D > E. Four possible pairs were presented to both the *SS* and *R* group.

Binary Transitive Pair

In the skipped intermediate transitive binary pair condition the subject was allowed to touch the stimuli in any order, such that $A > C$ or $C > A$ was acceptable. In this section the possible combinations of AC, AD, AE, BD, BE, and CE were presented to both groups.

Triadic Condition

Finally in the triadic set conditions, all possible 10 combinations from the set ABC were presented both groups.³¹ The monkeys were allowed to touch the stimuli in a free recall manor. For example, $A > B > C$ or $B > C > A$ and so on.

In all of the three conditions the subject was not allowed to perform any reiterative touches such as $A > B > A > C$, however, all repeat touches were permitted.

All monkeys were presented with this three part interweaved *concurrent* sequence task.

The programme which generated the testing trials was called SENS 1.8 which was designed by McGonigle within the Laboratory of cognitive Neuroscience. I was responsible for implementing the Sens programme for this particular paradigm. For example, I had to write and code over 80 different (20 per subject) Sens lesson files. The Sens programme, using its own free randomiser, displayed the testing trials onto a touch screen. If a trial had been successful a reward of a half shelled peanut was given from an attached dispenser.

A new experimental method of presentation on the touch screen was introduced. The icons were displayed, after the standard white square cue, but after every touch, (not every trial) all icons displayed moved around the standard 4*4 grid to a new spatial location. Thus the primate had to keep track and monitor the icons on every touch.

The monkeys were tested on this extremely difficult concurrent three part, icon moving procedure for an average of 50 trials per day. A criterion level of 60% complete correct over twenty consecutive trials was introduced.

³¹ See chapter four for a list of combinations

5.7.2 Results and Implications

The results of the emergent transitivity programme clearly supports the position that binary transitivity occurs before acquisition of the logical items of the whole set.

Figure 20 shows the results of the two monkeys in the relational *R* size condition in acquiring successful performance behaviour between the logical ordered set and the skipped intermediate transitive condition.

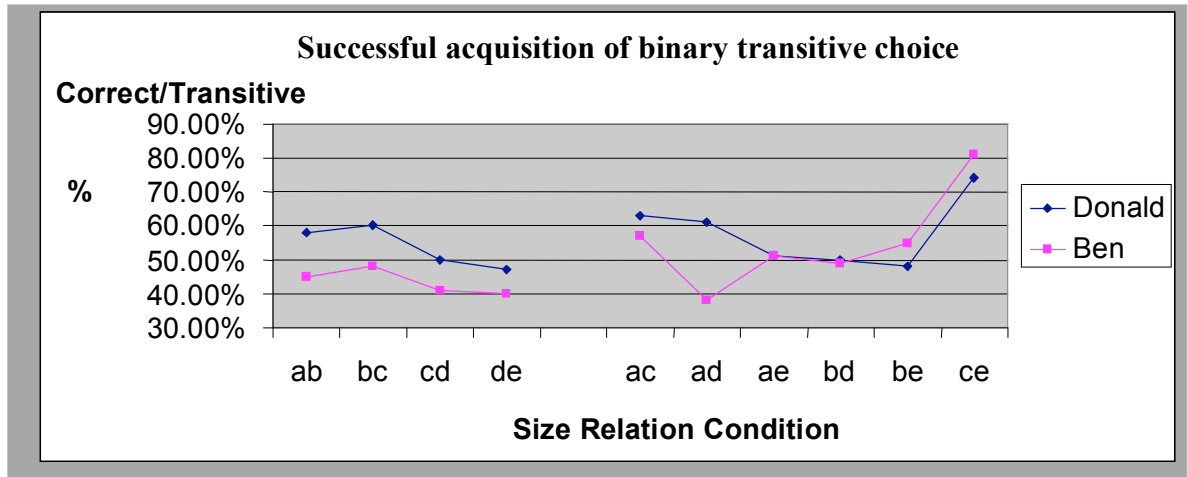


Figure 20 Acquisition of binary transitive choice in the size relation condition.

As this result was in a way predicted from the work by McGonigle and Jones, (1978; McGonigle and Chalmers, 1992, 1996) could the primates in the non-relational arbitrary set replicate the finding that logical relations on the first closed set does not need to be learnt in order for the primates to successfully acquire binary transitive performance.

Figure 21 shows that even in the non-connective set the binary transitive choices are easier to learn than learning adjacent paired items on a five term series.

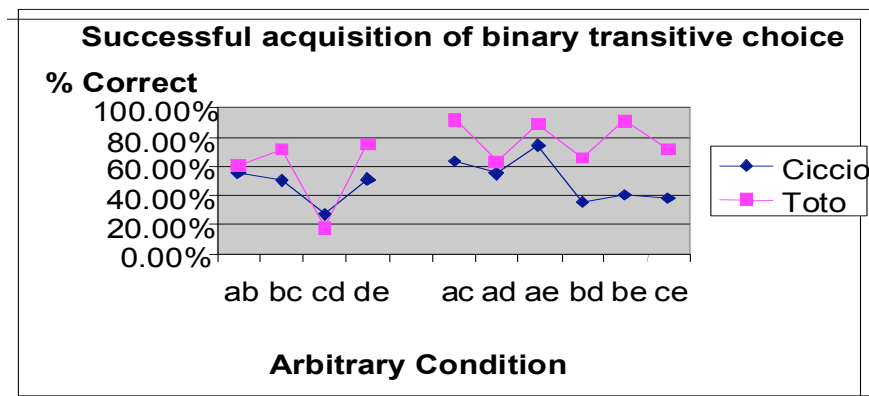


Figure 21 Acquisition of binary transitive choice in the arbitrary condition.

The concurrent testing of the ten triadic sets for both conditions showed a greater degree of task difficulty for the primates to complete. All four monkeys failed to achieve a score of over 60% success on this condition. That is they failed to order in any successful way the three items contained in each of the ten triadic sets. However, believe that this result is probably due more to the new movement of the icons rather than any cognitive limitation of the monkeys.

The results of this experiment confirm the work of McGonigle *et al* in that transitivity is not based on explicit seriation of the items tested e.g. A, bigger than B, B, bigger than C, produces AC which is (binary transitivity) but not A, bigger than B bigger than C which is seriation. In this experiment, training the connecting pairs of the series is concurrent with free ordering tests of transitivity and seriation. The two main results of this study are;

- Transitivity for all legal pairings in a five term series emerges before high levels of choice on the connecting pairs.
- High levels of transitive pairings do not generate seriation of triadic elements such that significant orderings of subsets BD, do not result in significant orderings of BCD etc.

The emergent transitivity experiment then confirmed the ontologically important finding from McGonigle *et al* (2003) that the skipping of intermediate items in the series such as AC does not require that the full connective set be learnt. $A > B > C$ in binary transitive relations.. (McGonigle, Chalmers and Dickenson, 2003; McGonigle and Chalmers, 1992; D'Amato and Colombo, 1989; Swartz, Chen and Terrace, 1991).

What this result suggests is that binary transitive competence is not only prior to seriation competences but is in fact less computationally demanding. The computation of relations that are displayed on the screen is driven by the task rather than, as Piaget would suggest the object themselves. This concurrent experimental design places a massive load on memory processes. After every touch, the icon migrates to a new position on the screen so the subject has to keep a visual track of where the icon was and went to. Without doubt certain information processing measures need to come into

play in order to solve these high computational demands. By scoring over 80% on some trials the subjects must solve these tasks.

5.7.3. Specific Implications for Davidson

These experiments appear to discover a particular and specific unfolding cognitive ontology, one that stems from an engine of relational primitives as opposed to language. Not only does this place Davidson's theory of how thought emerges in some doubt, but it also calls into question his theoretical stance on the utilisation of concepts. Davidson provides us with a basic list of conceptual resources that are necessary for any ontology of thought. He claims there must be;

“some sortal concepts for classifying the items in the ontology, there must be concepts for marking spatial and temporal position. There must be concepts for some of the evident properties of objects, and for expressing the various changes and activities of objects.” (Davidson, 2004, p140).

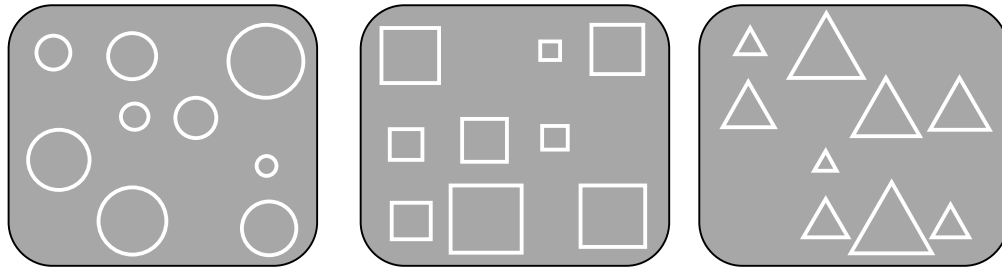
I am not too sure that McGonigle and his co-workers would necessarily disagree with this list. We have seen in his classification experiments how sortal concepts have emerged, and that the primate is able to classify items within a serial ordered list. We have also seen how through transitivity experiments, (tins and touch screens) how primates have developed the markers for spatial and temporal positions. The evidence is also there to show how by utilising efficient economic mechanisms the primate can develop sophisticated kinds of classification behaviours. But in order to fully be in a position to modify Davidson's account we need to understand why hierarchical organisation exists in primates? What benefit does it give to the non-linguistic animal? If classification gives the monkey little or no benefit then it is hard to see the evolutionary development of it and as such, the results seen may be due to some as yet undetected artefact of the experimental procedures. However, if hierarchical classification does offer the creature some utility then we are in a much stronger position to re-examine Davidson's account.

In order to answer these questions we need to return to the four year study by McGonigle, Chalmers and Dickenson. (2003) and explore the results on an experiment investigating reciprocal *linear size classification*.

5.8. Reciprocal Classification of Linear size Ordering (Part Three)

Recall from the previous discussion of this study that shape and size stimuli were being used to measure hierarchical classification. We saw in the part one of the experimental paradigm that the sequence length was extended across categories up to a three by three compositionality. Could size seriation also be extended in similar ways?

Linear size seriation Intra Class Condition



Interclass Condition

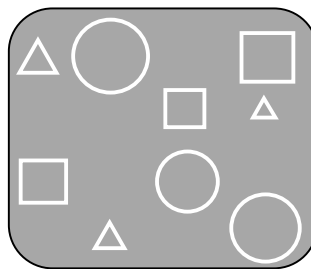


Figure 22: An over view of the liner size seriation task with classification. (McGonigle and Chalmers, 2001, 2003)

5.8.1. Experimental Design and Methodology (Part Three)

Subjects: Three monkeys were used in this part of the experiment. They had all taken part in both Part One and Part Two of the study. (To be clear these were not the juvenile monkeys I had been working with.)

Stimuli: *Intra-class condition:* The linear size seriation paradigm was also split into two sections which were run concurrently. In the linear size condition a series of nine white lined contoured items were generated for each shape. This was done by introducing six new size values, one size was the smallest and the other the largest and the remaining four items were interspersed within the set making a 9 different sizes in

total. Starting from the largest stimuli the difference between each one was reduced by 1 cm diameter, until the smallest stimuli was generated. Stimuli in this condition came from either class category A B or C. An example would be A1, A2, A3, A4, A5, A6, A7, A8 and A9 where A would be the class category – ‘Circle’ and 1 would be the smallest example of a circle moving all the way through to 9 the largest.

Inter-class condition: In the other condition, the linear series was overlaid with three categories with the first three sizes of the category series only, followed by the next three in category B and the final three in category C. This created an inter-intra class comparison. So here we have would see A1, A2, A3, B4, B5, B6, C7, C8, and C9, where ABC would be examples of the class category so A could be Circle, B could be Square and C could be Triangle. 1 would still remain the smallest icon and 9 would be the largest size.

See figure 17 for a graphical representation of the stimuli set.

Training Procedure B’ and B

The inter and intra-class conditions were interspersed randomly with an even mix within each experimental session. Again each session lasted on average around 50 trials. However, to prepare the monkeys for such a complex seriation of nine differing size items, a pre-training phase was introduced.

B’

In this pre-training phase an overlapping mix of sizes was given. The monkeys were given sizes 1 to 6 and 4 to 9. Pre-training was given with an equal distribution of inter and intra class versions all within the experimental session. A standard criterion for phase B’ was 75% complete correct across 20 consecutive trials. Again to be clear, the icons moved after every trial and not after every touch. In this condition the three classes were given, with three sizes within each class

B

In this experimental test phase four different conditions were run concurrently within every session. All three intra-class size conditions, A 1 to 9, B 1 to 9 and C 1 to 9, were randomly presented along with an inter-class condition where sizes 1 to 3 were from the first shape category, 4 to 6 from the second and 7 to 9 from the third. Again

an even mix of presentation of the two conditions was employed on the screen within every session,

Learning Criteria

McGonigle *et al* imposed two learning criteria for this experimental phase. They *treated* each condition separately, and as standard the monkeys had to obtain a 75% correct sequence touch across a minimum of 20 consecutive trials. This level of attainment had to be met for each of the four conditions. The other learning criteria demanded that the monkeys had to sustain a 60% correct criterion on both the intra and inter class conditions simultaneously, across fifty consecutive trials.

5.8.2. Results and Implications

We saw in Phase one and two of the touch screen series of experiments that a series that increased monotonically in size was easier to search than non-monotonic series, for monotonic size seriation creates the generative iterative relational rule of next bigger/smaller, an so on. As a result, McGonigle *et al* predicted that seriation once established in smaller sequences would transfer to larger, up to 9 item sequences, much faster than learning linked associations between all the elements in the size seriation.

McGonigle, 2001, 2003 report that all monkeys learnt with relative ease both inter and intra class conditions as shown in table 10, and that transfer to the full nine set was achieved at a much quicker rate than the previous classification procedure.

Phase	Sequence Condition	Mean Errors	Mean Trials
Inter-class	AAABBBCCC	233	571
Intra-class	AAAAAAAAA	720.7	1389.7
	BBBBBBBBB		
	CCCCCCCCC		

Table 10: Mean acquisition performance for all monkeys expresses as trials and errors to criterion for concurrent testing on inter and intra class conditions of monotonic size seriation.

The results showed how these non-linguistic creatures are capable of performance on a size seriation task that does not appear to develop in child development until around six. (Inhelder, B., and Piaget, J. (1965).

Using the ER/AER score of efficiency as detailed above McGonigle and Chalmers were able to determine just how efficient the monkeys were at the linear search task. We know that as the number of icons increase the task becomes extremely more difficult and that searches are likely to be uneconomic if the agent does not use some cost reducing metric to solve the task.

Figure 23 below clearly shows how as the number of icons increase the efficiency of the searches decreases.

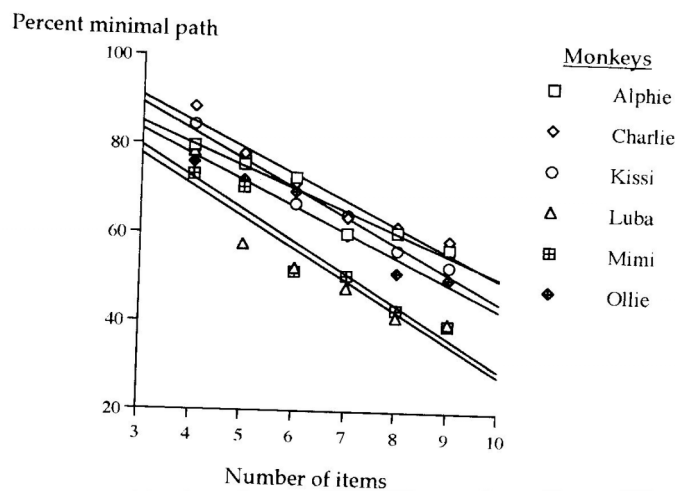


Figure 23. Search paths for monkeys as a function of the number of icons to be searched. (McGonigle and Chalmers 2001)

Again we can see how this measurement clearly shows the cognitive cost of such a task. Although the monkeys were being less efficient in their searches as the number of icons increased what we do still see is that even at nine items a 40% minimal path search is still an impressive efficient indication that they monkeys were developing effective search procedures. Clearly the monkeys are aiming to be as economic as possible.

McGonigle *et al.*, (2003) also showed that in the concurrent testing of inter v intra class that the monkeys were in fact availing themselves of the added constraint provided by the different categories that are present in the data. This result is clearly demonstrated in Figure 24

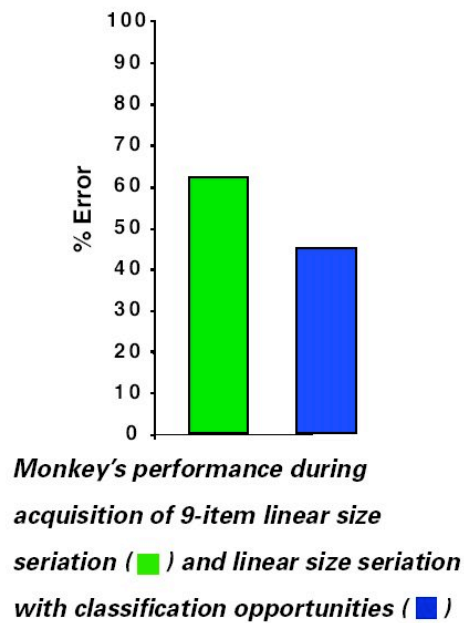


Figure 24: Inter and intra class comparison on a 9 item linear size seriation task. (McGonigle, Chalmers and Dickinson, 2003)

As this figure shows there is a consistent advantage of interclass over intraclass sequencing. The differences in shape and class that the interclass condition affords allowed the monkey to chunk the icons together. It is easier for the monkey to hierarchically classify objects than to search using only a linear size metric.

Taken together with the results the previous supervised and unsupervised phases of the experiment with the results of my own empirical study, all seem to indicate that that these data - reducing strategies emerge through an internal processes of self-regulation, motivated by economy, which can now be measured empirically through the ER/AER scores. The results from this condition demonstrate the adaptive value of their generative causal mechanisms. As McGonigle & Chalmers (1992) suggest that in the face of increasingly complex and difficult tasks presented over a protracted period, creatures (without symbols or semiotic instruments), are able to utilize the constraints present within the data set to produce progressively economic organisational structures.

Figure 25 clearly demonstrates the benefit of a longitudinal analysis, for it shows that progressive increases in task difficulty stimulate the emergence of increasingly selective information handling strategies on the part of the primate.

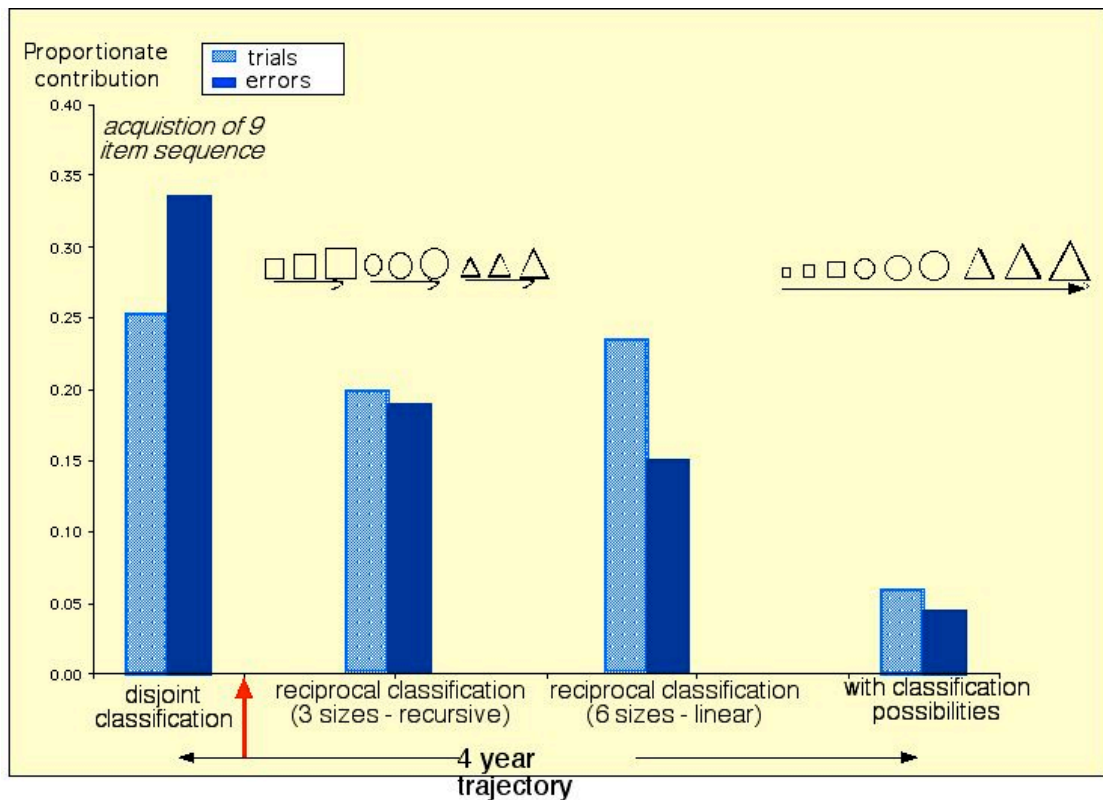


Figure 25 Emerging competences over time. (Taken from McGonigle 2004a)

Figure 25 also shows just how economic the monkey can be when given the opportunity to classify. The ability to classify is a tool in which the monkey uses to become effective and economic in their search strategies.

None of the arrays displayed in any of the procedures described in this section could spatial configurations have played a role in providing a solution the ordering rules. The spatial locations of every exemplar displayed changed at random from trial to trial. We see here a considerable contrast with the construction of cognitive development that Piaget has developed. We have seen in his tasks of seriation, that when a child is asked to seriate objects (for example a set of rods) the item that is being seriated usually gets manipulated and placed within a spatial array in front of them on a table. Here this is not the case. Not only is no manipulation occurring, there is no ‘shuttlings’ ‘fumlings’ and ‘gropings’ of objects that Piaget often reported in young children (Piaget and Szeminska, 1952). Classification does not require manipulation of objects within space to occur, proving further evidence that we should reject Piaget’s epistemic ontology and accept this other biological epistemic ontology based on the empirical finding that adaptive competences are co-present as lower bound primitives.

5.9 But what of Davidson?

The pattern of learning that has been observed through the lengthy experimental paradigms with non-linguistic creatures, show organised constraints, which have developed though the history of the testing procedure have in real terms reduced the costs of dealing with additional new items and sequences of higher level of difficulty. The subjects are clearly demonstrating the adaptive value of their generative cognitive mechanisms, and this indicates that the data reducing strategies emerge though a process of self-regulation, motivated by economy and by rational design. These strategies emerge only after increasingly difficult task demands. Adaptation to the task, therefore must be a rational design feature and here we see the primates doing exactly that, adapting to the complex demands of the task through utilising economy driven measures such as classification. Cognitive continuity between human and some non-humans can not be denied.

Am I now in a position to refute, or modify Davidson's claim that in order to be in possession of beliefs you need to have beliefs upon beliefs?

Again, I think not, not yet anyway. Although the above experiments show hierarchal classification in non-linguistic creatures, there is a problem. I do not think the problem lies in the ability to show competence in utilizing concepts in new frameworks or structures, I think that McGonigle *et al* experiments suggest that this is possible. The experiments show how monkeys in certain situations, rely on these data reducing strategies, and it is an empirical question to determine what situations the primates can utilise these strategies, both in the laboratory and if possible in the wild. These strategies, I believe are independent of the paradigm, and would occur in any situation in which would demand a similar adaptation to the task. No, part of the problems stems from what else cognitive systems do. That is being a cognitive system is without doubt to be able to plan and assess your own strategies to optimize executive control. McGonigle and Chalmers have shown that memory resources are minimized when order becomes imposed on the set and we have seen that the monkeys are very adapt at being able to identify the statistical structure that is within the set. However, it is one thing to say that creatures are good at identifying economy driving features it is another to impose an order from the beginning and to remain with that order.

So this leaves us with a chicken or the egg type problem, which of course needs to be clarified before any modification to Davidson position takes place.

5.9.1 The Chicken or the Egg.

Basically as McGonigle and Chalmers (1998) correctly point out that we are left with a problem of deciding which comes first.

“Do we have to experience statistical regularity to profit from it or are there general organizational mechanisms based on internal arbitration geared to cognitive economy which can contrive sequential order for us, enabling us to benefit from the orders as experienced?” (McGonigle and Chalmers, 1998, p525).

When supervised learning is part of the experimental paradigm the problem of statistical regularity is endemic to experimental paradigms and is hard to separate from the procedure. However, when the monkeys were allowed to classify using the objects within the classes by using their own preference, that is by free choice, the results indicate that the primates do have the general mechanisms that are directly causal to self organized behaviour and thus we can empirically determine whether non-humans can plan and assess their own strategies to optimise executive control. In the above interclass experiments the icons remained static until every trial was complete. Although a significant degree of on line monitoring was being imposed by the primates to solve the task, a more impressive demonstration of self imposed, free choice classificatory behaviour would be if the icons moved, not after every trial but after every touch. As a result the subject would have to demonstrate not only sophisticated classificatory behaviour as in the previous experiments but would also need to be able to master very fast complex on-line monitoring of all the icons displayed in order to correctly exhaustively search the icons. An online monitoring that one could say would be similar to sentence production/understanding. Are non-human creatures and indeed very young children able to executively monitor this string of ‘icons’ as well as being able to discover the statistical regularity that occurs within the string of icons displayed. And if so, what more does Davidson require in order for modification of his account to take place. Self organisational and regulatory principles appear to be part of an evolutionary story that emerges and develops in creatures without language. They do so in order to solve complex cognitive problems such as how to classify and seriate items so that cognitive load can be reduced and economy of

effort can be maintained. The results suggest that Davidson can no longer turn to language.

5.10 Summary

We have seen through the introduction of new paradigms based on touch screen technology, using non-human creatures with extensive longitudinal studies, several key theoretical positions which seriously begin to challenge Davidson's position on rational thought. Hierarchical classification for example, does not appear to be mediated by the agent's use of language. The non-linguistic creature is capable of classifying a range of icons, in a range of different sizes, in a range of different colours, in an range of different tasks. The learning profile shows the development of this recognised high level competence, not only in very young children, but in non-human agents, who are not bound by the cultural confines of language or spatial mapping, through a medium which no external manipulation can be performed. This ontological development has serious implications for Davidson's notion of how thought emerges. The necessary process of triangulation does not need to appear to be present in a creature for these cognitive competences to emerge. As a result the picture begins to look like the emergence of cognition does not necessarily need to have language as the 'magic bullet' for thought. But what exactly is happening in these new paradigms which paint this picture. We know that in some of the paradigms the primates are being supervised and in others they are given the chance to impose their own free search. What we see when they are given this opportunity is interesting variations in the learning profiles of primates who achieve the successful criterion runs in either the transitivity or classificatory/seriation paradigms. So is it the case that the non-linguistic creature, must,

A) have to experience first '*statistical regularities*' in order to produce behaviours that demonstrate these transitive or classificatory competences, or

B) can the primates discover by themselves, without any imposed learning, patterns of regularity that exists in the external world, where this discovery is based on internal general non-linguistic mechanisms, and that these mechanisms are not tied to a single task.

The results from the *Cebus* in the disjoint and reciprocal classification paradigms indicate that the animals are capable of self organisation and self regulatory principles which are part of a continuous evolutionary story and one where language is not the

main ingredient for such cognitive competences to develop. What is needed now is to fully examine how and when these self organisation/regulatory principles are spontaneously used and to determine the adaptive value of using these principles. Chapter six, the final chapter will try and pull all these themes together by highlighting two final experiments conducted by myself to determine exactly what modification of Davidson's account need to take place in the face of recent comparative evidence.

6. Self Organised Behaviour, Some Thoughts and Conclusions

6.1 Self Organised Behaviour An answer to the Chicken and Egg Problem

In the last chapter we saw how language does not appear to be a key component of the causal mechanisms of cognitive growth. Sophisticated cognitive competences in non-linguistic creatures have been evidenced in experimentally controlled conditions. However this is not the end of the story. To enable modification of Davidson's account of Rational Animals to take place we need to determine if languageless creatures are fully capable of being self organised creatures without the aid of specific learning conditions. In other words we are looking for behaviour which demonstrates the planning and organisational skill akin to those creatures that speak. Can non-human animals show sophisticated self organised behaviour that has neither been taught to them nor 'pick up' from the statistical regularities presentment in the external environment? If so, then this would, I believe seriously challenge Davidson's view of non-linguistic thought.

We have seen in earlier attempts to demonstrate self organized behaviour (McGonigle, De Lillo and Dickenson, 1994) human (young children) performance was constructed around a path based on item adjacency, which was found to be clearly correlated with age and success. Although a similar profile was eventually observed in the *Cebus*, the paths generated by these were neither as consistent nor as economical as those of four year old children. The behaviour of the older children was clearly self-regulated and based upon internal factors rather than any external statistical structures.

However, as a result of new paradigms developed by McGonigle and others self organized behaviour in non-linguistic creatures can now be explored using a free search, *self organized* paradigm, based around the linear, classification paradigms reported earlier. The subject, child or non-human has to search the icons displayed in anyway they wish to, the only task condition is that they produce a non-reiterative exhaustive search of all the icons displayed. As this is a free search paradigm no training is given as to 'which order' to interrogate first. This is the first difference to the previously reported experiment. The second difference is that in this new paradigm

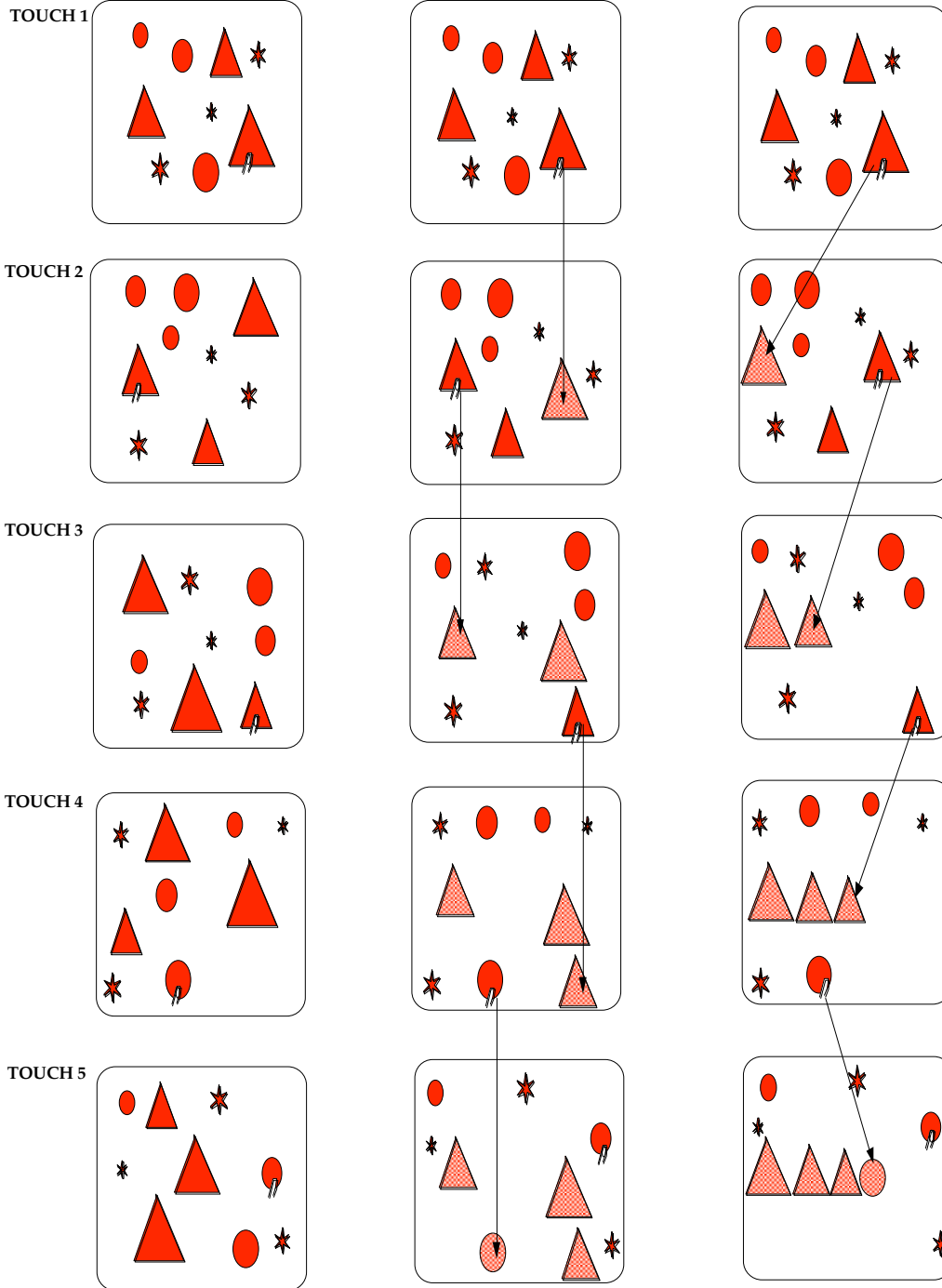
the icons move after each touch, thus this eliminates at all any spatial search heuristic that may be used. This new paradigm requires the subject to monitor all the icons and hold and maintain them in their own executive memory. This method of examination allows the precise level of working memory control to be assessed for this would be reflected in the learning of sequence length that can be controlled by the subject. It also provides an opportunity to observe what if any organizational devices are spontaneously used to make the task more manageable. (McGonigle, Ravenscroft and Chalmers, 2001) see Appendix .1 The self organized, free research paradigms developed can be seen in figure 26 below.


Figure 26: Explanation of Three Variants of the Self Organised, Free Search Paradigm

A. NO SPATIAL MARKER
Every icon moves position after every touch

B. WITH LOCAL SPATIAL MARKER
Touched icons remain in place:
every other icon moves

C. WITH REPRESENTATIONAL SPATIAL MARKER



 icon no longer changes location during that trial

In the first of these paradigms we see that when an icon is touched they all move to a different spatial location on the screen. No external cue is given to aid memory, whereas in the second paradigm the touched icon remains static, (local marker) meanwhile the other icons migrate to a new location on the screen around it. The same occurs for the next icon touched and so fourth until the whole set has been exhausted. Thus the static location provided a key external spatial marker to help the subject through the demands of the task. The final paradigm version is a touch screen variant of the classic rod seriation where there is a representation marker, where the touch icons become displayed in a linear manor across the bottom of the touch screen, thus providing a replication on of the external seriation tasks developed by Piaget.

I shall now examine the results of a series of experiments that have been developed with Dr. McGonigle in trying to resolve the chicken and egg scenario posed in the last chapter. The first experiment described below identifies categorical use in very young children, and the second experiment will then start to answer the question is categorical use dispositional or strategic in non-linguistic creatures.

6.2. Unsupervised spatial search tasks. My own empirical investigation into the self organised memory strategies

6.2.1. Experimental Design and Methodology

The experiment below investigates self organised memory strategies during unsupervised visuo-spatial search tasks by very young children. (3 years up to 4.9 years of age)

In particular this experiment consists of a displaying a number of exemplars from three semantic categories; Animals, Transport and Flowers. (See figure 27) These exemplars are randomly presented on a touch sensitive computer monitor, and are free to migrate around the visual array in a 4X3 grid, once they have been touched. All participants are told only to exhaustively search the visual array. As the exemplars migrate around the screen the participants must hold them in their working memory in order to solve the exhaustive search task.

Animal stimuli:



Horse



Cat



Dog



Rabbit

Flora stimuli:



Flower1



Flower2



Flower3



Flower4

Transport stimuli:



Car



Plane



Train



Bike

Figure 27: Real world semantic stimuli exemplars used in the self organized paradigm tested on young children.

The Paradigm

The Qualifying Phase

The experiment was conducted into two main parts. In the first, ‘*qualifying phase*’ all participants were given an exhaustive search task comprising of 4 stimuli from the total set of 12. (Figure 27) Two were exemplars from one semantic class and two from another.³² All 12 stimuli were eventually exposed to the young child during this first period. The presentation of the stimuli on the touch screen was controlled by the Sens computer programme files written by myself. When a stimulus was touched all stimuli, and not just the touched one, moved to a new random location as determined by the computer. The participants were allowed to touch the icons in any order they wished and they were also allowed to repeatedly touch an icon, as well as go back to any icon that they had previously been touched. An incomplete trial was when a participant gave up and no longer wanted to take part in the experiment. When the subjects had completed a successful trial, for positive feedback, a small animation of a duck appeared on the computer screen and sang a small song, when a trial was not successfully completed the screen went blank for 15 seconds.

In order to gain entry into the next phase of the experiment the young children not only had to achieve a 80% correct criterion run over 20 consecutive trials but also had to maintain an efficient strategy to touching the icons. That is, since 4 icons were displayed the child had to touch correctly the icons 4 times, thus providing an ER and AER score analysis detailed in chapter 5. (5.3) Any additional touches were classified as being uneconomic.

The Extended Phase

Those subjects that achieved this efficient search during this qualifying phase were then given a series of interleaved tasks presented in a pseudorandom order such that no one task level could be restarted until the full set of conditions had been tested. During this phase of the experiment the exemplars varied from 5 through to 9 icons with up to 3 exemplars per class as. In this part of the experiment, a wide combination of classes and exemplars were presented. For example a participant could have been presented with three icons from the transport class, along with two icons form the animal class. Presentation of icons and the order displayed was pseudo random, in order to ensure

³² For example, A participant may have been give two stimuli from Transport and two from Flowers

all classes and all icons were presented to all students. This pseudo randomisation was controlled by the SENS lesson files which again I wrote.

Subjects

The subjects were six male and female young children from the University of Edinburgh's Psychology department nursery with full informed parental consent. Their ages ranged from three years to nearly five years old. Three of the children had some prior experience of touch screen technology but none of them had experienced the dynamic movement of the icons before.

Testing Situation

The children were all taken from the nursery to a small testing room, by the nursery assistant and was introduced to the experimenter. In the testing room was a video camera to record all sessions, the computer plus a large 21 inch monitor touch screen, as well as desks and chairs. The experimenter gave minimal instructions to the child, and informed the child that all he/she had to do was to touch the pictures in any order on the screen to see if they could get the duck to sing a song. No child was tested for more than twenty minutes at a time and no matter how well or poor they had performed were given positive feedback in the way of collecting small cartoon stickers.

Possible Solutions

There can be two possible solutions to the task, the first solution, as we have seen above is the most economic solution, the minimum path solution. Here, each participant can touch each icon once, and in any order, but must not reiterate on any previously touched icon. If the participant does reiterate, then the minimal path route to success is no longer available as they now require additional touch to success. If the participant does require extra touches to reach success then this strategy is known as an exhaustive search strategy. An exhaustive search procedure will obtain a successful trial; however, it is important to note that it will not produce an optimal route to success as additional touches were required to completion as compared to the minimal path route to success. For this experimental paradigm the participants were allowed to perform repeat touches on the migratory icons without administering an exhaustive search score. An unsuccessful trial would be one where the participant failed to touch all of the exemplars displayed and gave up or when the experimenter intervened due to the participant's behaviour.

6.2.2. Results and Measures of Efficiency, Categorical use and Utility

Using the ER/AER method of efficiency, we can plot the average efficient ratio against optimal performance for all the six subjects who went on to qualify. This plot can be seen in figure 28

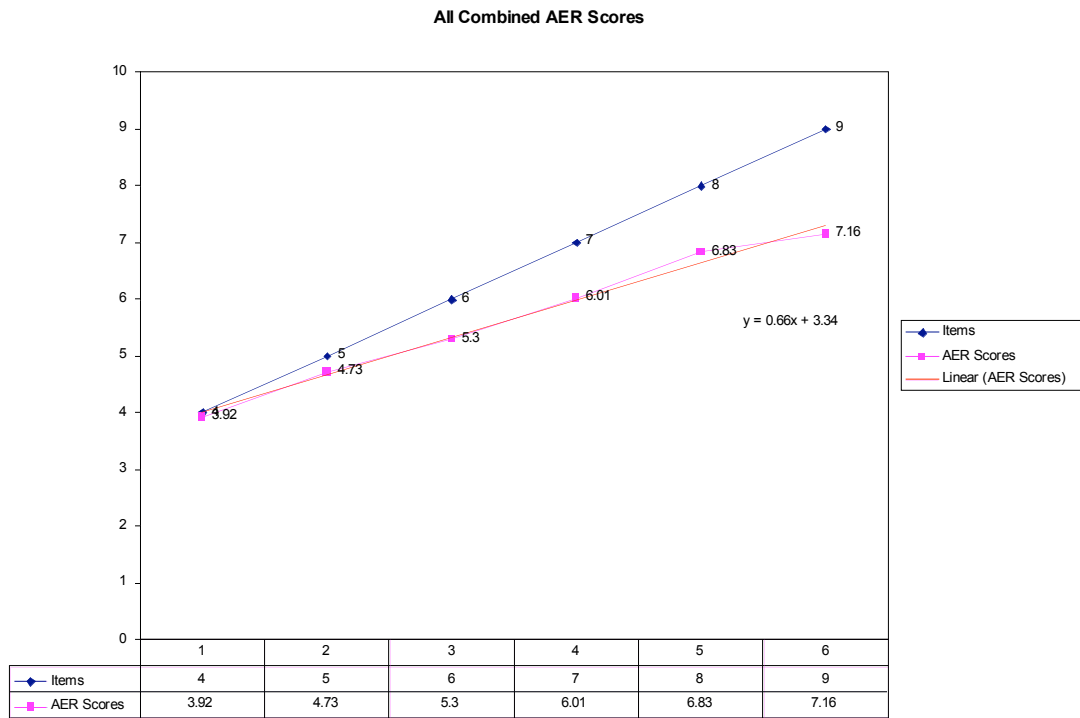


Figure 28: Group Function (trend analysis) showing mean AER efficiency as a function of set size

Figure 28 shows that there is a significant linear relationship between set size and efficiency, the bigger the set, the less efficient the children were in their self organised search procedures. However we can still see that performance is high across the group even for large sets. So we can see then that the young children are very categorical in their searches.

6.2.3 It is Efficient but is it Categorical?

However, it is still possible to have an efficient search strategy but not to classify objects. The ER/AER scores only show how economic that search was. What is needed is some kind of qualitative measurement that shows how the subject solves these tasks. One such measure, called the Euclidean Distance measure (ED) has been developed by Dr B McGonigle. This metric uses the fact that the output of behaviour

in these touch screen based tasks is delivered serially. For example, on a nine item set, with three icons per class, and with three classes, one could deliver a highly efficient AER score of nine but no classification competence took part in my execution. Thus the serial out put of touches could look like this;

a) A1,B2,C1,B1,C2,A3,C3,B3,A2.

A highly efficient score as there was no reiteration, however if the output delivered a serial order array like this

b) A1,A2A3,B1,B2,B3,C1,C2,C3

This would show a high degree of classification used. But this degree of classification is not measured in ER scores. However, it can be easily measured as In b) my ED score would be 0. However if my output was;

c) A1 B1 A2 A3 B2 C1 B3 C2 C3

then this would show a 1 step violation for As, and a 2 step plus an additional 1 step (later B error) for B's and a 1 step violation for the C;'s. As a result this would record a ED score of 5. (McGonigle and Chalmers, 1998, McGonigle, Ravenscroft and Chalmers, 2001). Note how ED scores are another weapon that researchers can use in the delivery of ontologies of cognition.

6.2.4 Utility

We are now in a position to use two new measurements. They are the quantitative measures of ER/AER and the qualitative measurement of ED. One tells us how economic the search is, and the other tells us how the search proceeded, whether the search was categorical or not. However, what is the utility of being able to classify, what does it bring to the creature. We know that it can be used to off load memory cost but is there any significant relationship between classification and efficiency? In order for us to correctly tell an evolutionary story about cognition one needs to be able to explicitly detail how, if a creature classifies a series of objects, that classification aids the creature. It is not a story about classification for classification sake.

As such what is needed is yet another measure a measure of *utility*. This would tell us are those who are better at classifying also more efficient, or does efficiency somehow perturb classification? Again these are important questions if one is to deliver an evolutionary theory of cognition. We need to be able to know what kind of adaptive advantage, if any, a chosen strategy brings to the creature.

Fortunately, a utility measure can be made, again developed by McGonigle (2001) and this measure uses the combined AER and ED scores. That is, the relationship between efficiency and categorical use can be assessed by cross correlation. And this can be seen in figure 31 below where the measures of gradient values for individuals at global efficiency are plotted against mean Euclidean distance for each subject for all sets.

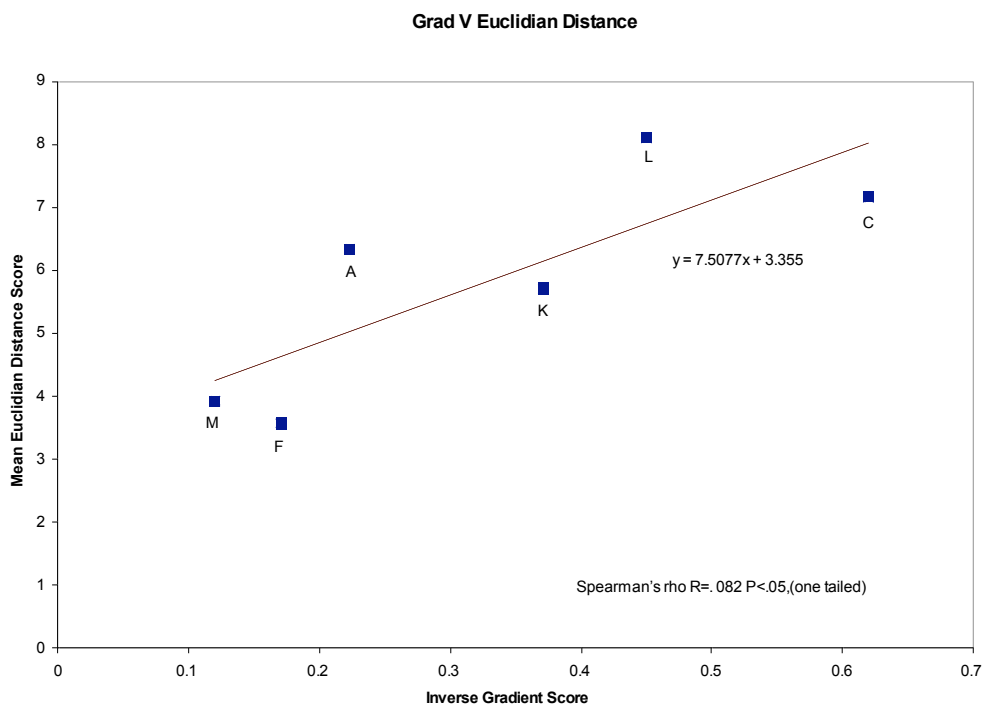


Figure 29: Cross Correlation score between efficiency and Euclidean Distance

The correlation in figure 29 shows that there is a significant correlation between being able to classify and being efficient. We can see in the figure that there is utility in being able to classify that is you become more economic in your search. By using these three measures of performance scores it is now possible to determine the utility or in other words the selective advantage of a chosen strategy. However this finding does not entirely show that categorical use is strategic and not acquired through some 'habit of mind acquisition, for even though the subjects were very young children they

certainly would have had prior knowledge of the categories presented, and were instructed through a linguistic medium. In order get around the problem of prior knowledge and the instructional medium of language, we need to turn to the *Cebus Apella* again.

6.3. Self Selection Free search with Juvenile *Cebus Apella*

One could not immediately replicate the same experimental design used for the very young children described above for at the time of experimental, it was totally unknown if the monkeys were capable of being able to actually touch the icons exhaustively, when upon each touch the icons moved to a new grid location on the touch screen. As a result of this unknown quantity, a smaller scale self selection study had to be implemented again by myself, which lasted nearly 24 months.

6.3.1. Experimental Design and Methodology

Subjects

Three juvenile *Cebus Apella* were used, they all had previous experience with the testing room and touch screen environment. All also had previous experience of touching *static* icons on the touch screen. However none of the primates had any experience in touching the new *dynamic* icons on the touch screen. A Perspex 4 X 3 grid was placed in front of the screen as earlier described in chapter 5 and aligned to the 4 by 3 grid on the computer screen. This Perspex grid was there only to aid touching of the screen and nothing more.

Stimuli.

The 5 item stimuli set was the same stimuli as used in the McGonigle *et al* (2003) studies. The stimuli set consisted of shapes of triangles, squares, circles, I glass and stars. They were all the same size and varied consistently in colour, for example a red square for a particular monkey was always a red square. (Another monkey may have been presented with a blue square). The order of presentation of the stimuli was controlled by a computer programmer as well as the random location of the icons displayed on the 4 by 3 grid. Each monkey was assigned five stimuli to the set ABCDE. The contents of ABCDE varied for each monkey.

Procedure:

The monkeys were tested in the testing room for an average of fifty trials per testing session. A successful trial was rewarded with a half peanut, and an unsuccessful trial was rewarded with the screen going blank for 30 seconds. Initially the monkeys were presented with just one icon, where after every touch the icon would move to a new location. After two sessions, another class of icon was presented. This experiment was not to measure categorical use in primates but to determine individual strategic list formation, which eventually could be used to investigate categorical use. The criterion standard was introduced to 80% correct over twenty consecutive trials. Once completed another icon, from a different class, was added. The aim of this procedure was to continue with this method of adding icons until all five were presented on the touch screen. As with the previous study with children, the monkeys had to seriate all the items displayed, in any order they self selected, however they were not allowed to reiterate on any icon, although repeats, that is touching the same icon over and over again was allowed.

6.3.2 Results

The results presented in table X from one particular phase ABC of the experiment below clearly indicate that the monkeys are capable of constructing their own lists.

Monkey/Order	abc	acb	bac	bca	# of Trials
Ciccio	78%	19%	1%	2%	288
Toto	62%	37%	0%	1%	91
Ben	58%	35%	6%	1%	98

Table 11 Preferred list order of three monkeys on a free search ABC paradigm.

Table 11 shows that the sequence 'abc' (coincidentally) was the preferred order by the three monkeys followed by acb and then the remaining two orders. The monkeys were not trained in any way to touch the icons in any particular order, this is a true example of full unsupervised learning. The choice of 'abc' for all of the three monkeys was of their own volition. This is particularly impressive as the spatial locations of the icons were all randomly placed on the touch screen so were the new migrations after every touch. The results indicate that the primates were not using any spatial reference or key to locate untouched items and to serially exhaust the set.

When we examine at a micro level of analysis we can determine the positional touches of each monkey.

	Position/Touch		
	1st	2nd	3rd
Icon	a	a	a
Ciccio	231 96.65%	3 1.26%	5 2.09%
Toto	79 98.75%	0 0%	1 1.25%
Ben	66 92.96%	4 5.53%	1 1.41%
Icon	b	b	b
Ciccio	8 3.35%	187 78.24%	44 18.41%
Toto	1 1.25%	49 61.25%	30 37.5%
Ben	4 5.63%	42 59.15%	25 35.21%
Icon	c	c	c
Ciccio	0 0%	49 20.50%	190 79.50%
Toto	0 0%	31 38.75%	49 61.25%
Ben	1 1.41%	25 35.21%	45 63.38%

Table 12. Positional Matrix of ABC touches

The result shown in table 12 demonstrate the preference that the three monkeys had for touches in a particular order the stimuli set of ABC. We see for example, that one monkey Ciccio, A was touched in the first position 96.65% of the time and only ever touched in the second position 1.25% of the time. Similarly for Toto, B was only touched in the first position 1.25%, but touched 61.25% of the time in the second position. Likewise for Ben C was touched 63.38% of the time in the third position.

Although the increments in the set expansion was conducted in such a manor that A was presented first then B and then C, no assumption could have been made that the monkeys on the criterion run would either follow the same expanded sequence, and maintain that sequence, for they equally could have touched the last item added (C) first and then A and then B. I believe that this simple experiment begins to demonstrate that the monkeys create their own lists using strategic rather than dispoitional factors. These results all point towards the conclusion that the general causal mechanisms, as outlined in the ontology of cognition proposed by McGonigle and Chalmers, are able to scaffold a system, maximising executive memory, through a process of cognitive economy which certainly looks like delivering a self organising, hierarchically capable processing agent.

A natural extension to the testing regime of the juvenile monkeys is to expand the self selecting list paradigm and examine the extent to which self organisation occurs through spontaneous self selecting strategies. For example, a similar self organising paradigm that was deployed to test young children could now be developed for testing on non-human creatures. The paradigm could easily have excluded any stimuli that the primate had prior knowledge and could have tested not only disjoint classification but also reciprocal classification. The dynamically moving stimuli after every touch puts a massive demand on working memory and forces the agent to make full use of the categories that are presented, whilst also approaching the task with his own strategic solutions. An approach that plans the route though the sequence of icons displayed until the set has been exhausted. It would have been a paradigm that would have tested self organising, self planned, strategic hierarchical classification in non-human subjects, and may have answered once and for all, whether; languageless creatures could have second order cognitive competences similar to the ones Davidson requires for thought.

6.4 Closure of the Primate Lab

However, it was at this critical juncture that the University of Edinburgh decided to close Dr McGonigle's primate laboratory down, and move the monkeys away from the University of Edinburgh's premises. As such no further testing could take place. The experiments were stopped right at this critical phase!

However, now we know how to test non-linguistic creatures for this sophisticated cognitive competence of self organised, self selecting classification, it becomes more of an empirical question as opposed to a philosophical one as to whether the *Cebus* could have eventually mastered this highly complex cognitive skill. All indications from previous testing suggest that over a period of time, through economic driven solutions, the primates may have been able to achieve this state of higher cognition. If this is empirically true what are the implications of such a seismic discovery. It is these implications that I would now like to concentrate on for the remaining part of my thesis, and then to provide an overall conclusion to Davidson's account of rational animals

6.5 Implications

There are many implications to be derived from what has been explored in this thesis and for clarity sake I would like to partition them up in the following ways.

- Implications for the Systematicity Challenge and the Language of Thought and the status of recursion in this.
- Implications for Davidson's account
- Implications for evolutionary accounts of cognition

6.6 Rejecting the Language of Thought, Meeting the Systematicity Challenge, and the need for Recursion in meeting this challenge

Fodor (1975) argued that thought involves computation upon representations, and that these are structured as sentences in a mental language known as mentalese. Fodor claims mentalese must be as rich as any language it serves and that that mentalese is itself innate. Taking this point, the necessary causal mechanisms for cognition, Fodor argues are the syntactic operations defined over representations. Fodor believed that syntax must meet three conditions, the first of which is that the syntax of the symbol is one of its physical properties; the second is that the syntax must be systematically related to semantics, and of course the third is that syntax is necessarily determinant of causal role. Recall that the core of Fodor's argument is that (1) processes of cognition consist of computational processes, and (2) computation requires a language over

which the computations are performed. The basic units of this language are conceived of as symbols: entities which of themselves are content-less or arbitrary. It is the symbolic representations for Fodor that have the syntactic structure and not the computations! It is by virtue of their structural relationships and the structural transformations which are possible that these symbols can serve as the vehicles of cognition. Fodor in essence was placing highly non-trivial restrictions on what the internal constitution of a thinking organism must be like: if a thing does not possess an internal system of representation that shares certain essential features with natural language, then it cannot be a thinker.

We have seen that Fodor's argument at the basic level goes something like this; propositions or a 'belief state' cannot by themselves be natural language sentences. For example, If I say '*Snow is White*' and a Japanese person states that '*Yuki ga Shiro*' (Snow is white) both of us have the same belief, we are expressing the same thought, however the thought 'snow is white' cannot be a natural language sentence, for in which language would that that thought be? Therefore according to the Language of Thought, the thought that *Snow is White* must be a representation that is tokened in our brain. Mentalese, therefore, is a symbolic system that is physically realised within the agent. Complex structural representations, Fodor, further suggests, are built up out of simple constituents, and the semantic content of a representation is a function of the semantic content of its 'smaller' constituents together with its syntactic structure.

Fodor (1987) and Fodor and Pylyshyn (1988), have argued for the systematicity of language production and understanding: the ability to produce/understand certain sentences is intrinsically connected to the ability to produce/understand certain others. Given that a native speaker is able to produce/understand a certain sentence in their native language, there will always appear to be a cluster of other sentences that they will be able to produce/understand. For example "John loves Mary" and "Mary loves John" are both natural English statements which are meaningful. And in general, if 'a R b' is meaningful, so is 'b R a'. Meeting this systematicity is an essential part of any account not only of language but also for cognitive thought as we are potentially able to have an infinite number of thoughts, from finite mechanisms. As a result Fodor and Pylyshyn, claim that if it is true that the ability to understand a sentence is systematically connected to the ability to understand many others, then it is similarly

true that the ability to think a thought is systematically connected to the ability to think many others. For as the Language of Thought states to think a certain thought is just to token a representation in the head that expresses the relevant proposition, the ability to token certain representations is systematically connected to the ability to token certain others. The language of thought explains this by postulating a system of representations with combinatorial syntax.

However, thought is not only systematic but also compositional: systematically connected thoughts are also always semantically related in such a way that the thoughts can be composed out of the same semantic elements. For instance, the proposition that *'tabby the cat chases birds'* is also connected to the proposition *'that birds chase tabby the cat'* but not to, say, propositions such as *'Whisky is the water of life'* or *'turn left at the supermarket'*. The answer the language of thought gives is to postulate a combinatorial semantics in addition to a combinatorial syntax, where an atomic constituent of a mental sentence makes (approximately) the same semantic contribution to any complex mental expression in which it occurs. This is what Fodor and Pylyshyn call 'the principle of compositionality'. Once you have a language of thought you automatically get the systematicity of thought, and that the atomic representations mean the same thing in all contexts in which they occur.

To summarize, the way a thought gets to have the content it has is as a function of (a) its atomic parts and (b) how they are combined. This is how sentences in mentalese get their meaning. However, how sentences in mentalese get their 'original meaning is critical. If complex structural representations are built up out of simple constituents, how do the simple constituents represent what they do in the first place?

"the problem is one of novelty, the construction of developmental forms out of existing ones. One of the more fundamental limitations of the growth model is that it does not explain where the growers come from". (Aydee 1997)

Where does meaningfulness originate from? (Haugeland, 1985). If Paul says *'snow is white'* or believes *'that P'* then he has according to the LOTH a token of mentalese in his belief structure that has the content that *P*. In other words the meaning of the public symbols (snow is white, or that P) come from the meanings of the internal symbols (symbols in mentalese = snow is white, or that p). But the internal symbols, especially at the atomic structure as cannot derive from something else, for they are

originals. Haugeland (1985) p27) So what we have is a state where ‘word meanings’ are derivative but yet thoughts have original meaning. Another account is therefore needed to explain this discrepancy between ‘original meanings’ and public language.

One way for the language of thought supporters to solve the original meaning problem has been not to focus on the semantics of atomic symbols themselves but to discover all the combinatorial syntactic properties of mentalese and the combinatorial rules governing its operations. (Fodor, 1975, 1978, 1980, Field, 1978, Rey 1997). However it is not clear that even if this was achieved by empirical study it would still necessarily provide the solution to the original meaning problem. Aydee (1997)

The language of thought is constructed as an empirical theory about the nature of cognition. Fodor does provide an account that explains the necessary components of cognition such as productivity, systematicity and compositionality. His language of thoughts account as the necessary causal function of cognition may not though necessarily complete the whole picture. . If ‘ordering’ is possible in non human species as shown on many examples by McGonigle and Jones (1975, 1978), McGonigle and Chalmers (1977, 1992, 1998, 2002, 2003), McGonigle, Chalmers, and Ravenscroft (2000) then how if these creatures, who do not have a representational shifting code of mentalese perform such tasks? What is needed is a different theoretical account of cognition that does not rely on mentalese or some other form of a shifting code.

The work of McGonigle *et al* also show that if relational encoding is a design primitive it must therefore function at a level at which representational manipulationists such as those who support the Fodorian language of thought model cannot account for. Relational encoding appears to fall outside the scope of the theory. We saw in studies by McGonigle and Chalmers that monkeys showed all the characteristics claimed for linear ordering and classification at a representational level (McGonigle & Chalmers 2001,2003, 2005), but the monkeys were not functioning at the level of a language of thought. However what McGonigle *et al* have shown is that animal thought is systematic, it does, without having to resort to a language of thought, show how if an animal knows ‘*bRa*’, it may also know ‘*aRb*’ as well as *aRc*, *cRa*, and so on. Therefore any appeal to a sophisticated language of thought in infrahumans may need to be readdressed in the light of recent evidence. Notice that this does not deny

the existence of a language of thought, nor some of the claims Fodor and others make of it, but it does deny the claim that a language of thought is the only way to account for the systematicity of thought. This is not the case.

Recursion

It is important if the systematicity challenge is to be met without a language of thought that it can account for all relationships that can occur within this mechanism. One particular relationship has recently had particular focus as detailed in the last chapter, that of recursion. Recursion, for the following point I am going to make, needs to be distinguished from iteration. Iteration is doing the same thing over and over again, whereas a recursive procedure is a procedure which is (partially) defined in terms of itself. A good way of looking at the difference between reiteration and recursion has been highlighted by Hurford (2004) using the example of the hall of mirrors effect. You see a reflection of yourself, and behind it you see a reflection of the reflection, and behind that you see a reflection of the reflection of the reflection, and so on.

Recall Hauser *et al.*, (2002) have argued that the single distinctive feature of the human capacity for language is recursion. The FLN they claimed is unique to language speaking creatures only and when stripped down to its barest form the FLN consists of a recursive mechanism. They used Fitch and Hauser to support this claim and this comparative evidence showed that although tamarins were able to learn finite state grammars they were not able to learn the more complex phase structure grammar that involves hierarchical organisation, which comprised of recursive mechanisms, which as they claim is a core feature that makes language possible. The difference between the two grammars is represented by a line diagram see figure 30 below

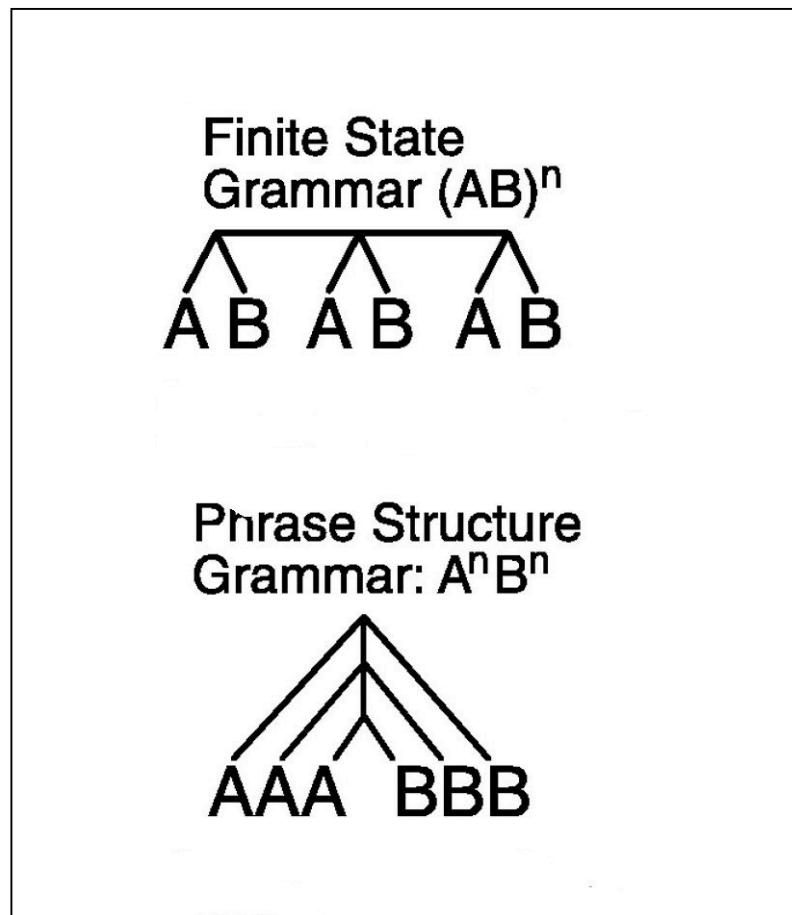


Figure 30: Modified Representation of Finite and Phrase Structure Grammar from Fitch and Hauser, 2004, p378.

The question that Hauser asks is the right one

“If one entertains the hypothesis that recursion evolved to solve other computational problems, such as navigation, number quantification or social relationships, then it is possible that other animals have such abilities. Why did humans, but no other animal, take the power of recursion to create an open-ended and limitless system of communication?” (Hauser et al. 2002 p1578)

However, it does appear that they did not come across the work of McGonigle, and the hierarchical classification experiments. The bottom representation in figure 30 can surely be compared with figure 31 which is a representation of the reciprocal hierarchical organisation of the *Cebus* from McGonigle *et al.*, (2003) study. As you can see there is no difference between the two.

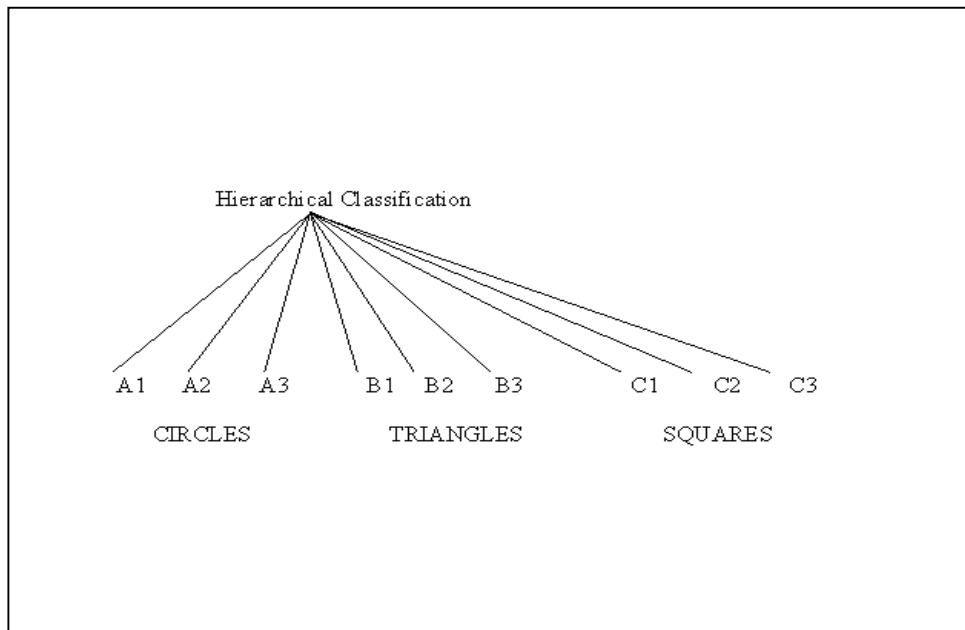


Figure 31 A Diagrammatic Representation of Reciprocal Classification.

The Cebus are not performing reiterative routines in this classification procedure, the non-human animals are classifying things that have parts that have subparts which have sub-subparts³³.

The question now remains as to whether the mechanism that underlies this form of hierarchical classification is really the same mechanism that Hauser, Chomsky and Fitch call the *recursive mechanism*. If they do see this hierarchical organisation as the same mechanism, which comparison of the two figures above tends to suggest it is, then their narrow language faculty argument needs to be readdressed. For common mechanisms such as recursion must be posited in a more general domain than the FLN. If, of course, they do not see this mechanism as being one and the same then further arguments by them need to be made as to why they think that these two underling mechanisms are to be placed in different faculties. Both mechanisms are subject to (quite possible the same) informatic pressures, and both are subject to the same economic pressures that deliver the most powerful adaptation for the least investment of resource.

³³ In the case of the variable size stimuli condition

A clue to what their response to this question may be lies in a recent paper by Hauser and McDermott (2003). They state in this paper that the hierarchical classification study McGonigle, Chambers and Dickinson, (2003) as a possible exception to the generalization that 'infinite productivity' is uniquely a human ability. However, this does appear somewhat odd. If it is the case that Hauser *et al*, believes that McGonigle *et al*, have found an infinite generative capacity mechanism in non-human animals then the assumption is that the theory posited by Hauser *et al* regarding the unique status of the recursive mechanism surely now needs to be readdressed for this would in theory leave the FLN *empty*. More needs to come from Hauser *et al*, if they fully acknowledge this study, which they seem to do

The systematicity challenge is met. Some non-linguistic creatures can over time and as a result of economic pressures develop strategies so that systematicity occurs in the production of non-linguistic creatures. An example of this, is hierarchical classification appears to be part of a non-linguistic creature's repertoire. The ability of recursion has high status in this competence, and this recursive mechanism is placed contrary to other reports (Christiansen & Kirby, 2003; Conway & Christiansen, 2001) within in a 'broad band' structure out with of any narrow faculty of language. An immediate consequence of this that recursion has a role in any normative account of the mental, both for human and for non-human alike. The empirical evidence has shown, non-linguistic reasoning does not '*come in stripes*' but is part of some constitutive principle(s).

To support the theory that non-linguistic reasoning is not stripped based we can turn to examples of hierarchal classification in the wild and with a different non-linguistic species. Bergman, Beehmer, Cheney and Seyfarth, (2003) investigated the hypothesis that Baboons (*Papio hamadryas ursinus*) can hierarchically classify by rank and kinship. They designed a playback experiment in which nineteen free ranging female Baboons were played a series of calls. These calls mimicked one of three fight (female to female) conditions. The grunts and screams mimicked by these calls have special significance for Baboons. Threat grunts are produced only when a female Baboon is threatening another subordinate Baboon, where as screams are only given by animals who are being threatened by a more dominant female.

The three conditions of calls played to the Baboons were;

- i) A threat-grunt-scream sequence which mimicked a within family rank reversal. (So, for example, where family A outranks family B, and family B outranks family C and so on the call mimicked was one where a subordinate B₃ threat grunted but the dominate B₁ screamed.
- ii) A between-family threat grunt sequence rank reversal. (This would be where a female Baboon from family C₁ would threat grunt and a Baboon from family B₃ would scream).
- iii) A within and between family no-reversal control condition was given that kept the female dominance hierarchy.

Bergman *et al* not only predicted that the Baboons would respond (look longer at the speaker) more strongly to calls i and ii over the control iii but more specifically they would respond even more to calls that simulated a between family rank reversal than a within family rank reversal (ii to i). This is because if a between family rank reversal took place then this would not only affect two animals (the two grunting and screaming) but would also effect many more individuals from the two families.

As predicted Bergman et al found that there was a significant difference between the subject's responses of the three. They also found that subjects looked toward the speaker significantly longer when hearing calls ii than calls i and iii.

These results confirm the hypothesis that non-human animals can classify members of their community simultaneously according to both individual attributes and membership of a societal group and do so without any human training procedure. It appears that the Baboons can understand that their group's female hierarchy can be subdivided into matriline and that they can organise their fellow Baboons into hierarchical, rule structured based groups.

As more and more identification, both within the laboratory and within the wild, of non-linguistic animals that have these advanced forms of cognitive states, continues.

Those that still hold to linguistic saltatory step in order to explain cognition must significantly have to readdress their position. Comments such as those made by Macphail “*there is a major shift between humans and non-humans, namely, language*” (Macphail 2000, p258), and “*there are no tasks that differentiate among species as a consequence of differences in capacity rather than differences in such factors as motivation and perceptual or motor capacity. I have, accordingly suggested that we should adopt the “null hypothesis” – namely, that all non-human vertebrates are of comparable intelligence.* (Macphail, 2000, p258), are clearly wrong. The comparative empirical evidence, derived from the complex paradigms of McGonigle and others, demonstrate that any theory (evolutionary or not) that has a tight coupling of language to thought is no longer a viable theory of cognition. But rather a more evolutionary continuative approach should be taken, an approach that does not have language as a necessary condition for thought.

Cognition, as we have seen, does not appear as a serial unfolding of one cognitive competence leading to another. Rather, the growth of cognitive competences clearly depends of the richness and diversity of a set of co-present of hardwired simple perceptual relations which can be used contextually as learning devises. (Bryant and Trabasso, 1971; McGonigle and Chalmers, 1998). The origins of cognitive growth is no longer a mystery for we can see the growth of cognitive mechanisms in the variety of cognitive structures that form the ontological lower bounds of the agent. This theoretical approach consequently supports what Gazzaniga et al (1998) reported, that qualitative differences pertain between species in their complement of adaptive specializations.

If this, as the empirical evidence suggests is true, what then for Davidson.

6.7. Some Thoughts

6.7.1. Some Thoughts about Language Not Being the Only Factor in Determining the Cognitive States of Creatures.

At the beginning of the thesis I stated that I wanted to explore the indicants of thought without language, in order to determine what underlies higher order representational

constructs. This, as well as demonstrating that non-linguistic agents can achieve higher-order cognitive competences, I believe I have done. I wanted to explore these issues because I wanted to be in a position to modify Davidson's holistic account of rational animal thought. I wanted to challenge the Davidsonian position that thoughts be ascribable only in dense networks of other propositional attitudes and that in order to attribute a complex network of propositional attitudes to another requires, in order for us to support this attribution, a rich pattern of behaviour. I do not believe the pattern of behaviour required cannot be demonstrated unless that creature is capable of speech acts. I deny Davidson's premise that only linguistic animals can have thoughts because I believe that a rich pattern of behaviour can exactly be identified or grounded through comparative empirical methodology such that if cognition such as classification through mechanisms of recursion can be found, precise methodology will unambiguously identify that competence. Being the interpreter of another no longer is a necessary condition for the identification of cognition. My modification of Davidson's argument therefore focuses on premise that only language can accurately determine the complex cognitive state of creatures. The modern methodology of comparative psychology provides us with the means to be able to deliver, the indicants of cognitive growth, how cognitive growth emerges, as well as being able to explore which creatures have this capacity and which do not. It is only a matter of empirical testing to determine which creatures have sophisticated cognitive capacities and others do not. This modern methodology is key and as such is worth emphasising exactly what is needed in order to deliver identification of such cognitive states in non-linguistic creatures. Economy, Measurements and Life History are all essential elements in determining, the root causes of complex behaviour of non-linguistic man.

6.7.2. Economy

The experimental paradigms devised by McGonigle and Chalmers and developed with associates based on behaviour based assessments of complex cognitive processes without using linguistic tasks revealed how children and non-human agents are self-regulating toward maximally economic information handling strategies. Humans and non-humans achieve this economy by utilising whatever constraints are present in the environment to construct generative and predictive search mechanisms. Humans and non-humans that are able to use these constraints are strategic, and intentionally plan a path through the array/environment presented, as in the self organising paradigms

showed. The evidence shows that language is not a necessary casual factor for economy. The *Cebus* imposed their own organisation on the free research lists, using more powerful economic information handling strategies when presented with increased task difficulty. These powerful information handling strategies are not based on linguistic (nor spatial) factors but are motivated by economy and learned utility. Serial control of behaviour does not depend on the possession of a linguistic competence, but reflects a hierarchical cognitive organisation with differing levels of cognitive abstraction. The behaviour based assessments show within the cognitive framework that the creature is on an open ended growth trajectory from a core set of relational design primitives. These relational design primitives are not abstract free, but play a grounding function in constraining the creatures search. A creature's ontological lower bounds and their resulting developmental trajectories are thus observable and measurable. (McGonigle, Dickenson and Chalmers, (2002)

6.7.3. Touch Screens and Measurements

In order to empirically determine the cognitive capabilities of any creature, human or non-human a sufficient theory of measurement and correct paradigm implementation is of course needed. We have seen throughout this thesis how the paradigms used on both the Squirrel monkey and on the *Cebus* deliver a serial out put of behaviour, akin to language production. Since the output from these paradigms is serial this in turn has lead to a whole new theory of measurement being developed. It is difficult to find other theories of measurement which give such precise ontological detail of the creature's cognitive competence. As such these new utility measurements should be seen as a weapon in which researchers can use to capture evolutionary theories of cognition.

Specifically we saw how a quantitative measure of sequencing efficiency can be determined using this serial output, where there ER/AER ratio's gives this necessary indication. We have also seen how this serial output can give necessary qualitative measures through the Euclidean Distance scores. This measure provides vital information as to how the subjects are solving these complex tasks. Surely a measure that is needed to unearth an evolutionary ontologies of cognition.

Finally in this section there was the overall measure of utility, of cross correlation between AER and ED scores. This exciting new measure determined the advantages of using such strategies adopted in task. For example, we saw in the free search condition, (McGonigle & Ravenscroft) that those children that were good at classifying were also efficient in their search strategies, thus indicating the utility of being able to classify. It makes you economic. Again I stress that these are new and valuable tools which can be used to decouple the relationship between language and thought.

The experimental paradigms devised by McGonigle and Chalmers and developed with associates based on behaviour based assessments of complex cognitive processes without using linguistic tasks revealed how children and non-human agents are self-regulating toward maximally economic information handling strategies. Humans and non-humans achieve this economy by utilising whatever constraints are present in task to construct generative and predictive search mechanisms. Thus humans and non-humans that are able to use these constraints are strategic, and intentionally plan a path through the array or the environment presented, as in the self organising paradigms showed. The evidence appears to indicate that language is not a necessary casual factor for this competence. The behaviour based assessments show within the ontological framework that the creature is on an *open ended growth trajectory* from these relational design primitives. These relational design primitives are not abstract free, but play a grounding function in constraining the creatures search. Their ontological lower bounds, and their resulting developmental trajectories are observable and measurable, and thus we can see how in agents in transitive and seriation experiments acquire long term dependencies before learning all the logical relations of the whole set. (McGonigle, Dickenson and Chalmers, (2002)

6.7.4 A Life History

New paradigms based on concurrency, new paradigms based on semi, supervised or free search approaches. New paradigms based on new technology. New theories of measurements, new comparative approaches are all key and crucial ingredients to unlock the cognitive competences of non-linguistic creatures and to deliver a true evolutionary continuous account of cognition.. However what is a critical part of unearthing non-linguistic cognitive competences is the life history of the creature itself

under investigation. The creature must be able to evolve, must be able to learn and develop within the experimental paradigm set. If one aims to detail the cognitive competences of non-linguistic creatures sufficient enough to provide evidence for an evolutionary continuous stance then it is critical that long term paradigms are developed which employ an increasing task difficulty which allows over time new competences to emerge from old. Discoveries of cognitive capabilities are not going to be made by 'snap shot' experimental design procedures. This long term view will allow for normative behaviour to be demonstrated, it will allow for competences to be demonstrated in a wide variety of tasks as opposed to a single experimental design. It will allow the evidence for an evolutionary continuous account of cognition to emerge.

By using comparative methods one can negate the influence of language, however certain responsibilities arise when this approach is taken. For example, the McGonigle, Chalmers and Dickenson study (2003), took over four years to complete, and in order to produce rich behavioural output over long periods a conducive experimental setting had to be provided. Indeed, it has been the colony management and husbandry procedures which have been used have contributed greatly to an environment made optimal for demonstrating consistently high levels of cognitive functioning of a kind never before recorded for the nonhuman primate. McGonigle, de Lillo, & Dickinson, (1994).

With long-term experiments based on the life history of the animal a significant factor it is necessary to consider not only the choice of primates but also the living and testing conditions. Experiments that last many years, some behavioral and mental problems can occur within the monkey due to poor conditions of captivity and poor testing regimes which of course seriously compromise the behaviour based assessments used to determine the ontological profile. McGonigle and Chalmers with co-workers developed excellent testing regimes where the primates voluntarily entered the testing cages and delivered rich behavioral outputs. Outputs that we have seen are necessary in order for new measurements to take place. Good results do not stem from poorly motivated subjects. It is apparent then that employing animals with longevity enables them to build up experiences of the task design and as we have seen throughout the greater the experience the subject has, the quicker the learning of tasks with even greater complexity appears to be. (McGonigle and Chalmers, 1998).

6.8. Some Thoughts about Davidson's Theory of the Emergence of Thought

I believe the experimental work I have detailed in this thesis also calls into question Davidson's theory on how thought emerges. Davidson's holistic position forces him to believe that in order to have any concepts, thoughts "*then, one must have a quite fully developed set of basic concepts*" (Davidson, 1997/ 2001 p123). This 'all or nothing' approach to the emergence of thought is counter to the comparative non-linguistic evidence presented. The cognitive competences in the *Cebus* emerged and developed over time, from being able to perform transitive inference tasks, then to seriate items within a large set to self organising self classificatory behaviour. The *Cebus* did not successfully classify all nine icons using a three class, three stimuli set at the very beginning. They eventually developed economic and strategic strategies to solve these complex cognitive tasks. In other words what the four year McGonigle *et al* (2003) study has shown is that the monkeys cope better with the latter more difficult problems than with the earlier more 'simple' tasks. The primate's cognitive performance begins at a less economic stage but with practice that performance becomes more and more economic.

This finding of cognitive economic emergence supports Harlow's (1949) "Learning to Learn", theory which described the ability of animals to slowly learn a general rule that could then be applied to rapidly solve new problem sets. "*[T]he learning set transforms the problem from an intellectual trial and tribulation to an intellectual triviality and leaves the organism free to attack problems of a new hierarchy of difficulty.*" (Harlow, 1959). As stated origins of cognitive growth is no longer a mystery for we can see the growth of cognitive mechanisms in the variety of cognitive structures that form the ontological lower bounds of the agent. Cognition is not an all or nothing process but emerges over time.

We do not know what that final stage of non-linguistic cognition is, due to the closure of the laboratory, however, the fact that the *Cebus* had strong momentum towards even greater efficiency (McGonigle and Chalmers, (2005) shows that the emergence of thought is not an 'all or nothing' development. The crude 'three barns on fire' analogy which represents the emergent process of higher complex thought based on the evolutionary comparative work of McGonigle *et al*, is add odds with Davidson's holistic position, but one that, in my opinion, has credence, for it can account not only

for the empirical data provided by McGonigle and others but also can account for differences in similar (Piaget) ontological accounts of cognition.

Davidson's major concerns regarding the thoughts of non-linguistic creatures is the ability of a creature to utilise new concepts into new frameworks. Davidson of course believes that non-humans cannot utilise concepts but we have seen in a variety of situations that some non-linguistic creatures can utilise the concepts of size, colour, shape and even weight in tasks that require the physical manipulation of blocks, the physical manipulation of tins, serially touching static icons on a touch screen and serially touching dynamic icons on the touch screen. McGonigle and co workers have produced a variety of tasks which all show the utilization of hierarchical classification both in different disjoint and reciprocal situations. The emergence of these competences is not associationistic but is due to internal pressures of economic cognitive demand. I believe that it is just an empirical question to demonstrate what other conditions these non-linguistic creatures can make use of these concepts, notice the question is not *if they can*, for this, due to the laboratory work of McGonigle *et al* and recent studies from the wild that these competences have been demonstrated. Consequently the question if experimental evidence could be produced which showed languageless creatures organising concepts in new structures and frameworks, I believe has been answered. (McGonigle and Chalmers, 1992). Notice too that this also answers Bermudez (2003) thought about what is the role of the comparative psychologists. He asks that if we are to ascribe thought to non-linguistic creatures, then the comparative psychologist must be able to deliver an empirically based account of how the languageless creature carves up its perceptual universe. The empirical evidence seems to suggest that in part it does so through the use of strategic strategies that are developed through economic and cost effective pressures.

6.9. Some Thoughts about Triangulation and the Necessary Condition of Communication

Davidson places a lot on his theory of triangulation. The reason why Davidson adheres to triangulation is that he wants the interpreter perceiving the other agent as having similar responses to what he (the interpreter) perceives as similar in the environment. Without this triangulation and the necessary condition of language, it would not be possible, suggests Davidson, for the 'interpreter' to give precise content to the agent's

thoughts. Davidson points out that communication depends on two individuals having common responses to common stimuli;

"if someone is the speaker of a language, there must be another sentient being whose innate similarity responses are sufficiently like his own to end provide an answer to the question, what is the stimulus to which the speaker is responding?" (Davidson 2001 (1992):p 120).

But I suggest that language and communication does not *necessarily* need to be this additional over arching factor in determining the contents of non-linguistics thought. We have seen how the *Cebus* can respond to certain stimuli over time, that is they begin to classify and to sort the icons on the touch screen, within the specific classes. We know that through the paradigm controls that the primates are not successfully achieving this competence though some sophisticated associationistic response. We also know that *all* the *Cebus* who attempted this experiment succeeded, that is we did not see one creature perform in one way, and another perform in a completely different way and a third perform in yet another different way. All the animals that were tested classified the icons, in similar ways. As a result, I can complete the triangle of causation that Davidson necessarily wants for thought. The *Cebus* have concepts and thoughts about classes and classification. In other words I do not need 'communication' for thought, and if I do not need communication for thought then I do not need the necessary link of language to thought.

A similar argument has recently been put forward by Lepore and Ludwig (2005) where they suggest that when animals are fighting over food they are responding to the same stimuli in similar ways, and, as we are inclined to say, '*recognize that they are doing so.....Here we have a triangle of causal interaction, and it seems to provide as good a guide to what the common object of thought is.* (p409).

6.10. Some Thoughts about Reason and Surprise

I hopefully have demonstrated in this thesis that Davidson is looking in the wrong place when he turns to surprise as an indicator of an agent having thought. He believed that any animal that demonstrates behaviour sufficient for us to attribute surprise, that animal must be aware of an 'objective/subjective contrast', that animal compares the thought it has now to a previous thought and consequently updates its

view of the world In other words it is a linguistic creature that not only comes to a new world view but is also able to compare the old with the new.

I have suggested that surprise is not the place we should be looking for examples of thought, instead we should be looking for thought in reasoning competences, even though there have been several psychologists such as Wynn (2004) and MacPhail (1998) who suggest that reason is also the wrong identifier to look for thought in non-linguistic creatures. Wynn's argument goes something like this; the fact that reasoning competences such as the ability to solve transitive tasks can be found in a wide range of creatures such as rats, pigeons as well as being identified in primates, shows that these types of paradigms do not in fact show thought in these creatures but show mores about the task design itself. Indeed Wynn is correct in highlighting this competence in a wide variety of creatures, but what he fails to note that this competence as McGonigle and Jones (1975) and McGonigle and Chalmers (1977) have shown, appears ontologically earlier than previously thought; The competency of transitivity appears before the competency of seriation and as it is ontologically lower down the order of cognitive development it may well be found in other creatures. This does not mean though that we should therefore abandon the process of looking to reason competences as identifiers of thought. It just means that we need to ensure that the competence we are looking for is a competence that is a true signifier of thought. For instance, it does appear that self organisation through the process of recursive classification may be that true signifier. As such I believe that we should continue to adopt the mechanism of looking for reasoned competences in non-linguistic creatures as an indicator of thought rather than to look for some other feature such as surprise.

The point that Davidson makes about surprise though is an interesting one. I am particularly interested in the fact that he acknowledges that a thinking creature must be able to review and do some on line monitoring of the situation, and compare it with a past situation. This review of how things are now with what the creature previously believed is the critical aspect of this argument as it gets over the bridge of just moving to a new world scene which may not require any sophisticated thought processes. However, on line monitoring and reviewing the environment and comparing it with what was just past also looks like an important feature. We have seen on many occasions how non-linguistic monkeys have this competence. This on line monitoring

is especially highlighted in the disjoint classification paradigm where the three icons within each of the three classes are identical, and must involve some form of ‘updating its view of the world’ by comparison of what has just been touched. There were no distinguishing features of the three identical stimuli within each class that ‘alerted’ or ‘triggered’ or ‘signposted’ the monkey to search for the next item within the class. No reiterations were allowed. So in order to successfully classify these items the monkey has to monitor and up date its view of the world monitor on line all the items, and compare each touch with the previous such that the first item of each category must take priority over the other two items left within the set. If this was not done then the primate could not achieve the classification competence necessary to solve the problem.

Thought allows you to make connections between other thoughts as described in the systematicity challenge and reasoning is an ordering of thought. Reasoning puts states of minds together, borders them and relates them together. Therefore, I believe that adopting this approach will still yield significant and interesting results when trying to provide any evolutionary continuity theory of cognition. The behaviour of the *Cebus* looks like the behaviour of a reasoned rational animal.

6.11 Conclusion: Some Final Thoughts. Why Davidson is Certainly Wrong and Yet May Still Be Right?

Davidson’s bar was clearly set high. In order to have thought one needs to have thought about thought. In order to have thought carries Davidson, thought needs to have language. Consequently, there is this tight coupling of thought and language. However, as stated I believe that Davidson’s position on non-linguistic thought needed modification in order to account for the recent and not so recent empirical evidence from comparative psychology. Modification of the development of thought certainly needs to be addressed, as well his belief that no non-linguistic creature can entertain concepts. But really what I have shown in this thesis is that it may be possible for some none human creatures to have very complex thought without the necessary condition of language. Complex thought in non-linguistic creatures can involve meeting the systematicity challenge; and utilize a recursive mechanism. There are animals that are capable of strategic hierarchical classification, which shows these creatures to be non-linguistic creatures self organizing, self directed planners.

The comparative psychological evidence suggests that non-linguistic creatures can have thought, and therefore Davidson is wrong to set the bar so high at demanding that **all** thought requires thought about thought. You can get a sophisticated form of cognition that does not genuinely depend upon language or some linguistic capabilities.

Or does it?

I believe that there is enough evidence in the literature to suggest that those creatures that do not have language, can obtain higher forms of cognitive thought. But, if some non human creatures are capable of higher cognitive thought then are they capable of reaching Davidson's *bar*. That is, do these creatures have a theory of mind, a representation of a representation? Or as Davidson would put it a belief about a belief? I think not, I do not think that these creatures have a representation of a representation of the world. A theory of mind capability. I think this is a difficult question to answer not because I believe that non-human creatures cannot have a theory of mind; it is just that I am sympathetic to the approach that Povinelli and Vonk (2003) take. That is, there is no experimental proof that languageless creatures have a theory of mind. That is, there have been no experimental paradigms that have isolated in their design the mechanisms and power of behavioral abstraction with respect to second order representation. The paradigms developed by McGonigle and others are not paradigms designed to test the existence of '*thought upon thought*', they are there to demonstrate the open ended nature of cognitive growth. However, I do believe that classic theory of mind experiments in comparative psychology will be unhelpful in exploration of evolutionary continuous accounts of cognition as long as they continue to rely upon determining whether subjects interpret behavioral invariances in terms of mental states. A view shared by Povinelli and Vonk. As suggested I support this position but I am concerned as is Andrews (2005) that Povinelli and Vonk are very close to a *reduction ad absurdum* in their accounts of theory of mind tests both for human and non-human as their model used for explaining chimpanzee theory of mind paradigms could just as easily be used for any child's performance in the false belief task. (Andrews 2005)

Being that I do not believe that non-linguistic creatures have a theory of mind but yet I believe that some primates have sophisticated forms of cognition that does not seem to depend upon language and also does not seem to be a story about ‘metacognition’. Is this a position that is contradictory? Is this a position that undermines any attempt at an evolutionary continuity theory of cognition? No I do not think so, and the reason why not is that I believe as do others, (Arbib, 2003;; Hauser *et al.*, 2002; and McGonigle and Chalmers, 2006) that some non-human species have evolved competences that are plausible precursors of human cognition and maybe even language. (Bybee, 1998) Hence this non-linguistic sophisticated cognitive organisation may be the precursors to our human ability to have beliefs about beliefs. So Davidson may yet still be right? Language may be the giver of second order representational states after all. But notice that this does not mean language is the giver of thought. Thought can exist without language, but maybe it is language that drives through beliefs about beliefs. Davidson talks about ‘*pre-linguistic*’ states that are found in non-human animals and that this state is independent of language and as such precedes it but where he goes wrong is that he underestimates exactly the power and scope of these pre-linguistic states. Davidson claims that the pre-linguistic states found in non-linguistic creatures are pre-cognitive. I would agree that some states in some animals are indeed precognitive, but where Davidson and I differ is that I would claim that *some* states in some animals are cognitive. As MacIntyre (1999) suggests, *the fact that non-linguistic cognition may be precursors to the development of human cognition does not preclude them from being cognitive themselves*. Gradualist evolutionary accounts of cognition are dependent upon more research showing which features might be candidates for generic, non domain specific competences which can realistically scaffold human competences (Hauser and McDermott, 2003; Terrace and McGonigle, 1994). McGonigle and his co workers have gone a long way advancing the case for evolutionary as well as ontogenetic continuity.

6.12 Final Conclusion. The need of evolutionary theories of cognition to adopt a dynamic ontological perspective.

To conclude, is Davidson right, in saying that in order to have *thoughts about thoughts, beliefs about beliefs* one needs language – I don’t know, maybe he is, maybe he is not, but either way he is wrong about the power of non-linguistic thought, and

therefore may be he is wrong about that too? And like Povinelli and Vonk I believe that ‘theory of mind’ approaches will not be able to determine an answer to that question either. But what I do believe is that in order to develop a truly evolutionary continuous account of cognition, the delivery of it cannot be left to one individual discipline. In order to deliver on such complex issues as the evolution of cognition one needs to adopt an interdisciplinary approach. An approach that must involve empirical comparative laboratory work, for this approach can ground some of the philosophical and theoretical concepts. Comparative psychology is thus the bridge than can be used between Philosophy and Psychology.

What I would like to suggest is that this thesis highlighted the fact that one should adopt a dynamic approach to learning and development. Note here that one should not adopt a dynamic approach to learning, and then a dynamic approach to development.³⁴ But rather an ontology of cognition should see learning and developing together as a dynamic system, for this approach will break down the distinction between learning and development and as we have seen, this is a necessary perspective for investigating cognition and an understanding of the causal mechanisms of cognition. (Fisher *et al*, 2000).

We saw how the *Cebus* had ‘*momentum*’ in its causal mechanisms. A rational cognitive creature from a collective set of design principles, ontologically speaking had impetus, and in fact the cognitive growth trajectory of the *Cebus* is as yet open. That is, more complex levels of cognitive competence of the *Cebus* could still be demonstrated. Learning and development are complex and dynamic phenomena. They appear to have open ended growth trajectories, as the work of McGonigle and others have shown.

By taking a dynamic approach we see that learning is not a serial unfolding, where there is a simple progression from one level to another by associating inputs to another. We have also seen that there are many kinds of learning mechanisms, and not just one, and each of these mechanisms interact and are dynamic. It is the dynamic

³⁴ For example we saw that Hull’s (1952) approach to learning theory was really just an accumulation of habits, where as Piaget’s developmental model focused on the global developments of human cognition (Inhelder, Sinclair and Bovet, 1974).

nature of these mechanisms that allow agents to scale and scaffold up. Consequently what we are aiming for is autonomy, surely that is what a cognitive rational creature is, it is a creature that has autonomy. The ability to be free to make choices and not to be tied to a coupling input output responses. A correct ontology or theory of cognition is one where over time cognition develops and grows dynamically through real-time interactions with its environments through using its own design features. It is a creature or indeed a system³⁵ that is capable of dynamic autonomous mental development. I suggest that dynamic ontologies of cognition show how new competences are build from old ones, how new states emerge from others, and must show how language is not the engine which drives all this.

So a rational creature is one that has autonomy, a creature that is free to represent possible outcomes and to act and plan upon those outcomes. Empirical issues which comparative psychology must address is characterized by the dramatic tension between Davis on one hand I think there is a big difference between saying that

- “the organism through natural selection, has evolved to be responsive to certain kinds of stimulus contingencies in the environment”

and saying

- “the organism is deciding/choosing/determining how its behaviour will be controlled”

and Clark on the other

- The question in short is how to do justice to the idea that there is a principled distinction between knowledge-based and merely physical-causal systems
- There seems to be a (morally and scientifically) crucial distinction between systems that select actions for reasons and on the basis of acquired knowledge, and other (often highly complex) systems that do not display such goal-oriented behaviours

As cited in McGonigle, Chalmers and Dickinson, (2001).

³⁵ This can include robots, artificial agents and so on.

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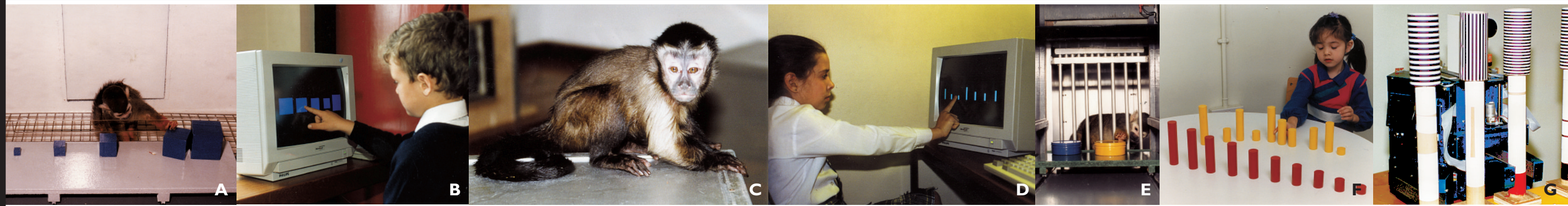
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Self organised memory strategies during unsupervised visuo-spatial search tasks by monkeys (*Cebus apella*) and very young children

Brendan McGonigle, John Ravenscroft, and Margaret Chalmers

Laboratory for Cognitive Neuroscience Centre for Neuroscience and Department of Psychology, University of Edinburgh
EH8 9JZ PH : 0131-650-4354, FAX: 0131-650-3461



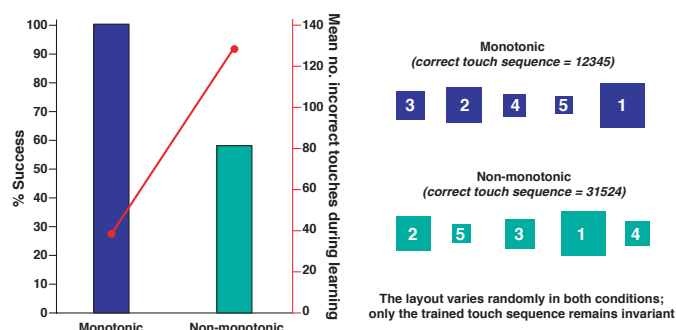
Agenda: The lab has a general aim of characterising complex intelligent systems with a specific goal of identifying the key design features of powerful adaptive learning and memory mechanisms based on self-organisation and self-regulation principles in biological and artificial agents

Executive memory

Deriving from core work on executive control, we have been investigating the thesis that memory in advanced primates is active and strategic, and subject to self-organising procedures such as chunking and classification, designed to make memory storage economic and recall efficient (1). Using touch screen based procedures emphasising executive serial control (2), we have developed a family of interactive tasks which we outline in the sections below.

A. Supervised and Semi-Supervised Serial Learning

This enables a direct assessment of executive competences in a variety of species (3). The tasks involve sequence learning of elements (see photos B & D) as in size seriation where the subject must order icons e.g. an ascending order of size (still one of the best indices of cognitive growth in humans - see photo F).



Performance on a size sequencing task by 5 year old children, showing % successful subjects (histogram) and number of incorrect touches (red line).

Economy

The core result here is that only one seriation procedure is effective even though all the test arrays look the same for each subject and for each condition. That is the monotonic series is learnt, all other non-monotonic procedures are either inefficient or impossible. This sort of result has been interpreted by us (4) as indicating that linear ordering procedures of this sort are successful because they are data reducing and economic of memory resource. In monotonic seriation, successor items can easily be predicted and generated from a number of antecedent examples within the series.

Utility

Following on from our first ever demonstration of transitive choice mechanisms in monkeys (5) we have now revealed size seriation competences in *Cebus apella* for up to 9 items or more.



Touch screen based tasks given to monkey: nine-item size sequencing

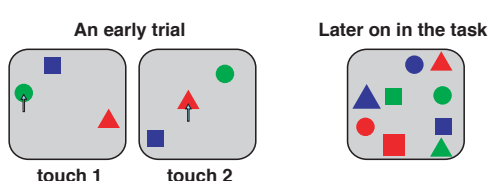
In addition, however, we have shown that, given the opportunity to classify similar elements by shape, monkeys' seriation performance is further improved, indicating that category based memory is superior in controlling executive function.

Given that this economy can now be recorded objectively, a further question is the extent to which subjects can apply economy criteria in selecting their own procedures within a free recall task.

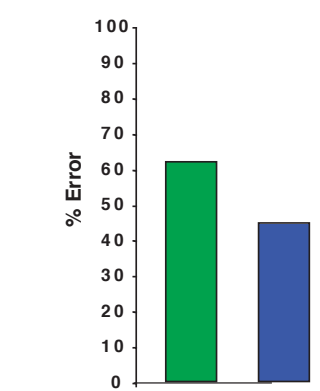
B. Self-organised memory

Free search task

Here the subject must simply touch all the objects on a screen without re-iteration. Crucially, the objects move around after every touch, allowing us first of all to gauge very precisely the level of working memory control in terms of actual length of sequence that can be controlled. Second, however, it allows us to see what, if any organisational devices are spontaneously used to make the task more manageable



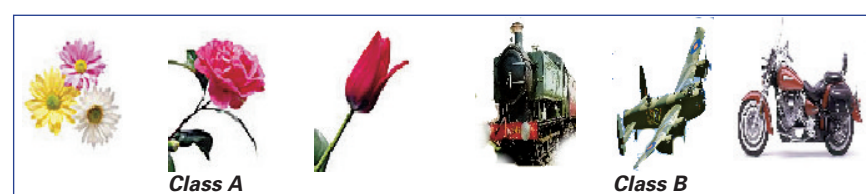
On every trial, each shape must be touched once even though the icons move around after each touch. As the game progresses, more and more icons are added, eliciting (usually) some kind of organisation by the subject - a rote list or a strategy of touching e.g. all the red ones first, etc.



Monkey's performance during acquisition of 9-item linear size seriation (■) and linear size seriation with classification opportunities (■)

Semantic Memory – The Current Study

Using the free search paradigms here we have sought evidence for the operation of dynamic principles in the self-ordering behaviour of 12 very young children from 2.6 yrs approx. to 4.5 yrs approx. The stimuli have been derived from a collection of digitised images of familiar items which can be classified into 3 main groups.



Example subset.

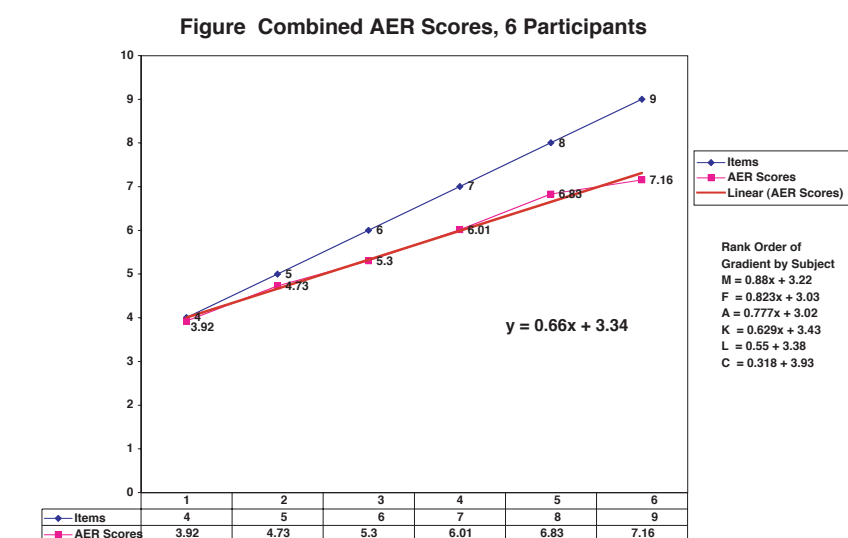
Design and Procedures

The experiment was in 2 main parts. In the first, all subjects were given an exhaustive search task comprising 4 stimuli derived from the set of 12. Two were exemplars of one class, two were exemplars of another. Thus all 12 stimuli were exposed to the subject during this first qualifying period. Subjects who could achieve efficient search during this period were then given a series of interleaved tasks presented in pseudorandom order such that no one task level could be retested until the full set of conditions had been tested. During this phase the number of icons per task level varied from 5 through 9 icons with up to 3 exemplars per class.

Measures and Results

Efficiency Ratio (ER) : Complete success is indicated by exhaustive and economic search. A 4 icon condition, for example means that only 4 touches are necessary to satisfy the exhaustive search requirement. From this we can arrive at a metric of economy expressed as a ratio of minimum path based touches to the total number of touches actually recorded. A ratio of unity (Min = Max) would reflect the most economic search; the ratio for less efficient outcomes declines progressively from unity. This ratio can also be adjusted for set size (AER). This means that an ER of 0.8 for a 4 item set becomes 0.32 (0.8 x 4) and allows us to achieve a common currency whereby ER scores from larger sets can be placed on the same scale. Thus an ER of 0.8 for a 6 item set would be (AER) 0.48 - a higher score than that for 4 items, and rightly so given that the task is harder.

The figure below plots the average AER for all 6 successful children against optimal performance.



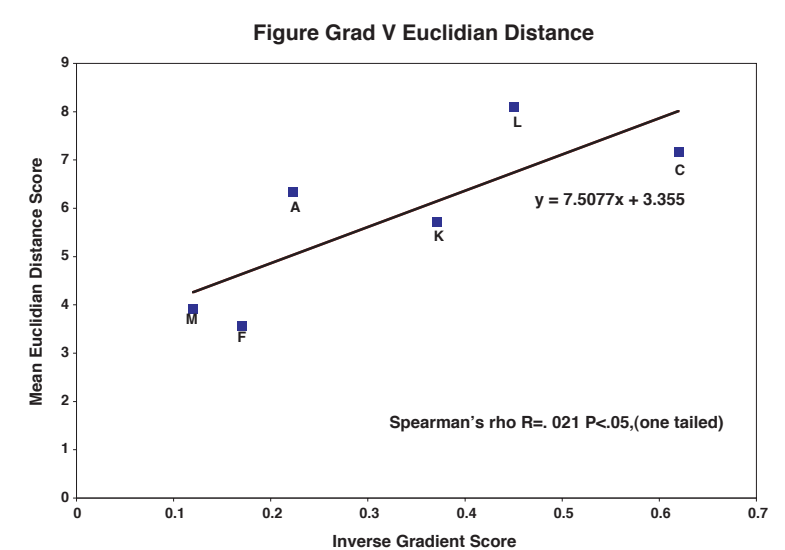
Group function (trend analysis) showing mean (AER) efficiency as a function of set size

This shows a significant linear relationship between set size and efficiency. The bigger the set to be ordered, the less efficient the subject became. However, performance was still high even with the large sets as can be seen by both the trend test and slope value. The trend tests for individual subjects also show a range of variation, however, which enables us to cross-correlate relative efficiency with categorical competences.

Euclidean Distance Metric

Our measure of categorical competence is based on the mean Euclidean distance between items from the same set. As the output from the subject is serially ordered, perfect categorical competence in a nine-item series would express itself as A1 A2 A3 B1 B2 B3 C1 C2 C3. On this measure, the Euclidean distance measure is 0. In the case, however, of A1 B1 A2 A3 B2 C1 B3 C2 C3, there is a 1 step violation for the As, a 2 + 1 step violation for the Bs, and a 1 step for the Cs - a total score of 5

Given these two indicants of performance, we can assess the relationship between efficiency and categorical use by cross-correlation. To do this, we have used the gradient values for individuals as global efficiency measures and plotted these against mean Euclidean distance for each subject for all sets. This is represented in the figure below



Correlation between (r = 0.82) between the index of efficiency (taken from trend values) and Euclidean Distance averaged for all sets

Is Categorical Use Dispositional or Strategic?

As children adopted a categorical procedure almost from the outset, an issue is the extent to which subjects can arbitrate between 'good' and 'bad' search procedures without prior knowledge of the categories.

Cebus apella : organised lists

Prior categorisation is not possible in our final study where the stimuli were simple shapes derived from an arbitrary set. Here we summarise results from one of four juvenile *Cebus apella* (see photo C) who have been tested on the unsupervised free search paradigm described above, using three shape categories a, b and c.

We find they construct their own lists suggesting strategic factors. A sample of this performance is given in the table below.

A typical data set showing Ciccio's self-selection of a consistent sequence (abc)

Sequence	Number	% of Possible Correct Sequences (n=6)
abc	187	78.24%
acb	44	18.41%
bac	3	1.26%
bca	5	2.092%

Conclusions

Using a combination of supervised and unsupervised serial learning procedures, we have begun to assess the partiality of search procedures in maximizing executive memory performance. In all this, cognitive economy seems to feature as a major player leading to the concept of adaptive utility which places memory and cognition in a truly evolutionary context.

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