Theory of mind in chimpanzees

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Abstract

This study investigated whether chimpanzees have the ability to understand that other organisms have beliefs and desires, namely Theory of Mind. A range of levels of Theory of Mind were examined rather than solely looking at the ability to pass a false belief test. The main subjects were chimpanzees from Twycross Zoo, but bonobos, spider monkeys, children and autistic adults were also included in some of the experiments. The studies were on: the comprehension of causality, joint attention, the comprehension of desires, the comprehension of false beliefs and metacommunication in play. Two pilot experiments are included in the appendices. It is suggested that chimpanzees and bonobos, but not spider monkeys could understand causal relationships. Chimpanzees and bonobos but not spider monkeys showed a low level of joint attention. Under experimental conditions, chimps and bonobos used dyadic joint attention, triadic joint attention, mutual gaze and made protoimperative, but not protodeclarative, gestures. Those chimpanzees that had been hand-reared by humans generally showed higher levels of joint attention. A test for comprehension of nonverbal desires was capable of being understood by children slightly earlier than they understood a verbal desire test but no significant trends were seen in the chimpanzees. It is postulated that this was because the test required the interpretation of drawn pictures. A test for comprehension of nonverbal false beliefs was designed and tested on children to determine whether it was testing false beliefs. The children found this test slightly harder than a verbal false belief test, but were able to give 100% correct scores by the time they were six years old. One of four chimps was able to pass this test. The chimpanzees as a whole produced better results in response to this test than children aged 4-5 years. No autistic people were able to pass the nonverbal false belief test. In the study on play, it was shown that the play face was used by juvenile chimpanzees and bonobos as a means of communicating that their behaviour was only play during conspecific play. The subjects' play face rate was minimal during self play. However, it was not possible to determine whether the subjects had any mental understanding of the need to communicate about their behaviour. A pilot study showed that chimpanzees may be capable of mental rehearsal when solving a physical problem.

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1. A philosophical background to animal cognition

In this chapter I want to give a brief overview of the opinions of philosophers towards animal minds from the ancient Greeks to contemporary philosophers who are also familiar with psychology. I then want to examine the thorny problem of anthropomorphism. Chapter 2 is a critical literature review specifically of theory of mind and examines research conducted on both animals and humans. An outline of the whole thesis is given in the second chapter.

1.1. Ancient philosophers

According to Richard Sorabji (1993), Plato (427-348 BC) did grant animals a reasoning part of the soul and it is plants, not animals who lack beliefs. He says that beasts are not confined to mere sense impressions and that there may be some who could aspire to reflections about things "being thus and so" (Plato's Republic). Aristotle (384-322 BC), in contrast, makes a sharp intellectual distinction between animals and humans despite his belief in a gradation of biological forms. Animals, he says, are not capable of reason (Aristotle's History of Animals - see Midgley 1979). They are credited with technical knowledge but, for example, it is only *as if* dolphins calculate how big a breath they need before diving (Aristotle's History of Animals - see Sorabji 1993). The Stoics were even less generous than Aristotle: they increased the province of reason which now included memory, emotions and perceptions, but since they denied reason to animals, the latter were more impoverished than ever (Sorabji 1993).

The thirteenth century philosopher and saint, Thomas Aquinas refuted this view. He agreed with the Aristotelian belief that there is a continuum of life: he said that some of the lowest animal kinds scarcely surpass vegetable life, but he added that although humans and animals were generically the same, the sensitive capacity was much higher in people (Aquinas II Contra Gentes 1255; see Gilby 1951: 499). His perception of the differences between humans and other animals was far sighted.

> **As regards sensible forms there is little difference between men and animals, for they are similarly worked on by external sense-objects. But there is a difference as regards the implications of the sense situation. For while animals perceive**

> **these purposes by a kind of natural instinct, men need to make comparisons. What is called the natural estimative power in animals is called the cogitative power in men, for these purposes are discovered by drawing comparisons: it is also called the particular reason. Then, as regards memory, man does not merely have the sudden recognition of the past, as in the sense-memory of animals, but also the power of reminiscence...**(Aquinas summa Theologica 1a.xxviii 4,c and ad 2 1266-1273; see Gilby 1951: 621)

Aquinas further differentiates between people and animals by concluding that although animals may take pleasure in objects, they can do so only if these objects are related to food or sex, whereas we can appreciate beauty for its own sake. This capacity of human 'sense-judgement' allows us to see objects in terms unrelated to us, although for animals,

> **a ewe knows this lamb, not as being a lamb, but as something to be suckled, and this grass, not as grass, but as something to be eaten** (Aquinas II de Anima, lect. 13 c.1266-1272; see Gilby 1951: 659).

In addition, we have the power of committing an action of our own volition. Aquinas says that there is a two fold knowledge of an end: imperfect and perfect.

> **Imperfect knowledge is merely perceiving a goal without understanding of purpose as such or of the adaptation of means to ends; animals enjoy that kind of knowledge through their senses. Perfect knowledge requires more, namely, understanding of the meaning of purpose and of the relation of means to end; it is proper to an intelligence. Hence the complete character of voluntary activity, endowed with deliberation and freedom, is found in rational nature alone. From imperfect appreciation of purpose there follows incomplete voluntary activity, the apprehension and spontaneous desire without deliberation which is typical of animals** (Aquinas Summa Theologica 1a-2ae. vi. 2 1266-1273; see Gilby 1951: 682).

1.2. Contemporary philosophers

Under the philosophical jurisdiction of Aquinas, animals were even granted souls, yet by the seventeenth century they had been relegated to the level of machines. René Descartes, considered to be the father of modern philosophy, wrote in his Discourse on Method that as theological errors go,

> **there is none more powerful in leading feeble minds astray from the straight path of virtue than the supposition that the soul of brute is of the same nature with our own** (Descartes; reprinted 1978).

Feeble minds beware! Descartes had two main grounds for reducing animals to automatons. First there is an argument by analogy: if the mechanical canaries fashionable at the time could be created by human industry, then surely God in his wisdom could do a better job. Secondly, he was a fervent believer in experimentation and both observed and conducted many dissections. He made it clear that in humans, the brain was intimately concerned with subjective consciousness. Since animals also have brains he was faced with the prospect of granting them the same cognitive capacities as a person, or nothing. He chose the latter since animals fail the intellectual scale he had devised, and he had already denied them the limited spiritual status that Aquinas had been prepared to allow them (Descartes 1978). His reasoning was as follows: if a mechanical ape and a mechanical person were constructed, one would not be able to tell the difference between the animal and the machine, but there would be a difference between a person and the machine. The 'android' would fail two tests: it would react to knowledge on the basis of its design and without showing any creative reasoning; neither would it be able to sustain a conversation with a person. Descartes was thus the real progenitor of the Turing test.

Descartes left a two pronged legacy: the first part being his definition of animals as automatons and the second, his famous division of mind and matter into two separate entities. The damage which Descartes wrought ought not to be underestimated. For nearly three hundred years Western philosophers and scientists have struggled to unify bodies and brains and exorcise the ghost in the machine. Furthermore, his theory on animal capabilities ultimately paved the way for the behaviourists.

This is not to say that Descartes had no contemporary critics. Fellow philosopher Hobbes accused Descartes of publishing 'old stuff' and in reply to the oft quoted dictum, 'I think therefore I am', Hobbes replied

> **It seems not to be a valid argument to say, 'I am conscious therefore I am consciousness,' or 'I am intelligent, therefore I am an intellect'. For I might as well say, 'I am walking, therefore I am a walk'** (Descartes, reprinted 1970).

Philosophers after Descartes tended to pay less attention to physiology and more attention to the mind. The philosopher, John Locke, who lived between 1632-1704 is perhaps best remembered in psychology for his concept of a *tabula rasa*. He believed that knowledge is determined by the accumulation of experience rather than by innately determined rules. Thus minds of animals and humans alike were compared to blank boards upon which the mental life could be written. If one did not begin to speak and interact with other people, one would not rise above the intellectual level of a cockle or an oyster, according to Locke. What distinguishes people from animals is the capacity for abstract thought. Locke allowed animals memory, perception, sense and a modicum of reason. They are "tied up within these narrow bounds [of sense perception]." His refutation of innate ideas and the granting of reason to animals seems to be somewhat arbitrary; up until this point, Aristotelian and medieval scholastic tradition viewed reason as the boundary between human and animal thought, and Descartes had granted them nothing (Locke 1959).

David Hume, a Scottish philosopher, was not prepared to allow animals a large capacity to reason, although he believed that animals had a richer mental life than Locke allowed them. Hume divided human knowledge into two categories: Relations of Ideas, and Matters of Fact. The former can be demonstrated using subjective mental activity without the physical world being a necessity, whereas the latter is based on what Hume termed 'cause and effect'. By this he meant all instances where one deduced something from a different perceptual experience. All connections are made from our past experiences and Hume is sceptical of human knowledge to the point of saying,

> **All inferences from experience, therefore, are effects of custom, not of reasoning.... Without the influence of custom, we should be entirely ignorant of every matter of fact beyond what is immediately present to the memory and senses** (Hume 1902).

Thus, if our connections between one event and another are, to some extent, arbitrary, this considerably reduces the gap between humans and animals. He specifically treats animal cognition in the Enquiries. He maintained that the theory of understanding human mental capacity would be considerably strengthened if the same theory could be used to interpret similar phenomena in animals - perhaps this was a premonition of the burgeoning of animal psychology. He said,

> **First, it seems evident that animals as well as men learn many things from experience, and infer that the same events will always follow the same causes.... This is still more evident from the effects of discipline and education on animals, who, by the proper application of rewards and punishments, may be taught any course of action, and most contrary to their natural instincts and propensities...the animal infers some fact beyond what immediately strikes his sense, and this inference is altogether founded on past experience** (Hume 1902).

Reason plays little part in animal or child cognition, nor in most people's every day life for that matter. He did allow that instinct could govern much of animal, and indeed, some human knowledge, but he was quite adamant about the relation between human and animal thought. It was, he said, based on the same mechanisms and thus human superiorities were merely a matter of degree. In the Treatise he argued that pride, humility, love and hatred, fear, anger, courage, grief, envy, malice and 'other affections' all exist in animals and 'the causes of these passions are likewise much the same in the beast as in us'. This is a strong claim for a common biological basis underlying both human and animal behaviour (Hume 1888).

Another philosopher whose ideas are relevant to current scientific practice is Schopenhauer. He coined the word 'motivation' (Schopenhauer 1915). He believed that one could arrive at a complete knowledge of the consciousness of animals by selecting a limited set of the major differences between the human and the animal mind. One major difference is the ability to think in abstract terms. According to him, animals live in the present and have a limited understanding, but are incapable of reflecting on past and future events (Schopenhauer 1915). As Wittgenstein (1976) said "We say a dog is afraid his master will beat him; but not, he is afraid his master will beat him tomorrow."

Schopenhauer, unequivocally but somewhat unoriginally, postulates that the main difference between us and other animals is language: "It is by the help of language alone that reason accomplishes its most important achievements," (Schopenhauer 1883).

Popper was perhaps the first philosopher to put forward a theory approximating to modern cognitive science, albeit unintentionally. Although he believed, like Descartes, that something over and above brain activity is necessary for thought, he postulated a psychological category outside the realm of human thought which is potentially open to animals. He divided the world into three: world 1 is the brain; world 2 is subjective consciousness and world 3 contains ideas derived from physical products of human societies. Hence an idea can be found in a book in world 3 and can live independently of any human mind perceiving that idea. He allowed animals to attain level 2 and have rudimentary mental events, but denied them entrance to world 3 (Popper and Eccles 1977). For all we know, he may have been too hasty since chimpanzees may have mental representations of tools used to crack nuts (see Boesch and Boesch (1984) on mental maps in wild chimpanzees).

1.3. Physicalism and folk psychology

In an influential paper published in 1974, Thomas Nagel wrote,

> **Consciousness is what makes the mind-body problem really intractable. Perhaps that is why current discussions of the problem give it little attention or obviously get it wrong...philosophers share the general human weakness of explanations of what is incomprehensible in terms suited for what is familiar and well understood, though entirely different.... And careful examinations will show that no currently available concept of reduction is applicable.**

Nagel, dealing with this problem, made two major points in this paper entitled 'What is it like to be a bat?'. Nagel could have chosen any animal but he chose one close enough to us (a mammal) for us to empathise with it and distant enough for us to have very little conception of its subjective experience, since we have no idea how it feels to echolocate. By posing this question, he did not mean what is it like for us to imagine what it is like to be a bat, but rather, what is it like for the *bat* to be a bat. The somewhat depressing answer is that we can't imagine what it is like.

The second point was on physicalism. He saw the major flaw in what he termed the 'reductionist euphoria' as being that it left out the subjective quality of experience. He said

> **...no matter how the form may vary, the fact that an organism has conscious experience *at all* means, basically that there is something it is like to *be* that organism.... We may call this the subjective character of experience** (Nagel 1974).

He adds that even though we cannot accommodate a detailed description of bat or Martian phenomenology, this does not mean that we can claim that bats and Martians do not have experiences as rich as our own. Using a reductionist and objective criterion, by definition, something is left out and this is the subjective character of experience. It is precisely this quality that we cannot afford to lose since it is the subjectivity of mental states that makes them what they are. Nagel does not, as one might at first expect, refute physicalism; instead he hopes the dilemma will be solved by creating an objective classification of subjectivity.

In the Nagel sense, we never can know what it is like for us to be a bat. The bat is a metaphor and one that can be examined closer to home. How can we ever know what it is like to be another person, especially those people who have very different experiences from ourselves, such as the blind? We can never be another person and the workings of their mind will always remain opaque to us. Whilst we can appreciate the philosophical intractability of this problem, at the same time, we do know what other people think, particularly those close to us. Human society could not function if all we could do is make a stab in the dark at other people's thoughts and feelings. Instead we use folk psychology to determine other peoples' minds on a day to day basis. I believe we may be able to amalgamate this concept with that of cognitive psychology to decipher animal minds.

Folk psychology is the common sense yet immensely rich structure of laws and generalizations which give sense to pain, belief and desire. As Fodor says, 'Common sense psychology works so well that it disappears' (Fodor 1987). To understand another person we tend to describe them in psychological terms; we give them beliefs and desires depending on their background and what we know of their personality and from this we predict how they would react given the circumstances they find themselves in and the mental states we have attributed to them.

Folk psychology follows what is known as soft functionalism. This is the belief that brain states produce mental states, but, using an analogy from computer terminology, the underlying hardware need not be the same as the resultant software. My friend and I may both have the same desire to go for a walk, but this does not mean that our brains are in identical states; similarly if I play chess with a computer, the computer and I may both 'believe' that if it moves its king, the outcome will be checkmate. However, my brain state and the computer's silicon chip will not be in the same state. Nor do I think that the advent of optical programming or 'wet-ware' will change this state of affairs.

Folk psychology does have critics, in particular Churchland and Stich who would rather see the mind explained purely in neural terminology. They believe this cannot yet be done, but wish research to be directed towards this end. There are two main arguments directed against them. The first is Nagel's point: neuroscience, even if sufficiently advanced, can never truly comprehend what it is like to have a sensation for that requires the ability to have the sensation. Secondly, when we interpret another person, we do so using our knowledge of their psychology and their outward behaviour. We do not interpret their actions using neurological terminology. A person can get angry, but a brain can't; a brain can't show that is angry, be angry at anyone or get angry in a certain situation. Emotions are personal not neurological. This is analogous with the human genome project. Whatever the rights or wrongs of spending many years and large sums of money on mapping the 'average' person's genes, the results are unlikely to tell us, as some would claim, what that person is like, nor is it the grail that will reveal what it is to be human.

Beer (1991) believes that folk psychology's major fault is that it is ill equipped to deal with people who are classified as insane in our society and with animals. His quibble is with the mechanism of thought. If our minds think in the language the thinker happens to speak, then does it follow that prelinguistic children and animals are devoid of thought and mentality? Fodor's (1987) answer is to suggest a language of thought which is universal to cognitive beings and onto which spoken language is mapped. His idea is reminiscent of Chomsky's blueprint for language which seems to be in keeping with some of the current linguistic studies. It seems that Fodor may be halfway there and with sufficient ethological information, we will eventually be able to incorporate the mentality of animals into a type of folk psychology without being overly anthropomorphic.

One approach towards this goal might be to use the philosophies put forward by John Crook on consciousness (1980) and Daniel Dennett (1988) on intentionality. As Dennett said,

> **As a philosopher, an outsider with only a cursory introduction to the field of ethology, I find that the new ethologists, having cast off the strait jacket of behaviourism and kicked off its weighted overshoes, are looking about somewhat insecurely for something presentable to wear** (1988).

Because the approaches suggested by these two men form a core framework for my thesis, they are dealt with in more detail in the following chapter. I would now like to deal with the problem of anthropomorphism.

1.4. Anthropomorphism

One of the insults hurled at cognitive ethologists is that they are anthropomorphic. It is, therefore, advisable to say a few words on the subject at this point. The painter Francis Bacon said that as we are human, we are obsessed with ourselves. We even imbue nonhuman objects, animate or inanimate, with human attributes. Not only do we have our species-centred view point to contend with, but we must be aware of our own personal background. As Bertrand Russell said in 1927, "Animals studied by Americans rush about frantically, with an incredible display of hustle and pep, and at last achieve the desired result by chance. Animals observed by Germans sit and think, and at last solve the solution out of their inner consciousness..." (quoted in Calvin 1994).

The problem of anthropomorphism arises when the behaviour of an animal, defined in terms of physical movements and interactions with conspecifics, is named using language terms that usually describe human actions. Naive readers of biology are apt to fall into the trap of either attributing human motives to animals or else believing that biologists attribute human motives to them. It is important to remember that many technical biological terms do have a different meaning in common parlance, words like 'fit' and 'selfish', but conversely, when dealing with animals as advanced as primates, and which we do have a tendency to be more anthropomorphic about, biologists use words expressly to give a human feel to the action, even if they are not suggesting that the behaviour does contain the same mental content as it would if we were watching a human perform that behaviour. As de Waal says,

> **The dilemma of a primatologist may be compared to that of a pianist listening to a record of a classical piano concert. He is unable to distance himself from the processes by which the music is produced. Instead of 'pure' enjoyment of a series of patterned sound waves, he automatically imagines a grand piano and feels the chords and the melodies, so to speak, in his fingertips. Similarly scientists cannot completely distance themselves from primate behaviour. Almost everything they see reminds them, consciously or not, of their own experiences.**

He adds that this need not be a disadvantage. The tradition of quantification is now so well ingrained that we are not going to sink back into pet lovers' talk.

> **Piano players undoubtedly listen more carefully and analytically to a piano concert than the average listener. In the same way, our background as social beings provides us with a depth of insight into social relationships that is bound to guide our thinking and theorizing when studying primates. Allowing for this influence is not the same as uncritically giving in to it** (de Waal 1987).

The cruel bind that Western researchers find themselves in is that they have never scientifically attributed beliefs and desires to animals and are now finding it difficult to begin to do so. They run up against their innate prejudice against anthropomorphism as well as feeling uneasy about employing the same terminology to describe animal minds as that used for human feelings. Midgley (1979) says this worry stems from the philosophical view that talking about animals' feelings commits us to knowing exactly how they feel, which is extreme.

On the whole, Japanese scientists do not have this problem. They have always assumed that the animals they are studying have minds, and for the same reason, there has been very little work done in this area. Kawai (1969) says that Western thinking is characterised by the belief that our place in nature is a vertical one. This is the reason why Darwinism was so offensive to Victorians as it represented a change in structure from top down, God to human, or people made in God's image, to bottom up, people evolving from animals. The Japanese by contrast, have no such secular hang ups. Their place in the world is horizontal and fluid, with people, deities and animals being interchangeable; Buddhism being the most explicit version of this ideology. Having said that, only those people who sin are reincarnated as animals.

The success of Japanese primatologists was the uncovering of kin and rank networks. This was a product of their own society. Status, rank and kinship are given much attention and so it was natural for them to look for the same phenomenon in monkey society. Sugiyama, talking of ethological interpretations, says,

> **...in these explanations, there is no room for living things. At least in mammals, including primates, each has its own motivation, thought and feelings and soul in its own behaviour** (1980).

I would like to make three points about anthropomorphism. The first is that when describing an animal's behaviour or mental processes, I will use words that have different connotations to the layperson. These words in this context have biological meaning, and by using them I am not suggesting that I know how the animal feels or thinks, nor that its thoughts or feelings are the same as human mental processes. Secondly, there is an argument for continuity. We have evolved from primates and although we are radically different, I suspect that we are motivated by the same basic emotions. This is not to say that our emotions are exactly the same as theirs, but that primates are likely to be more understandable to us and less alien than an insect or a Martian. Thirdly, if we are naturally anthropomorphic about chimps, chimps are likely to be panmorphic about us. Whilst the ideal is to conduct experiments in theory of mind where one asks, What does the animal think about what is going on in another animal's mind? in practice this is difficult to do in any rigorous or controlled fashion. Hence, although it is a second best option, it is still acceptable to ask what the animal thinks is going on inside a human's mind since the animal will probably treat the human more or less like an honorary member of its own species.

2. An overview of Theory of Mind

Theory of Mind is whether an animal can not only ascribe mental states - beliefs and desires - to itself, but can attribute these same mental states to another. As such it includes conscious thinking and a certain degree of intelligence.

It is fair to say that theory of mind (ToM) has been neglected outside of human psychology. We cannot see brain processes and the results of any attempts to test for them do not have the same clarity science has become accustomed to expect. When questions about the mental states of animals are raised, we tend to demand perfection prematurely. We are often convinced that it is not worthwhile to study this sort of phenomenon because we cannot hope to prove anything with absolute certainty (Griffen 1991).

For the most part, any evidence available on animal mental states comes either from anecdotes or the laboratory. As Kummer and Goodall (1985) have said, "we almost completely lack an ecology of intelligence. No other dimension has so systematically not been studied in the field."

The aim of this thesis is to attempt to examine theory of mind (ToM) in chimpanzees in a setting with minimal social deprivation, in which ToM might be exhibited. I chose to work in a zoo with animals that have not been used for experiments before so that I could a) have some level of control and rigour in my experiments; b) work with animals unused to testing; c) observe the animals in a condition that was more natural than that of a laboratory, and d) have the opportunity to compare the responses given by the chimpanzees with those of other animals. I chose chimpanzees because they are our nearest living relative and have been proven to have some degree of intelligence and to share some traits with us. The other species I studied were bonobos, spider monkeys and humans - both children and autistic adults.

The introduction to the thesis outlines the basic components of theory of mind and the framework which I have used to test it. This section is followed by experimental evidence from the animal world. There follows a discussion of how theory of mind applies to children. I have then examined two quite radically different approaches to the question of animal mentality, that of Donald Griffen and a contrasting method employed by Daniel

Povinelli. The former is a theoretician, in this arena at least, and the latter is an empiricist. Finally, the aims and content of the thesis are outlined.

2.1. Components of Theory of Mind

Theory of mind was originally a phrase coined by Premack and Woodruff (1978) who asked whether their chimpanzee subject, Sarah, had ToM. "In saying that an individual has a theory of mind, we mean that the individual imputes mental states to himself and to others...A system of inferences of this kind is properly viewed as a theory, first, because such states are not directly observable and second, because the system can be used to make predictions, specifically about the behaviour of other organisms." There are a number of components incorporated into the ability to have ToM. The main ones are discussed below, some of which are discussed in greater detail in the relevant chapters of the thesis.

2.1.1. Machiavellian intelligence

Machiavellian intelligence is a hypothesis put forward in response to the question proposed by Jolly (1966): what is the natural function of intelligence? The social life of a primate is highly problematical. The social context in which a primate finds itself is complex, highly changeable and contingent upon its own actions. It may be necessary for an individual to change tactics during interactions. Thus primate intelligence is not just social, but Machiavellian in its origins (Humphrey 1976). A loose definition of this type of social intelligence includes 'the ability to apply knowledge of problems', 'awareness of the world around' and 'social competence' (Whiten and Byrne 1988).

I am more concerned with ToM than Machiavellian intelligence, but the two overlap. A primate in a social environment, needs to have a rudimentary understanding of its conspecifics' psychology (Humphrey 1980) and this 'psychology' is ToM. The core framework for ToM is intentionality.

2.1.2. Intentionality

Dennett (1988) provides a framework with which to examine ToM known as intentionality. Intentionality does not mean the intent to undertake an action, but 'aboutness'. Two features of intentionality should be noted. First, mental propositions are referentially opaque. Two sentences may be connected logically but the mental component is resistant or opaque to the logic which would normally and automatically be associated with it. For example, consider the two statements: 'Mary kicked her donkey', and 'Mary knows her donkey is in the stable'. Since the donkey is a hoofed, herbivorous mammal, it follows logically that Mary kicked a hoofed, herbivorous mammal. But this second proposition is referentially opaque: Mary may know there is a donkey in the stable without knowing that there is a hoofed, herbivorous mammal in there. The aboutness of intentional terms is thus selective. This is more than an abstruse philosophical discovery; it offers a guide for borderline cases or precursors of the mental (Whiten and Perner 1991) such as early pretence (Leslie 1987). The second assumption is that the creature to whom intentional states are attributed is rational.

I intend to use intentionality as the skeleton upon which ToM can be fleshed out. According to philosophical and ethological usage, intentional levels are described as follows:

First order: Sarah *knows* that the bananas are in the box.

Second order: Sarah *knows* that her trainer *wants* to eat the bananas.

Third order: Sarah *knows* he *thinks* that she *wants* to eat the bananas.

This final stage is crucial for a full comprehension of belief-desire psychology.

However, Perner and Wimmer (1985) for example, as well as other psychologists, use a slightly different notation where they distinguish between the mental states of the subject (the mindreader) and the target. In what has been referred to as third order intentionality, they would speak of Sarah attributing a second order mental state to the trainer (he *thinks* she *wants*) and hence this would be called second order intentionality. Although I am going to use Dennett's definition, it is useful to realise the discrepancy in wording if not meaning between the two approaches.

Knowing another's mental states is sometimes referred to as mindreading; embedded mindreading is third order intentionality that refers back to the subject, e.g. I know that he knows that I want x. But as Dennett reminds us

> **...you wonder whether I realise how hard it is for you to be sure that you understand whether I mean to be saying that you can recognise that I can believe you want me to explain that most of us can keep track of only about five or six orders under the best of circumstances** (1988).

At the moment there is no hard evidence to show that nonhuman animals can understand third order intentionality. The achievement of this level of mindreading would imply that the animal not only had this ability, but was capable of deception, holding false beliefs and had a concept of self awareness. As Bennett (1976) states, "..if [a language-less creature] A can think that B thinks that A thinks that P... then a language-less creature can manifest a belief about his own beliefs."

Dennett believes that we may catch a glimpse of an animal's level of intentionality using the Sherlock Holmes Method. The great detective discovers the criminal by leaving something of vital importance to the criminal in a room, perhaps evidence that could lead to their conviction. He then calls "Fire!" and the person who rushes into the supposedly burning room to retrieve the item is the suspect. On a more practical level Smith (1977) suggests that "Intention...can be assessed from the animals' attempts to manipulate each others behaviour in terms of their own known goals, the communicator continuously adjusting its performance to the kind of responses it elicits."

2.1.3. Consciousness

Since an animal's body is a prominent feature of its own world, and contributes enormously to its sensory input, it seems likely that if animals are conscious, they are conscious of their own bodies. What is crucial is the extent that they are aware, i.e., whether they know that they are the subject of their own mental processes. According to strict behaviourists, it is more parsimonious to explain animal behaviour without postulating that animals have any mental experiences. Griffen (1991) has two arguments against this idea and these are dealt with in section 2.4.1.

The second framework with which I intend to examine mentality is Crook's (1983) guide to consciousness although it is less practical than Dennett's in terms of hypothesis testing because of the implicit assumptions made in it. Crook suggests that five levels of consciousness can be distinguished:

1. **Proprioceptive body awareness**: Closed loop systems monitoring the interdependence of bodily processes which involve continuous attention to inputs from many different sources. It is an inner feel from bodily states which may be important during rapid decision making.
2. **Awareness of situational contingency**: An awareness of the relations between bodily positioning and environmental situations such as prey attack. This requires an implicit reference to position of the self.
3. **Awareness of agency**: A continuous monitoring of body positions in time and space.
4. **Awareness of social agency**: A continuous monitoring of the relations between self and other in complex mammalian societies. This is likely to lead to manipulative or collaborative behaviour and may result in cheating.
5. **Linguistic self-consciousness**: Insight relating to inner feel and agency in behaviour leads to clear symbolization of self as an agent and the use of pronouns in language. As language develops the use of metaphor in expressions of knowledge means that consciousness becomes primarily concerned with meanings and awareness is constrained by words.

An example of level three consciousness is the foraging pattern of kestrels. They have spatio-temporal mapping of their territories. At certain times of the year they know exactly where to go in order to find the largest population of voles with pregnant mothers and juveniles. Ranging missiles that can monitor where they are in time and space and home in on a target also employ awareness of agency, but we would consider neither the missile nor the kestrel to have consciousness or self- awareness. It is only the last two levels that are considered to be fully blown consciousness and it is only with these that I am concerned. I have split each into two to give greater predictive power.

4. **Awareness of social agency**:

a. Animals react to each other on the basis of their behaviour. No mental states are required.

b. Animals react to each other on the basis of their knowledge of each others' mental states. At least second order intentionality is required.

5. **Linguistic self consciousness**:
a. Animals communicate with each other using referential communications, i.e., vocalizations that have meaning to both utterer and receiver and are not just emotional and involuntary responses.
b. Symbolization of the self as an agent and an understanding of pronouns in communication.

Attributing consciousness by a subject to a target requires three components (Crook 1983):
Empathy: defined as being when an animal identifies with the feelings and emotional states of another.
Analogical sympathy: in a nonemotional situation A, the subject experiences x, therefore, it knows that in A, the target will also experience x. Cheney and Seyfarth (1990) refer to this as being a 'good behaviourist'.
Concordance: vocalizations between subject and target using referential communication where the subject is intending to communicate its mental state to the target. The key feature of this processes is the confirmation of our attributions through mutual checking.

Empathy and concordance require at least level two intentionality. Analogical sympathy requires level 4.a. of consciousness and concordance requires level 5.a.

2.2. Experimental evidence for Theory of Mind in animals

2.2.1. Self awareness

The first test of self-awareness was Gallup's (1970) mirror experiment. He habituated chimps to mirrors and then anaesthetised them. While unconscious, red paint was daubed on their foreheads and wrists. On waking they examined the paint on their wrists but not on their heads. When given a mirror they rubbed the paint on their heads. Gallup concluded that this showed self recognition and self-awareness. Since his initial experiment, numerous replications have been tried with other primates but without much success. So far, fourteen species of New and Old world monkeys, two gibbon species and elephants have been tested. Rhesus and stumptail macaques were given one and a half years to get used to a mirror, yet these species still failed to recognise themselves (Povinelli 1991). Although Patterson's gorillas use mirrors as tools for self inspection and from her accounts, it does appear that they show mirror self recognition (MSR), they have not been given the mirror test with an anaesthetic (Patterson 1984. Organgutans can recognise themselves in mirrors (Suarez and Gallup 1981). However, Swartz and Evans (1991) conducted the mirror test on 11 chimps. Only one of them touched the red mark although several did show self directed behaviour using the mirror as a guide.

The failure of these experiments may indicate that primates other than some chimps have no concept of self-awareness. Alternatively, it may suggest that self recognition is not the same as self-awareness (Gergely 1994). Gallup states that MSR implies self-awareness and self-awareness is tantamount to being aware of being aware. Being aware of one's own mental states and their relation to various external events allows one to gain inferential access to the mental states of others. However, Gergely argues that 3 year olds show MSR but fail ToM and autistics lack ToM and have MSR thereby disproving Gallup's theory. He argues that there are a number of independent changes leading up to ToM and those that are preconditions for passing the test are: (1) the organism has to appreciate the duality between the projection of objects in the mirror and their relative position in the environment; (2) the organism must have the capacity to detect the perfect contingency relations between its body movements and the corresponding movements of its mirror image; (3) it must have constructed a visual feature representation of the physical appearance of the not-directly visible parts of its body; and (4) upon detecting the mismatch between the visual representation and the corresponding image in the mirror, the organism must be able to re-establish the mirror-reality-correspondence relation by modifying its self-representation through attributing the mismatching visual features in the mirror image to the representation of its body. Rhesus monkeys (Gallup and Suarez 1986), pigtailed macaques, elephants (Povinelli 1989) and infants less that 15 months old (Bertenthal and Fisher 1978; Lewis and Brooks-Gunn 1979) do not show MSR but they satisfy conditions 1 and 2. They can comprehend the duality implicit in mirrors and can locate objects in space other than themselves using the mirror. However, they do not seem to be able to construct a representation of the visual appearance of their nonvisible body surface in spite of extensive experience with a mirror.

There is a developmental aspect to MSR. Children do not acquire the ability to recognise themselves until 18-24 months (Lewis and Brooks-Gunn 1979); chimps do not show MSR until they are between four and a half and six years old (Povinelli, Rulf, Landau and Bierschwale 1993) and when children were given tests on delayed self recognition using a video camera and polaroid snaps, only 25% of 3 year olds (but all 4 year olds) would reach up and remove a sticker from their heads after seeing themselves on film (Povinelli, Landau and Perriloux, in press)

2.2.2. Communication

Cheney and Seyfarth's work (Cheney and Seyfarth 1990; Cheney 1984) shows that vervet monkeys are able to use vocalizations in a limited referential way. They have 3 different types of predator signal for snakes, eagles and one for leopards and caracals. When playbacks of a particular alarm call were conducted, the vervets reacted with appropriate behaviour for that type of predator, e.g. the snake call caused the vervets to stand on their hind legs and scan the grass. When one individual's alarm call was played until habituation, the monkeys still reacted correctly to a playback of its alarm call for a different predator.

The playback of acoustically similar grunts shows that the grunts 'mean' different things. A grunt given to a subordinate causes the dominant to look up and towards the speaker, whereas a similar sounding grunt given to another group caused the vervet to look away from the speaker.

The vervets were also able to form categories. Three groups of vervets have overlapping ranges. Intergroup encounter calls were played from group A and group C to group B. Calls were played from either the A range or the C range. Females and juveniles were used as they do not transfer from one group to another. They responded more strongly to a vocalization when it was played from an inappropriate range than when it was played from the vocaliser's own range.

Further evidence for representational signalling comes from a study of rhesus macaque screams (Gouzoules, Gouzoules and Marler 1984). Calls given by infants in aggressive incidents were discrete leading the authors to infer that the calls were not related to arousal level. Five different kinds of calls were given which correlated with the class of opponent and the level of physical aggression. From observations and playbacks of the screams to the mothers, it seemed that they gave differential responses depending on the perceived threat to her offspring.

Bekoff and Jamieson (1990) have argued that one of the real tests of intelligence would be to observe whether an animal took into consideration another animal's knowledge of a situation. This is known as the audience effect when one is dealing with vocalizations. For instance, if an animal calls when there is a predator about because the target has not seen it and if the subject does not call when the target has seen the predator, we could infer that the subject had ToM. Cheney and Seyfarth (1990) attempted to test this by exposing a mother and infant vervet to either a predator or food. In one scenario the mother and infant both knew about the food or the predator, but in the other, the infant was ignorant. There was no evidence that the mother was aware of her infant's mental state.

Although there is evidence of referential communication and limited syntax use in language-using apes, I am not going to discuss this. Whilst it appears they are using language in a rudimentary form by human standards, training an animal to use language, although informative, is not biologically relevant and may increase the animal's cognitive capacity above that of its non-language using conspecifics.

Vocalizations are not the only means of primate communication. Gestures, gaze and body language may also be used. Menzel (1975) hid objects in a chimpanzees' cage when only one chimp, the 'leader' for that day, could see it. All the chimps seemed to know where the object was as soon as they were released. When one of the objects was a toy snake, they rushed over making alarm calls and buried it in dead grass.

2.2.3. Empathy

In a study conducted by Borke (1971) it was shown that children as young as three had an awareness of other peoples' feelings and could identify the specific situations that evoke different kinds of responses. Happiness was the most easily recognizable emotion and the distinction between generalized unpleasant and generalised pleasant experiences was the most pronounced one. The children had greater difficulty relating to either sadness or anger. Borke suggests that this is because these are more complex emotions. It may be that happiness relates to desire fulfilment, whilst sadness and anger are associated with unfulfilled desires and beliefs, both of which children have more difficulty in attributing to themselves and others (see section 2.4.).

Very little research has been done on empathy in nonhuman primates and almost all the evidence is anecdotal in nature (O'Connell 1995).

2.2.4. Deception

Following from de Waal's (1986, 1982) publications of anecdotal evidence of deception, and Byrne and Whiten's (1985) paper on tactical deception in baboons, Whiten and Byrne analysed anecdotal evidence of deception (1988; Byrne and Whiten 1992). They defined tactical deception as "...acts from the normal repertoire of an individual, used at low frequency and in contexts different from those in which it uses the high frequency (honest) version of the act, such that another familiar individual is likely to misinterpret what the acts signify, to the advantage of the actor (see table 2.1.).

The tactical deception study aimed to collect data from all species of primates, but the results indicated that by far the greatest number of deceptive acts were seen in Cercopithecine species and Pan; of all the species, only chimpanzees showed nine of the thirteen categories of deception recorded. This may be observer bias and/or time spent studying these animals. (This is borne out to some extent by Mitchell (1991) who witnessed 21 instances of deception in captive gorillas in 81 hours of observation.) However, Byrne and Whiten (1992) in a further study of tactical deception were able to take sampling bias into account to an extent and showed that Papio and Pan still yielded disproportionately high records of tactical deception compared to the null hypothesis that rates in different taxa are truly equal and that the variation observed is due only to differing numbers of studies. Records were stringently categorised to determine what level of evidence was required before it could be determined whether a particular case study included deceptive behaviour. At the highest level, level 2 indicated that the primate could represent certain mental states of others. Level 1.5 indicated that the primate could understand how the world appeared from another's viewpoint which need not necessarily require the primate to mentally represent what the other could see. A record rated at level 1 or above needed to convincingly document (1) an animal being made to misinterpret the situation (2) by an agent who benefits from the misinterpretation (3) using a behaviour deployed tactically, i.e. not in the normal and expected way for the species. The numerical distribution of records that were rated level 1 or above are shown in figure 2.1. Figure 2.2. shows the distribution of records for tactical deception for those reports that implied higher order intentionality - level 1.5 and 2. Only one record of monkey behaviour suggests an ability to impute intentional states. Byrne and Whiten (1992) refer to behaviour which they rate as level 2 as 'lying' since it requires the attribution of intentionality in a deceptive manner. The only evidence I have come across for lying in sign language using apes has been from gorillas (Patterson and Cohn 1994; Patterson and Linden 1981).

Table 2.1. Types of tactical deception (after Whiten and Byrne 1988).

Concealment

The agent's behaviour functions to conceal something from the target.

Hiding from view: The agent hides an object, or a part or whole of itself, by screening it from the target's view.

Acoustic concealment: The agent acts quietly, such that the target's attention is not attracted.

Inhibition of attending: The agent avoids looking at a desirable object when such looking would lead one or more targets to notice it.

Distraction

The agent's behaviour functions to distract the target's attention away from some locus at which it is directed, to a second locus.

Distract by looking away: The agent distracts the target's attention from one locus by looking away at another locus in such a way that the target also looks there.

Distract by looking and vocalization: The agents distracts the target's attention by looking away at another locus and vocalising in such a way that the target also looks there or at least loses the original focus of attention.

Distract by leading away: The agent leads the target away from the first locus to another one, allowing the agent to return to the first location free of competition.

Distract with intimate behaviour: The agent shifts the target's attention to some part or extension of its own body, which is highlighted posturally or gesturally.

Creating an image

The agent's behaviour functions to create an impression which, rather than merely affecting the target's attention as above, causes the target to misinterpret the behaviour's significance for itself in other ways.

Present neutral image: The image is non-threatening just in the sense that it is of little or no significance to the target.

Present affiliative image: The image is not merely neutral, but is affiliative.

Manipulation of target using social tool

The agent manipulates one individual, the 'social tool', so as to affect the target to the agent's advantage.

Deceive social tool about agent's involvement with target: The agent's behaviour misleads the social tool about the significance of the involvement of the agent with the target.

Deceive social tool 1 about social tool 2's involvement with the target: The agent's behaviour misleads one social tool about the significance of the involvement of a second social tool with the target.

Deceive target about agent's involvement with social tool: The target is deceived about the significance of the results of the agent's action on the social tool.

Deflection of target to fall guy: The function of this behaviour is to divert the target who poses a problem towards a passive victim, the fall guy.

Figure 2.1: Numerical distribution of records of tactical deception (i.e. level 1 and above) across taxa of primates showing evidence that individuals can cause others to be misled. Taxonomic levels have been chosen for grouping species as appropriate to the amount of data available. Note that for each species studied by each observer, each type of deception reported is counted only once; the real number of records is thus often much higher than these counts (after Byrne and Whiten 1992).

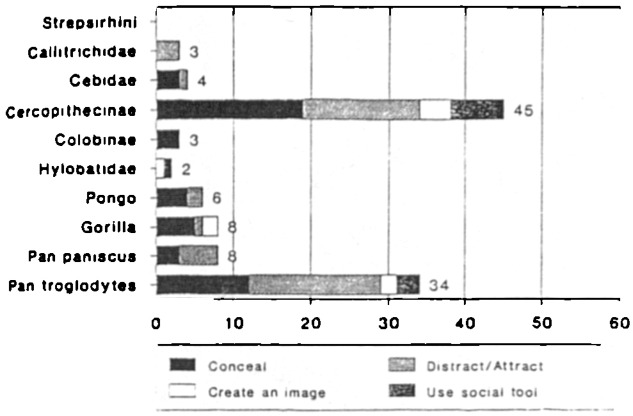
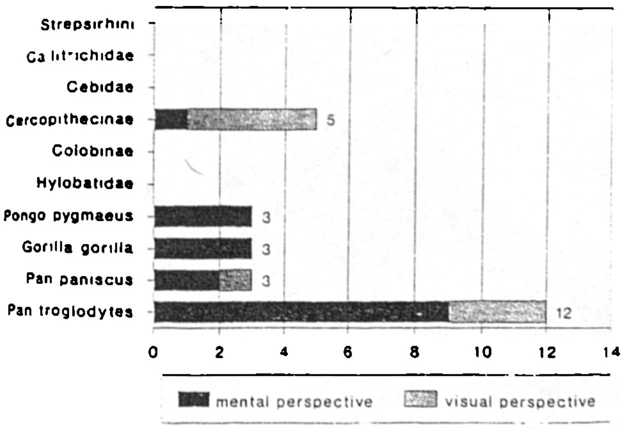


Figure 2.2: Numerical distribution of records of 'higher-order' tactical deception (i.e. level 1.5 and 2) across taxa of primates, showing evidence that individuals can adopt the perspectives of others (after Byrne and Whiten 1992).



2.2.5. Play

Russon (1990) has suggested that there is a high degree of similarity between human and chimpanzee play in the early stages of infancy. Both babies and young chimps show play faces at about 4-5 months. Object play is seen in chimps at 4-6 months and in humans at 6-8. Chimps are also ahead to begin with in sensory motor ability at 4-6 months; this kind of behaviour only appears at 9-10 months in children. Chimps are more concerned with possessive use of objects such as taking them away from one another, whereas humans use the objects' features such as building towers out of blocks and playing ball games. Both appear to comprehend the difference between animate and inanimate objects (Dienske 1986).

Play is a controversial subject. If one assumes that animals do play and that play has a function such as improving locomotory capacity and other skills as well as helping the subject to form social bonds (Smith 1982) then it is possible to examine the cognition of play. Bateson (1955) claims that in primates play could only occur if the participant organisms were capable of some degree of metacommunication, i.e. of exchanging signals which carry the message that this behaviour is play.

2.3. How do children see the world?

It is thought that children do not acquire ToM until they are 3-5 years old. The acid test of intentionality is whether children can not only comprehend third order intentionality but can also understand false beliefs. One way of testing for ToM is to show a child a Smartie box and ask her what she thinks is in the box. When the child answers 'Smarties' or 'sweets' she is shown that there are cake candles (or pencils) inside. She is then asked either, 'What did you think was in the box?' or else, 'What does your friend think is in the box?' If the child has the ability to represent another person's mental states, she will say that the other child will think there are Smarties in the box. Children younger than 4 are usually unable to do this and suppose that everyone knows there are candles inside (Perner, Frith, Leslie and Leekam 1989). This age group is neither capable of understanding a false belief and nor remembering that they had originally thought there were Smarties inside (Astington and Gopnik 1991). Thus young children do not seem to differentiate between knowing that they know and knowing that another knows when dealing with false beliefs.

However, children can remember unfulfilled desires. In the context of a game, children were asked to express a desire which was fulfilled or unfulfilled and they were then asked to recall their original desire. In experiments using toys as the 'desired' object, 79% of 3 year olds and 88% of 4 year olds said they had not got the toy they wanted when their desire was unfulfilled (Astington and Gopnik 1991).

This indicates that 3-4 year olds can operate using belief-desire psychology. Although 2 year olds may not be able to understand beliefs, Wellman (1991) believes they may still be capable of understanding desire psychology. A group of 2 year olds were told a story with a doll character who wanted an object which was in one of two locations. There were three scenarios: finds-wanted - the character gets what she wants; finds-nothing; and finds-substituted, where the doll found an attractive object in the location she was looking, but not the one she wanted. Children then had to predict the character's subsequent action: whether she would search in the second location or stop looking. Two year olds appropriately predicted continued searching in the Finds-nothing and the Finds-substituted situations and also that the character would be sad in these cases but happy in the Finds-wanted one (Wellman 1991).

Wellman and Bartsch (in Wellman 1991) analysed 10,000 natural child utterances and concluded that genuine reference to desire using 'want' began very early, even before the second birthday, with belief terms such as 'think' and 'know' being used much later, around age 3. They showed that reference to desire was well established by the age of two, and that reference to belief begins at about age three. Two year olds clearly distinguished their own desires from those of others, but it was not until they reached 3 years of age that they could distinguish their beliefs from other peoples'. References to self-other were comparatively rare, but again indicated that children refer to desires before beliefs. However, it is as yet unclear whether children as young as two fully understand the meaning of the words they use. Indeed, Wellman states that children refer to beliefs by age three, but children do not usually pass the false belief tests until age four to five (Perner 1991; Wimmer and Perner 1983).

The difficulty for children in making these distinctions lies not so much in the internal state of the knowledge but in their inability to represent and conceive of the transference of mental states according to Perner and

Ogden (1988). They showed that no 3 year olds and few 4 year olds could understand that the transfer of information led to knowledge, although they understood that eating led to satiation. The latter is similar to knowledge in that it is an internal state. Perner and Ogden believed that this was because children of that age do not perceive the mind in terms of internal representation but in terms of situational attitudes. That is, they understand themselves and other people as having mental attitudes towards situations. Expressions like 'Ahmed wants X' or 'Sunita pretends Y' are seen as either real or imaginary depending on the situation, and are understood as a situation, not a mental representation of a situation. Leslie (1987) differs from Perner as he sees pretence as an indication of metarepresentation: a representation of a representation.

Perner's theory (that mental states are understood by children in the form of situational attitudes) may be correct for the following reasons: (1) children find it difficult to comprehend false beliefs and to believe that their beliefs were once wrong; (2) they tend not to understand that a person can have both positive and negative beliefs or character traits at the same time (Miller and Aloise 1989); (3) children seem to be able to infer psychological states, but below 4 and even up to 7 years of age, they do not fully discriminate between 'guessing', 'knowing' and 'remembering' (Miller and Aloise 1989, Povinelli 1991, Povinelli et al 1992); (4) autistic children are thought not to possess ToM and yet many of the competent adult autistics can act as if they have ToM. Tests show that is unlikely that they have acquired ToM; rather, they have gained the ability to predict - to a limited extent - peoples' actions by inferring what their psychological states might be without explicitly knowing that others do have mental states (Happé pers. comm.). It may be the case that they, like young children, see the world in terms of situational attitudes as Perner has suggested.

Autism is a disorder which may help to shed light on our comprehension of ToM. Autism is thought to result in a lack of ToM and leads to impairments in imagination, socialisation and communication (Frith 1989). Happé and Frith (1992) believe that both primatologists and psychologists would benefit from a closer understanding of each others' work. They think that even if autistics do not have ToM they can manipulate behaviour to achieve a desired end (by sabotaging a game, for instance). This seems to indicate an understanding of goal directedness and a rudimentary knowledge of desires as drives; both of which also seem to be present in some primate behaviour, even though ToM has not, as yet, been proven in their case either.

Both Happé and Frith (1992) and Gomez (1992) draw a distinction between protodeclarative and protoimperative communication and discuss its implications for nonhuman primates. According to Happé and Frith (1992), during protoimperative communication, a word always means the same thing, i.e. an autistic who says 'apple' always means 'give me an apple'. Protodeclarative communication is ostensive-inferential: it conveys the subject's intention to transfer a piece of information which may be context specific. For instance, pointing at a toy may mean 'look at that toy' or it may mean 'give me that toy'. Happé and Frith say that neither autistics nor nonhuman primates are capable of the latter type of communication as they do not possess a ToM capable of systematically representing and manipulating intentions.

Leslie (in Leslie and Frith 1987) believes that protodeclaratives underlie ToM since they are the more complex form of communication and require metarepresentational capacities. The goal of a protodeclarative gesture may be to share experiences or an interest in an object or even with another, and this requires the ability to represent the other's mental states; at the very least, an ability to represent another person perceiving and being interested in something.

Gomez (1992) however, disagrees. At about one and a half years old, his gorilla began to treat a person as a subject. When making protoimperative gestures she looked the person in the eyes and used a combination of joint attention behaviour and gestural activity to initiate the request. This attention checking and visual contact is also seen in human children and seems to imply some understanding of other peoples' mental processes (See Butterworth 1991 and Gomez 1991) of at least first order intentionality. This led Gomez to suggest that protoimperatives may be as important as a precursor to ToM as protodeclaratives. Just as Gomez can scale up protoimperatives to first/second order intentionality, one can scale down protodeclaratives. In the case of the latter, the goal of the subject may not be to provoke a mental experience in another but an emotional or attentional reaction. The subject seeks to provoke the external sign of having an experience in a target, e.g. a smile or a directional gaze. Still, there does seem to be a difference between protoimperatives and protodeclaratives. Gomez says "..what we know is that normal infants, autistic children and anthropoid apes are able to use some attentional cues to perform requestive functions, but only the former use them to perform protodeclaratives."

Although Happé would agree with the above, she disagrees that protoimperatives always indicate first order states of mind; instead she believes that they can show metacommunication: not that the subject wants x, but that the subject wants the target to know that it wants x, which is the equivalent of third order intentionality or embedded mindreading (Happé pers. comm.)

There has been very little research done in this area. Gomez suggests that autistics do not fully understand the meaning of other peoples' vocal and facial expressions (Baron-Cohen's concept of mind-blindness 1990). Hand-reared primates may be sensitized to human facial expressions, but we do not know whether they do communicate using protodeclaratives in the way that Gomez has indicated. Furthermore, It seems that there is some confusion over what exactly protoimperatives and protodeclaratives can and do mean. What these gestures mean to another individual is likely to be context dependent and will also rely on the intellectual capacity of the signaller for their interpretation, for example, a gesture by an autistic person and a normal person may look the same but may have different meanings.

2.4. Two approaches to understanding animal cognition

2.4.1 Griffen

Donald Griffen's original claim to fame was as the discoverer of bat echolocation (Griffen 1958). Over the past decade or so, he has turned his attention to the problem of animal consciousness and has written a series of books which, whilst theoretical, nevertheless, rely very heavily on published reports of animal behaviour to back up the claims he makes. In this section, I am going to outline what I consider his major arguments are, and then discuss them.

Griffen believes that an animal may be considered to experience a simple level of consciousness if it subjectively thinks about objects and events. Since an animal's body is a prominent feature in its own world, and contributes enormously to sensory input, it seems likely that if animals are conscious, they are conscious of their own bodies, and to this extent are self-aware. Many scientists require an animal to have propositional self-awareness: that it is able to think, "It is I who am smelling that food." Griffen argues that we should leave this question aside until the simpler levels of consciousness are proven (Griffen 1991). He says that

> **If we allow a particular animal to be aware of a reasonably wide range of objects, events and relationships in the world around it, while denying the possibility of self-awareness, we run the danger of redefining self-awareness in a roundabout way as a sort of perceived hole in the universe.**

He adds that self-awareness is assumed to be a trait possessed only by our own species, but that direct evidence for this is almost nonexistent (Griffen 1978).

In his most recent discussion of simple consciousness, he has moved a little way from his earlier intellectual position where he talked about consciousness in much the same way as every one else: by giving lists of which activities require consciousness. In 1984 he said that the most essential aspect of consciousness was the ability to think about objects and events, whether or not they are part of the immediate situation, and that only animals capable of being in conscious states, were able to perform free voluntary movements. He quotes Armstrong who said that being conscious was being able to perceive one's own mental states. Armstrong gives the, by now well worn, example of driving a car. Once we learn to drive we can do so almost automatically and with very little concentration or thought. However, if another car swerves towards us we immediately concentrate on what we are doing. Most animals may spend their lives in this state of automatism, suggests Armstrong, but true consciousness is the perception or awareness of the state of our own mind, a 'self scanning mechanism in the central nervous system' (Griffen 1982). In some ways this is akin to Ryle's distinction between knowing *how* and knowing *that* (Ryle 1949 - although he says that in humans, 'knowing' requires both). Applied to animals, it is widely held that they may know *how* to perform complicated patterns of behaviour, but they do not have the understanding *that* they are performing such actions.

According to strict behaviourists, it is more parsimonious to explain animal behaviour without postulating that animals have any mental experiences. Griffen has two arguments against this idea. The first is the argument from physiology. Neurophysiology has so far discovered no fundamental differences between the structure or function of neurons or synapses in humans and other animals. Thus, unless one denies the reality of human mental experiences, it is actually more parsimonious to assume that mental events are as similar from species to species as the neurologicial processes are. This implies a continuity, though not identity, of mental experiences among multicellular animals. Griffen says that the belief that mental experiences are a unique attribute of a single species is not only unparsimonious, it is conceited (Griffen 1978).

The second argument comes from the parsimony of postulating consciousness in animals.

> **The ability to think about the probable results of alternative actions and to choose the one most likely to achieve a desired result is especially valuable when animals face unpredictable problems in carrying out important activities such as obtaining food, avoiding predators or other hazards, seeking mates or raising young** (Griffen 1991).

As Popper says, a foolish impulse can die in an animal's head rather than lead it to needless suicide (Popper 1972).

To deal with Griffen's first point: he claims that because neurophysiology is basically similar throughout the animal kingdom, there is a continuity of mental experience. This is a little like saying that there is a basic similarity between the chemicals that we are composed of and those of some types of rock, therefore, humans and rocks must share a continuity of life experiences. Obviously this is an exaggeration of the claim that Griffen is making, but to pursue the point, rocks and humans do share a continuity of life experiences to some extent: we are both subject to the vagaries of the climate and should we remain outside for long periods of time, both will become damaged, or changed. However, the similarity we have to rocks is almost negligible, and it is our *reactions* to outside forces that is one of the crucial differentiating factors. To return to Griffen's point, we do not fully understand the neurological basis for the acquisition of knowledge, nor what structural similarities or differences in the brains of various species might entail. Even if we knew how a person would react when their brain was in state X, it does not necessarily follow that another animal whose same portion of the brain is in state X will a) react in the same way, and b) feel the same way.

Secondly, there may indeed be a continuity of mental experiences between us and mammals, but this does not mean that there is in other animals. This is not to say that a squid, for example, is not highly intelligent and possesses a form of consciousness, but the empathy we have for mammals derives from experiences we know we share: mate bonding, social bonding, suckling of young, care of offspring, and because we know we inhabit a very similar environment. This is probably a failing - albeit a reasonable one - on our part: we can't imagine what it is like to be a squid. Hence I would argue that the mental experiences of animals that are very different from ourselves and which live in completely different environments are not going to be continuous with ours. I do not deny, though, that they may be as likely to have mental experiences as mammals are.

Finally, although there may be phylogenetic continuity between us and other animals, this does not necessarily mean that there is a mental continuity. Povinelli, for example, posed two distinct phylogenetic trees showing how the mental capacity of great apes (including ourselves) may differ (see figure 2.3. and section 2.4.2.). In Griffen's defense, I would like to say that as a species, one of our limitations is in dealing with gradation, we like to see things in black and white with neat cut off points, preferably between us and other animals. Should someone discover or recreate our recent ancestors, I think we would be faced with serious problems over how we ought to deal with them precisely because of this general inability .

Griffen's second point is the argument for consciousness from parsimony. The brief response is: not necessarily and it depends on what is meant by consciousness. The lower levels put forward by Crook (proprioceptive body awareness, awareness of situational contingency and awareness of agency) would be a parsimonious definition of consciousness. At a higher level, it is unclear whether and how many times (other than in ourselves) consciousness has evolved; the absence of animals as obviously intelligent as ourselves suggests that higher level consciousness is not a definite possibility in evolution (unlike, say, limbs for locomotion in land living animals) and that consciouses may be costly to run (our brains use 20% of our energy budget).

Griffen is unique in the way in which he has interpreted the kinds of animal behaviour which most scientists take for granted. For instance, he says that the ability to abstract salient features out of a complex pattern of stimulation, often involving more than one sense, requires a refined ability to sort and evaluate sensory information so that only particular combinations lead to the appropriate response. The example he gives is of a lion seen by a gazelle. The antelope recognises the lion for the predator that it is from whatever angle or distance and in most cases can also ascertain whether the lion is a danger at that particular moment (Griffen 1984).

In response to this, I'd suggest that these abilities (without denigrating their importance or complexity in any way) are likely to be at least partly genetically hardwired. Consciousness also obviously arises from a genetic basis, but this hardwiring allows a flexibility in the software. Thus to see a behaviour that is likely to be a genetically inherited pattern of behaviour, does not mean that it is a conscious behaviour. Griffen deals with this problem to some extent as I have outlined below.

He postulates two major approaches to solving the problem of animal cognition. First, he says that we may infer conscious mental states when an animal completes an action which may or may not be genetically determined, but does so in a novel or varied way. Some green herons fish using bait. They use different kinds of bait and may even modify it, breaking a twig to the appropriate length, for instance. The trait has not spread throughout the whole population.

Secondly, communication may offer a window with which to view animal thought. Communication allows experimental verification, and he suggests the following framework.

Communication...may involve any of three kinds of relationships, alone or in combination:

1. The message may relate directly to the animal's perception of the immediate situation, that is, it may report about current sensory information.
2. The animal may report about information acquired at an earlier time and stored as some sort of memory.
3. The animal may announce an intention or a plan for future behaviour (Griffen 1978).

An important distinction to note here is between 'brute' and 'institutional' facts (Searle 1969). The former are physical or mental data or relationships that do not depend on social rules, whereas the latter are rules embedded within a social matrix. The latter is important for the interpretation of animal communication. For instance, a brute fact about a honey bee is that a bee with a stomach full of two molar sucrose recruited 77 of her sisters by a waggle dance 90° to the vertical. This makes no sense unless one knows the social rules that provide a framework within which these actions become meaningful.

Griffen's first point is that consciousness can be seen when a behaviour is varied in a novel way by the animal. He gives the example of a green heron fishing. Let me give a similar example. On the Galapagos islands, woodpecker finches use twigs to fish for insects in crevices. They have been observed to correct their hunting procedure. One individual was seen trying to break a twig in two that had proved too long, and another picked up a forked twig, found it too difficult to work with and turned it round. Does this prove they have consciousness? What may have happened is that over evolutionary time, finches learned by accident how to fish by failing to remove a piece of bark from the entrance to a hole in a branch, accidentally pushing it into the hole and touching the prey which moved towards the entrance. Operant conditioning on individual birds could have induced more intentional fishing behaviour, and genetic assimilation may have taken place in the population as a whole. Birds with a greater capacity for trial-and-error learning would imitate those who invented the technique and thus survive at a higher rate. In time the population would then contain not only brighter birds but those with an instinct hardened to pick up and manipulate sticks in the first place (Grant 1986). Examining how an animal or a species has learnt a novel behaviour which is analogous to fishing in the green heron shows how learning theory and genetic programming can produce this type of behaviour and does not prove the argument for or against consciousness.

Another example nearer to home is hominid tool use. Nicholas Toth specialises in trying to recreate hominid tools. *Homo habilis*, he believes, made tools opportunistically; the various shapes were determined by the original shape of the raw material. The appearance of stone hand axes date from the emergence of *Homo erectus*. It took Toth and co-workers several months to learn how to make these axes and he concludes, first, that the toolmakers had a mental template of what they wanted to produce and were intentionally imposing a shape on their raw material, and secondly, that they had a mental capacity above living apes (Leakey 1994). I do not doubt that these hominids shared many of our traits, but the point I want to make is that simply because a conscious human can, after an initial struggle, imitate complex behaviour produced by a creature which, in this case, we have reason to believe is evolutionarily close to us, we cannot necessarily infer that they were conscious in the same way that we are.

Griffen's second argument is that communication can allow experimental verification for the content of animal minds. The first two points he makes, on animals using current sensory information and reporting about information stored in the memory, do not, I feel, really count. All animals are able to use sensory perception to react to their environments, and animals have memories, some of prodigious capacity such as hoarding animals who are capable, in some instances, of storing and remembering the location of thousands of nuts. This ability, stunning as it may appear to us, again looks like a product of learning (which is not self-aware and does not show high level consciousness) and genetic hardwiring. Where Griffen does appear to be on the right track is in point 3, where he says we may use an animal announcing an intention about future behaviour as a clue to its thought processes, although he does not give examples to illustrate his point. The key word is announcing. A bird building a nest as a plan for future egg-laying does not prove that it has a concept of what it is planning. A bird building a nest may inadvertently 'announce' to ethologists what kind of behaviour they can expect, however, the bird does not intend to announce to anyone what it is planning. Therefore, intentionality in the form that Dennett used, rather than 'intent to', should also be included in this point.

The crux of this whole question is not really whether animals have lower level consciousness as defined by Crook. In my opinion, it is whether they have the ability to transcend this to a higher level of consciousness which necessitates an implicit, or semi-implicit understanding of what it is that they do in their daily lives, even if not the capacity to have full blown self-awareness and the ability to be self-reflective. Griffen seems to conflate the subjective experiences that animals surely must have, with the idea that if they have subjective experiences, they then have the ability to think.

In summary, Griffen has immeasurably enriched the field of cognitive ethology. The conclusions he arrives at and, to naive readers, seemingly blanket application of consciousness, may be unpalatable to some. Nevertheless, he has raised questions that others were afraid to pose, increased awareness of the issue and initiated an atmosphere in which others may come forward to fill in the blanks in his theory. One of his more subtle but important contributions was not his stress on the continuity of animal consciousness, but rather his questioning of our preoccupation with mammals as the only creatures capable of having any mental experiences. We may find intelligence in pockets rather than in a neat, linear pattern increasing up the phylogenetic tree. The search for animal thought could turn out to present a patchwork mosaic of consciousness.

2.4.2. Povinelli

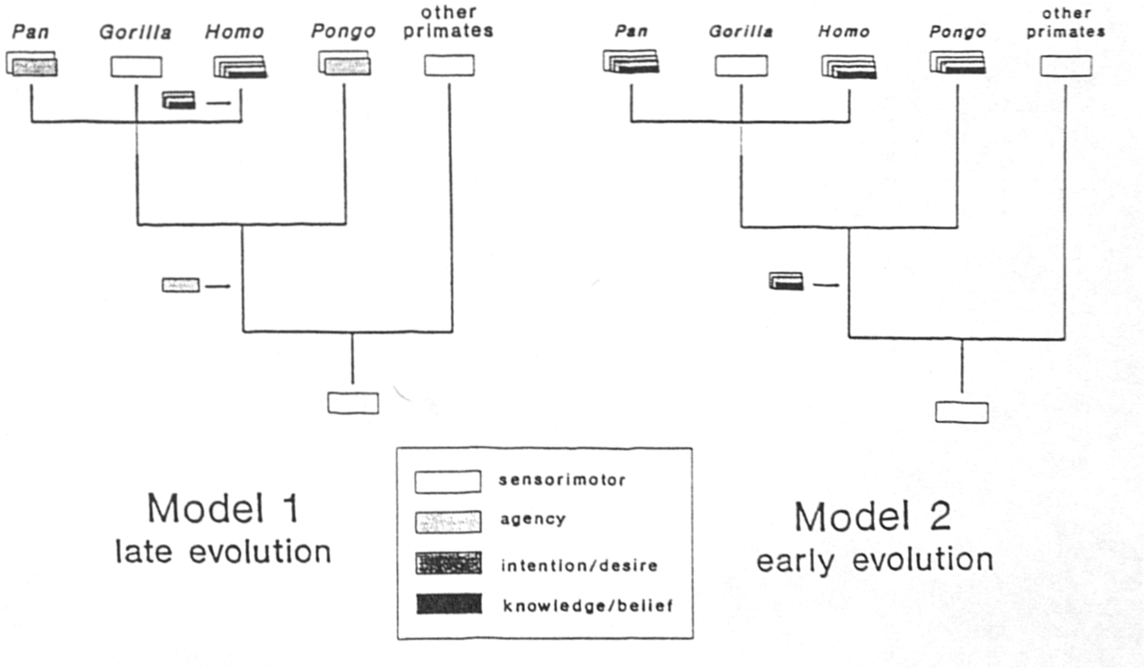
Daniel Povinelli, the director of the New Iberia Research Centre, in South-West Louisiana, is an empiricist. He has, however, recently written some rather more theoretical work. I will discuss his ideas on 'psychological evolution' before examining some (but by no means all) of his most critical experiments on ToM. He writes

> **As evolutionary biologists interested in aspects of the evolution of human cognition, we see comparisons of psychological development within the great ape-human clade as offering an ideal method of determining which features of human cognition are exclusively derived in the human lineage. For example, by carefully comparing the psychological development of chimpanzees, orangutans, gorillas and humans, we will ultimately be able to specify where in their development they diverge, in which directions, and ultimately for what reasons.** (Povinelli and Eddy in press).

They propose two models (see figure 2.3.) for the great ape-human clade. In model one, the 'capacity for conceiving of agency' evolved in the ancestor of the great ape-human clade and is shared in most descendants of this group. Unique evolution in the human lineage, including most conceptual capacities underlying understanding of mental states per se, occurred later. In model 2, the bulk of the development pathways governing mental state attribution evolved in the ancestor of the great ape-human clade and are thus present in most of the descendants. In both models, gorillas are represented as having undergone unique evolution resulting in the reversal of certain character states such as physical growth and maturation rates. There may be unique innovations in other lineages as well. These two models represent fairly extreme ends on a spectrum of possibilities concerning the exact timing of the evolution of mental state attribution.

Povinelli conducted two major experiments on guessing and knowing and role reversal in chimps, both using the same piece of equipment which consisted of a table with two pairs of covered food cups in the middle. On one side of the table were handles, and by pulling one set of handles, one of the food cups would slide to each end of the table. In the role reversal experiment (Povinelli, Nelson and Boysen 1992) food was hidden by an experimenter out of sight of a stooge. Two of the chimps were trained as informants and had to point out to the stooge in which of the cups the food had been hidden. The other 2 chimps were trained as operators. They did not see where the food had been hidden. When a human informant pointed to the cup in which the food was hidden, the chimps learnt to pull the right set of handles. Either comprehending pointing (the operators) or being able to point (the informants) to the correct food cup resulted in both stooge and chimp obtaining the food reward. The roles were then reversed and 3 out of 4 chimps showed immediate comprehension of the new task. No rhesus macaques showed evidence of role reversal (Povinelli, Parks and Novak 1992). However, on closer examination of the evidence, during the transfer test, Sarah, performed at chance level. Her performance then improved. The performance of the other 3 chimps initially deteriorated but still remained above chance levels. Two of the monkeys did eventually learn to respond appropriately, but the researchers felt that on examination of video evidence they showed no comprehension of their new social roles.

Figure 2.3: Two models for the cognitive evolution of the great ape-human clade (after Povinelli and Eddy, in press).



Povinelli, Nelson and Boysen (1990) then conducted an experiment with chimps on inferences about guessing and knowing. An experimenter hid food in the food cups whilst one person, the Knower watched. A third person, the Guesser, remained out of the room while the food was being hidden. Both Guesser and Knower then pointed to the covered food cups. Whomever the chimps pointed to, would pull the handles of the table to allow the food cups to slide towards themselves and the chimp. However, since only the Knower knew where the food was, the chimps would only obtain a food reward by pointing to him or her. Three out of four chimps were able to pass this test. A second version of this task required the Knower to wear a blue hat. S/he then passed it to the Guesser when s/he became the Knower. This discriminative cue seemed to have no effect on the chimps' performances. The final procedure was that both the Guesser and the Knower stayed in the room, but the Guesser placed a paper bag over his/her head. Sarah did not give responses that were above chance on this section, and although the others did, the percent of correct scores dropped in all but one chimp.

It seems strange that Sarah did not pass this test and was also the worst in the transfer stage of the role reversal experiment when she was the oldest (one could argue that if chimps have the capacity to understand that seeing leads to knowledge, she ought to have developed it) and had had the most human contact and language tuition. Another criticism which the researchers raised was that they were forcing the chimps to choose between simultaneous and contradictory sources of information which might have been unnatural and difficult for them. In an unpublished experiment conducted in 1988, Premack set up a similar situation with very young chimps who pulled the trainer that knew where the food was towards them using a piece of string. No pointing was involved. They achieved significantly correct responses in 24 trials. Despite the fact that the chimps in Povinelli et al's experiment did have scores that were significantly above chance, they did not score that highly. Darrell, for instance, a typical example, chose the Knower 62% of the time, which is not far above a random level.

Povinelli et al argue that the chimps could have been using a rule - 'select person who remains in room', but that when that person remained in the room with a bag over their head, they had no basis for making inferences about the state of knowledge that results from those conditions. It does seem as if the chimps were using a rule, at least to begin with since they had so many trials (10 a day for about 4 weeks, although this aspect of the experiment is not clearly dealt with). That 3 of them could chose the Knower when the Guesser was wearing a bag does not necessarily mean that the chimps knew the Guesser was ignorant about the location of the food. The alternative is that they used another rule - 'choose person without a bag over their head'. This would accord with the initial drop in their responses and show that they were able to learn a novel variation of a task quickly after such extensive training.

There was no evidence that macaques could tell the difference between the Guesser and the Knower (Povinelli, Parks and Novak 1991). One monkey was even trained using an explicit cue - a pink glove, but was not able to use this cue when the Guesser remained in the room. The monkeys did not use simple rules, such as always choosing the same experimenter. Three of them had 600 trials each and one had 800.

A version of this experiment was conducted on 3 and 4 year old children (Povinelli and de Blois 1992). Three year olds were not able to point to the Knower and neither were they able to verbalize why they didn't know where the reward had been hidden. Four years olds were able to give correct responses to both the verbal and the nonverbal aspect of this task. One four year could not, and could not give a correct explanation why not either, leading Povinelli and de Blois to suggest that it was not the children's age per se that led to their success or failure, but rather that the child had reached a certain developmental level; the term 3 year old, they suggested, should be abandoned in favour of a more narrow definition of age classes. They felt that the results from this experiment justified its claim to test the subjects' understanding of the relationship between the perceptual act of seeing and the resulting mental state of knowing. They added, "3 year old children, although they have been both producing and responding to pointing for nearly 2 years, do not appear to be aware of how it functions to create knowledge in themselves."

The main criticisms I have of this work on chimps are that a) small sample sizes were used; b) the chimps were all different ages and sexes; c) they were very familiar with humans and test situations: 3 of them had been used in cognitive studies (one-to-one correspondence, colour discrimination, use of colour as an attribute, drawing, cross-modal discrimination, same-different concepts and numerical competence), and Sarah had had extensive linguistic practise; d) a huge number of trials was given to the chimps, in total about 430 each in the guessing and knowing experiment and between 250 and 750 for the role reversal study; and e) pointing is not something which chimpanzees or monkeys do naturally. Povinelli has taken some pains to demonstrate that it was not unnatural behaviour: some of the chimps used 'pointing' that was similar to a begging gesture and the role reversal study was replicated using a rhesus macaque that had spontaneously pointed since she was an infant (Hess, Novak and Povinelli 1993). Moreover, he argued that pointing, even if somewhat unnatural, was acceptable, since the children were required in the experiment described below to use an unnatural gesture, namely, placing their hand through a wire mesh and putting it palm down on a painted handprint. This is a spurious argument since giving one species an unnatural manoeuvre does not make it acceptable to give both species an unnatural one. Children play games with their parents, peers and teachers from a young age and the 'hand print' gesture may have been simply another game to them. My final criticism is that Povinelli makes little or no acknowledgement of the animals' natural history when devising experiments.

Povinelli has rectified criticisms a), b) and to some extent, d) in his new research programme. The chimps he and Eddy (in press) used for a battery of 15 tests on seeing and knowing were within 8 months of age of each other and the sample size was 6-7. The chimps were asked to point to one of two experimenters in order to be rewarded with food. In the base line trials, one experimenter had a block of wood and the other had some food. In the 'probe' trials, one of the experimenters had their vision occluded in some way, for instance, they would both wear blindfolds, but one would wear it over their eyes and the other over their mouth. These probe trials were slotted in between the base line trials in blocks of ten. From the results, Povinelli and Eddy felt that a) young chimps develop algorithms in order to track gaze; and b) learn rules about the configuration of faces and eyes on the one hand and subsequent events on the other. They thought that there was no evidence to suggest this was embedded in a matrix of intentionality. They arrived at these conclusions because none of the chimps showed an immediate disposition to gesture towards the person who was visually connected to the situation. In 4/5 naturalistic treatments (hands-over-eyes, looking-over-shoulder, eyes-open-versus-closed and attending-versus-distracted) the subjects showed no immediate appreciation that only one of the experimenters could see them. The subjects showed a learning curve within the blocks of trials and also throughout the whole battery of tests. Povinelli and Eddy's final conclusion was that whilst one cannot be certain and it is important to remain open-minded, in both chimps and young children, evidence of mutual gaze and gaze monitoring only demonstrates that they have learned that eyes provide important clues about the behaviour of others and does *not mean that they* understand how looking is linked to any mental state in the agent. They sum up their work by saying, "we feel comfortable concluding that despite their striking use of (and interest in) the eyes, 5-6 year old chimpanzees apparently see very little behind them."

However, by experiment 7 the chimps performed significantly above chance. The chimps may have been learning what they were being required to *attend* to, rather than learning set rules of thumb. In subsequent trials, the chimps performed better and started giving correct responses earlier even though the task was novel. In addition, the results from the children they tested casts doubt on the validity of the task as a measure of understanding visual perception as a knowledge acquisition device. Three year olds, who would normally respond badly to this kind of experiment, had no problem immediately gesturing selectively to the person who could see them. Moreover, 5-6 year old chimps may not have developed the cognitive capacity required. Young children are able to recognise themselves in a mirror by the time they are 18-24 months old; 4 of the chimps could recognise themselves in the mirror, but did not learn to do this until they 3-4 years old and the other three still could not do so. Thus if a genuinely mentalistic appreciation of seeing does not emerge until two to two and a half, and if chimpanzee psychological development is slower, one might not expect to see evidence for this ability in chimps younger than 6. The latter is backed up since Povinelli (1994) tested 6 three and four year old chimps and none showed an appreciation that seeing leads to knowing using the model for guessing and knowing that he had tested the older chimps with.

In summary, his latest feelings on the matter are that "it is impossible to say with much definitiveness what chimpanzees really know about the mind. They clearly act *as if* they understand intention, knowledge, and possibly belief; but the extent to which that behaviour is supported by learned or inferred rules remains uncertain," (Povinelli 1994). Overall, no other researcher has done so much in such a short space of time to rigorously investigate ToM in nonhuman animals. Whilst he has become far more sceptical of the mental abilities chimps are capable of, he is an example to ethologists working in this field, for he is open minded and retains an exemplary critical attitude to the work of others as well as his own.

2.5. An outline of the aims of the thesis

Child psychologists have identified certain key stages in the cognitive development of children. In doing so, they have outlined behaviour which they feel reflects the mental level which the children usually reach at a certain age. My aim in studying theory of mind was to attempt to adapt experiments that had been conducted on children by psychologists and make them suitable for chimps. In this way, it could be determined whether chimpanzees fulfil the same behavioural criteria which child psychologists require human subjects to show in order for humans to be accredited with theory of mind. Attempting to follow in the path of the child psychologists does not imply that their experiments are flawless, nor that they have proven what they set out to prove. However, as a starting point in a relatively new field, it is worthwhile using and adapting these experiments, whilst retaining a degree of scepticism about what the results may imply.

If the nonhuman subjects do show behaviour that is similar to the behaviour witnessed in children by the child psychologists, then one would have to determine whether nonhuman subjects can be accredited with theory of mind. If so, what is the real difference between humans and nonhuman primates? A positive result would call into question the validity of the work conducted by the psychologists and would cause it to be re-examined more stringently. The central question would be whether very young children do have theory of mind. It is often assumed that normal children are more cognitively advanced than they may be in reality, because we know they will develop into people who are capable of acting as if they understand the mental states of others. Even when children use words that indicate internal mental states, it does not mean that they have a full understanding of the words they are using.

If the nonhuman subjects do not show any behaviour that is similar to children's behaviour when the same type of experiments are conducted on them, one can conclude one of two things. One could argue that if nonhuman subjects do not show these types of behaviour, they simply do not have theory of mind. An alternative suggestion is that nonhuman subjects do have theory of mind, (or rather, an approximation to it) but that humans are able to go beyond conventional ToM and achieve higher levels of intentionality. Further work would then be required to determine whether there is species-specific behaviour that indicates an understanding of a conspecific's mental state.

However, as stated above, the child psychologists have outlined behaviour that to many psychologists indicates comprehension of theory of mind and as a starting point I believe I am justified in using their experiments. Furthermore, as outlined in section 2.3: How children see the world, they have proposed a hierarchy of mental understanding. The thesis follows this hierarchy which begins with causality, a concept thought to be understood by infants, followed by joint attention, desire comprehension, and finally the litmus test of theory of mind, understanding false beliefs.

In adapting these experiments, I have tried to keep the essence of the experiment the same and to insure that the necessary controls were present, not just within species but between the different species studied, whilst making allowances for the biological nature of different animals. Mike Tomasello (pers. comm.) is very open about the fact that he is seeking to determine whether or not chimpanzees have human-like capacities. I would argue that although that is in essence what all of us in this field are doing, we must still try and look at the situation from the animals' point of view and ask what would be biologically relevant for that animal, and what behaviour is part of their natural repertoire? The question, 'Does the animal have theory of mind as we have defined it for humans?' ought to remain uppermost in our minds, but at the same time, we need to look at the social and mental life of the species we are studying, and if necessary, adapt our original question.

Chapter 3 is on general methods and outlines the personal histories, housing conditions and feeding regimes of the animal subjects. Chapters 4 to 8 are data chapters and are presented in the order of complexity of the mental capacities I was seeking to test. Chapter 4 deals with whether the animals have an ability to understand cause and effect. This is important for a later development of theory of mind for although our thoughts, beliefs and ideas are distinct from the physical world of objects and behaviour, they are also causally related to that physical-behavioural world. Causal influence goes from mind to world and from world to mind: mental states cause actions in the world and the world causes mental states. An initial understanding of physical causality may be the bedrock for an understanding of cause and effect where mental states are taken into consideration. Chapter 5 focuses on joint attention and is composed of an observational study and 3 experiments. Joint attention is considered a precursor to theory of mind for perception is thought to be instrumental in the acquisition of beliefs and desires. Chapter 6 deals with nonverbal comprehension of desires and chapter 7 with nonverbal comprehension of false beliefs. Chapter 8 is a second observational study, this time on play behaviour and whether the play face is a gesture used for metacommunication. Metacommunication is thought to be highly advanced cognitive behaviour requiring second order intentionality. The conclusion for the whole thesis forms chapter 9. Two failed pilot studies are dealt with in the appendix.

3. General methods

This chapter deals with the study site and the animal subjects: their ages, kinships, friendships, dominance relationships, housing and feeding patterns are all discussed. Human subjects are dealt with in the chapters in which they feature. Methods of data collection and analysis are also dealt with in each chapter separately.

3.1. Study site

My main study site was Twycross zoo situated off the M42 between Birmingham and Leicester. This particular zoo was chosen because it had a large number of common chimps (19 adults, 3 adolescents, 3 juveniles and 3 infants) which, unfortunately for the chimps, were housed in nonnatural conditions. There was one semi-natural group; all other chimps were kept in groups of two or three and it would now be difficult to house them together given their xenophobic natures. However, the fact that they were in small groups and slept singly in cages at night made conducting experiments on them easier. In addition, Twycross is the only British zoo which has bonobos (2 adults and 2 juveniles). I worked at Twycross every week day from the beginning of June 1993 to the end of April 1994.

In addition I worked at Dudley zoo from January 1994 to March 1994. Dudley is a Victorian zoo in the heart of Birmingham and only has three chimps, one of whom appears to be mentally retarded. However, the staff there were very willing to accommodate me when I was having problems generating a sufficient sample size at Twycross (due to the director rather than lack of available chimps).

3.2. Chimps

Table 3.2. gives stud details for the chimps at Twycross and for Pepe at Dudley. The kin networks that are relevant to this study are that Ellie and Peter are siblings, their parents are Sam and Benjie; William and Beckie are siblings; William and Holly and Beckie and Holly are half siblings.

Table 3.1: The name, sex, place of birth, date of birth, parentage, and rearing details are given for the chimps at Twycross and Pepe at Dudley.

Name	Sex	Hand reared	Born	D.o.b.	Parents
Sam	M	?	W. Africa	1954	
Coco	F	?	W. Africa	1965	
Chops	F	?	W. Africa	1969	
Noddy	F	?	Africa	1971	
Louis	M	Y	Twycross	13.2.76	Oscar and Sush
Robert	M	Y	Twycross	12.8.74	Oscar and Coco
Kip	M	Y	Twycross	22.4.76	Oscar and Coco
Rose	F	Y	Twycross	30.5.76	Oscar and Tina
Jillie	F	Y	Twycross	16.11.76	Oscar and Judy
Lottie	F	Y	Twycross	28.9.78	Oscar and Coco
Tojo	F	?	Africa	1976	Illegal import
Ricky	M	?	Africa	1979	Illegal import
Jambo	M	Y	Twycross	9.6.82	Robert and Coco
William	M	Y	Twycross	30.6.82	Robert and Noddy
Holly	F	Y	Twycross	27.12.82	Robert and Chops
Benjie	M	N	Regent's Park	12.1.82	Bimbo and Brenda
Sam	F	N	Kenya	1980	Institute of Primate research
Jollie	F	N	Colchester	16.9.83	George and Mandy
Beckie	F	Y	Twycross	1.6.85	Robert and Noddy
Mellie	F	Y	Africa	1957	Monkey sanctuary
Flynn	M	Y	Twycross	23.3.86	Kip and Noddy
Josie	F	Y	Dudley	20.2.88	Pepe and Bella
Ellie	F	Y	Twycross		Benjie and Sam
Vickie	F	Y	Twycross	18.8.90	Benjie and Lottie
Jomar	M	Y	Twycross	28.12.90	Robert and Noddy
Peter	M	N	Twycross		Benjie and Sam
Mini	F	Y	Twycross	25.10.92	Benjie and Jollie
Mwekundu	F	Y	Twycross	3.6.93	Jambo and Lottie
Dudley					
Pepe	M	N	Chester	2.5.60.	?

3.2.1. Housing

The chimps at Twycross were all housed in cages that consisted of an indoor cage, night pens and an outdoor enclosure. There was heating under the floors of their cages.

The largest group contained 2 males, 4 females and an infant (Benjie, William, Rose, Sam, Holly, Jolly and Peter). Next to them was an adjoining cage containing Ellie, Beckie and Mellie. Ellie and Beckie had been hand reared; Ellie was being reintroduced back into the group, Beckie had been housed with another pair of chimps, Josie and Flynn, and Mellie had been in the larger group. It probably would not have been too difficult to reintroduce Ellie since both her parents were in the large group and they were the most dominant individuals. However, Sam disliked Beckie intensely and she, Rose and Holly would attack her. Therefore, Ellie and Mellie kept her company and acted as a go-between. An attempt to reintroduce her was made in January 1994 and she was nearly killed. Throughout the rest of my stay at the zoo and whilst I tested her using the nonverbal desire test and the false belief test, she was housed in 2 interconnecting night pens and kept on her own. The other chimps could communicate with her through the wire mesh at night.

Prior to this time, the 2 groups of animals could communicate and see each other through the dividing wall of the indoor enclosure and hence, in the observational study, when gaze direction was examined, they were treated as a group of 10 since they did watch each other and could interact to some extent through the wire mesh.

The night pens were built of 2 inch wire mesh and were interconnecting. Generally the connections between them were closed and the animals were kept singly except for Rose, Sam and Peter who stayed in one together, and sometimes Jolly and William. Beckie, Mellie and Ellie normally shared a large night pen, although initially, Ellie was taken back in to one of the keeper's houses at night. The pens were filled with shredded paper for them to make nests out of. On one side of the room containing the pens was a window into the visitors' corridor. The indoor enclosure was stone with a window into the visitors' corridor running the full length; there was a 2 inch wire mesh wall dividing one indoor enclosure from the other and both contained a door into the outdoor enclosure which had a rubber flap over it to keep out drafts when the door was open. The indoor enclosures contained large metal shelves, a metal climbing frame, ropes, a TV (that no longer worked) and a daily supply of cardboard boxes. The outdoor enclosure was a grassy area shaped like a semi-circular flat topped hill. At the foot of the hill was a concrete path that ran round it, on the other side of this was a wall topped by a glass partition which encircled the enclosure. There were 4 dead trees in the outside enclosure with ropes strung between them at different levels.

The routine of these animals was they were given a large meal and a drink individually in their night cages in the morning. Beckie, Ellie and Mellie were allowed the run of the outdoor enclosure for half an hour, often with Benjie, and later on, with Jolly as well. The 3 females were put in their indoor enclosure and had no more access to the outdoor section for the rest of the day. The larger group were allowed the run of their indoor enclosure and the outdoor one from about 9.30 until 4. When all the chimps first entered their indoor enclosures, sunflower seeds were scattered across the floor. At night they were all brought in and housed individually in the night pens and given another large meal.

Josie and Flynn were kept together. Their night pens had 2 walls of 2 inch wire mesh and 2 of stone; each pen had a window. Their pens were filled with shredded paper. The indoor enclosure was of stone with a window either side and a skylight. It contained metal shelves, a wooden climbing frame, ropes, cardboard boxes and a barrel. The outdoor enclosure was completely enclosed by wire mesh with a woodchip floor. It contained a metal climbing frame, loose barrels, a barrel hung from a rope, a tyre swing, ropes and bungee ropes. The animals were let out in the morning at 8 - 8.30 after a feed in the night pens. Thereafter they had the full run of both indoor and outdoor enclosure and could get part of the way into one of their night pens - a 'porch' in effect, which meant they were out of sight of the visitors. When they entered their day pen, there were crisps and sunflower seeds on the metal ledges. The director gave them sweets and drinks of ribena a couple of times during the day. They were brought in at 4.30 and given another meal.

Vickie and Jomar and Mambie the gorilla slept in the keepers' houses at night. Between 7.30 and 8am they were brought to their indoor enclosure which was of stone with windows on three sides and which could be divided down the middle. Mambie was put on one side and the 2 chimps on the other. Their meals were put along the window ledges. At about 10 the partition was removed and the outdoor enclosure opened. The indoor enclosure contained 2 metal and plastic climbing frames, ropes, balls and boxes. The outdoor section was completely enclosed by wire mesh, it was grassed and had a wooden 'adventure playground' style climbing frame. During the afternoon Mambie was removed for at least a couple of hours and put in with the gorilla group. All 3 animals were given a drink in the afternoon and later, about 5, taken back to the keepers' houses.

These were the chimps that I normally worked with. However, there were another 13 chimps who were much older, more aggressive, less active and harder to observe because of the layout of their cages. I included these chimps in the causality experiment. Because of the difficulties mentioned, I did not attempt to study them for the joint attention observational work and did not want to include them in the experiments since very few toys would have been novel to them as they were the chimps originally used in the PG Tips advertisements. I could not do any of the other experiments with them because of their aggressiveness and because the wire mesh in their night pens was 3 inches wide; one of them had ripped open the director's arm from wrist to shoulder by pulling her arm through this gap.

These older animals were housed in the following combinations: Louis, Chops and Jillie; Lottie and Jambo; Robert and Coco; Noddy, Tojo and Ricky; and Kip, Sam and Evie. Their indoor enclosures were very small and contained nothing. They were built of stone with a window into the visitors' corridor. The outdoor enclosures had grass and a dead tree in each one. They too were very small and narrow and were bounded by wire mesh. The animals were fed and given drinks in their night pens and were then allowed out. They were brought back in and fed at 4.30 - 5.

The 3 chimps at Dudley were housed in a underfloor heated small indoor enclosure in which they slept and which contained a plastic crate, a tyre swing and some straw. One side had a window onto the visitors' corridor and the roof had bars over the top. The keeper had to climb up above the cage and throw food down to them through these bars. There was a door with a small, barred window which opened onto the keepers' corridor. Sometimes the chimps swapped places with the gorilla. His cage was larger and had a wall composed of bars that was adjacent to the keepers' kitchen. During the time when I was conducting the desire and false belief test, the chimps were housed in this cage. A 1 inch wire mesh was put over the bars (since they were wide enough apart for the chimps to put their arms through) and the mesh was cut to allow the handles on the drawers of the box to protrude into the cage.

The outdoor enclosure, to which they had access all day unless the weather was very bad, was also small with a woodchip floor and a wooden climbing frame. It was surrounded by a moat and an electric fence. The animals were fed in the morning at about 9 and then again when they were locked in at night at 4-5.

3.2.2. Food

The chimps were fed fresh fruit and vegetables, bread and a seed mix for their 2 main meals. During the day they were given sunflower seeds and in some cases, snacks (see previous section). In the morning they were given a drink of milk and at night they were given ribena.

3.4. Bonobos

Stud details for the bonobos are given in table 3.2. The relevant kin relationship in this group is that Kichele is Diatou's daughter.

Table 3.2: The names, sex, place of birth, date of birth, parentage and rearing details are given for the bonobos.

Name	Sex	Hand reared	Born	D.o.b.	Parents
Kakouwet	M	N	San Diego Zoo	7.6.80	Male (0034) Female (0023)
Diatou	F	N	Stuttgart Zoo	21.10.77	Male (0054) Female (0055)
Kichele F	N	N	Stuttgart Zoo	19.4.89	Male (0054) Female (0075)
Jasongo	M	Y	Wuppertal Zoo	2.8.90	Male (0038) Female (0106)

3.4.1. Housing

The bonobos were housed all together in a large night pen with 2 inch wire mesh in a room with windows round it. During the morning they had access to these night pens and to their indoor enclosure; in the afternoon they were allowed in the indoor and outdoor sections, the night pens were cleaned and they were then given access to them again.

The indoor enclosure contained a pool of water which was warm initially (they drank from it and floated toys and bits of food in it, splashed water at each other, but were not seen swimming in it whilst I was there, although the keeper said they used to), metal ledges, dead trees, ropes, a hammock, plastic crates, cardboard boxes and balls. There was one large window looking into the visitors' section. The outdoor enclosure was the same as the one the large chimp group had.

3.4.2. Food

At 8am the bonobos were given a drink of skimmed milk and fruit and vegetables in the large indoor enclosure. Some days browse (beech, oak, hawthorn, lime, hazel, birch or poplar) was put into the enclosure for them. At midday they were given 2-3 tablespoons of pap which consisted of bran, curds and honey; sunflower seeds were scattered on the floor and they were given a drink of ribena. Mid-afternoon they were individually fed a snack such as a cereal bar or toast and honey, and when they were brought in at night they were given fruit and peanuts.

3.5. Spider monkeys

The stud details are given for the spider monkeys in table 3.3. F1 and M1 were handled by their previous owners but neither of them were or could be handled by humans at Twycross. None of the monkeys were hand reared.

Table 3.3: The birth place, date of birth and parentage are given for the spider monkeys

Name	Born	D.o.b.	Parents
Spike	S. America	23.8.86	Wild caught
Josie	S. America	24.10.84	Wild caught
Cher	Twycross	23.6.91	M1 and F1
Dee	Twycross	7.2.89	M1 and F1
M2	Suriname	24.10.84	?
F3	Chester	15.6.81-7.9.94.	?
M3	?	? (arrived in Twycross 1958)	?
F4	London	? (arrived in Twycross 25.7.70)	?

3.5.1. Housing

Four of the spider monkeys were housed in pairs, the other 4 were in a family group. All the monkeys had an indoor enclosure containing metal ledges and a metal pole running horizontally across their cage, constant access to drinking water from a bottle and access to their outdoor enclosure from 9 - 4. The indoor enclosures had a small window facing the outdoor section and a large one which overlooked the visitors' corridor. The outdoor areas were grassed and enclosed by wire mesh; they contained wooden climbing frames and ropes. The monkeys were kept in the indoor pen at night and fed first thing in the morning, dried food was scattered around, and they were given a second large meal in the evening.

3.5.2. Food

They were given fresh fruit and vegetables morning and evening, monkey chow and eggs in the morning and bread and butter in the evening.

4. The perception of causality in chimpanzees, bonobos and spider monkeys

Aim

The aim of this experiment was to determine whether chimps, bonobos and spider monkeys have any comprehension of causality by adapting one of Leslie's 1982 experiments with human infants.

4.1. Introduction

The understanding of cause and effect (causality) probably has a distinctive role in a child's development (Leslie and Keeble 1987). The comprehension of causality may be linked to what Baron-Cohen (1995) terms the Intentionality Detector (ID). ID is a perceptual device which interprets motion stimuli in terms of the primitive volitional mental states of goal and desire. ID is labelled primitive in the sense that it is the basic skill needed to interpret the self-propelled motion of any object or other animal as if that object or animal is an agent with goals and desires. Understanding that one moving object can cause the motion of another object may be an even more primitive skill than ID. Comprehension of causality may ultimately lead to an animal developing ID and thus understanding that agents are goal-motivated. An understanding of mind is based upon the perception of behaviour and is likely to be initially understood through first order representations of behaviour. This understanding is based on a practical understanding of the physical world. More advanced mental representations are based upon an understanding of causality based not upon the transmission of mechanical forces through physical contact, but upon the transmission of information (Gomez 1991). Therefore, if monkeys and apes cannot understand causality, it would appear highly unlikely that they could ever develop an understanding of the causal relationship between an agent's intention and an agent's action.

In the Treatise on Human Nature (1888) Hume wrote that we perceive cause and effect through prolonged experience of events that are regularly conjoined. Piaget (1955) proposed that the understanding of cause and effect (causality) is achieved through the active experience of producing effects oneself. In contrast, Michotte (1963) has argued that a comprehension of causality is immediate and occurs without prior experience or the ability to use language. He gives the example of cartoons. The observer can 'see' causal reactions between objects, despite knowing that only drawings are involved. This in itself is not an argument against the Humean or Piagetian idea of the perception of causality, since infants who watch cartoons may have had some experience of everyday objects and be able to transfer these to the cartoons without knowing that the cartoons are drawings.

Leslie (1982, 1984) and Leslie and Keeble (1987) created several habituation style experiments specifically to determine infants' perception of causality. Their results indicated that a Michottean understanding of causality is shown by infants by the time they are 27 weeks old. Leslie and Keeble stated that it is unlikely that Piaget was correct, since infants at such an early age would not have had direct experience at producing effects themselves.

One of Leslie's experiments was adapted for chimpanzee, bonobo and spider monkey subjects (Leslie 1982). He showed infants aged 24 to 38 weeks and infants aged 13 to 21 weeks old a film clip on a loop for continuous projection. The clip showed a Russian doll on a table-top. A hand moved in from the left side and picked the doll up before retreating off screen. This was termed the contact sequence. In the no contact sequence, the hand appeared as before but did not grasp the doll. Both hand and doll moved off screen, but without the hand touching the doll. One group of infants (group I) was shown the film in this order: contact/no contact. Group II viewed the film in the opposite order. Group III viewed the films in the order contact followed by another version of the contact film. In this version the hand appeared from the right of the screen instead of the left. All infants were shown the first set of films until habituation and were then shown the second film. An analysis of the last habituation trial versus the first dishabituation trial indicated that the infants were dishabituating and that the extent of dishabituation was greatest for the groups I and II. Leslie suggested that the infants were able to distinguish the lack of contiguous relationship between the hand and the doll. In addition to adapting Leslie's experiment, in this study, I have gone one step beyond Leslie's original experiment by creating experiments using social causality (i.e. physical causality involving social objects)

4.2. Method

Subjects

Four spider monkeys, 2 bonobos and 11 chimps were used. Another 8 chimps were sampled but were dropped from the study as they did not fulfil all the criteria necessary during the course of training, as were 4 other spider monkeys and 2 other bonobos (the juveniles).

Three types of causality experiment were conducted on the subjects. All involved food. Each experiment was in the form of two films that differed from each other in only one respect: one film had a cause and effect and was labelled 'contact', and the other did not and was labelled 'no contact'. Films 1. and 2. were shot on a Hitachi 8mm VM-E23E camcorder. Film 3. contained BBC footage from the film "Too close for comfort" produced by Alastair Fothersgill and made at the Natural History Unit, BBC Bristol. Film 2 was more socially complex than film 1, and film 3 was more socially complex than film 2. As well as being socially more complex, films 2 and 3 were more complex than film 1 in another respect: film 2 showed 2 noncausal sequences where film 1 showed only one; film 3 contained an edited sequence of events, it thus necessitated at least a rudimentary understanding of television programmes, i.e. that 'cuts' in an action sequence do not mean that several distinct and unrelated events are occurring.

Film 1:

Contact: A banana is lying on a table. A hand reaches in from the left hand top corner and picks up the fruit. Both hand and banana move out of sight.

No contact: A banana is lying on a table. A hand reaches in from the left hand top corner, but before it grasps the fruit, the banana rises from the table and 'follows' the hand out of frame.

Film 2:

Contact: A person (Sheila O'Connell) is sitting eating a banana. A second person (Deirdre O'Connell) enters from the left and sits next to Sheila. Deirdre pushes Sheila who falls over to the right. Deirdre takes her banana and starts to eat it.

No contact: Sheila is sitting eating a banana. Deirdre enters from the left, sits down next to her but does not touch her. Sheila falls over to the right and the banana moves by itself over to Deirdre who picks it up and starts to eat it.

The banana was on a piece of white thread and was made to move with the help of Patrick O'Connell who was out of camera shot.

Film 3:

Contact: Chimps in a forest are hunting a colobus monkey. They chase through the forest after it, catch it, tear it apart and start to eat it.

No contact: This sequence is played backwards so that the monkey is reassembled and escapes backwards from its pursuers.

Each film clip for films 1. and 2. were 20 seconds long. They were transferred from the high 8 tapes they had been filmed on, onto normal VHS tape at BBC Television Centre's News edit room and were then edited at the BBC's Kensington House edit suite. Each of the four 5 minute films consisted of every film clip repeated to form a continuous loop.

The third film had clips that were 30 seconds long. This 30 second clip was made by editing shots together that had originally come from "Too close for comfort". The BBC footage was on VHS, but the hunting sequence created for experiment 3 was edited from VHS onto beta tape. Once the edit sequence had been compiled, this beta tape was transferred back onto a VHS. Again the clip was copied a number of times to make a 5 minute film sequence. For the no contact scene, the same procedure was carried out except that the beta tape was played backwards onto a forwards recording VHS.

This procedure entailed a loss of quality of the picture since in each of the three films, the final film was a third generation copy of the original. However, it was still clear to a human observer what was on the screen, moreover, even films for transmission on television have been decreased in quality by one generation without significant loss of picture information

All 6 VHS tapes were played with a normal VHS recorder; they were recorded by filming the television screen in the editing suite using the camcorder. This was done in order to transfer the VHS tapes back onto high 8 tape. During the actual experiments, the camcorder was used as a video-recorder and plugged into a television, both of which were set up outside the subjects' cages.

Each subject was allowed to view the tapes on its own. Subjects were divided into two groups. One group saw film 1. in the order contact followed by no contact; the other group saw film 1. no contact, followed by contact. This procedure was repeated for film 2. When it was possible, subjects that had seen film 1. contact first, were shown film 2. no contact, first. Film 3. was only shown to the chimps since it would not have been relevant for the spider monkeys. I was not allowed to show film 3. to the bonobos as the keeper felt it might excite them, despite the fact that bonobos have never been known to hunt in the wild.

Once the subject was looking at the screen, they were timed to see how long they would look at the picture before looking away. 'Looking away' was counted as the subject shifting their gaze from the screen to any other object or conspecific. The experimenter stood directly behind the television throughout and since the reflection from the screen fell onto the glass in front of the subject, it could clearly be seen whether the subject was looking at the picture or not. The stop-watch was restarted as soon as the subject looked back at the screen and this was treated as a new 'looking time'. The film was shown to the subjects three times. The camcorder was stopped and a mean looking time obtained from these 3 scores. Further looking times were obtained until the subject had produced 3 looking times that were lower than the mean of the first 3. The subject was then assumed to be habituated.

The second tape was played in the camcorder and 3 looking, or dishabituation times, were obtained. This is the precise methodology used by Leslie (1982). However, I have included a total of 5 animals in the analysis who did not provide this minimum of 9 scores; 2 chimps and 1 monkey did not produce 3 dishabituation times when watching film 1. and 3 chimps did not do so when watching film 2. That they did not look for the full 3 dishabituation trials is not important for the analysis I conducted. The sample sizes were as follows: film 1. - 9 chimps, 2 bonobos and 5 monkeys; film 2. - 8 chimps, 2 bonobos and 3 monkeys; film 3. - 9 chimps.

4.3. Results

The minimum number of trials the subjects could be given before they habituated was 6: 3 trials before a mean was taken, and 3 trials where the looking times were lower than the mean. When the subjects were shown film 1, all the chimpanzees and the bonobos were habituated by the sixth viewing of the film, but 2 out of the 5 monkeys took longer (7 trials and 9 trials). One chimpanzee took longer than 6 trials to habituate (11 trials) when shown film 2; all the monkeys were habituated by the sixth trial. Again, one chimpanzee took longer than 6 trials to habituate to film 3 (8 trials). In all but one case (Melody, film 3) the subjects who took longer to habituate had a lower mean score.

When the chimps were shown film 1., in the order contact, no contact, their looking times increased dramatically when they saw the no contact sequences. The chimps who were given the films in the opposite order looked longer at the no contact sequence than their counterparts had looked at the contact sequence. The differences between dishabituation and habituation times were not as great as those seen for the first group, just as one would expect. Those who saw the no contact film as their dishabituation trials continued to look for approximately an equal length of time for all 3 trials. Those chimps who saw the contact film as their second film started to habituate quite rapidly (see figure 4.1. and tables 4.3. and 4.4.).

A similar pattern emerged from the results of film 2. Those who saw the films in the order contact, no contact showed a large difference between their dishabituation times and the habituation ones, and looked for longer at the no contact sequence. The looking times for the 4/6 of the animals who saw the films in the order no contact, contact looked more or less equally at both films. There was no discernible pattern between the 3 sets of scores for the dishabituation trials in the no contact group: 1 chimp looked longer in the second and third trial, one looked for a shorter amount of time, and two refused to look at the screen again. One interpretation would be rapid habituation for 3/4 subjects. The scores for the contact film over the last 3 sets of dishabituation trials remained roughly equal (see figure 4.2. and tables 4.7. and 4.8.).

This pattern was repeated for film 3. The subjects who saw the film in the order forwards, backwards, looked far more at the backwards version of the film than the forwards one; the animals who saw the films in the reverse order, looked for longer at the forwards version. Overall, the subjects spent more time looking at this film than they had at either of the other two films. Those chimps who saw the backwards version of the film as their dishabituation trials generally showed looking times that did not tail off too much, whereas those who saw the forwards running film did begin to habituate (see figure 4.3. and tables 4.10. and 4.11.).

When the monkeys were shown film 1., 3/4 of those who saw the film in the order contact, no contact, looked at the second film for longer than they had looked at the first contact film. However, the one monkey who watched the film in the opposite order looked for an equally brief period of time at both film sequences - 1 second. There was no discernible pattern for their looking times over the 3 trials on the dishabituation sequence (see tables 4.5. and 4.6.). For film 2., two out of 3 monkeys looked at the contact film for longer than the no contact film when they were shown the films in the order no contact, contact. I could not persuade any monkeys to watch these films in the reverse order. There was no discernible pattern for their looking times over the 3 trials on the dishabituation sequence (see table 4.9.).

A two factor mixed factorial ANOVA (i.e. MANOVA) was carried out on the chimps' and the bonobos' scores (Klunear and Gray 1994). The 2 types of tests carried out were a) comparing the first and the last habituation trials and b) comparing the last habituation trial with the first dishabituation trial from each individual. In both cases, the factors that were examined were difference between the order of the films, the difference between trials and the interaction between the two.

To deal with point a) first: there was no significant difference between the groups who had seen the films in the order contact, no contact, or backwards, forwards. Neither was there any significant interaction between showing the chimps either sequence first. In every case there was a significant difference between the first trial and the last, indicating that the chimps were all habituated (see table 4.1).

When comparing the last habituation trial with the first dishabituation trial, there was a significant difference between the last habituation trial and the first dishabituation trial for all three films (film 2 bordered on significance p=0.06). In film 1 there was a significant difference between both the order and the interaction. There was no significant difference between the groups who had seen the films in the order contact, no contact for film 2, or backwards, forwards for film 3; nor was there a significant interaction between showing the chimps either sequence first for film 2 and 3. The exception was for film 1 (see table 4.2).

A matched pairs ANOVA was not conducted because the subjects were in matched pairs for each trial, but were not matched between orders. However, parametric and nonparametric matched pairs tests were done between trials and also between orders. The results obtained were very similar to the results given by the MANOVA with two exceptions. There was a significant difference between orders for film 1 when comparing the first results for the dishabituation score contact/ no contact versus no contact/contact (Wilcoxon matched pairs test: N1=5; N2=6; p<0.05). The results from the MANOVA showed no significant difference. The second exception was for film 2 where there was a significant difference between the last habituation trial and the first dishabituation trial; the difference was almost significant (p=0.068) using a matched pairs t test (df=8; p<0.05).

Table 4.1: The results of a two factor mixed factorial (MANOVA) are shown. The chimps' and bonobos scores are compared on the first versus the last habituation trials for all three films.

Film	Interaction		Order		First versus last habituation		Df
	F	P	F	P	F	P	
1	4.160	0.072	2.260	0.140	37.780	0.000	1,18
2	0.010	0.929	0.550	0.479	15.140	0.005	1,16
3	2.260	0.176	0.410	0.544	13.040	0.009	1,14

Table 4.2: The results of a two factor mixed factorial (MANOVA) are shown. The chimps' and bonobos scores are compared on the last versus the first dishabituation trials for all three films.

Film	Interaction		Order		Last versus first dishabituation		Df
	F	P	F	P	F	P	
1	10.630	0.010	10.520	0.010	16.920	0.003	1,18
2	0.820	0.392	2.330	0.165	4.800	0.060	1,16
3	0.700	0.430	0.950	0.362	13.000	0.009	1,14

Figure 4.1: The last habituation time and the first dishabituation times for film 1. The graph on the left shows the group of chimps and the two bonobos who received the contact, no contact sequence first, and the graph to the right shows the chimps who received film 1. clips in the order no contact, contact.

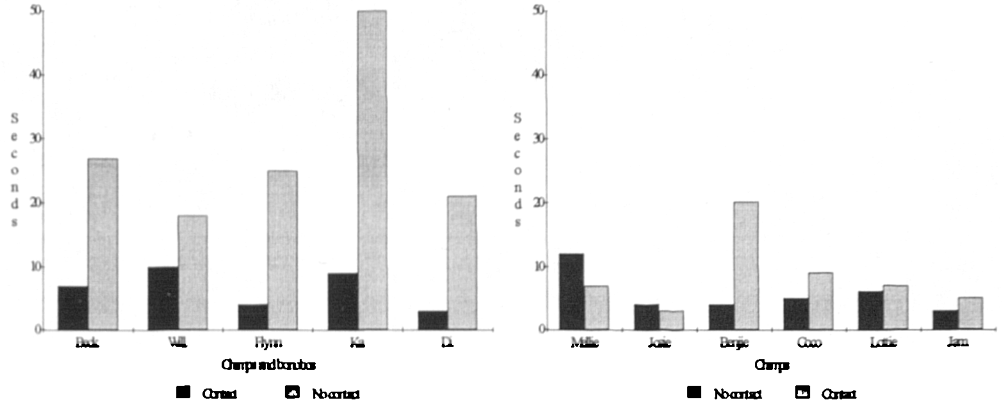


Figure 4.2: The last habituation time and the first dishabituation times for film 2. The graph on the left shows the group of chimps and the bonobo who received the contact, no contact sequence first, and the graph to the right shows the chimps and the bonobo who received film 2. clips in the order no contact, contact.

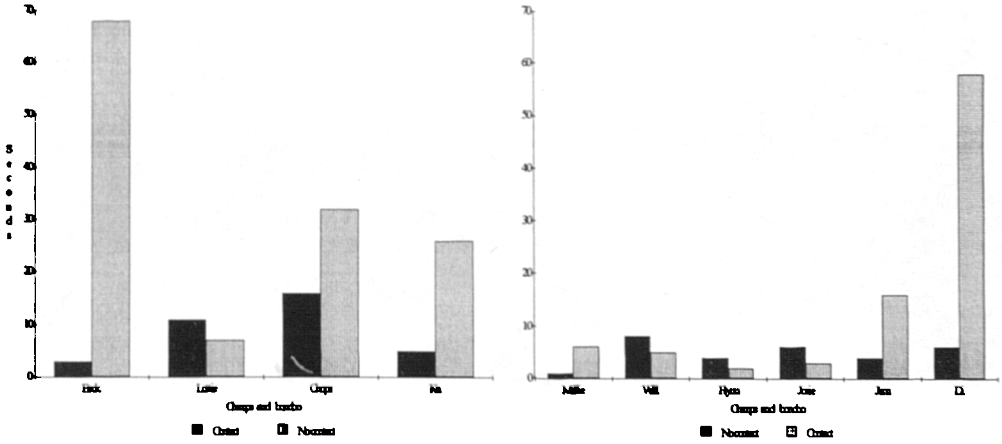


Figure 4.3: The last habituation time and the first dishabituation times for film 3. The graph on the left shows the group of chimps who received the forwards, backwards sequence first, and the graph to the left shows the chimps who received film 3. clips in the order backwards, forwards.

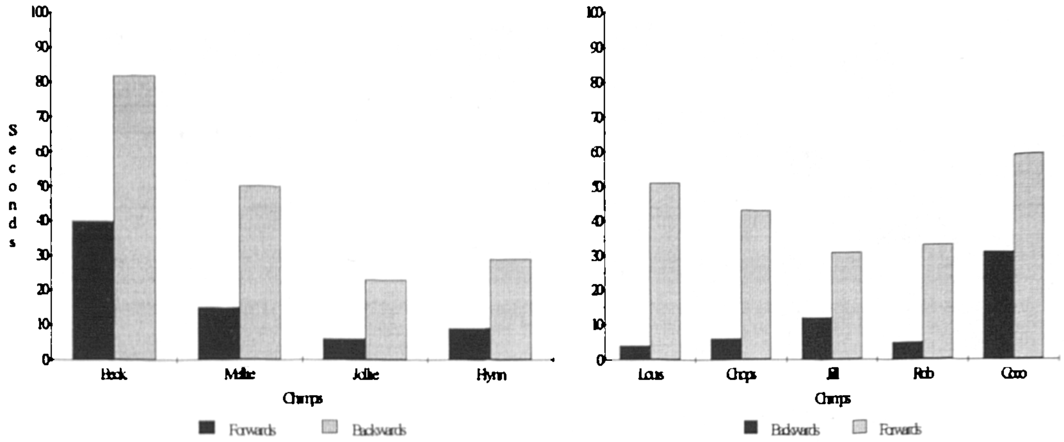


Table 4.3: The habituation and dishabituation times are given for the chimps and the two bonobos, Kakouwet and Diatou, who were given film 1. in the order contact, no contact. The first three habituation scores are given for the contact film, followed by their mean and then the next habituation scores (scores were obtained until the subject had three scores below the mean). These results are then followed by dishabituation scores for the no contact film. The scores are in seconds.

	Beckie	Will	Flynn	Kakouwet	Diatou
Contact	29, 22, 13	28,13,15	16,11,10	16,9,8	13,6,6
Mean	21	18	12	11	5
Contact	16,17,7	7,9,10	4,7,4	11,5,9	3,4,3
No contact	27,29,15	18,23,10	25,18,20	50,32,18	21,4,15

Table 4.4: The habituation and dishabituation times are given for the chimps who were given film 1. in the order no contact, contact. NC=no contact; C=contact. The scores are in seconds.

	Mellie	Benjie	Coco	Lottie	Jambo	Josie
NC	31,15,8	27,13,13	44,8,17	44,23,12	44,25,5	10,15,11
Mean	18	17	23	26	24	12
NC	18,3,12	11,4,4	22,11,5	11,5,7	15,10,3	5,3,4
C	7,6,4	20,3,4	9	6,3	5,5,8	3,6,2

Table 4.5: The habituation and dishabituation times are given for the spider monkeys who were shown film 1. in the order contact, no contact. The scores are in seconds.

	M3	F4	F1	F2
C	20,2,19	4,2,2	11,5,8	11,12,34
Mean	13	2	8	19
C	7,4,2	3,2,1,1	15,2,21,2,3,2	4,5,14
NC	12,6,21	5,1,4	31,3,10	6,7,18

Table 4.6: The habituation and dishabituation data from the one spider monkey who nearly managed to complete watching film 1. in the order no contact, contact. The scores are in seconds.

	M2
NC	2,3,2
Mean	2
NC	1,1,1
C	1,1

Table 4.7: The habituation and dishabituation scores are given for the chimps and the bonobo, Kakouwet who were shown film 2. in the order contact, no contact. The scores are in seconds.

	Beckie	Lottie	Chops	Kakouwet
C	22,5,13	36,2,9	30,6,11	26,23,6
Mean	13	15	15	18
C	18,28,10,3,42,8,5,3	3,9,11	11,17,16	17,6,5
NC	68,9,8	7	32	26,24,20

Table 4.8: The habituation and dishabituation times for the chimps and the bonobo, Diatou, who watched film 2. in the order no contact, contact. The scores are in seconds.

	Mellie	Will	Flynn	Josie	Jambo	Diatou
NC	27,43,18	60 5,5	12,21,4	11,12,9	4,29,17	28,11,15
Mean	29	23	12	11	16	18
NC	3,2,1	6,6,8	3,4,4	14,3,6,6	7,5,4	16,6,6
C	6,4,2	5,4	2,9,4	3,3,3	16,16,7	58,103,32

Table 4.9: The habituation and dishabituation times for the spider monkeys who were shown film 2. in the order no contact, contact. The scores are in seconds.

	M3	F1	F2
NC	12,23,2	6,10,10	23,4,16
Mean	12	8	14
NC	12,8,4	8,8,9	14,9,3
C	11,2,1	9,2,6	5,8,8

Table 4.10: The habituation and dishabituation times for the chimps who were shown film 3. in the order forwards, backwards. F=forwards; B=backwards. The scores are in seconds.

	Beckie	Mellie	Jollie	Flynn
F	42,46,52	40,20,14	46,9,12	27,33,28
Mean	46	24	22	29
F	9,18,40	29,36,7,14,15	14,19,6	28,25,9
B	122,29,9	50,26,24	23,29,16	29,15,56

Table 4.11: The habituation and dishabituation times for the chimps who were shown film 3. in the order backwards, forwards. The scores are in seconds.

	Louis	Chops	Jill	Rob	Lottie
B	7,29,13	55,28,20	107,29,42	35,5,3	112,19,106
Mean	16	34	59	14	79
B	9,3,4	11,28,6	21,10,12	11,2,5	19,32,31
F	51,4,18	43,2,11	31,33,14	33,16,11	59,20,20

No statistical test was carried out on the monkeys who watched film 1 since only one monkey could be persuaded to watch the films in the order no contact/contact. Likewise, in film 2, only one monkey watched the films in the sequence contact/no contact. Instead, a one way ANOVA was conducted on the larger group of monkeys. There was no significant difference between the first habituation and the last habituation trial and between the last habituation trial and the first dishabituation trial for either film 1. or 2. This coupled with an examination of the results for the one monkey who saw the films in a different order from the larger group and the fact that no other monkeys could be persuaded to watch, may be taken as an indicator that they might not understand causality: Film 1. (first habituation versus last habituation trial:

F(1,6)=1.25; p=0.307; last habituation versus first dishabituation trial: F(1,6)=1.67; p=0.244); Film 2.(first habituation versus last habituation trial: F(1,6)=0.89; p=0.445; last habituation versus first dishabituation trial: F(1,6)=0.08; p=0.808).

4.4. Discussion

The fact that there was a significant difference between the first habituation score and the last habituation score for all three films watched by the chimps and the bonobos indicates that they were habituated. The rise in looking time when the films were changed is consistent with dishabituation rather than fatigue.

There was a significant difference between the last habituation scores and the first dishabituation scores for films 1, 2 and 3 indicating that the animals detected a new event in the film. There was a significant difference in the interaction for film 1. This may be because the last habituation times were very similar for both groups of subjects - those that saw the film in the order contact/no contact, and those that were shown the film in the order contact/no contact. However, there was a large difference between the dishabituation times. The subjects that saw the film in the order contact/ no contact, looked for longer at the no contact version (which was presented to them as the second film) than the group who were given the films in the order no contact/contact looked at the contact film (which was the film shown to them as their second film). This indicates that both groups reacted as if they considered that the no contact film looked strange. The group that had seen the 'normal' contact film first looked for longer at a 'strange' film, the no contact version; the group that saw the 'strange' film first, dishabituated to the 'normal' film, but then did not carry on looking at if for a long time. They had already seen the no contact film and in comparison, the contact film did not seem strange. These results may be taken as evidence that chimpanzees and bonobos react in the same way as young children when the children watch films where the only change between the two versions of each film is that one has a cause and an effect, and the other shows the same events but without a cause. The same can not be said of the results from the subjects watching film 2 because there was no significant difference in the interaction.

In film 3 there was no interaction indicating that the subjects looked for approximately as long at each film no matter what order the film was presented in. I would argue that this is because of the intrinsic nature of the film. Film 3 showed a hunting sequence which the chimpanzees found fascinating whether it was played to them forwards or backwards (the male subjects in particular rocked backwards and forwards, their hair stood on end and they gave low panthoots). An alternative possibility is that the animals were simply reacting to the novelty of backwards locomotion. However, if this were the case, there should be an interaction effect. Those chimpanzees who watched the film in the order forwards, backwards would look for longer at the backwards version because of its relative novelty than those chimps who watched the film in the alternative order. It is also possible that the chimpanzees could not fully understand the film because it was an edited sequence of events rather than one continuous shot. However, all the chimps shown these films had had access to television at some point in their lives. The crucial point to make about film 3 is that it acts as a kind of control. This film is far more complex than the simple causal sequence depicted in film 1. It may be that the chimpanzees and bonobos were able to understand causality as indicated by the results in film 1, but because of the complexity of film 3, they were not able to understand causality in this film.

I was able to interest far fewer of the monkeys in the television than the chimps. This in itself would not suggest that they are incapable of understanding causality since watching TV is not a natural habit. Despite this, some of the monkeys were able to watch the screen long enough to become habituated. However, there was no significant difference between the last habituation and the first dishabituation trials for the monkeys that did watch films 1. and 2. which may indicate a lack of comprehension of causality. Furthermore, experiments by Visalberghi and Limongelli (1994) on comprehension of cause and effect in tool using capuchin monkeys have shown no indication that they can understand causality whereas the same experiment repeated on chimps indicated that the chimpanzees could (Limongelli, Boysen and Visalberghi 1995). In Visalberghi et als' experiments, if the monkeys were frustrated in their attempts at using familiar tools, they did not alter their tool use in order to obtain a food reward. It may be that monkeys are goal and motivation oriented only. They can learn how to use tools and act as if they have a goal in mind motivated by the reward of food, but this does not mean they have an understanding of cause and effect, hence the results of the Visalberghi and Limongelli experiment. I would expect to obtain similar results from spider monkeys having watched them trying to get food out of an orange juice bottle filled with seeds. It seemed to me that they had no understanding of the effect of their actions and that any seeds they were able to gather were merely gleaned fortuitously.

Since the objects in the noncausal sequences in films 1 and 2 appear to move by 'magic', and the backward version of the chimp hunt in film 3 is out of the normal perpetual range of the subjects, these noncausal sequences induce the subjects to dishabituate. Whilst this means that the animals recognise there is something strange going on, this does not mean that they understand causality. Other experiments in the same vein use computer-generated objects, such as coloured balls, which appear to adults to be rational and goal-directed agents. Using a similar habituation, dishabituation paradigm, Gergely, Nadasdy, Csibra and Biro (1995) showed that infants will dishabituate to agents that appear to be nonrational and nongoal-directed. Their explanation of the results is that young infants of twelve months old have a basic understanding of causality, and are taking the intentional stance when interpreting the goal-directed behaviour of rational agents. This study runs into the same problems as my experiment: the infants may respond by dishabituating to the noncausal sequences because they look odd. Young children my be hardwired to react to objects as if they are goal-directed and causal using a low level perpetual mechanism (Leslie and Keeble 1987), but this does not mean they understand either causality or goal-directed intentional behaviour.

An alternative way of testing causality would be to use a typical discrimination paradigm, training subjects to respond to causal and noncausal sequences. They could then be given a variety of discrimination transfer tasks which show different versions of causal and noncausal sequences with a limited number of trials. This might indicate whether the subjects have a natural concept for causal sequences (see Cerella1979, 1982; Herrnstein 1979; Herrnstein and Devilliers 1980 for discrimination learning of natural concepts in pigeons). The flaw in this type of design is that primates may quickly learn to abstract the common features in each set of trials thus picking the correct noncausal sequence without comprehending causality.

In summary, this chapter indicates that chimpanzees may be able to understand simple causal sequences. This is the first study using a nonverbal human infant paradigm with other primates and it may prove useful to others who would like to pursue this nonverbal approach. The next chapter examines whether chimpanzees, bonobos and spider monkeys can show behaviour that in children would be interpreted as the basic developmental steps towards theory of mind. It is suggested that joint attention, the subject of the next chapter, is a skill which can lead to understanding intentionality by comprehending shared attention.

5. Joint Attention

Aim

This particular chapter contains an observational study and three experimental ones focusing on the gaze direction of bonobos, chimps and spider monkeys.

5.1. Introduction

Joint attention is broad term given to the use of and comprehension of eye gaze and accompanying gestures. It is seen as a precursor to metarepresentation and thus theory of mind (Baron-Cohen 1991; Leslie and Happé 1989) and as a developmental milestone to theory of mind (Tomasello, in press). It is viewed as a higher mental ability than understanding physical causality (Baron-Cohen 1995; Gomez 1991).

In this chapter, an overview of joint attention is given, followed by a more detailed discussion on protoimperatives, and protodeclaratives, (two types of gesture that can accompany joint attention) and mutual gaze. A discussion of joint attention as a way of mind-reading follows. The effects of enculturation (sustained human contact with great apes) on joint attention are considered. An outline of the whole chapter is dealt with prior to the general methods.

An overview of joint attention

By about the age of 6 months, babies can begin to orientate themselves towards the side of the room their caretaker is pointing at (Butterworth 1991) although they cannot locate the object the caretaker is pointing to. By the time they are 8 months old they can show referential or triadic looking - they can look at an object that another person looks at by using direction of eye gaze (line of sight), characteristically looking from the object and back to the person (Baron-Cohen 1991). Bakeman and Adamson (1984) divide triadic JA into two categories: the first is labelled passive joint engagement and is where the infant focuses on the same object that an adult is looking at, but without glancing up at the adult; coordinated joint attention is the same as referential looking. In one study the rate of passive joint engagement was 16.6% between the baby and its mother and 2.3% coordinated joint engagement at 6 months of age. But by 18 months the rate of passive joint engagement was 21.5% and 26.6% for coordinated joint engagement.

Giving, showing and pointing to objects all emerge between 9-12 months. For the first year of their life, babies behave as if their own field of vision is shared by an adult and cannot comprehend gaze directed to the space behind themselves. This does not mean, though, that the infant cannot perceive that others also have a perspective on a space that is common to several points of view (Butterworth 1991). An alternative explanation proposed by Tomasello (in press) is that the child's concept of space is not as highly developed as their ability to direct other peoples' attention to objects and events.

Joint attention behaviour (referential looking, eye contact and gestures which sometimes accompany the eye movements) are often absent in autistic children (Loveland and Landry 1986; Landry and Loveland 1989; Mundy et al 1986; Sigman et al 1986). Baron-Cohen (1991) and Leslie and Happé (1989) argue that this form of behaviour is a precursor to the development of metarepresentational abilities and hence theory of mind. Tomasello (in press) goes one step further, stating that the acquisition of JA is a developmental milestone that is of no less importance than the acquisition of ToM and, therefore, should not be treated as a precursor.

However, the fact that JA may be either a precursor or a milestone to ToM does not mean that there is any underlying mental comprehension on the part of the infant engaged in JA. We know that ToM does develop at a later stage in children (when they are able to give self-aware and verbal answers to false belief questions), but it is difficult to prove that there is any mental comprehension present at an earlier age. JA may be an innate response to which a mental understanding is attached with age (but see section on 'Joint attention as a way of mindreading' for an alternative view and the general conclusion for a further discussion). Alternatively, joint attention could be a learnt response. Infants are normally exposed to maternal head-turns which serve as a stimulus for operant-reinforcement contingency. To begin with, the infant may happen to turn their head to the same side as the mother and is rewarded by seeing an object of interest. Cases in which the infant turns to the opposite side from the mother are not rewarded. Over time and a number of trials, the infant's head turns to the same side as the mother become conditioned (Moore and Corkum in press). There is no need to assume that the infant represents what the adult is looking at. Neither is it necessary to assume that referential joint attention (where the infant looks from the object back to the adult) means that the infant is checking what the adult is looking at. Adults seek to draw infants' attention to objects and this establishment of joint attention will usually be followed by some continuation of the interaction by the adult - a smile, a gesture or a vocalization. Once the infant's expectation of seeing an object has been fulfilled, it would then expect some other interesting adult behaviour. Thus the infant would naturally turn back to check the adult's face. Therefore, Moore and Corkum argue that even in referential joint attention, the infant need not be representing the other as looking at an object. However, a conditioned form of behaviour does not mean that the infant cannot represent the object whilst still being unable to represent the adult's representation of the object.

Protoimperatives and protodeclaratives

Pointing gestures fall into two categories, either protoimperative or protodeclarative, where the former indicates a desire for the object and the latter indicates a desire to create an attentional state in the target according to some interpretations. For instance, pointing at an apple may mean that the actor wants the apple, or it may mean that the actor wants the target to look at the apple. Baron-Cohen (1989a) defines protoimperatives as pointing in order to use another person to obtain an object and protodeclarative pointing as pointing in order to comment or remark on the world to another person. Protoimperatives need not take into account the mental states of a person, only their physical interactions, whilst commenting entails mental and not physical interaction. He has shown that both normal and Down's syndrome children can understand protoimperative and declarative pointing. Autistic children have more difficulties in understanding protoimperatives than other children but they seem to be even worse at understanding protodeclarative pointing.

Happé and Frith (1992) and Gomez (1992) have discussed the implications of protoimperative and declarative gestures for nonhuman primates. Happé and Frith state that neither autistics nor nonhuman primates are capable of the latter type of communication as they do not possess a ToM capable of systematically representing and manipulating intentions.

Leslie (in Leslie and Frith 1987) believes that metarepresentation underlies both protodeclaratives and ToM. The goal of a protodeclarative gesture may be to share experiences or an interest in an object, and this requires the ability to represent the other's mental states; at the very least, it may be the ability to represent another person perceiving and being interested in something.

Gomez (1992) however, disagrees. At about one and a half years old, his gorilla began to treat a person as a subject. When making protoimperative gestures she looked the person in the eyes and used a combination of joint attention behaviour and gestural activity to initiate the request. This attention checking and visual contact is also seen in human children and seems to imply some understanding of other peoples' mental processes of at least first order intentionality (See Butterworth 1991 and Gomez 1991). This led Gomez to suggest that protoimperatives may be as important as a precursor to ToM as protodeclaratives.

Just as Gomez can scale up protoimperatives to first/second order intentionality, one can scale down protodeclaratives. In the latter, the goal of the subject may not be to provoke a mental experience in another but rather to provoke an emotional or attentional reaction. The subject seeks to provoke the external sign of having an experience in a target, e.g. a smile or a directional gaze. Still, there does seem to be a difference between protoimperatives and protodeclaratives. Gomez says "..what we know is that normal infants, autistic children and anthropoid apes are able to use some attentional cues to perform requestive functions, but only the former use them to perform protodeclaratives."

Although Happé would agree with the above, she disagrees that protoimperatives always indicate first order states of mind; instead she believes that they can show metacommunication: not that the subject wants x, but that the subject wants the target to know that it wants x, which is the equivalent of third order intentionality or embedded mindreading (Happé pers. comm.) Moore and Corkum (in press) argue that all one can say at this stage about pointing behaviours is that the infant may understand that by pointing, the gesture will tend to lead to an adult head turn and an interesting subsequent response from the adult.

It seems that there is some confusion over what exactly protoimperatives and protodeclaratives can and do mean. What these gestures mean to another individual is likely to be context dependent and will also rely on the intellectual capacity of the signaller for their interpretation, for example, a gesture by an autistic person and a normal person may look the same but may have different meanings. Given that there is little consensus, I am going to follow Baron-Cohen's definition (1989a) whilst remaining neutral on the question of underlying mental ability (see section on general methods for an objective ethogram of joint attention in primates).

Mutual gaze

Another type of joint attention behaviour is mutual gaze, which may be alternated with following the line of sight of the target (Gomez 1991). Eye contact plays an important part in the development of early social interactions in human children (Schaffer 1984; Trevarthen and Hubley 1978; Butterworth 1991). It also plays a critical role in reconciliation behaviour in chimpanzees (de Waal 1989). To return to Gomez's hand reared gorilla - she was presented with a problem: how to get out of a locked door when the lock was out of her reach. For the first 6 months of her life, she used a box to stand on; after about a year she would push or drag a human to the door and climb on him, in effect, using him as a box. At about one year of age, she would gently lead the human to the door looking from his eyes to the lock and back. The interpretation given by Gomez is that the gorilla looks into the experimenter's eyes to check that he is attending to her actions. This interaction is based upon an understanding of humans as subjective entities whose autonomous behaviour can be influenced through a particular kind of causal contact, namely mutual attention.

Joint attention as a way of mind reading

Leslie and Happé, (1989) argue that joint attention behaviours such as pointing are examples of metarepresentation because they show 'ostensive communication' which requires a theory of mind. Ostensive communication is defined as 'any act in which one person places a stimulus in the environment of another person for purposes of communication and which achieves communication. Pointing as well as language is included in this definition.

Tomasello, Kruger and Ratner (1993) and Tomasello (in press) also argue that what underlies infants' early JA skills is their emerging understanding of persons as intentional agents which means that they comprehend that (i) other persons may attend selectively and intentionally to some things in the environment and ignore others; (ii) other persons may intend for them to selectively attend to some things in the environment and ignore others; and (iii) with certain behaviours they may induce other persons to intentionally attend to new things in the environment. Hence prelinguistic one year olds and the young gorilla show at least a rudimentary understanding of the perceptual abilities of people in relation to the behaviours that can subsequently be generated (Tomasello, in press; Gomez 1991;). Therefore, an understanding of attention, since it is one of the primary processes of cognition, may involve an understanding of mind.

Baron-Cohen (1994) has suggested that two mechanisms operate when dealing with gaze direction: 'EDD' - eye direction detector, and 'SAM' - shared attention mechanism. EDD facilitates dyadic gaze which is widespread throughout the animal kingdom and does not necessarily show any understanding of mind. It evolved because eye direction is important since if an animal is staring at another animal there are, in general, only three possible meanings: the agent is going to fight, mate with or eat the target.

SAM allows humans, and great apes, to some extent, to verify if two organisms are attending to the same thing. Baron-Cohen refers to this as 'triadic representation' (e.g. [I-see-(Mummy-sees-the-bus)] and [I-see-(Mummy-sees-Daddy)]). SAM is essential for JA and the development of a theory of mind. Evidence for Baron-Cohen's theory comes from a survey of 16,000 children aged 18 months. Each child was tested for the ability to understand protodeclaratives, whether they could monitor gaze direction and if pretend play was present. The children that failed all three were diagnosed as autistic. Two children were able to pass the first 2 tests but did not show pretend play. No children who lacked the ability to demonstrate protodeclaratives and gaze monitoring were able to show pretend play. Therefore, Baron-Cohen (1994) states that SAM is necessary for ToM.

Some deceptive behaviours of chimpanzees may be explained in terms of a causal understanding of attention and action. For example, a chimpanzee covering his erect penis when a dominant male appears demonstrates that he understands a part of the causal chain, which has to do with attention, and which may lead to the dominant's aggressive reaction and he tries to alter it (Whiten and Byrne 1988, 1990; Gomez 1990). In the wild, chimpanzees follow the visual gaze of others to interesting and useful objects and events (Plooij 1978; Menzel 1975) but there have been no studies conducted so far which would show that they engage in more extended bouts of joint attention in their natural habitat. However, there is evidence to suggest that 'enculturated' great apes (defined in the following section) do engage in joint visual attention in interactions about objects and alternate their gaze from target to object (Savage-Rumbaugh 1990; Gomez 1991; Carpenter, Tomasello, Savage-Rumbaugh, in press) and can demonstrate pointing gestures which Call and Tomasello (in press) believe to be referential. This effect of enculturation is dealt with in the next section.

The effects of enculturation in great apes on their ability to use joint attention

Carpenter et al (in press) gave a group of children and two groups of chimpanzees an imitative learning test where their imitative ability as well as their JA skills were recorded. One group of chimpanzees were 'enculturated' (the term was suggested and defined by Tomasello, Savage-Rumbaugh and Kruger (1993) as "chimpanzees raised from an early age in more human-like cultural environments - with more exposure to objects and artefacts, along with humans who direct their attention to objects and instruct them in their use"; these chimps had also used a lexigram keyboard for symbolic communication; but see next paragraph) and the other group was 'mother-reared'; each group contained three subjects, two of which were bonobos. Carpenter et al determined that the enculturated chimpanzees were more similar to human children than the non-enculturated chimps in the following ways: (1) their attention to objects in compliance with the experimenter's request; (2) their joint attention during less structured periods, and (3) their use of declarative gestures to direct the experimenter's attention to objects. The enculturated chimpanzees looked for longer during JA bouts than the mother reared chimps and less than the children. They were more similar to the chimps and less like the children in their looks to the experimenter's face, which were brief. Thus, in looks to the face, there is no effect of enculturation. A strong relationship was seen between the subjects' joint attention skills and their imitative learning skills for both humans and chimps. No species difference was recorded between the two types of chimp.

One problem with this study is that the mother-reared chimps had had extensive contact with humans. There is evidence to show that by 30 days of life, chimps reared with people already perform higher and at much more human-like levels than mother-reared chimpanzees on several measures of visual orientation (Bard et al 1992).

There are few experiments on joint attention in primates and none that attempt to show systematic evidence for different types of joint attention in three species of primate.

Joint attention: an outline of this chapter

This chapter is divided into four sections. The first section is an observational study which attempts to determine to what extent (if any) joint attention features in the natural social life of bonobos, chimps and spider monkeys. The following three sections are experimental studies. The first attempts to determine whether the subjects were capable of following the line of sight of the experimenter (myself). This ability is one of the most basic tenets of joint attention (see section on an Overview of joint attention). It is unlikely that subjects would be able to show more complex joint attention behaviours if they were not capable of following line of sight. In the second experiment, a novel toy was given to each subject for 5 minutes. The conspecifics housed in the subjects' cage were then allowed to enter the cage. Since the incoming animals could not see the toy beforehand, the aim was to see if the subject would give any protoimperative or protodeclarative gestures, especially given that if the subject had ToM, it should know that its conspecifics would not have seen the toy before. In children, sharing or showing is likely to occur in this type of situation (Baron-Cohen, pers. comm.). This experiment attempted to determine whether subjects could and would use more complex forms of JA and whether they would indicate behaviourally that they had taken into consideration the mental state of their conspecifics. , i.e. that their conspecifics did not *know* about the toys.

The final experiment aimed to test whether the subjects could show any JA behaviours, in particular, protoimperatives and protodeclaratives, especially towards a human experimenter when faced with a moving toy as opposed to a non-moving toy. The set-up in this experiment is more formal since the subjects are not actually able to play with or touch the toy. One individual cannot keep the toy to itself, and any individual which makes a gesture or establishes eye contact due to the stimulus presented by the toy, does not run the risk of having the toy taken away from them. This risk may have prevented individuals showing JA gestures in the previous experiment.

5.2. General methods

The subjects used were bonobos, chimpanzees and spider monkeys. Spider monkeys were chosen as a contrast to chimps since, first, it is widely held that monkeys are not as intelligent as chimpanzees, although the fact that this view is widely held does not mean that it is true; secondly, they have a similar style fission-fusion society to chimpanzees, and finally, they do not appear to use staring as a threat behaviour as often as other monkeys I have observed.

In the observational study and experiments 2 and 3, direction of gaze was noted, as well as the action of the animal directly before and after its gaze. The other conspecifics present in the same area (either indoor cage or outdoor enclosure) were also observed. Overall there were 8 possible categories for line of sight for the subjects, and 5 types of JA.

Gaze could either be towards:

F - Food.

C - Conspecific (in which case, the target was named).

S - Self.

O - Object (which was any item in their cage that was neither food nor another animal).

V - Visitor (to a human).

LA - Looking around, i.e. vigilance (the subject might simply be looking around; here the subject's eyes moved continuously and did not alight on any particular object).

R - Resting (its eyes would be shut).

N - Nothing (it might be staring vacantly where it was surmised that the subject was not looking at anything. In this category, the subject's line of sight did not connect up to an object, its eyes appeared glazed, and were still rather than making the slight movement characterised by alert gaze towards an object; and finally, the subject itself was not moving).

The subject might, at the same time, be manifesting joint attention behaviours. These were divided into 5 categories:

Dyadic joint attention was where a subject was looking at something which a conspecific was also looking at but the subject did not glance from the object to the conspecific and back at the object. Dyadic joint attention is what Bakeman and Adamson (1984) referred to as 'passive joint engagement'.

Triadic joint attention (or 'coordinated joint attention', Bakeman and Adamson 1984) is where the subject and a conspecific are both looking at the same thing, but here the subject looks from the object to the direction of gaze of the conspecific and back. In the ethological literature, triadic would imply that three animals were involved. In the psychological literature, the triad is determined by the numbers of components present: the subject, the target and the object of their joint attention, and that a triadic representation may be taking place. Since my comparison is with psychological studies of humans, it is important to retain the terminology used by psychologists to avoid confusion. Each time triadic joint attention was observed, the object that was being stared at was noted, as was the target of the subject's triadic gaze, or the other individual that was staring at the same object as the subject when the subject was engaged in dyadic joint attention.

Mutual gaze with a conspecific, where each animal must be directly staring into the other's eyes and not looking at any other part of its body. In this case, attention is coordinated between two individuals, but.no triadic gaze is taking place since a third object or conspecific is not involved. The conspecific taking part in mutual gaze was always noted.

Protoimperative gestures. The subject gestures with a hand or a foot towards an object and used triadic gaze (alternating gaze from the object to another organism). The object is within reach of one or both animals; if it was then given to the subject, the subject showed an acquisitive interest in the object by playing with it or eating it.

Protodeclarative gestures. The subject again gestures with a hand or a foot towards an object and uses triadic gaze, but in this case, the object is out of reach of both animals and is an object the subject did not seem to be interested in acquiring, either because this is impossible (such as the sun or a star) or because it was known that the subject never played with or ate certain objects. If the object was not an impossible one to give and it was put within reach of the subject, the subject would show no interest in physically interacting with it.

Each time a protodeclarative or a protoimperative was observed, it was also noted what object was being gestured towards and the conspecific with whom gaze was shared.

These definitions are not water-tight and it is not possible to show what level of mental complexity underlies each one, but at this point, given the paucity of work conducted on joint attention in nonhuman animals, it is conservative to attempt to replicate experiments conducted by child psychologists whist making no claims about what, if anything, the subjects are actually mentally representing. However, to be able to show that chimpanzees produce the same patterns of observable behaviour as children implies that there is at least *prima facie* evidence that whatever child psychologists assume underlies human behaviour also underlies that of chimpanzees. This may prompt us to re-evaluate the claims of the child psychologists or to reassess the cognitive processes involved in these kinds of behaviours.

Analyses were conducted within and between species where possible. Joint attention was analysed first including mutual gaze and then excluding mutual gaze. The reasoning behind this is that mutual gaze may play a role in attention (see introduction) but it does not include an object as a focus of attention which triadic and dyadic joint attention do. Following Carpenter et al (in press), the chimpanzees were also split into two groups for the purpose of analysis: enculturated, defined for the purposes of this study as having been hand reared for a minimum of two years from birth, and mother reared, where the subject had remained with a natural group and was never physically handled by a human without anaesthetic.

Methodological problems

Unfortunately, sometimes the numbers in the samples were small (n=4). Since it was not possible to increase the sample size given that there are a limited number of subjects overall, the results were still analysed using a t test. However, one needs to be cautious when interpreting the results since there is an increased risk of a Type II error occurring (i.e. the test indicates that the null hypothesis is correct when it is not). However, because this bias acts conservatively against the hypothesis under test, we can at least feel confident that when a result is significant, it really is significant.

Determining the direction of eye gaze in nonhuman subjects is more difficult than it is in humans since the white sclerota is rarely seen. However, in all three experiments, the subjects were within a metre of me and were facing me, so that I had a clear view of their eyes. It was possible to determine the direction in which their eyes were looking by taking the pupil as the central reference point. Understanding where spider monkeys are looking is somewhat easier than following eye direction in chimpanzees and bonobos because of the contrast between their pupil and the iris (which is pale blue). Furthermore, in an experiment on JA conducted by Povinelli and Eddy (in press) 4 observers scored 86-92% inter-rater reliability over 112 trials when attempting to determine where 7 chimpanzees were looking during the experiment. At worst, it can be argued that even if the exact location of the object the subject is looking at cannot be determined, the general direction of their gaze is apparent from head movement (Butterworth 1991).

Given the procedural difficulties inherent in these experiments, it would have been preferable to have had a blind scorer. However, this was not possible as there were no students available at the zoo who could have taken on this kind of work over the period of time required. An alternative might have been to film the experiment. Indeed, the subjects were filmed, but because of the lighting conditions (the subjects are behind glass) the film was not of sufficient quality to use for this study.

5.3. Observational study

Aim

To determine to what extent (if any) joint attention features in the natural social life of bonobos, chimps and spider monkeys.

5.3.1. Method

Eleven chimps were used, which included 4 males and 7 females; 5 (3 females and 2 males) were under 10 years of age. Four bonobos were used, one male and female adult and one male and female juvenile. Seven spider monkeys were used, 3 males and 4 females; 2 females were 4 and 2 years old; all the other monkeys were adults.

The day was divided into 3 sections and 5 hours of focal sampling were conducted per individual animal, split as evenly as possible over these three sections of the day. This ensured that observational time was conducted during feeding as well as resting periods for each subject. Data were collected every 2 minutes using scan samples. For each scan sample the type of data collected is outlined in section 5.2. on general methods. The direction of gaze of the focal animal was noted as well as the action of the animal directly before and after its gaze. The conspecifics in the same area as the focal animal were also noted. There were 8 possible categories for line of sight of the subjects and 5 types of JA which are discussed in section 5.2. on general methods. Duration of JA lasts less than 30 seconds on average (Carpenter et al, in press) so each observation can be treated as independent.

5.3.2. Results

Joint Attention

Joint attention hardly occurred at all in the spider monkeys observed (see tables 5.1., 5.2., 5.3. and 5.4.). Dyadic joint attention was the only type of joint attention seen in spider monkeys. Joint attention occurred at relatively low levels for the two chimp species. None of the animals showed any protoimperatives or declaratives during the time they were observed. The main difference between the two chimp species was that the mean percentage of time spent in mutual gaze was much higher for the bonobos than it was for the chimps, yet the bonobos showed no triadic gaze.

Gaze above chance levels

The conjoint probability of two subjects looking at the same object or organism at the same time was assessed using a binomial test, with p as the probability of A looking at an object and q the probability of B looking at the same object. There are four possible conditions: 1) neither subject looks at the same thing [(1-Pp)(1-Pq)]; 2) subject A looks, but subject B does not [Pp(1-Pq)]; 3) subject B looks, but subject A does not [Pq(1-Pp)]; 4) both subjects look at the same object/organism at the same time [PpxPq]. The observed and expected values are given for 4) [PpxPq] since this is the only category which is relevant for an analysis of joint attention. The expected values were calculated based on the assumption that the animals gazed at objects at random with respect to each other. Gaze could fall into one of eight different categories, however, only five of these need concern us since 'resting', 'looking around' and 'looking at nothing' preclude any joint attention (see section on general methods and table 5.1.). Thus there were five initial categories, plus, in the conspecific category, other group members were included. For example, Josie , who was housed with Flynn, had five categories that could have constituted joint attention: food, objects, conspecifics (Flynn only in this case), visitors, and self. The chimpanzees in the larger group had ten categories, because there were seven chimpanzees in the group rather than two (conditions were otherwise identical to those for Josie and Flynn). For each species, there were approximately an equal number of items in each category; for instance, in the Objects category, there were roughly an equal number of objects in the cage where the large group of chimpanzees were housed as there were in each of the cages where the younger chimpanzee pairs were kept. The average proportion of time spent looking at the objects in each of the categories was calculated to give the expected p values for each individual (see table 5.1.) and was rounded up to the largest, nearest whole number to give a more conservative expected value. 'Looking' was interpreted as including dyadic, triadic and mutual gaze (see tables 5.3. and 5.4.). The expected number of scans of JA at chance levels was compared with the actual number of observed scans of JA and a binomial test was carried out to compare the observed with the expected values (see table 5.2.)

Subjects were compared in pairs when they naturally lived in pairs (4 chimps). Beckie and Melody were in a separate cage from the other 5 chimpanzees, but they were treated as if they were in one large group because all that separated them was wire mesh, and they interacted and used JA with the rest of the group through this wire). Where subjects lived in a group (7 chimps, 4 bonobos and 4 spider monkeys they were paired with every other subject possible. Because the testing of all possible dyads in the large group of chimps (a total of 21 combinations) necessitated multiple comparisons of the same individuals, the Bonferroni procedure was applied to modify the rejection level for statistical significance (after Norusis 1993). Consequently the rejection level for tests in this group is p=0.05/21 or p=0.002. The rejection level for tests conducted on the bonobos is p=0.05/6 or p=0.008, and for group 1 of the spider monkeys is p=0.05/3 or p=0.017.

The results from table 5.2. indicate that 6 pairs of chimpanzees (n=11; 23 dyads) used JA with each other; 4 pairs used JA above significant levels. All of the bonobos (n=4) used JA with each other; 4 of the 6 pairs showed JA above significant levels. Two pairs of spider monkeys used JA, but none of the five pairs (n=7) showed JA above significant levels.

Table 5.1: The data are given for the number of scan samples during which each subject used gaze, split into categories according to the focus of their gaze. There were 150 scan samples per individual. F=Food; O=Objects; C=Conspecifics; V=Vigilance; S=Self; R=Resting: A=Looking around; N=Looking at Nothing. For the calculation described (in Gaze above chance levels) only the categories Food, Objects, Conspecifics, Visitors and Self were used since these are the only ones in which JA can occur. (1) The actual number of scans during which the subject was looking at an item (i.e. the number of scans looking at food, objects, conspecifics, visitors and self added together); (2) the actual number of scans looking at an item as a proportion of the total number of scans (i.e. column (1) divided by 150); (3) the expected proportion of scans that each subject is predicted to allocate to each item on the assumption that all items are of equal interest to the subject (i.e. column (2) divided by the number of items). Column (3) hence shows the expected probability for a given individual to look at any one item. The probability of joint attention between two individuals by chance alone is therefore obtained by multiplying their respective expected probability values (from column (3)). These are shown in table 5.2.

CHIMPANZEES

	Gp size	F	O	C	V	S	R	A	N	1	2	3
Ben ie	7	23	5	32	29	1	23	9	27	90	0 60	0 060
William	7	10	11	40	10	18	20	22	19	89	0 59	0 059
Holly	7	32	2	37	-	14	4	61	-	85	0 57	0 057
Jolly	7	11	5	48	5	56	9	4	12	125	0 83	0 083
Sam	7	8	1	54	17	5	18	35	12	85	0 57	0 057
Beckie	7	3	12	46	7	15	21	30	15	83	0 55	0 055
Melody	7	53	1	24	5	15	29	11	10	98	0 65	0 065
Flynn	2	-	25	18	9	5	32	32	15	57	0 38	0 076
Josie	2	21	24	32	14	10	6	41	2	101	0 67	0 134
Vickie	2	16	43	35	7	4	7	37	7	105	0 70	0 140
Jomar	2	11	40	42	5	3	7	41	1	101	0 67	0 134
Total		188	169	408	109	146	176	323	114			

BONOBOS

	Gp size	F	O	C	V	S	R	A	N	1.	2.	3.
Kakouwet	4	13	22	66	5	5	-	37	2	111	0.74	0.106
Diatou	4	12	-	63	4	7	15	7	37 86	0.573	0.082	
Kichele	4	10	6	95	6	-	-	26	6 117	0.78	0.111	
Jasongo	4	16	18	79	5	1	-	25	4 119	0.793	0.113	
Total		51	46	303	19	13	15	95	49			

MONKEYS

	Gp size	F	O	C	V	S	R	A	N	1.	2	3.
Spike	4	33	9	23	7	18	1	77	6	90	0 60	0 086
Josie	4	9	-	44	13	2	23	53	18	68	0 453	0 065
Cher	4	16	8	46	1	23	2	68	3	64	0 627	0 090
M2	2	9	-	7	16	5	1	109	2	37	0 247	0 049
F3	2	3	-	35	8	27	19	59	2	73	0 487	0 097
M3	2	18	4	5	2	8	1	103	7	37	0 247	0 050
F4	2	14	5	28	9	23	-	52	20	79	0 527	0 105
Total		102	26	188	56	108	47	521	58			

Table 5.2: Comparison of the frequency of joint attention observed with that expected at chance levels. The expected number of scans of JA at chance levels were obtained by multiplying the expected probability by the total number of scans collected (150); this value was then rounded up or down to the nearest whole number. The number of JA scans observed were compared to the number expected using a binomial test. Since the pattern of observed scans among dyads was highly skewed (with most dyads scoring zero, but four chimpanzee dyads scoring $\geq$10), each dyad was tested separately. Because the testing of all possible dyads in group 3 of the chimpanzees (a total of 21 combinations) necessitated multiple comparisons of the same individuals, the Bonferroni procedure was applied to modify the rejection level for statistical significance (after Norusis 1993). Consequently the rejection level for tests in group 3 is p=0.05/21 or p=0.002. In bonobos, the rejection level is p=0.05/6 or p=0.008, and for group 1 of the spider monkeys is p=0.05/3 or p=0.017.

EP(JA)=Expected probability of JA at chance levels.

EN(JA)=Expected number of scans of JA at chance levels.

O=Observed number of scans of JA.

p=Results of binomial test. N.S.=not significant.

CHIMPANZEES

Individuals a.	 b.	EP(JA)	EN(JA)	O	p
Group 1. p<0.05					
Flynn	Josie	0.01	2	10	0.001
Group 2. p<0.05					
Vickie	Jomar	0.02	3	34	0.001
Group 3. p<0.002					
Benjie	William	0.004	1	0	N.S.
	Holly	0.003	0	0	N.S.
	Jolly	0.005	1	0	N.S.
	Sam	0.003	0	0	N.S.
	Beckie	0.003	0	0	N.S.
	Melody	0.004	1	0	N.S.
William	Holly	0.003	0	0	N.S.
	Jolly	0.005	1	0	N.S.
	Sam	0.003	0	0	N.S.
	Beckie	0.003	0	0	N.S.
	Melody	0.004	1	0	N.S.
Holly	Jolly	0.005	1	2	0.193
	Sam	0.003	0	1	0.472
	Beckie	0.003	0	0	N.S.
	Melody	0.004	1	0	N.S.
Jolly	Sam	0.005	1	10	0.001
	Beckie	0.005	1	0	N.S.
	Melody	0.005	1	0	N.S.
Sam	Beckie	0.003	0	0	N.S.
	Melody	0.004	1	0	N.S.
Beckie	Melody	0.004	0	17	0.001

BONOBOS

Individuals a.	 b.	EP(JA)	EN(JA)	O	p
p<0.008					
Kakouwet	Diatou	0.009	2	19	0.001
	Kichele	0.012	2	9	0.001
	Jasongo	0.012	2	6	0.003
Diatou	Kichele	0.009	2	3	0.160
	Jasongo	0.009	2	1	0.552
Kichele	Jasongo	0.012	2	17	0.001

MONKEYS

Individuals a.	 b.	EP(JA)	EN(JA)	O	p
Group 1 p<0.017					
Spike	Josie	0.006	1	2	0.269
	Cher	0.007	1	0	N.S.
Josie	Cher	0.006	1	3	0.045
Group 2 p<0.05					
M2	F3	0.005	1	0	N.S.
Group 3 p<0.05					
M3	F4	0.005	1	0	N.S.

Table 5.3: The number of scan samples during which each individual subject exhibited dyadic, triadic or shared JA. 150 scan samples per subject were taken at two minute intervals.

CHIMPS

	Dyadic	Triadic	Mutual	Protoimp./dec.
Benjie	-	-	-	-
William	1	-	-	-
Sam	3	-	-	-
Holly	2	-	3	-
Jolly	6	3	-	-
Melody	1	-	-	-
Beckie	8	-	8	-
Josie	1	2	5	-
Flynn	5	4	2	-
Vickie	6	-	7	-
Jomar	7	-	14	-
Total	40	9	39	-

BONOBOS

	Dyadic	Triadic	Mutual	Protoimp./dec.
Kakouwet	4	-	7	-
Diatou	9	-	12	-
Kichele	-	-	17	-
Jasongo	2	-	8	-
Total	15	-	44	-

MONKEYS

	Dyadic	Triadic	Mutual	Protoimp./dec.
Spike	2	-	-	-
Josie	1	-	-	-
Cher	6	-	-	-
M2	-	-	-	-
F3	-	-	-	-
M3	-	-	-	-
F4	-	-	-	-
Total	9	-	-	-

Table 5.4: The JA data are summarised in the following table which contains the mean percentage of time in which JA occurred in bonobos, chimps and spider monkeys. The mean in this case is calculated for each individual per 150 scans per subject. n=the number of individuals in the study.

	Dyadic	Triadic	Mutual	Protoimp./dec.	n
Chimps	2.4	0.54	2.36	-	11
Bonobos	2 49	-	7.33	-	4
Monkeys	0.85	-	-	-	7

The focus of joint attention

Chimps spent most of their time in dyadic JA looking at objects and most of their time in triadic JA looking at conspecifics, with mutual gaze being the highest category. Bonobos looked at conspecifics most in dyadic JA as did spider monkeys; the bonobos spent most time (and more time than chimps did) using mutual gaze (see table 5.5.).

Between species comparison of mutual gaze

Chimps and bonobos did not differ significantly from each other in their use of dyadic gaze when analysed with a 2 tailed independent t test ($t=0.060$; $df=13$; $p>0.05$); neither did chimps and monkeys ($t=1.854$; $df=16$; $p>0.05$), but there was a significant difference between bonobos and monkeys with bonobos using more dyadic gaze than the monkeys ($t=4.264$; $df=9$; $p<0.05$); bonobos used mutual gaze significantly more than chimps did ($t=2.422$; $df=13$; $p<0.001$).

When the chimps were split into two groups, enculturated (n=7) and mother reared (n=4), the enculturated chimps showed significantly more JA irrespective of whether mutual gaze was included ($t=2.702$; $df=9$; $p<0.05$); ($t=2.825$; $df=9$; $p<0.05$).

Table 5.5: Mean percentage of time spent in JA observed in chimps, bonobos and spider monkeys where the object of JA is stated. Each subject was scan sampled 150 times. F=Food; O=Objects; C=Conspecifics; V=Vigilance; S=Self; R=Resting: A=Looking around; N=Looking at Nothing.

	Dyadic					Triadic					Mutual gaze
	F	O	C	V	S	F	O	C	V	S	
Chimps	0.480	1.333	0.364	0.242	0.123	0.180	0.364	-	-	-	2.242
Bonobos	0.830	0.333	1.5	-	-	-	-	-	-	-	6.667
Monkeys	0.19	0.572	-	-	-	-	-	-	-	-	-

F=Food, O=Object, C=Conspecific; V=Visitor; S=Self

5.3.3. Conclusion

Joint attention

Under natural conditions, JA was seen in 6 pairs of chimpanzees (n=11) and in 4 pairs, the number of JA scans was significantly above chance. All the bonobos used JA with one another; 4 of the 6 pairs showed JA above significant levels. Two pairs of spider monkeys showed JA but not above a significant level.

The younger, handreared chimpanzees used more JA than their older, mother-reared conspecifics (Vickie, Jomar, Flynn, Josie, Beckie and Jollie). The only chimpanzee who used joint attention and who had not been hand-reared was Sam.

Whilst chimps and bonobos show more than monkeys, only true JA in the form of triadic gaze was seen in chimps. Moreover, no protoimperatives or protodeclaratives were witnessed in the 55 hours of chimp watching, 20 hours on bonobos and 40 hours with the spider monkeys.

The focus of JA was directed mostly to objects in the case of the chimpanzees and mainly to conspecifics in bonobos and monkeys. Far more mutual gaze was seen in the bonobos than in the chimps or the monkeys who almost never used it. There is a very human-like quality to the mutual gaze in bonobos and it is used as a signal for the start of play behaviour (see chapter 8 on Metacommunication in Play Behaviour). So it seems strange that they showed no triadic JA under normal circumstances.

5.4. Experiment 1

Aim

To determine whether the subjects were capable of following the line of sight of the experimenter (myself).

5.4.1. Method

The same subjects were used in the experiment as those used for the observations with the exception that one juvenile female chimpanzee aged 3 was included and with the proviso that the subjects who did not co-operate were not included. Eight chimps were used: 5 females and 3 males; 6 of whom (4 females) were under 10 years of age. Two adult bonobos (one male and one female) and 7 spider monkeys (4 females and 3 males, of whom all except one 4 year old female were adults) were also included.

With each subject I obtained mutual gaze and would then turn my head slightly and look at something else, moving my eyes relatively more than I turned my head so that eye direction could not simply be inferred from head movement alone. If I was not able to establish mutual gaze with the subject, they were not included in this experiment. After mutual gaze had been established and I had looked at an object, I would look back to the subject and then to the object. This checking behaviour from the object to the subject was conducted three times, i.e. I looked at the object three times; it also enabled me to determine whether the subjects were following my line of sight even though my gaze direction was the test stimulus. Checking from the subject back to the object by the experimenter is, if a bias did occur, likely to result in an underestimation of the animal's ability to follow gaze (for example, if the subject glanced very quickly at the object of my attention). This may have occurred in the monkeys more than great apes.

If the subject had not followed my line of sight by the third time I looked at the object, it was considered that they were unable to follow gaze direction. This procedure was repeated ten times per subject over a period of weeks so that it would not appear that I was 'crying wolf'. It was important not to look at anything of special interest in case the animals might have looked at that object anyway. Usually I would look at a particular tree or a parked car.

5.4.2. Results

The results from this section are given in tables 5.6. and 5.7. Only one of the seven monkeys managed to follow my gaze and then on only one of the trials. In order to determine whether the animals were following my line of gaze more than would be expected by chance, I compared the observed and expected values based on the very conservative assumption that the animals could look in only three directions: where I was looking, at me, or elsewhere. This gives a probability of responding correctly of 0.333. In fact, the subjects could look in any direction over 360^{0} in one plane, and to count as looking at the same object I was looking at, they would need to target their gaze to an area in the region of $5/360^{0}$. Moreover, the subjects are not confined to looking in one plane only: if one imagines that their field of vision is a sphere in which they are in the middle, they could look at almost any point on the surface of that sphere. Hence, to take a probability of 0.333 for looking at the correct location is extremely conservative.

Table 5.6: The raw data for each of the subjects is given,. excluding the monkeys since only 1/7 looked in the correct direction, and then only once.

CHIMPS	Score out of 10
Benjie	5
Beckie	6
Melody	10
Ellie	8
Josie	6
Flynn	7
Vickie	5
Jomar	5
BONOBOS	
Kakouwet	10
Diatou	4/6

Table 5.7: The mean percentage of times the subjects followed my line of sight.

	Mean percentage	Min. score	Max. score	n
Chimps	65	50	100	8
Bonobos	87.5	66.67	100	2
Monkeys	2 8	1	1	7

When the chimps were analysed together, using the normal approximation to the binomial and Fisher's procedure for combining probabilities they followed my gaze significantly above chance ($Chi^2=43.881$; df=16; $p<0.05$). Bonobos could also follow my line of sight significantly above chance ($Chi^2=16.680$; df=4; $p<0.02$).

There was a significant difference between enculturated and mother reared chimps (independent $t=4.890$; df=6; $p<0.01$).

Comparison between species

Chimps and bonobos were able to follow a line of sight significantly more than spider monkeys did: chimps ($t=9.239$; df=13; $p<0.001$); bonobos ($t=3.101$; df=7; $p<0.02$). There was no significant difference between the abilities of the chimps and the bonobos to follow line of sight ($t=0.666$; df=8; $p>0.10$).

5.4.3. Conclusions

The ability to follow line of sight is well above a random level of a third for some chimps and both bonobos. With a more precise expectation based on the angle actually subtended by the object of gaze, the results would obviously be more significant statistically.

I had the impression that bonobos are better, or more interested, in following line of sight than chimps; on some occasions the subject who obtained a score of 100% would walk over to the other end of the cage and peer out in the direction I was looking, checking back to see what I was looking at. It proved impossible to gain mutual gaze for more than a second with the juvenile bonobos. Monkeys do not seem to understand line of sight. However, this may be an unfair conclusion to draw at this stage since they found direct human gaze a threat (the monkeys made typical threat gestures towards me when I stared at them: raising their eyebrows and baring their teeth) and this may have prevented them from showing gaze-following. In natural conditions it would be possible for the subjects to have followed gaze direction without making direct eye contact. It is also possible that they could have glanced extremely quickly at the object I was looking at and away again when I was looking at the object. Nevertheless, the monkeys (with one exception) did not meet my gaze.

As stated in the general introduction to this chapter, It is possible that the subjects were conditioned to follow my line of sight (Moore and Corkum in press). However, the objects that I looked at were chosen in order to avoid the possibility that the subject might have chosen to look at that particular object of its own volition. Hence the objects were unlikely to have been sufficiently rewarding to have resulted in such fast conditioning. However, the fact that the subjects could follow line of sight and were probably not conditioned into showing this behaviour does not mean that they were able to represent mentally that I was looking at an object.

A further consideration is the reliability of these data given the procedural difficulties outlined in the methods. I think it is fair to say that despite the fact that my gaze was the test stimulus, I was still able to follow whether they were looking along my line of sight. Povinelli and Eddy's experiment (in press) shows that humans are able to follow chimpanzee gaze with a high degree of accuracy and the pale iris of the spider monkeys facilitated detecting their eye direction. At the very least, I could accurately determine the general direction they were looking in by using their head movements. However, since there is a high degree of subjectivity about the collection of data in this experiment further studies should be conducted in more controlled environments with the opportunity for blind scoring (see Povinelli and Eddy, in press, for the ideal procedure for inter-rater scoring in JA in chimpanzees).

5.5. Experiment 2

Aim

To determine whether the subjects would use joint attention, and in particular, whether they would use protoimperative or protodeclarative gestures.

5.5.1. Method

Four chimps and 4 spider monkeys were used in this experiment, drawn from the same set as mentioned in the general methods. Two male and 2 female chimps were used. There was one male (Benjie) over 10 years of age. Three female spider monkeys were used (2 and 4 years old, and one adult). The fourth monkey was an adult male. It was not possible to conduct this experiment on the bonobos as the female was heavily pregnant and their keeper felt it might unduly excite her.

A novel toy was given to each subject for 5 minutes. The conspecifics housed in the subjects' cage were then allowed to enter the cage. Since the incoming animals could not see the toy beforehand, the aim was to see if the subject would give any protoimperative or protodeclarative gestures especially in the light of the fact that if the subject had TOM, it should know that its conspecifics would not have seen the toy before. In children, sharing or showing is likely to occur in this type of situation (Baron-Cohen, pers. comm.).

A control was conducted for each animal. The subject was observed for an hour at the same time the following day. Again, the subject was observed for 5 minutes on its own; conspecifics were then allowed to enter and data were collected for the remaining 55 minutes. The only difference in the two procedures was that no toy was put in with the animals in the control.

Data were collected for an hour on the subject in exactly the same way as they were collected for the observational study, except that the scans were taken every 30 seconds instead of every 2 minutes.

The toys that were used were plastic stacking castles and a plastic toy car with the chimps, and the castles, the car and a shape sorter with the monkeys. A different toy was used with each subject and the toys were deemed to be interesting to the subjects since they played with them.

5.5.2. Results

Protoimperatives, mutual gaze, triadic joint attention and dyadic gaze were all witnessed in the chimps during the experiment, but only dyadic and mutual gaze were shown by the monkeys (see table 5.8.).

Table 5.8: The number of scans in which each subject exhibited various types of JA behaviour, including protoimperatives. A total of 120 scans were taken per subject. The two species used in this experiment were chimps and spider monkeys.

CHIMPANZEES

	Object	Dyadic	Triadic	Shared	Protoimp.
CONTROL					
Benjie	-	3	-	-	-
Beckie	-	4	-	2	-
Josie	-	1	1	-	-
Flynn	-	3	1	-	-
Mean	-	2.75	0.5	0.5	-
EXPERIMENT					
Benjie	6	-	-	1	-
Beckie	19	4	4	1	-
Josie	10	-	2	3	2
Flynn	70	1	4	-	1
Mean	26.25	1.25	2.5	1.25	0.75

MONKEYS

	Object	Dyadic	Triadic	Shared	Protoimp.
CONTROL					
Spike	-	-	-	-	-
Cher	-	1	-	2	-
Dee	-	-	-	3	-
F3	-	-	-	-	-
Mean	-	0.5	-	1.25	-
EXPERIMENT					
Spike	6	2	-	1	-
Cher	32	4	-	-	-
Dee	60	16	-	-	-
F3	23	14	-	1	-
Mean	30 25	9	-	0 5	-

A comparison was made between the control and the experimental conditions using individual animals as the unit of analysis. A 2 tailed matched t test was used where the subjects were matched with themselves in the experimental and control conditions for the following tests.

Chimpanzees

In the chimps, there was no significant difference between the control and the experiment when joint attention (dyadic, triadic, mutual gaze and protoimperatives) was compared in the two situations (t=2.191; df=3; p>0.05). Neither was there a significant difference when joint attention without mutual gaze (dyadic, triadic and protoimperatives pooled) was compared between the control and the experiment (t=0.837; df=3; p>0.05); shared gaze was not seen significantly more in the experiment than the control (t=0.878; df=3; p>0.05). There was an almost significant difference in the levels of dyadic gaze between the experiment and the control (t=2.324; df=3; p<0.055).

When triadic and protoimperative JA were analysed separately, there was no significant difference in the levels seen between the experiment and the control: triadic (t=2.191; df=3; p>0.05); protoimperative (t=1.567; df=3; p>0.05). There was a significant difference between the two conditions when triadic and protoimperative JA were treated together (t=2.905; df=3; p<0.05).

There was a significant difference between JA levels shown by enculturated and those seen in mother reared chimps in the experimental situation (all types of JA examined together: independent t=6.766; df=2; $p<0.05$).

Spider monkeys

There was a significant difference between the level of dyadic gaze (t=2.406; df=3; $p<0.05$) but not mutual gaze (t=0.728; d=3f; $p>0.05$) in the experiment and the control conditions for spider monkeys.

Comparison between the two species

There were no significant differences between chimps and monkeys when comparing the use of mutual gaze (t=0.293; df=3; $p>0.05$) or dyadic gaze (t=1.954; df=3; $p>0.05$) in the experimental condition.

5.5.4. Conclusions

Despite the fact that chimps and bonobos use almost no JA in the control condition, the chimps used triadic JA and protoimperatives in the experimental condition.

There did not seem to be any evidence to suggest that the subjects had an understanding of the fact that the other chimps were ignorant of the toy; neither were there any gestures indicating showing or sharing. This is, perhaps, not too surprising given that chimpanzees rarely share toys and do not normally make protodeclarative gestures towards one another. However, this need not mean that they have no knowledge of another individual's state of mind: it may simply be that they have no interest in sharing objects with others.

I did observe some interesting interactions between a male and female chimp. The female was smaller, younger and subordinate to the male; both were adolescents. The male played with the toy both when he had received it first and when the female had been given it. When he was not playing with it, the female edged towards the toy, all the while monitoring the gaze direction of the male. When he looked up, she looked away and then started to eat sunflower seeds scattered near the toy. In this way she approached the toy more closely. She looked to see if he was looking and when he wasn't, moved to get the toy. As she was about to get the toy, he looked up and she looked away again. He now came over and removed the toy from its location near her, although he did not play with it. On an earlier occasion during the same period of observation, she simply monitored his gaze and tried to get close when he wasn't looking.

When the male had been given the toy and was playing with it constantly, the female tried to elicit chase behaviour. She would attract his attention and run off a little way to get him to follow her. This was successful eight times; she then attempted to double back and get the toy, but he seemed to realise what her intention was and retrieved the toy before she could reach it.

The only evidence for protodeclaratives came from this male chimp who showed the keeper the toy and held it out to her to look at when she arrived after the toy had been placed in the cage. From the chimp's point of view, he could not have known that she had already seen the toy; indeed, she did not demonstrate any interest in seeing the toy. However, this example does not provide enough evidence to suggest that the chimp knew anything about the keeper's state of mind. Since she was the person who had reared him and still had extensive contact with him, he may have been used to showing objects to her. Alternatively he may have been using the toy as a means of attracting her attention for some other purpose. However, after she returned the toy to him, he did not seem to demand her to play with him or to give him food, but instead played by himself.

In the second instance, he gestured towards the toy whilst looking at the female in his cage and then hit her. He was not playing with the toy, but two minutes earlier she had tried to chase him away from the toy so that she could attempt to get it.

In summary, this experiment showed that the chimpanzees, bonobos and spider monkeys did not make protodeclarative gestures to conspecifics during this experiment. However, the amount of triadic joint attention and the number of protoimperatives increased between the control and the experimental conditions in the chimpanzees and the bonobos. The following experiment aims to test whether chimpanzees, bonobos and/or spider monkeys are capable of using protoimperative and protodeclarative gestures towards a human. The animals may be more used to showing, sharing and requesting from humans as the anecdote given above illustrates.

5.6. Experiment 3

Aim

To test whether the subjects could show any JA behaviours, in particular, protoimperatives and protodeclaratives, especially towards a human experimenter.

5.6.1. Method

The same subjects were used as those that were included in the observational work except that a juvenile female chimp that had been used in experiment 1 was substituted for one of the adult female chimpanzees. This brought the total number of subjects to 10 chimps, 4 bonobos and 8 spider monkeys.

A small wind up dinosaur was placed outside the subjects' cage separated from them by a thick pane of glass so that they could see the toy clearly, but were not able to touch it. The toy was wound up in front of the subjects and allowed to run down (this took 40 seconds). After 5 minutes had elapsed, the toy was wound up again. Altogether 10 minutes of data were collected per subject recording all instances of JA that occurred on scan samples at one minute intervals. Subjects were treated as if they were simultaneous focals (i.e., the toy was placed in front of the cage and every individual in that cage was sampled at the same time). As Altmann (1974) says, "Although focal sampling...does not exclude the possible use of a focal (sub)group of animals, such sampling will usually be practicable only when it is possible to keep every member of the focal subgroup under continuous observation during the sample period....Under most circumstances, the only condition under which such a record can be obtained is that in which all the individuals in the sample group are continuously visible throughout the sample period." This was possible to do in the present experiment because no more than 4 subjects were sampled at once, all subjects were within a metre of me, they were all close together, close to the toy dinosaur and were always visible throughout the sample period.

As stated in the introduction, it is difficult to tell the difference between a protoimperative and a protodeclarative. The conventional definition of a protoimperative gesture (see page 78) is where the subject gestures with a hand or a foot towards an object and uses triadic gaze (alternating gaze from the object to another organism). The subject then shows an acquisitive interest in the object by playing with it or eating it. This definition could not be used here because the subjects could not reach the toy and it was not given to them afterwards. It was thus not possible to tell if they were gesturing towards the dinosaur because they wanted it (a protoimperative) or if they wanted to draw attention to it (a protodeclarative). In order to get round this problem, I made the assumption that any gestures towards the toy and referential looking from the toy to myself were protoimperatives. This was because the subjects saw me place the toy in front of their cage and they are used to humans supplying them with food and toys. Therefore, if they did want it, one would assume that they would expect me to be able to give it to them. (There is the possibility that the chimps may have wanted to draw my attention to the toy - a protodeclarative - as I was attending to them and not to the toy. However, I assume that this is unlikely because they had seen me place the toy in front of them and so the need to make me attend to the toy, whilst it can by no means be ruled out, is probably minimal.) Since they are not used to receiving food and toys from conspecifics, I assumed that any gestures towards the toy and referential looking to a conspecific would be a protodeclarative.

The control consisted of the same procedure being conducted the following day at the same time, but using a dinosaur of exactly the same 'species' which could not be wound up, i.e. it had no key to wind it up with. The reasoning behind this choice of control was that a moving object might naturally attract attention, therefore, in the control the dinosaur is the same as the experimental dinosaur except it is static: it neither moves, nor has the ability to move. Moving objects attract pointing gestures more than static objects (Franco and Butterworth 1989).

5.6.2. Results

In the experiment, both the chimps and the bonobos showed protoimperatives, triadic joint attention to the experimenter and each other, and dyadic gaze. The monkeys showed only dyadic gaze and no gestures or gaze that would constitute true JA (see table 5.9.).

A comparison was made between the experiment and the control. A 2 tailed Wilcoxon test or a matched t test was used; the former was used when the sample size was small but above 6.

Although the chimps stared more at the dinosaur during the control period, there was no significant difference between the experiment and the control (Wilcoxon: $T=8$; $n=8$; $p>0.05$). Neither was there a significant difference between the number of times the monkeys stared at the dinosaur in the control and the experiment (matched $t=5.196$; $df=3$; $p<0.01$).

Chimps used significantly more dyadic gaze with each other during the experiment: (Wilcoxon: $T=3$; $n=10$; $p<0.01$). There was no significant difference in the use of dyadic gaze between the two conditions in bonobos (matched $t=3$; $df=3$; $p>0.05$); but there was an almost significant difference in monkeys (Wilcoxon: $T=0$; $n=8$; $p>0.05$).

No triadic gaze was seen in the monkeys, but the chimps used significantly more triadic gaze with one another during the experiment:(Wilcoxon: $T=1$; $n=10$; $p<0.01$); the bonobos did not show a significant difference (matched $t=1$; $df=3$; $p>0.05$). Although the sample size is small, the trend of the data is in the right direction.

Chimpanzees and bonobos engaged the experimenter significantly more in triadic gaze during the experiment than in the control: chimps (Wilcoxon: $T=1.5$; $n=10$; $p<0.01$); bonobos (matched $t=4$; $df=3$; $p<0.025$). Although the monkeys stared at the experimenter significantly more in the experiment, their stares were used as threatening behaviour (the monkeys used typical threat gestures: raising their eyebrows and baring their teeth) (Wilcoxon: $T=3$; $n=8$; $p<0.05$).

When triadic and dyadic gaze were compared within one condition, no significant difference was found between the two in the experimental condition in chimps (Wilcoxon: $T=10$; $n=10$; $p>0.05$) or bonobos (matched $t=0$; $df=3$; $p>0.05$). There was no significant difference between dyadic gaze and triadic in the control condition in chimps (Wilcoxon: $T=13.5$; $n=10$; $p>0.05$) or bonobos ($t=1$; $df=3$; $p>0.05$).

Although the chimps used more protoimperative gestures (mainly directed towards the experimenter) during the experimental condition, when their protoimperative and protodeclarative gestures were analysed together, neither they nor the bonobos used these gestures significantly more often: chimps (matched t=1.937; df=9; p>0.05); bonobos (matched t=1; df=3; p>0.05) . Monkeys did not use either form of JA gestures. For parsimony, the gestures used by the chimps and bonobos were treated together and deemed to be protoimperatives since they were accompanied by referential looking directed towards me rather than to conspecifics.

When JA was examined altogether (including mutual gaze) there was a significant difference between the experiment and control conditions in chimps (matched t=4.710; df-9; p<0.05) but not bonobos (matched t=0.951; df=3; p>0.05). When mutual gaze was not included in the JA, again there was a significant difference between the two conditions in chimps (matched t=4.571; df=9; p<0.05) but not in bonobos (matched t=1.578; df=3; p>0.05).

There was no difference between the use of JA behaviour between enculturated and mother reared chimps in the experimental condition (independent t=0.499; df=8; p>0.05), nor when shared gaze was excluded from the analysis (t=0.651; df=8; p>0.05).

Table 5.9: The number of scans on which different types of JA were recorded for each individual in the experiment and the control. Ten scan samples were taken per subject.

CHIMPANZEES

	Object	Dyadic	Triadic		Shared	Protoimp.
			me	consp.		
CONTROL						
Benjie	4	2	1	-	-	1
William	-	2	-	-	-	-
Jolly	-	1	-	-	-	-
Beckie	2	1	-	-	-	-
Melody	-	1	-	-	-	-
Ellie	1	1	-	-	-	-
Josie	1	-	-	3	-	-
Flynn	6	1	2	-	-	1
Vickie	2	1	-	2	-	1
Jomar	1	3	1	-	-	-
Mean	1.7	1.3	0.4	0 5	-	0.3

	Object	Dyadic	Triadic		Shared	Protoimp.
			me	consp.		
EXPERIMENT						
Benjie	3	-	4	5	-	9
William	-	3	-	-	-	-
Jolly	-	3	-	-	-	-
Beckie	2	4	-	2	1	6
Melody	-	3	-	-	-	-
Ellie	-	4	-	-	1	1
Josie	-	8	1	-	1	4
Flynn	4	8	-	-	1	2
Vickie	-	4	1	4	1	5
Jomar	-	5	1	2	1	-
Mean	0.9	4.2	0.7	1.3	0.6	2.7

BONOBOS

	Object	Dyadic	Triadic		Shared	Protoimp.
			me	consp.		
CONTROL						
Kakouwet -	-	-	-	-	-	
Diatou	-	-	-	-	-	-
Kichele	-	1	-	-	1	-
Jasongo	-	-	-	-	1	-
Mean	-	0.25	-	-	0.5	-
EXPERIMENT						
Kakouwet 1	1	1	3	-	-	
Diatou	1	1	-	-	-	-
Kichele	2	1	-	-	-	-
Jasongo	2	1	-	-	-	1
Mean	1.5	1	0.25	0.75	-	0.25

MONKEYS

	Object	Dyadic	Triadic		Shared	Protoimp.
			me	consp.		
CONTROL						
Spike	-	4	-	-	-	-
Josie	-	4	1	-	-	-
Cher	-	5	-	-	-	-
Dee	1	4	-	-	-	-
M2	-	1	7	-	-	-
F3	5	1	-	-	-	-
M3	1	1	-	-	-	-
F4	1	1	-	-	-	-
Mean	1	2.625	1	-	-	-
EXPERIMENT						
Spike	-	4	-	-	-	-
Josie	-	5	1	-	-	-
Cher	-	8	-	-	-	-
Dee	1	8	-	-	-	-
M2	-	3	1	-	-	-
F3	2	3	-	-	-	-
M3	-	1	4	-	-	-
F4	1	1	-	-	-	-
Mean	0 5	4 125	0.75	-	-	-

Comparison between species

There was a significant difference between the use of dyadic gaze in chimps and monkeys in the experiment, with chimps using more dyadic gaze (independent t=2.348; df=16; p<0.05); there was a significant difference between the amount of dyadic gaze shown by bonobos and monkeys - the monkeys used dyadic gaze more (independent t=2.670; df=9; p<0.025). There was no significant difference between chimps and bonobos (independent t=1.208; df=12; p>0.005). The monkeys did not use triadic gaze. There was no significant difference between the levels of triadic gaze between chimps and bonobos; however, only 1 out of the 4 bonobos used triadic gaze, whereas, 5 of the 10 chimps showed this form of gaze (independent t=1.376; df=12; p>0.05).

5.6.4. Conclusions

Again the experimental situation highlights the fact that chimpanzees and to a much lesser extent, bonobos, but apparently not spider monkeys can and do use triadic gaze to each other and to the human experimenter, as well as protoimperative gestures. Bonobos used JA less than chimpanzees in these experiments. It is strange that there is a lack of significant results for the bonobos compared to the chimpanzees, especially since all the bonobos used JA towards one another in the naturalistic study but not all of the chimpanzees did (n=7/11). The small sample size of bonobos may be a likely explanation, especially as the trend of the results is in the same direction as those from the chimpanzees.

The monkeys used JA (in the form of dyadic gaze) but this may be because they happen to be focusing on the same object at the same time as their conspecifics rather than that they were monitoring the attendance of others (using peripheral vision) or in the same way that the chimp species were when they used triadic JA.

It can be argued that the control should have consisted of the same methodological procedure but without the toy dinosaur. The toy dinosaur was chosen because it could not be wound up. The control was always presented to the subjects after the experimental dinosaur, therefore, it was assumed that the subjects would be less interested in the dinosaur since it was no longer novel. This is borne out to some extent because there was a difference in gaze and gestures between the experimental and control conditions. However, JA is more often elicited by movement than by static objects (Franco and Butterworth 1989).

5.7. General Discussion

The differences between the data collected in the observational study and the experiments serves to illustrate the fact that chimps and bonobos do have the ability to use JA, but do not use this skill much in their everyday lives. One possibility is, of course, that in a captive situation, there is little to stimulate the animals and less that is novel. The chimpanzees and the bonobos used JA significantly above chance levels, but within the chimpanzees, it was the handreared chimpanzees who used the most JA. This result accords well with the findings from Carpenter et al's study (in press).

They indicated that rearing chimpanzees in a human environment increased the level and duration of JA. In the observational study and experiments 1 and 2 I found a significant difference between the levels of JA used by the enculturated and the mother-reared chimps. That there was not a significant difference in all three experiments may be because of the small sample size, particularly of the mother-reared chimps. It may also be because in Carpenter et al's study, the mother-reared chimps had actually had significantly more human contact, tuition and experimental work conducted with them than the enculturated chimps in this study. Neither was her sample size for the mother-reared chimps much larger than mine, and her sample size for enculturated chimps was less than half mine in all cases except for my experiment 2 where they were the same. It may be that the use of sign and symbol 'language' pushes the animals' ability much further so that a significant difference can then be seen, even when comparing them against 'mother-reared' chimps who have also been handled.

Another reason why their study may have shown a difference between the two rearing techniques may simply be because two thirds of the subjects were bonobos and not chimpanzees and yet they were analysed together as if they were one species. However, it does seem that chimpanzees and bonobos are affected by human contact and that this may be proportional to the amount and nature of their interaction. This suggests that the effects of enculturation are on a continuum; the more contact with humans apes have, the more their behaviour varies from that of their non-humanised conspecifics. This may, in part, be due to conditioning in human-reared great apes (conditioning of JA is described in the introduction (Moore and Corkum, in press)). This conditioning of JA is only likely to occur in enculturated great apes since wild chimpanzees rarely teach their offspring directly (teaching requires the use of JA), nor does JA in captive observational conditions occur at a high level.

Any triadic gaze and protoimperative gestures directed towards a human could be explained by the fact that the animals have had contact with humans, especially their keepers, and have learned that humans 'control' their lives and that the humans can be affected in various ways which will lead to the acquisition of toys and/or food. It is significant that the spider monkeys have had the same level of keeper interaction and have not learned to do this, although, the monkeys could, of course, be using peripheral vision to monitor conspecifics. Moreover, the chimps and bonobos direct JA gestures and gaze towards conspecifics who have no means of obtaining access to desirables like toys and food. However, one should not undermine the mental ability of monkeys since their natural use of gaze and gestures are different from chimpanzees and bonobos.

A further argument is one that has been raised by Povinelli and Eddy (in press). They state that chimps have the ability to spontaneously follow gaze direction, but do not understand what this implies. Povinelli (pers. comm.) would also be inclined to be more sceptical about the claims researchers make for the mental capacity of young children who are able to follow gaze direction. However, recent work by Leekam, Baron-Cohen et al (in press) shows that autistic children are able to pinpoint exactly what the experimenter is looking at, but they, unlike normal children, Down's syndrome children, chimps and bonobos, do not spontaneously follow gaze. This suggests that there is something special about this spontaneous ability, although Povinelli is correct to suggest that this behaviour may be innate (in other words, the animals do not have any capacity to understand the mental states of others).

Another point that needs to be raised is why the bonobos showed fewer triadic JA behaviours and fewer protoimperative gestures, yet a much higher level of mutual gaze than the chimps did? The sample size of the bonobos is particularly small (although no smaller than in the majority of other ToM studies), and hence the results may not be generally true for the species as a whole. However, I feel that the results are robust and a high level of mutual gaze is also witnessed in bonobo play behaviour (see chapter 8 on metacommunication in play). Mutual gaze features heavily in play and from my general observations, it appears as if gaze is being used as a means of communication. One possible hypothesis is that although there is much emphasis on the comprehension of triadic JA and protoimperatives in very young children in the child development literature, triadic JA is not something which adults use as extensively as mutual gaze. When we communicate with one another, we use gaze extensively and the lack of appropriate gaze during conversations is the first thing people comment on when interacting with autistic or Asperger's syndrome people (Frith 1991; pers. obs.). Therefore, I would conclude that mutual gaze as a means of communication is at least as cognitively important as triadic JA.

To conclude, the chimps and bonobos have the ability to use JA, albeit at low levels, whereas the monkeys did not follow line of sight or attend directly to the eyes of conspecifics (although they could have been using peripheral vision to monitor gaze direction). However, the results of this study should be strictly viewed as preliminary work since there are problems of interpretation because a) a blind observer did not score any of the results; b) there is still confusion over what JA behaviours can and do mean in humans, let alone in other species; and c) as frequently is the case in ape studies, the sample sizes are small and the comparisons between species are not matched for age or sex. Nevertheless, this is the first step towards looking at behaviour widely held to be cognitively important in humans. Determining what kinds of JA behaviours are present in animals may help to clarify the problems inherent in the child psychology literature on the subject. At the very least, this study may act as a guide for future work on JA in nonhuman species. The following chapter examines the role of desire comprehension which is thought to be the next developmental stage after JA in the ability to mindread.

6. The Comprehension of Desires

Aim

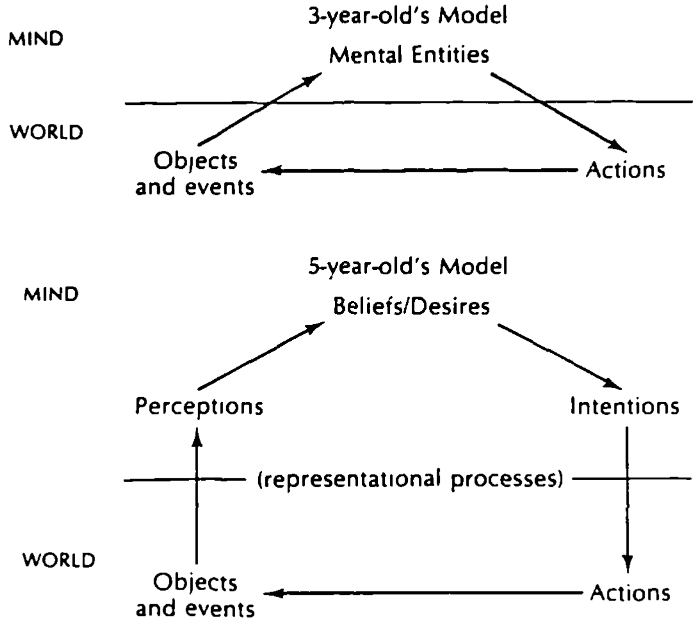
This study attempts to see if chimpanzees could learn to select pictures depicting another chimp's desire. The experiment was conducted on children who are a control for the other two groups to confirm that the experiment is testing nonverbal ToM ability.

6.1. Introduction

The ability to mindread seems to fall into two basic capacities: comprehension of desires and comprehension of beliefs. Children acquire the ability to understand desires at around age 2-3 although they cannot yet understand beliefs. Wellman (1991) sees belief-desire psychology as a triad involving beliefs, desires and actions. People engage in actions because they believe those actions will satisfy certain desires. Thus knowing a person's beliefs and desires will enable one to predict their action, and if their action is known, one can explain it in terms of beliefs and desires.

Wellman argues that children younger than three have no concept of belief, and that this is because they cannot yet represent a belief in the mind of an other. "Simple desires embody no notion of representing an apple in your head, simply wanting one...it is possible to imagine a simple desire psychology - one resting essentially on a conception of internal states directed towards obtainment of objects in the world [that is] quite different from a belief-desire psychology which rests centrally if not wholly on a conception of internal cognitive states representing truths about the world." However, Whiten (1991) points out that two year old's grasp of the representational nature of wants may be severely restricted but that if a child wants an apple and not a pear, it is hard to imagine that they would not have a representational image of their desire. Moreover, it is difficult to imagine someone searching for an object which they want (or they think the subject of the story wants: a task used by Wellman to test desire comprehension) without an internal representation of what they have to search for. Astington and Gopnik (1991) partially agree with Wellman since they believe that children initially have a mentalistic but non-representative theory of mind.

Figure 6.1. Three year olds' and five year olds' models of the relation between the mind and the world (after Astington and Gopnik 1991).



To return to Wellman's (1991) concept of belief-desire psychology as a triad involving beliefs, desires and actions: he states that a simple desire psychology requires the subject to first, engage in goal-directed actions, and secondly, to have certain emotional reactions (getting what you desire yields happiness, not getting it produces frustration, unhappiness etc.). Astington and Gopnik (1991) disagree with Wellman at this point. They state that children need to understand that (1) desires are not the same as actions, that (2) they need to understand the relationship between desires and the satisfaction or otherwise of that desire - which is an outcome, not an action, and that (3) desires are representational states as they involve a representation of objects, not the object itself (see figure 6.1.). Three year olds can understand that a mental entity can lead to an action, but not until they are 4-5 years old will a child understand that intentions mediate between mental representations of a desire or a belief and the subsequent action. Bennett (1991) disagrees. He states that neither belief nor desire can help explain behaviour except when the two are combined. Young children, in his opinion, use a belief-desire psychology, but only the child's own beliefs are attributed to the subject.

Wellman and Woolley (1990) have demonstrated that children can solve desire tasks with ease, but fail on belief-desire reasoning, as has Astington and Gopnik (1991) who show that understanding a desire can be as difficult as understanding a belief, when understanding another's desire depends on comprehending that person's belief. However, children can remember their unfulfilled desires even though they cannot remember and report their earlier false beliefs (Astington and Gopnik 1991; Astington et al 1989).

Wellman and Bartsch (quoted in Wellman 1991) used evidence from natural language to determine when children start to refer to beliefs and desires. They used the longitudinal English corpora of utterances from ten children in the CHILDES database (MacWhinney and Snow 1985). Almost 400,000 child utterances were included in the transcripts. Desire terms were taken to be: want, wish, afraid, care (about) and belief terms were: think, know, expect, wonder, believe, understand. Approximately three per cent of the utterances included one or more of these terms, so the .sample of utterances was reduced to 10,000 child utterances. These were coded into: (1) instances of genuine psychological reference; (2) conversational uses and (3) uninterpretable uses. They showed that reference to desire was well established by the age of two, and that reference to belief begins at about age three (see figure 6.2). References to others in relation to themselves were comparatively rare, but again indicated that children refer to desires before beliefs (see figure 6.3.). Astington and Gopnik (1991) state that children initially assume that other peoples' desires will be like their own and that prior to this, they have equal difficulty or ease in understanding their own and others' mental states. However, it is as yet unclear whether children as young as two fully understand the meaning of the words they use. Indeed, Wellman states that children refer to beliefs by age three, but children do not usually pass the false belief tests until age four to five (Perner 1991; Wimmer and Perner 1983). Neither is it known whether language can act as a developmental scaffold for ToM.

Figure 6.2 . Natural language occurrences of verbs of desire (want) and belief (think and know) used for psychological reference, as a percentage of all uses of these verbs (after Wellman 1991).

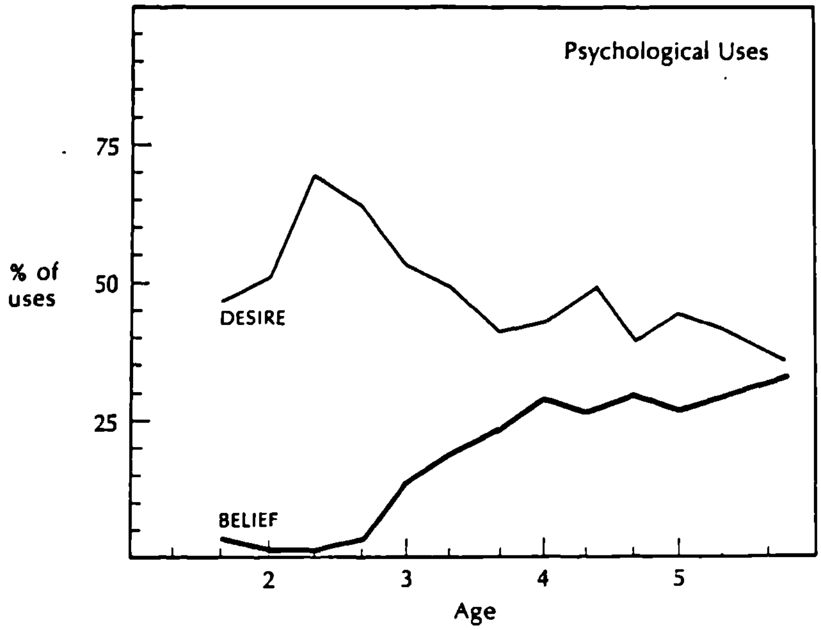


Figure 6.3. Natural language occurrences of verbs of desire (want) and belief (think and know) used to distinguish the mental states of self and other, as a percentage of uses of these verbs (after Wellman 1991).

Harris (1989, 1991) takes a different view of desire comprehension. According to him children rely not on theory of mind to comprehend other peoples' mental states but on a distinctive type of imaginative understanding. The subject imagines what they would feel if they were 'in their shoes'; this generates an 'as if' or pretend emotion. At a more advanced level, appreciation of another's current emotional state requires the subject to imagine not just what the other person feels, but what they believe and what they want. In order to do this, children progress along a developmental path from self-awareness, defined as being aware of their own mental states, through to a capacity for pretence and the ability to distinguish reality from pretence, to finally, the ability to engage in an imaginative understanding of other peoples' mental states. Harris (1989) says, "Given their capacity for pretend play, children can imagine wanting something they do not actually want." This is a twofold process: (1) the child imagines having a particular desire or belief, (2) they imagine the actions, thoughts or emotions that would ensue if one were to have those desires or beliefs.

At present, it is unclear at exactly what age children obtain a full comprehension of desires nor what is understood by the child when it uses or hears words indicating desire. Neither is it clear whether children represent desires or understand them in terms of goal directed actions. However, Whiten (1991) states that even though it is not possible to tell how children, or any other mindreading being from a machine to an animal, can or would understand desires and beliefs it is possible that chimpanzees may have the ability to comprehend desires. As yet no one has explicitly looked at comprehension of desire in chimpanzees; ethologists have concentrated on straightforward ToM as it has been understood by them (although no experiments have been designed specifically to test false beliefs). Arguably, some of the work cited by Byrne and Whiten (1988, 1991, 1992) may show an understanding of desire on the part of the animal. If the subject *intended* to deceive another, it would have had to have a comprehension of the target's desires (see example of Belle and Rock and their deceptive 'arms race' for food). It is possible that the chimpanzee Sarah showed a comprehension of desires in her ability to chose the correct response when given pictures of a problem and the solutions to it (Premack and Woodruff 1978). For instance, when the actor wanted the bananas, but couldn't reach them, she chose the response of the actor standing on a chair.

Bennett (1988) pointed out that Sarah may simply have understood the problem and chosen the correct solution. This may certainly be true. I would argue that she must have some comprehension of desires, as well as the ability to see that this is a problem for the actor and the ability choose the correct solution. At a lower level, all she may have done is thought that she would like those bananas and that if she were unable to reach them, this is the solution she would adopt. When she was given a trainer she liked and one she disliked in various predicaments, she chose the solutions to help the trainer whom she liked and chose compounding problems for the one she disliked. I think this backs up the hypothesis that she was reasoning from an egotistical point of view, although absence of evidence is not evidence of absence, i.e. it does not prove that Sarah does not have the ability to comprehend desires.

Premack and Woodruff's experimental argument against Bennett was as follows: They made a film clip of an actor, say trying to open a biscuit box. He stops, pushes up his sleeves and then resumes trying to open the box. The subjects were familiarised with the video; it was then shown to them in the experiment and stopped at the point where he is about to roll up his sleeves. The choices the subjects were then shown another film clip which depicted either a relevant choice (actor resumes opening box), an irrelevant one, or 'next', (actor rolls up his sleeves). The subjects all made the relevant choice.

There is little wrong with this experiment as it stands, but as a refutation of Bennett it fails for the following reasons: first, only children were used and not even Sarah was given this test. Furthermore, Premack and Dasser's (1991) argument that it is perfectly feasible to argue how a chimpanzee would respond having seen how children would react is not watertight by any means. Secondly, the films show the actor resuming whatever task it was he was engaged in, so by familiarising a child with the film, it will be obvious what happens next, i.e. the theme is trying to open the box and rolling up their sleeves is only a minor incident. Thirdly, the children are presented with the choice of the actor continuing what he was doing, or doing something irrelevant to the theme. The fact that the children chose the relevant outcome does not show that they (and hence Sarah) had a comprehension of another person's desire. Whiten (1991) would agree as he seems to take this as a more parsimonious and equally probable strategy employed by Sarah, rather than that she is comprehending intentions as Premack and Woodruff stated. But further experimental work is needed to prove this.

So far there is only anecdotal evidence of comprehension of desire in chimpanzees, and whilst desire has been reasonably well researched in the psychological field, the existence of the problem has not even been recognised in the ethological one.

To reiterate, it is unclear how and when children fully understand desires, nor what they are mentally representing, if anything, when they use words indicating desire. Nevertheless, experiments from the child psychology literature are all that are available at present and the purpose of the experiment discussed in this chapter is to create a nonverbal desire test which uses the principles of the verbal desire task designed by the child psychologists. The children are a benchmark for the chimpanzee study.

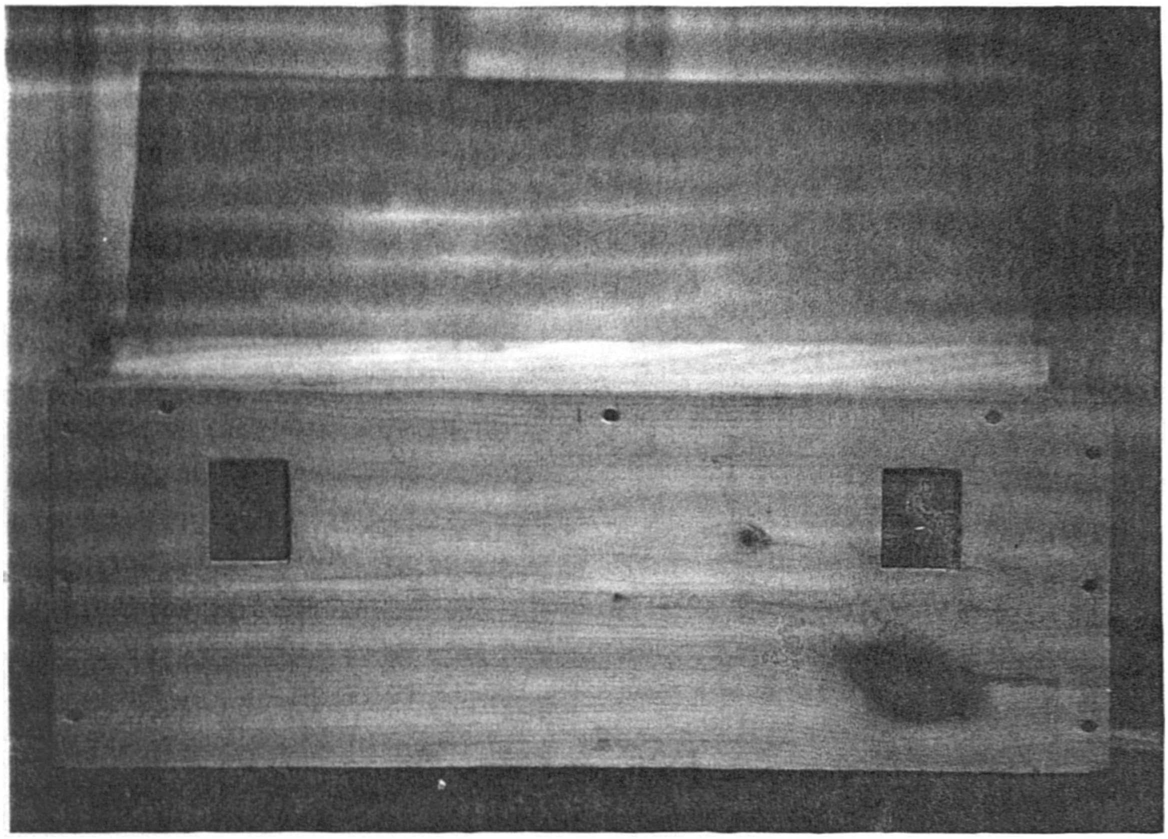
6.2. Methods

6.2.1. Apparatus

The equipment used was a wooden box 56cm long, 30cm broad and 20cm high with 2 drawers and a holder above the drawers for A4 flash cards (see figure 6.4.). The subjects had to pick the appropriate drawer to obtain a reward.

All the subjects, both human and nonhuman, had experience at operating this type of equipment having completed the false belief experiment prior to this (see chapter 7 on beliefs). Subjects were given the test(s) individually, out of sight of any other subjects.

Figure 6.4. The box used to test nonverbal comprehension of fulfilled and unfulfilled desires. Flash cards illustrating a subject desiring an object or a neutral subject were placed on the board at the back of the box. Subjects had to open one of the two drawers at the front which were baited from the back of the box. The reward was placed in the drawer beneath the flash card depicting a subject desiring an object.



6.2.2. Subjects

The children were from St Anne's Roman Catholic First School, Nuneaton. All of them had previously been given tests by me. However, in the time interval between testing them for comprehension of false beliefs (see next chapter) and testing them for desire comprehension, some of them had left school, had birthdays (so fell into a new age class) or were sick on that particular day. The sample sizes are thus slightly different in this chapter and the next. 9 six year olds, 12 five year olds, 6 four and 8 three year olds were tested.

Four chimpanzee subjects were used, two males and two females. They were aged 34 (Pepe - male), 9 (Beckie - female), 7 (Flynn - male) and 6 (Josie - female). The younger three had been hand reared for the first two years of their life and were housed in small groups. The two youngest were housed together (see chapter 3 on general methods for more information on housing).

6.2.3. Procedure

The name, age and sex of each child was noted down. They were then given two tests before the nonverbal desire experiment. The first was the Sally-Ann test for ToM. The second one was Harris et al's (1989) test for desire. The reason for replicating published work was to have a standard of comparison by giving the same children both verbal tests as well as the nonverbal test (see chapter 7 for nonverbal false belief test). This was essential in order to check that the nonverbal tests were measuring desire and false belief comprehension in the same way that the child psychologists have assumed them to be measured by the conventional verbal tests.

ToM: Verbal test for children

A stuffed toy orang (Ollie) and a cat (Custard) were used. The narrative employed was:

"Ollie really loved Smarties and he had been given one today. But Custard also loved Smarties, so because Ollie did not want to eat his Smartie right now, and he didn't want Custard to get it, he hid the Smartie. [The Smartie is hidden in one of the drawers of the box and is put in from the front with the aid of the child: this helps them understand how the box works without having to be told by the experimenter in the experimental situation]. Then Ollie goes away. But Custard had been hiding all this time and watching Ollie and he knows where the Smartie is. So he decides he's going to eat Ollie's Smartie later on. He takes it out from the drawer and hides it in here. [With the child's help, the Smartie is placed in the other drawer. Custard leaves]. Now Ollie comes back and he's feeling hungry. He wants his Smartie. Where do you thing he's going to look for it?"

The location of the Smartie in its original hiding place was alternated with each child. The children's memory was checked by running through the scenario with them again to insure that they remembered the Smartie's location in the two conditions.

Desire: Verbal test for children

The same toys were used and two empty cans of coke and tango. The narrative used was as follows:

"Ollie really loves tango. But he hates coke. Today Ollie had bought a can of tango. He leaves it here while he goes for a walk. But while he's away, Custard comes up and sees his can of tango. Custard knows that Ollie loves tango and he hates coke. He decides to play a trick on Ollie. He pours all the tango out of the can and he fills it full of coke. So now this tango can is full of coke. When Ollie comes back from his walk, he is hot and thirsty and he thinks he'd love a drink of tango. He takes a big swig from his can. How do you think Ollie will feel?"

The drink that Ollie liked was altered for each child. The scenario was run through with each child to check that they remembered which can of drink Ollie liked and what had happened to the drink.

The nonverbal desire experiment was then conducted. To keep the procedure as similar to the chimps' as possible, very little was said to the children regarding the experiment although they were praised and encouraged. It was not explained how they could obtain the Smartie or why they should choose a particular drawer.

Procedure for nonverbal desire experiment (used for all subjects)

Training phase

Two flash cards were placed on the box, one above each drawer and a reward was placed in one of the drawers. The subjects could not tell from the experimenter's actions, which drawer the sweet was in. Smarties were used for the children; jelly babies, jelly fruits, rolos, polos, carob drops, twix pieces, munchies, opal fruits, coconut, mango, pear and grapes were used for the chimps.

One flash card showed a child (in the case of the children) or a chimp (in the case of the chimps) desiring an object, the other was neutral (see figure 6.5). The subject had to choose the drawer below the picture showing the child or the chimp desiring an object. This drawer always contained the reward. The pictures were hand drawn by the author. Subjects were allowed as many attempts as it took to obtain a correct response significantly above chance. A response that was significantly above chance was a score of 8/10 on the last 10 trials using a binomial test, or, if the number of trials exceeded 10, a normal approximation to the binomial was used with the formula:

$$t = (O-E)/\text{square root of } Np(1-p)$$

where 0 is the observed number of correct responses, E the expected number of correct responses. E=Np where p is the probability of a correct response by chance (p=0.5) and N is the total number of trials.

The procedure was then repeated using another pair of flash cards. Before each attempt, the position of the flash card showing a desiring chimp was randomly altered by tossing a coin. The neutral flash card was placed above the other drawer.

Transfer phase

The procedure was repeated using two more pairs of flash cards. The first of these showed a desire and a neutral state as described above; the second last pair of cards showed an unfulfilled desire. The child subjects were only allowed one attempt for each pair and the chimps were allowed ten attempts. Again, the chimps needed 8 out of 10 for significance. The chimps were given more attempts than the children because children learn faster than chimps. In addition, since the chimps were tested first thing in the morning before being fed, it is likely they would still try another location, even if they knew where the location of the sweet ought to be (risk sensitive foraging preferences: Caraco et al 1980). In contrast, children (who have been subjected to more intense socialisation than the chimpanzees) will expect to find sweets and other foods in a more limited range or locations, and are thus less likely to search other possible hiding places. Moreover, children are used to playing games and undergoing tests where the aim is to choose the correct response regardless of whether or not a food reward will

However, it could be argued that only the first trial should be taken into consideration in the transfer section for both the children and the chimpanzees. Reinforcing the chimpanzees by rewarding them when they pick the correct card simply conditions them into discriminating between the two cards without an understanding of why they are choosing a particular card. Transfer to a new task which is highly similar to previous tests allows some subjects to make fewer errors when attempting the new task (rhesus macaques: Shepp and Schrier 1969; Mackintosh 1974). As Harlow (1959) phrased it, subjects can 'learn to learn'. However, rhesus macaques (Harlow 1959) and gorillas (Fisher 1962) will only show fewer errors on the second trial of a new problem if they have had prior experience of a similar task in which they were given over 250 pairs of objects. In the comprehension of desire experiment, none of the subjects were allowed to discriminate between such a large number of pairs of flash cards.

A second consideration is that the subjects may selectively switch their attention to a particular dimension as Pavlov noted (1927). It is possible that this can result in class-concept learning in which the subjects either discriminate correctly by abstracting the common features in each set of trials, or, more usually, where they rote-learn the correct members of each class (Vaughan and Greene 1984 in pigeons; Gaffan 1977 and Schrier, Angarella and Povar 1984 in primates). To counteract this the design of the flash cards was such that there should be no way that the subjects could pick up cues other than that the actor wants something. In other words, there were no cues that were constant throughout the training cards or the transfer cards. This made the test more difficult and thus far more conservative since direction of eye gaze as an indication of desire was not constant throughout the cards, yet eye gaze is usually used for precisely this purpose (Baron-Cohen 1994).

Pair 1.

a) Chimp/child holding a banana and looking at it.
b) " next to a banana but not looking at it.

Pair 2.

a) Chimp/child 'asking' to be groomed/have hair combed but not looking at the other person/chimp.
b) The two chimps next to one another but not looking at each other. The child and mother next to one another, in the same position as a) but this time the child's comb is sticking out of his pocket.

Pair 3.

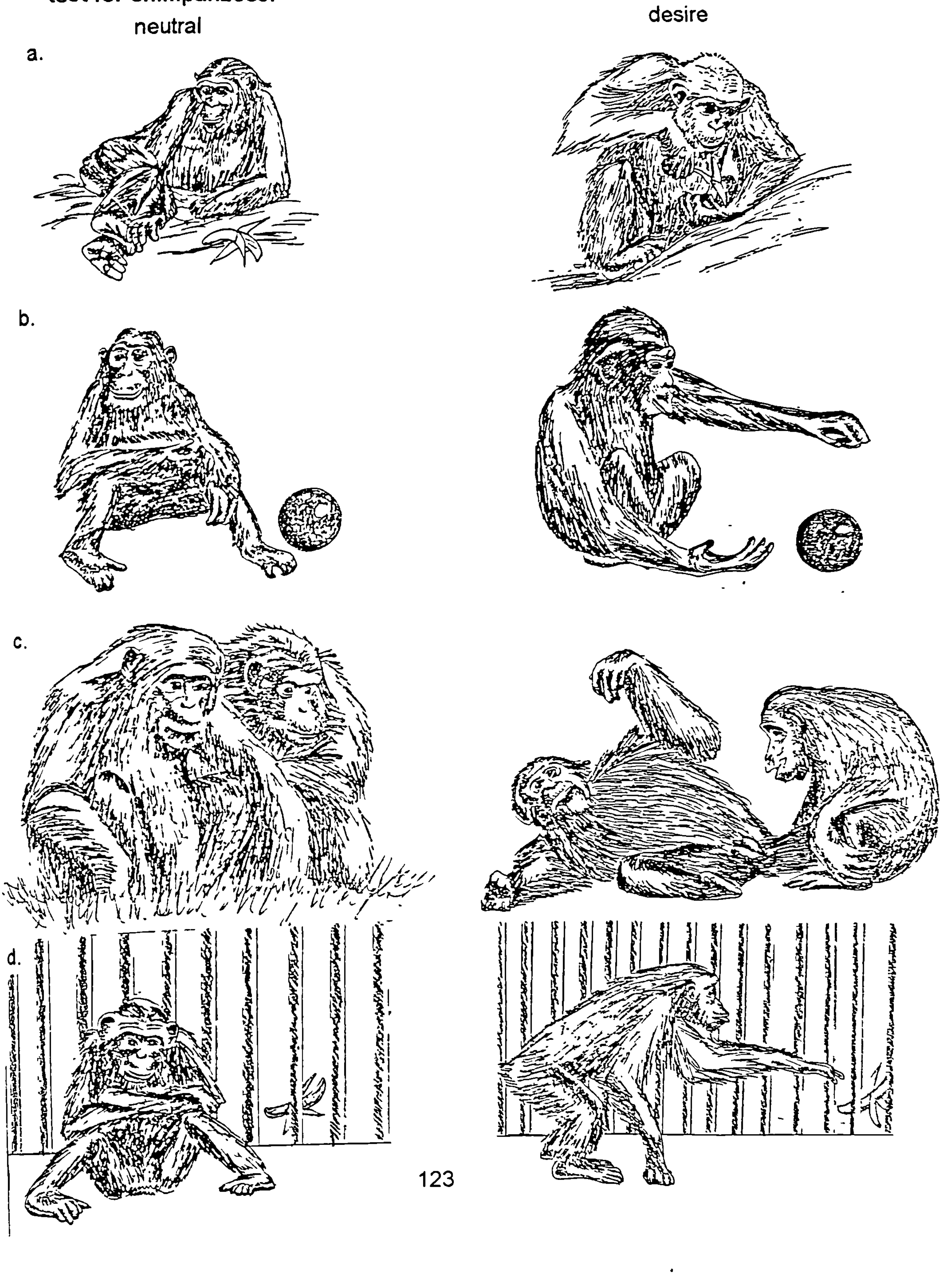
a) Chimp/child holding and looking at a toy (ball/car).
b) " next to toy but not touching it and looking away.

Pair 4.

a) Chimp looking at and 'pointing' at a banana outside its cage. A child looking at and pointing at a toy on top of a cupboard.
b) Same as above without the looking and pointing.

In this chapter, tests for significance were 1-tailed.The issue is whether there is any evidence that the subjects can pass a desire test. The null hypothesis is that they cannot do significantly better than chance. A non-significant result OR a significant negative result means that the subject cannot pass the desire test. Since we are asking only whether a subject can do significantly better than chance, not whether the result is significantly larger or smaller than chance, a one tailed test is both appropriate and the only proper procedure.

Figure 6.5: The pictures used for the flash cards in the nonverbal desire test for chimpanzees.



6.3. Results

Both children and chimps had the most difficulty with pair 2 which showed grooming/hair brushing. On the whole, the chimps did better on pairs 1 and 4 which involved food (see table 6.1.). Both children and chimps had problems when the cards were not moved for more than 2 trials - they would often look in the opposite drawer from the correct card.

6.3.1. Children

There was a trend for increasingly correct responses to both the Sally-Ann test and the desire test with age. The 3 year olds were not particularly good at solving either test. However, both they and the 5 and 6 year olds did well on the fulfilled desire test but there seemed to be no coherent pattern between or within any age group when one examines their responses for the unfulfilled desire test. The raw data for the children's responses are given in table 6.1.

A third of 3 year olds gave the correct answer to the Sally-Ann task and 22.2% gave the right response to the desire test. The 6 year olds achieved exactly the same response for both tests and for the fulfilled desire test: 88.9% (see table 6.2.). For the Sally-Ann test, the 4 year olds scored just above chance levels, the 5 year olds were exactly at chance levels (p=0.5) and only 6 year olds scored well above chance. Both the 3 and 6 year olds scored very well in the desire test (87.5% and 88.8% respectively) but the others produced scores that were around chance levels, and there seemed to be no discernible trend for the unfulfilled desires.

By grouping the children according to class, a clear and linear progression is seen where the older children became increasingly better able to comprehend the Sally-Ann and Harris desire test; all the class of 6 year olds were able to give correct answers to both tests (see table 6.3.). Over 80% of the children in all classes apart from the 4-5 year olds were able to perform well at the fulfilled desire experiment, but the children in all 4 classes hovered at just over random levels for the unfulfilled desire. The class of 3 year olds was the same as the group of children aged 3, and in the class of 6 year olds, no children aged 7 were tested.

Table 6.1: Actual results for all the children tested giving their name, age, response to the Sally-Ann test for TOM (SA), the Harris desire test (Dt) and the nonverbal fulfilled desire (D) and unfulfilled desire (UF) test. Correct responses are portrayed as (+) and incorrect as (x). The children are split into school classes denoted by the dotted line.

Child	Age	SA	Dt	D	UF
Dean	3	x	x	+	x
Laura	3	x	x	+	+
John	3	x	x	+	+
Emily	3	+	+	+	+
Alice	3	+	+	x	x
Alex	3	+	x	+	+
Oliver	3	x	x	+	x
Vicki	3	x	x	+	+
Lia	3	x	x	-	-
……	……	……	……	……	……
Luke	4	x	+	x	x
Sean	4	+	+	x	+
Emily	4	+	+	+	+
Beckie	4	+	x	x	+
Daniel	4	x	x	+	x
Martin	4	+	x	+	x
Nicola	5	x	+	x	+
Laura	5	+	+	x	+
Chris	5	+	+	x	x
Beola	5	+	+	+	+
Bethan	5	x	+	+	+
Craig	5	+	+	+	+
Adrian	5	x	x	x	+
Daniel	5	x	x	+	x
……	……	……	……	……	……
John	5	+	+	+	+
Eedie	5	x	+	+	+
Laura	5	+	+	x	+
Hannah	5	x	+	+	x
Charles	6	x	+	+	x
David	6	+	+	+	+
Sean	6	+	+	+	x
Wayne	6	+	x	+	+
……	……	……	……	……	……
Phillip	6	+	+	+	x
Charlotte	6	+	+	+	+
Laura	6	+	+	x	+
Daniel	6	+	+	+	x
Nicola	6	+	+	+	+

Table 6.2: Mean percentage correct response given by children for the Sally-Ann test for ToM (ToM), the Harris desire test (Dt), the desire pair of flash cards (D) and the unfulfilled desire pair of flash cards (UF) where the children have been grouped according to age.

Age	SA	Dt	D	UF	n
3	33 3	22.2	87.5	62.5	8(9)
4	66.7	50	50	50	6
5	50	83.3	58 3	75	12
6	88 9	88 9	88 9	55 6	9

Table 6.3: Mean percentage correct responses given by children for the Sally-Ann test for ToM (ToM), the Harris test for desire (Dt), the desire flash card (D) and the unfulfilled desire flash card (UF) where the children were grouped according to their class.

Class	SA	Dt	D	UF	n
3-4	33 333	22.222	87.5	62.5	8(9)
4-5	57 143	64 286	50	64 286	14
5-6	62.5	87 5	87.5	62.5	8
6-7	100	100	80	60	5

The responses the children gave for all four tests were tested for significance levels using a 1 tailed binomial test with a probability of 0.5. A 1 tailed test is appropriate in an experimental situation because there are only two responses the subject can give: correct and incorrect. Since the purpose of this study is to determine whether the subjects have the ability to comprehend a belief-desire psychology, it would not make sense to ask whether subjects score significantly below chance levels. Rather, scores at or below chance levels all imply that subjects lack the ability to solve belief-desire problems. One extra 3 year old was included in the analyses for the Sally-Ann and Harris desire test (she refused to do the rest of the experiment). All results are grouped according to either age group or class the subject belonged to (the raw data are presented in table 6.1.).

Sally-Ann test for ToM

The only significant result was for 6 year olds and the class of 6 year olds at 0.05 significance levels: 3 year olds(p=0.254); 4 year olds(p=0.344); 5 year olds(p=0.613); 6 year olds(p=0.02); class 4-5(p=0.395); class 5-6(p=0.363); class 6(p=0.013).

The Harris desire test

Five and 6 year olds gave significantly correct results for this test, as did the class of 5-6 and 6 year olds at 0.05 significance levels: 3 year olds(p=0.09); 4 year olds(p=0.656); 5 year olds(p=0.019); 6 year olds(p=0.02); class 4-5(p=0.212); class 5-6(p=0.035); class 6(p=0.031).

The nonverbal desire test

Fulfilled desire

Three and 6 year olds gave significantly correct answers to this part of the experiment. The class of 5-6 year olds also gave a significantly correct response; 4/5 six year olds gave the right answer and since the 6 year old age group had a significant result, the nonsignificance of the results from the class of 6 year olds is probably due to the small sample size: 3 year olds(p=0.035); 4 year olds(p=0.656); 5 year olds(p=0.387); 6 year olds(p=0.02); class 4-5(p=0.605); class 5-6(p=0.035); class 6(p=0.188).

Unfulfilled desire

No group produced a significant result : 3 year olds(p=0.363); 4 year olds(0.656); 5 year olds(p=0.073); 6 year olds(p=0.5); class 4-5(p=0.212); class 5-6(p=363); class 6(p=0.812).

Figure 6.6: The responses the children gave to the fulfilled desire test (D) and the unfulfilled desire test (UD) are shown grouped according to age and school class.

3 year olds

	UF +	UF x
D +	5	2
D x	0	1

4 year olds

	UF +	UF x
D +	1	2
D x	2	1

5 year olds

	UF +	UF x
D +	5	2
D x	4	1

6 year olds

	UF +	UF x
D +	4	4
D x	1	0

class 4-5

	UF +	UF x
D +	4	3
D x	5	2

class 5-6

	UF +	UF x
D +	4	3
D x	1	0

class 6

	UF +	UF x
D +	2	2
D x	1	0

Fulfilled and unfulfilled desire

A comparison was made between the responses children made to the two different aspects of the nonverbal desire test: fulfilled and unfulfilled desire, and between the verbal Harris desire test and the nonverbal desire test. A binomial test was used where $p=0.5$ in order to determine whether a significant proportion of children gave the correct answer to both tasks (see figures 6.6. and 6.7.). The analyses were conducted by age group as well as class and significance was taken to be $p<0.05$.

No significant association was seen in any age group or class between being able to give the correct response to either the fulfilled or the unfulfilled desire task, although all the children apart from the 4 year olds, showed a tendency to give correct answers to both tests: 3 year olds($p=0.363$); 4 year olds($p=0.109$); 5 year olds($p=0.307$); 6 year olds($p=0.5$); class 4-5($p=0.09$); class 5-6($p=0.637$); class 6($p=0.5$).

Nonverbal fulfilled desire and the Harris desire test

There was no significant association between the fulfilled desire responses and the responses to the Harris desire test in any age or class. However, when the children were examined by their classes, there was a trend showing that they gave increasingly correct results to the two tasks, culminating with the class of 6 year olds who scored 4/5 on both tests: 3 year olds(p=0.004); 4 year olds(p=0.016); 5 year olds(p=0.613); 6 year olds(p=0.09); class 4-5(p=0.09); class 5-6(p=0.015); class 6(p=0.188).

Figure 6.7: The responses the children gave to the fulfilled desire test (D) and the Harris desire test (Dt) are shown grouped according to age and school class.

3 years old

	Dt +	Dt x
D +	1	6
D x	1	0

4 years old

	Dt +	Dt x
D +	1	2
D x	2	1

5 years old

	Dt +	Dt x
D +	6	1
D x	4	1

6 years old

	Dt +	Dt x
D +	7	1
D x	1	0

class 4-5

	Dt +	Dt x
D +	4	3
D x	5	2

class 5-6

	Dt +	Dt x
D +	6	1
D x	1	0

class 6

	Dt +	Dt x
D +	4	0
D x	1	0

6.3.2. Chimpanzees

Training phase

On the training phase using the first pair of flash cards Pepe, Flynn and Beckie had overall scores significantly above chance (Pepe: $p=0.011$; Flynn: $p=0.055$; Beckie: $t=1.671$; $df=58$; $p<0.05$) and Josie scored 9/10 correct ($p=0.011$) on her last 10 trials.

Using the second pair of flash cards, Beckie, Pepe and Josie scored 8/10 ($p=0.055$) for their last ten trials and Flynn scored 9/10 ($p=0.011$) right. Overall in the training phase Pepe had 79 trials, Flynn had 80, Josie had 99 and Beckie had 89.

Transfer phase

The chimps did not choose the correct card in either of the transfer stages significantly above chance. However, Josie and Pepe obtained 7 out of 10 correct answers on both the desire and the unfulfilled desire test cards which is almost significant (8 out of 10 would be significant for a one tailed test): fulfilled desire: Flynn($p=0.172$); Josie($p=0.172$); Beckie($p=0.623$); Pepe($p=0.172$); unfulfilled desire: Flynn($p=0.623$); Josie($p=0.172$); Beckie($p=0.623$); Pepe($p=0.172$). Moreover, Josie chose the correct answer the first time she was presented with the desire card and she, Pepe and Beckie chose the correct card the first time they were presented with the unfulfilled desire test. Nevertheless, there was no overall trend in the order of their responses (see figure 6.8.).

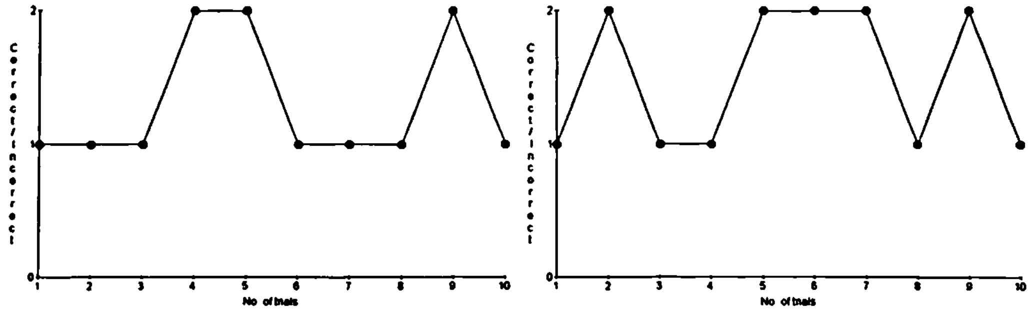
Pooling the results for each individual using Fisher's procedure for combining probabilities suggests that there is no underlying tendency for the animals to score at better than chance levels at either test: desire ($Chi^2=3.309$; $df=8$; $p>0.05$); unfulfilled desire ($Chi^2=3.733$; $df=8$; $p>0.05$). The percentage of correct responses for each chimp are given in table 6.4.

Table 6.4: Responses to the training and transfer phases as a percentage for each chimp individually.

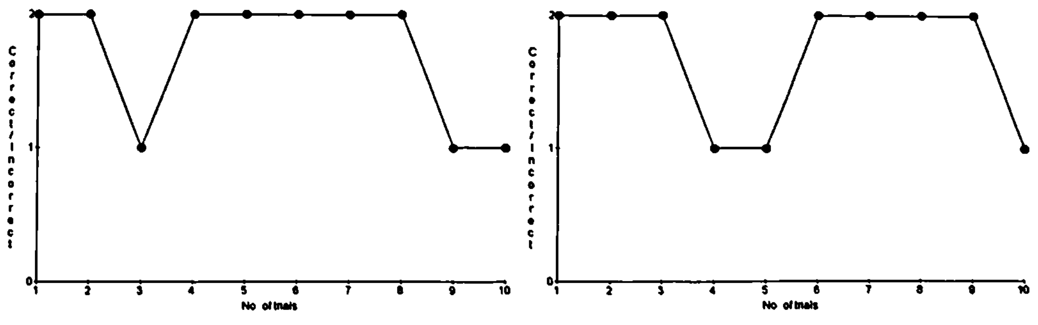
Cards	Flynn	Josie	Beckie	Pepe
Training card 1	80	57.5	65.5	90
Training card 2	55.7	57.7	56.7	52.2
Desire	30	70	50	70
Unfulfilled desire	50	70	50	70

Figure 6.8: The responses each chimp made for the fulfilled desire (left hand graph) and unfulfilled desire (right hand graph) are shown. A correct choice was marked as 2 on the y axis and an incorrect choice as 1.

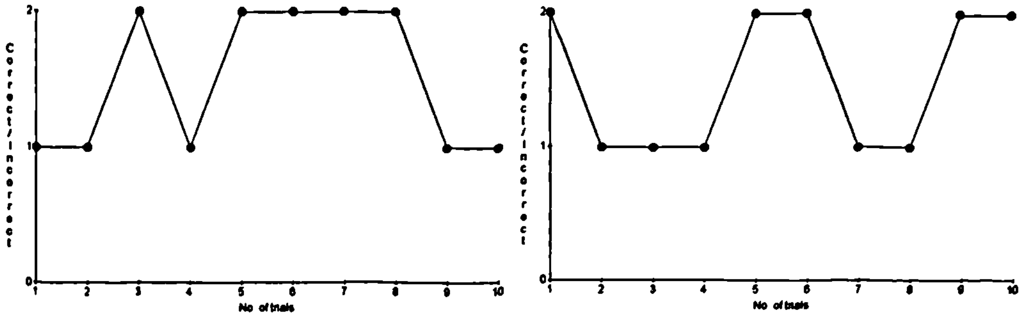
Flynn



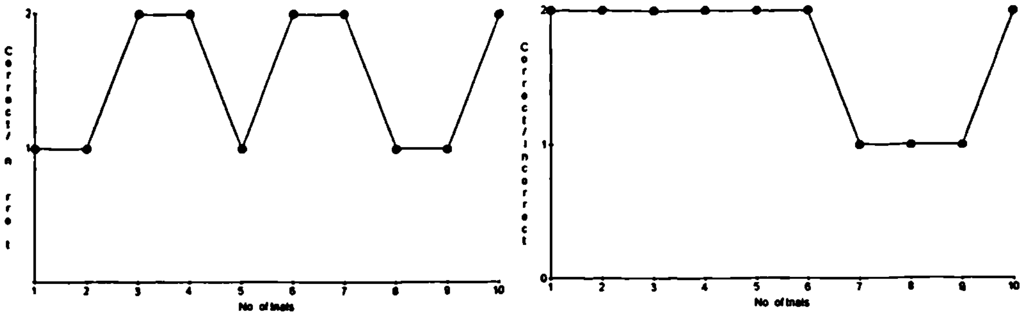
Josie



Beckie



Pepe



6.4. Conclusion

The expectation is that children from the age of 2 should be able to understand a desire test (Harris et al 1989; Wellman 1991), and indeed, children above 3 (apart from the 4 year olds who were perhaps an anomaly) did well on the nonverbal fulfilled desire test. Another prediction is that unfulfilled desires are harder than fulfilled desires. This was born out by my results: no age group were really able to understand the unfulfilled desire test, although 75% of the five year olds were able to give a correct answer to this part of the task.

These results suggests that the children found the nonverbal fulfilled desire task easier than the verbal desire task, therefore the nonverbal task is

* It is possible that showing the subjects film clips of actors desiring or not desiring objects or food might be less ambiguous. The actors would not be frozen in time as they are in pictures or photographs and the subjects might find this more realistic. Probe trials could be inserted between training sessions; this would reduce the likelihood of the animals learning what cues they should pay selective attention to, or showing rapid discrimination learning.

a test they ought to be able to satisfy to qualify for comprehension of desire psychology.

The chimpanzees fail even this weak test and they were given every chance by making the criteria for passing less stringent. The chimpanzees were given ten trials in the transfer phase for both fulfilled and unfulfilled desire whereas the children only had two trials, one each for the fulfilled and unfulfilled part of the task.

What conclusions can we draw from these results? First, if we take the test at face value, chimpanzees clearly don't have what ever it is that the children have at age three upwards and are not capable of passing desire tasks (whether this indicates an understanding of desire comprehension on the part of the children is another matter). There is some evidence for this since the chimpanzees are equally bad at both the unfulfilled and the fulfilled desire tasks, whereas the children have problems with the former, but not with the latter.

Secondly, an alternative explanation may be that the chimpanzees could not interpret the meaning of the cards so it was an unfair test. The pictures may have been ambiguous to them, and they have not had any practise at interpreting images represented in pictorial form prior to this test. If this is the case, what they learned in the training phase was not to 'read' desire, but simply to discriminate between the pairs of pictures: a discrimination task analogous to learning the difference between stars versus squares. *

A third possibility is that the chimpanzees needed more training since they learn more slowly than children. The children saw this as an interesting game but chimpanzees do not and have not had any practice at playing games.

However, had the chimpanzees scored above a level that was statistically significant, what could have been concluded? It could be argued that they had achieved the same results as a three year old child, although this in itself would not prove that they had understood another chimpanzee's desires. A more parsimonious explanation would be that the subjects were choosing the flash cards on an arbitrary basis. They might have learnt to choose the correct card because they were reinforced by the sweet reward, regardless of why that particular card was the correct one to choose.

In conclusion we can surmise that the nonverbal desire test may be a weaker version of a verbal desire task. However, we need a better designed test that is nonverbal, can test desire comprehension at the same level as the verbal task and can be used with animals. A fool-proof task such as this is complex to design and has not yet been conceived. Nonverbal false belief tasks are perhaps easier to design since they do not have to use ambiguous (to nonhuman animals, at least) pictorial representations of mental states. The following chapter deals with a nonverbal false belief task that was tested on chimpanzees. Children provided the baseline study for the validity of the task.

7. The Comprehension of False Beliefs

Aim

The following experiment attempts to test comprehension of nonverbal false beliefs and has been conducted on autistic adults and young children as well as chimpanzees. The children are, once again, a control for the other chimpanzees to ensure that the experiment is testing nonverbal ToM ability as defined by the child psychology literature.

7.1. Introduction

Beliefs are understood after desires (Perner 1991; Wellman, 1990; Wimmer and Perner 1983); the comprehension of a false belief is the litmus test of theory of mind and is usually achieved by about age 5.

An understanding of other peoples' minds (and hence their beliefs) is coded in levels of intentionality (Dennett 1988, 1987; see chapter 2). Autistic people do badly on tests requiring a comprehension of intentionality (Leslie 1991). Baron-Cohen et al (1985) used the Sally-Ann test (see previous chapter) to show that 85% of 4 year olds, 86% of Down's syndrome children but only 20% of autistic children could give the correct answer. Perner et al (1987) tested understanding of false beliefs using the Smartie task: 92% of 6 year olds gave the correct answer to this test, but only one out of 8 autistics that were tested did.

As far as nonhuman animals are concerned, it seems that the evidence regarding monkeys' ability to mindread is inconclusive, but that in the main, it tends to be negative (Cheney and Seyfarth 1991). For example, rhesus and Japanese macaques showed no understanding of lack of knowledge in their own infants regarding either food or a 'predator'. Anecdotal evidence for theory of mind in great apes is somewhat controversial, but seems to be more positive than the experimental evidence for monkeys. Byrne and Whiten (1988, 1991, 1992) have records collected from scientists of tactical deception in primates, with disproportionately high amounts of deception recorded in chimpanzees and baboons. However, not all recorded cases of deceptive behaviour may be intentional, but could easily have been learnt through conditioning (see chapter 2; Byrne and Whiten 1985). In the case of food calls, chimpanzees do not seem to take into account the audiences' state of mind. The calls are correlated with the amount of food present, rather than whether or not another chimp is already aware of the food (Wrangham 1975; Hauser and Wrangham 1987). Here the chimp's knowledge of another chimp's knowledge may simply be over-ridden by motivational factors incited by the presence of food.

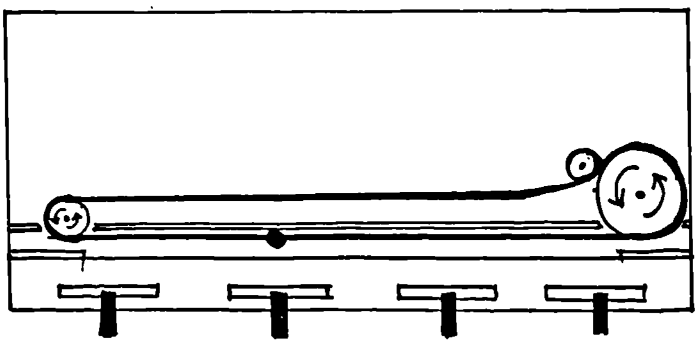
Povinelli, Nelson and Boysen (1990), and Povinelli, Parks and Novak (1991) have shown that 3 out of 4 chimps, but no rhesus macaques, are able to understand that the visual perspective of a human trainer leads to knowledge (see chapter 2). However, this experiment does not show what is to some (Wimmer and Perner 1989) the crucial component of theory of mind, namely whether chimpanzees can comprehend false beliefs.

7.2. Methods

7.2.1. Apparatus

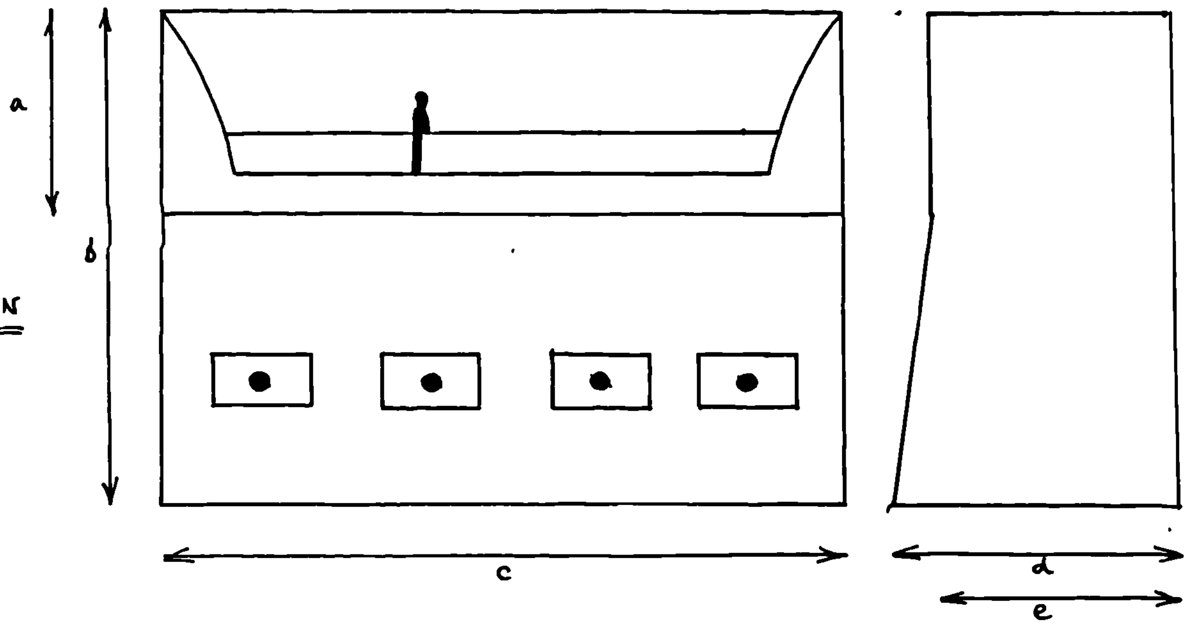
The apparatus was a wooden box, 91.5cm long, 46cm broad and 63cm high with 4 small wooden drawers and a fan belt upon which a coloured peg (a large, red wooden dolly peg used for hanging out clothes) could be hooked (see Fig. 7.1.). When the box was placed on a desk and the subject seated in front of the box, they could not see behind the facade of the box, nor how a hidden lever mechanism attached to the fan belt operated; neither could the person who sat behind the box see the front of it.

PLAN

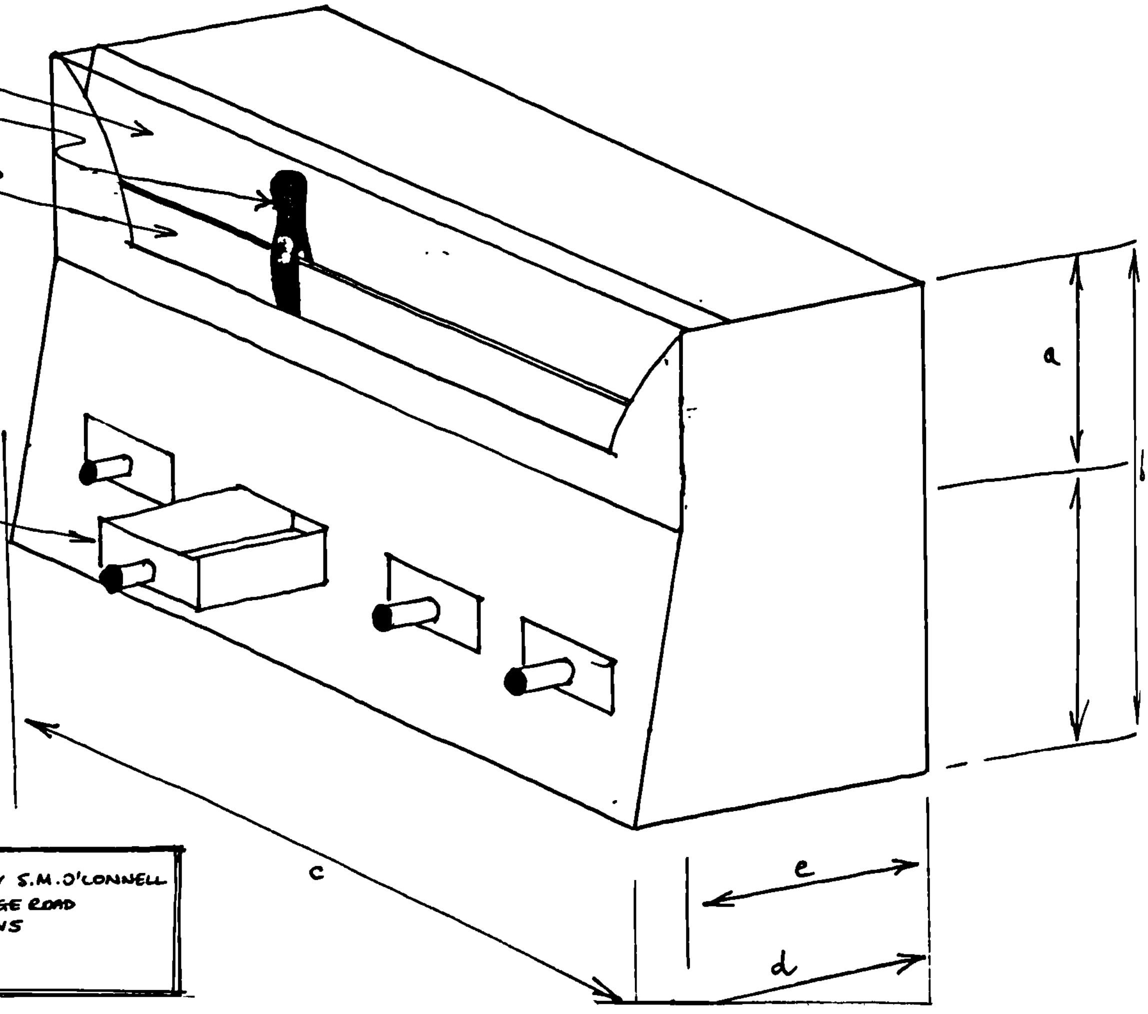


DIMENSIONS (mm)	
a	2300
b	6300
c	9150
d	4600
e	3000
f	
g	
h	
i	

FRONT & SIDE ELEVATION



3-D PERSPECTIVE DRAWING



"PEGGED BOX" DESIGN BY S.M. O'CONNELL
93a GRANGE ROAD
LONDON W5

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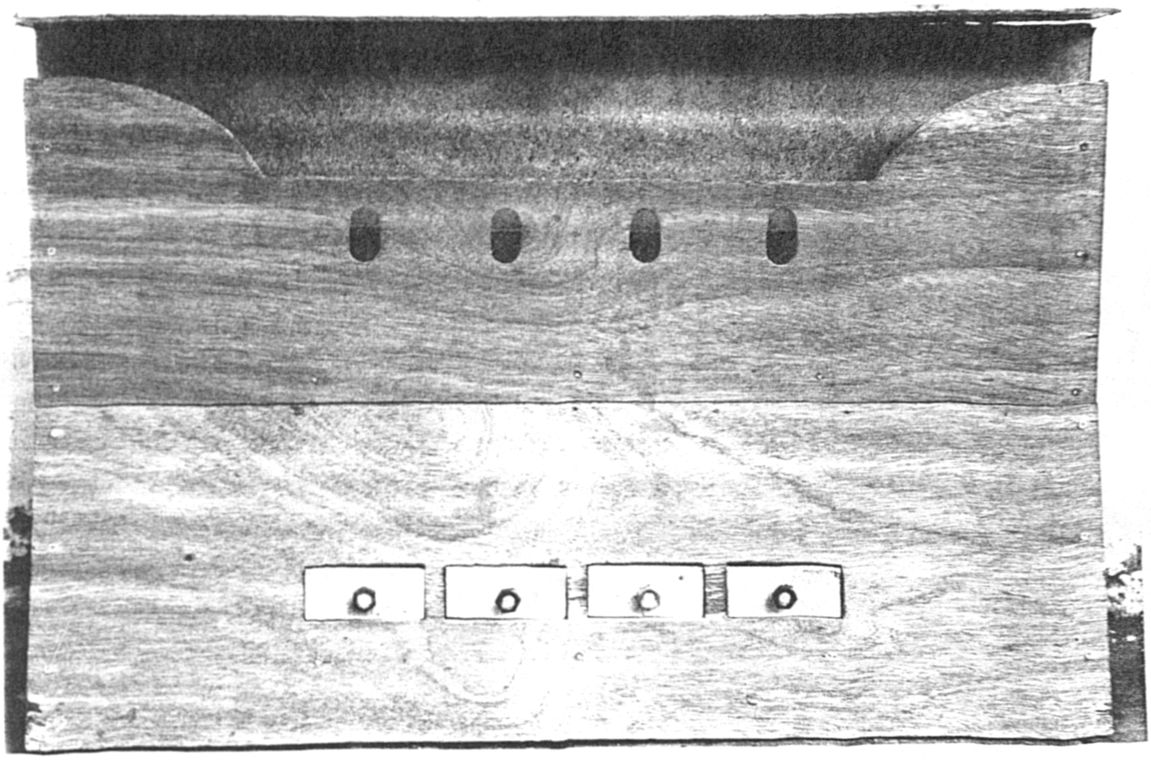
Figure 7.1: The wooden box used for the nonverbal theory of mind experiment. The peg is placed on a fan belt at the top of the box and is centrally placed above one drawer when it can be seen through one of the perspex windows (the ovals at the top of the box). The pegs used were painted bright red and were long enough to be seen above the window as well as through the perspex. The subjects had to pick one of the four drawers. The correct drawer contained a reward. See methods sections for more details.



7.2.2. Chimps

Subjects

The same 4 subjects were used as described in the previous chapter on desire comprehension. Subjects were tested individually and out of sight of the other experimental subjects.

Training

The experimenter (myself) stood at the front of the box and put the peg above one of the drawers, hooking it onto the fan belt so that it stood upright. I then went round the back of the box and placed a sweet or piece of fruit in the corresponding drawer. Subjects were allowed to choose a drawer and remove the sweet if they chose the correct drawer. The procedure was repeated, placing the peg above one of the other drawers on a random basis. This was done by picking one of 4 cards with A, B, C or D written on them which corresponded to the drawers on the box. Choosing one of the four drawers on a random basis naturally resulted in all four drawers being chosen approximately an equal number of times. This procedure for picking which drawer the peg was to be placed above was also used in the experimental phase.

Initially the subject was allowed to have more than one attempt at opening the drawers, but once they had understood how to open the drawers and that there would only be one reward in one of the drawers, they were then allowed no more than one attempt for each trial. The box was pulled back away from the bars and out of their reach. The training was terminated when the subject had an overall response that was significantly above chance levels or when, in the last block of trials, they chose the correct drawer 6 times out of 10. The former was determined using a normal approximation to the binomial (see chapters 5 and 6) and the latter using a standard binomial test where $p=0.25$ to determine the number of correct trials out of 10 that corresponded to a significant difference from chance at $p=0.05$ level.

Experimental Phase

This was divided into two conditions, condition 1 (Ignorance) and condition 2 (Knowledge). The order of these was random and was decided upon by the experimenter tossing a coin. The same number of trials that a subject had needed in the training phase, was given to them in the experimental phase, but half of these were Ignorance and half Knowledge. The latter acted as a kind of control (see rationale for further explanation). Two procedures were followed which are outlined below.

Procedure 1

In Ignorance, person A (myself) placed the peg above a drawer and put a sweet in the corresponding drawer as before. When person A had gone round the back of the box to put the sweet in, person B (Erica Long) moved the peg directly above another drawer without saying anything. Person A could not see what person B was doing, nor where the peg had been moved to. A correct response would be for the subject to open the drawer that *had* been labelled by the peg although the peg had been removed from that location.

In Knowledge, the same procedure was followed, except that when person B moved the peg, person A either saw her and watched, or looked afterwards to see where the peg was. Person A then went round the back of the box and put the sweet in the drawer below the peg. The correct response would be for the subject to open the drawer that was labelled by person B with the peg.

This procedure was adopted for one chimp (Pepe).

Procedure 2

For the other three chimps, the fan belt mechanism was used since two experimenters were not allowed in with the chimps. The experimenter put the peg above one drawer and then used a lever with a ratchet mechanism at the back of the box which moved the fan belt and hence the peg from above the middle of one drawer to the middle of one of the other drawers on a random basis.

In Ignorance, the experimenter placed the reward in the drawer which had originally been labelled by the peg, although the peg was no longer there.

In Knowledge, the experimenter looked at where the peg had been moved to and put the sweet in the drawer that was now labelled by the peg.

Thus the rationale and the conditions in the experiment are the same for both procedures except that either 2 people or one person alone can operate the equipment. For all the chimps, the way in which the experimenter saw the peg's new location was varied. Sometimes the experimenter would walk round one side of the box, sometimes round the other, or else look over the top. The sweet was placed in the drawer before the subject was allowed to open any of the drawers, but was not always put in at the same time, i.e. the reward was sometimes put in the drawer corresponding to the final peg position before the peg was moved to its final position; at other times the reward was moved from its original position to the new location after the peg had been moved, or else the reward was not placed in immediately but was put in a drawer after the peg had been moved to its final position. In addition, the bait was always kept behind the box so that the subjects could not see it. This variation was to insure that there could be no constant visual and auditory cues. Therefore the subjects should not have been able to choose a rule of thumb such as: New peg position if peg moved before baiting, or Old peg position if peg moved after baiting. However, the experimenter was associated with the rewards in the box since I entered the chimp house carrying the sweets or fruit and would, when necessary, chop them up in front of the chimps. In other words, it is assumed that the chimpanzees learnt that it was the experimenter who placed the rewards in the box, rather than that they had appeared by some other means.

Pepe and another female housed with him, Bella, were initially reluctant to use the box. The training phase was tried first thing in the morning when they had just got up, a little later on (but still before they were fed), after they'd been given their breakfast, and at two different times in the afternoon. The time when the subjects were most responsive (and hence, the one which was used more often) was first thing in the morning.

To begin with, fruit rewards were given to Bella and Pepe: bananas, pears, grapes, kiwi, mango, tomatoes, oranges and peanuts. Eventually the subjects were given sweets, but most of the time they would lose interest if the same sweets they had eaten the day before were given to them for a second day running. The sweets were: sugar free carob bars (various types), sugar free carob drops, rolos, twix, marathon, bounty bars, munchies, jelly babies, jelly fruits, caramel biscuits, health bars, opal fruits, maltesers, minstrels, Smarties and polos.

Bella was dropped from the experiment during her training phase as she became distressed when caged on her own. Pepe became enthusiastic about doing the experiment just before the experimental phase was reached; no doubt because by that stage we did not even try to give him anything else but sugar-filled sweets.

The other three chimps were fed coconut, mango, pear, grapes, polos, jelly babies, jelly fruits, Smarties, twix and carob drops. In general they weren't interested in doing the experiment for anything less than sugar-filled sweets. The experiment was conducted at the same time each day with them (first thing in the morning before their breakfast) as they showed no hesitation in either the training or the experimental phase and that was the best time for the keepers' schedule.

7.2.3. Children

Subjects

The same subjects were used as described in the previous experiment on desire comprehension. Sample sizes were 10 children aged 3, 5 and 6, and 11 four year olds. Subjects were tested individually and out of sight of the other children. Only one subject did not complete the false belief task.

Procedure

Each child was asked their name, age and date of birth. They were given the Smartie test for theory of mind: a closed tube of Smarties was shown to the child and she was asked what was inside. When she'd replied "sweets" or "Smarties", the tube was opened to show the real contents: dried beans. The lid was then replaced and the child was asked what she had thought was in the Smartie tube before it was opened.

Training

Person B (myself) sat at the front of the box next to the subject and recorded the subject's responses. Person A (Nadine Williamson) placed the peg above one of the drawers and then went round the back of the box and put a sweet in the corresponding drawer. She said "Okay" and the subject was allowed to select a drawer. The first time this happened, Person B played the role of the subject to demonstrate to the subject what was happening, without telling them what to do. They were then told that it was their turn. The subject was allowed to try more than one drawer if they got the wrong drawer first time round. The second time they chose the wrong drawer, Person B demonstrated where the sweet was. The third time the training phase carried on and the subject was only allowed one attempt. Once the subject had chosen the correct drawer four times in a row, the experimental phase started.

Experimental Phase

If the subject had a score of 8 or less attempts in the training phase before the 4 correct responses in succession, then Ignorance and Knowledge were repeated 4 times each. If the subject had more attempts before the 4 correct responses in a row, then that number, divided by 2, was the number of times that Ignorance and Knowledge were repeated respectively. For example, if the subject had 10 attempts and then got 4 right in a row, Ignorance and Knowledge were each repeated 5 times. In practise, all subjects except 1 had less than 8 attempts before achieving 4 correct answers in a row. Therefore, they all had 4 trials of Ignorance and 4 of Knowledge.

Procedure 1 was used for the children. Both person A and person B were allowed to talk to the subjects, but they did not say anything that was of relevance to how the experiment was to be attempted by the subject other than:

"We're going to play a game. Person B will show us how."

"Now it's your turn. Wait until she says its okay." (The "okay" is the verbal equivalent of pushing the box forward within reach of the subjects; this was the signal for the chimps that they could choose a drawer):

The rewards given were jelly fruits or Smarties.

7.2.4. Autistic adults

Subjects

Sixteen autistic adults from SANDs, Gravestone, Kent were tested. Five subjects were dropped from the nonverbal false belief task since they could not complete the training phase.

Procedure

Each adult was given the British Picture Vocabulary Scale by Francesca Happé and if their language was sufficient, the Smartie test, and the Sally Ann task were given to them. Their name and date of birth were obtained from the staff of SANDs. A member of staff remained in the room whilst the tests were conducted. Each subject was tested on their own.

Training

The training phase was conducted in the same manner as it was for the children except that the autistic adults were allowed up to 20 trials. The experimental phase was conducted if the subject responded correctly 7/10 times during training. Sweets were not used as rewards in these tests. A bean was hidden which they gave back to us once they had discovered which drawer it was in. They did not appear to need food rewards in the way that the chimps and some of the children did, and on balance, it was thought better by the staff that they should not be given sweets.

Experimental Phase

The experimental phase was conducted in the same manner as it was for the children except that the autistic adults were allowed up to 16 trials composed of 8 Ignorance and 8 Knowledge trials given in a random order. They were allowed to look in any drawer they liked on both the training phase and the experimental phase until they found the bean, rather than only being allowed one attempt per trial. We were also more lenient in this part of the experiment in that the trials were continued if it looked as if the subject was beginning to give the correct response. In addition, we made much more of a show about looking at each other and the peg (Knowledge) and looking deceptive in the Ignorance condition. Francesca Happé acted as the experimenter B and I acted as experimenter A and hid the bean. This was because I had no prior experience of dealing with autistic people and it was felt that someone with more experience should take on the role of experimenter B who needs to sit next to the subject and communicate with them.

Conditional Experiment

As suggested by Uta Frith and Francesca Happé, a second test was conducted on the same subjects 6 weeks later. The aim of this test was to repeat the nonverbal false belief test but without the social component. Frith and Happé argued that mentally retarded people would not be able to give the correct responses to a test with two complex rules, but would be able to comprehend a task that required theory of mind. However, if the autistic subjects failed the ToM task, they might still be able to complete the conditional test correctly. If this hypothesis proved correct, it would indicate that the autistic people were failing the test because of the social component and not because of another failing such as lack of memory or logic skills. The training procedure was kept exactly the same as described in the section on training for autistic people. In the experimental phase I would, as usual, place the peg above one of the drawers and Francesca would move it to another location; I would then hide the bean. However, I always remained at the front of the box when she moved the peg. Before she moved the peg, we stuck a large piece of coloured cardboard on the box. The card ran the whole length of the box and was placed above the drawers. One piece of cardboard was red with a large number 1 on it. This indicated that rule 1 was to be followed which was that the bean would be in the drawer that I had labelled with the peg. This was the equivalent of the Ignorance condition, but without the need to understand ToM. The second piece of cardboard was silver with a large number 2 on it. This rule was that the bean would be in the drawer currently labelled by the peg which Francesca had moved and was equivalent to the Knowledge condition but without the need for social understanding. We checked that the subjects could tell the difference between the colours and the numbers.

7.2.5. The rationale behind the nonverbal false belief experiment

Ignorance acts as the false belief condition. The subject knows that the peg is no longer where the experimenter thinks she put it. Ignorance also acts as a test of comprehension that not-seeing leads to incorrect knowledge (a false belief).

Knowledge acts as both a control and a test of comprehension that seeing leads to knowledge and can thus be viewed in two ways.

There are two types of control possible: (1) the peg does not move after it has been placed in its original location by the experimenter - this is the training phase; (2) all conditions are kept the same as Ignorance bar the crucial component that the experimenter and subject both have access to the same knowledge. In this sense, Knowledge acts as a control to Ignorance because all conditions are kept the same except the crucial component which is that the experimenter sees or does not see, respectively, where the peg is.

If the subject does not have theory of mind, then she will not give the correct response to Ignorance, but will give the correct response to Knowledge. Here Knowledge is treated as a control and at its lowest level: the current position of the peg is still being associated with the location of the food. There should be a significant difference between the responses to the two conditions.

If the subject has theory of mind, she should give correct responses to both Ignorance and Knowledge and there should be no significant difference between her responses to the two conditions. In this case, Knowledge is not simply a control, but acts also as a test of the fact that seeing leads to knowledge. Thus Knowledge is a 'correct' belief test, but not a false belief test.

It is assumed that any element of learning should be minimal since it is thought unlikely that a subject would be able to hold two conflicting rules of thumb for Ignorance (food-is-in-drawer-labelled-by-the-peg's-first-position) and Knowledge (food-is-in-drawer-labelled-by-the-peg). Hence, if the subject does not have ToM and is using a rule of thumb, they would only be able to give correct answers to one condition. One would expect that over a great many trials, if a rule of thumb were used, the subject would do better at one condition, but then might start to use a different rule of thumb. The subject would then become better at the second condition, but their performance for the first condition would deteriorate. Once they realised that two different procedures were operating, it might be possible for them to learn how to respond correctly but without comprehension of ToM. In this case, one would see a learning curve.

If the subject was able to obtain significantly correct results to both the Ignorance and the Knowledge condition, it was assumed that they had an understanding of the experimenter's false belief.

7.2.6. Some methodological caveats in retrospect

The methodology is roughly the same across all three groups of subjects; in practise the children had 4-6 trials which included giving the correct answer 4 times in succession (a score of above chance levels) and 4 attempts at both Ignorance and Knowledge; the autistic adults had up to 20 trials and needed to score above chance (7/10) in one block of 10 trials; the chimpanzees had to score above chance. The chimpanzees were then given exactly the same number of trials in the experimental side of the procedure as they had been given in the training session; half the trials were Ignorance and half Knowledge.

The reason for giving the autistic adults more trials than the children was twofold: a) we thought it would take them longer than the children to learn the rule of thumb in the training session (which proved to be a correct assumption) and b) we thought it would be better for statistical purposes to give them more trials in the experimental part of the procedure. By the time we were conducting the autistic study, I had already analysed the results from the child study and I felt that it had been a mistake to give the children so few trials. I thought there were enough trials over sufficient subjects to make the results worth analysing, but I wanted to make sure the results from the autistic work would be more readily statistically analysable.

It was a mistake not to have given the chimpanzees twice as many trials in the experimental procedure as they had been given in the training session. This would have made the methodology more similar to the experimental protocol for the children. However, my concerns over increasing the amount of trials was twofold: a) the chimpanzees would quickly become bored and in addition, I had a limited time period over which this experiment could be conducted due to the keepers' considerations, and b) I wanted to give the chimpanzees the minimum number of trials possible since I did not want them to learn a rule-of-thumb. This concern is dealt with more fully in the section below.

Finally, although the chimpanzees and the children were given minimal cues, the autistic adults were shown exaggerated 'looking' and 'deceptive' behaviours by Francesca. She is experienced at working with people with autism and felt that it was highly unlikely that any autistic subjects would be able to pass this test. However, there was a slim chance that they might if shown more leniency. In the event, this leniency seemed to make little difference (see results section). In many respects I would have been happier not to have exaggerated our eye movements, etc., but in some ways this has made the results more robust: the autistic people were not able to pass this test despite being given much more help than was given to either the chimpanzees or the children.

7.2.7. Analysis

The results are analysed in two main ways. First, each group of subjects, the children, the autistic adults and the chimpanzees, are dealt with separately. The number of times the subjects gave the correct response to the nonverbal false belief test were analysed. In addition, the number of times the children and some of the autistic adults gave correct responses to the Smartie tests were analysed. Specific details of the tests are given in the results section.

Three statistical points need to be made. First, in section 7.3.1. a total of 37 tests were conducted on the correct responses given by children for the nonverbal false belief task and the Smartie test. A further 14 tests were conducted on the association between giving the correct response to the nonverbal false belief test and the Smartie task, 7 tests on the association between the Smartie task and the Sally-Ann task, 7 tests on the association between the Sally-Ann test and the Ignorance condition in the nonverbal false belief task, 7 tests on the difference between the responses given for the Ignorance and Knowledge conditions on the nonverbal false belief test and 7 tests in the final analysis where the proportion of correct and incorrect answers were given. Given that there is a large number of tests, there is a likelihood that some of these tests will be significant purely by chance (79 x 0.05 = 3.95) which would mean that the four least significant results should be discarded, or alternatively, the p-value taken for significance could be adjusted. However, this argument only applies when the same set of data or subjects are being repeatedly tested. In this particular instance, that would only apply to tests within the age-classes, of which there are 9 tests per age group and 9 tests per class of children where the class was their school group (e.g. class 5-6 year olds). This means that 9 x 0.05 = 0.45 tests might be significant by chance alone. In fact, when the tests resulted in a value that was significant, significance levels were well below 0.05. Therefore, it is unlikely that these tests produced significant values by chance alone.

Secondly, tests for significance were 1-tailed. In these tests, the question is whether there is any evidence that the subjects can pass a false belief test. The null hypothesis is that there is no evidence that they can pass the test. A nonsignificant result or a significant negative result means that the subject cannot pass the false belief test. Therefore,1-tailed tests are appropriate.

Thirdly, I was, unfortunately, only allowed to conduct this experiment on 4 chimpanzees. As it was not possible to increase the sample size, the results were still analysed using a t test but one needs to be cautious when interpreting these results. Given that the sample size is small, there is the possibility of a Type II error occurring, i.e. the test indicates that the null hypothesis is correct when it is not.

The second way the analysis was carried out was by examining the proportion of correct and incorrect responses given by each group of subjects for the nonverbal false belief task (see section 7.3.5.).

7.3. Results

7.3.1. Children

As predicted in the rationale behind the pegged box experiment, all the children did well on Knowledge but the younger children did less well on Ignorance. The older 5 year olds and the 6 year olds gave significantly correct responses to Ignorance and there was little difference between their results for Ignorance and Knowledge. Using a binomial test to show whether the children scored correct (3 or 4 out of 4 correct), all children were able to correctly answer the Knowledge part of the test, and children who were 4 and older were able to give correct responses to the Ignorance condition.

The test for ToM using Smarties shows the same trend that is found in published research on ToM: the younger children gave incorrect responses but all the 6 year olds and the older 5 year olds were able to give the correct answer. They demonstrated that they could understand a false belief. The raw data are given in table 7.1. and summary analyses are given in tables 7.2. and 7.3. Table 7.2 shows the children's responses summarised according to their age group. Apart from the 5 year olds, the other children showed a trend of increasing correct results up to 3.2 mean right answers by the 6 year olds. All of the children gave approximately similar mean results for the Knowledge condition, ranging from 2.4 to 3.1. Table 7.3. shows the results grouped according to class rather than age. The trends remain the same. The 6 year olds in class 6 showed a mean score of 3.8 for Ignorance and 2.8 for Knowledge which is the highest mean score in the two analyses. Obviously the older age classes will contain older children. The difference between a child in a higher class and one in a lower class who is the same age in years is only a few months but even a small difference can be crucial in whether ToM is understood or not at this early stage of their development. Therefore, all the results are analysed according to class as well as age group.

When the children's responses to the nonverbal false belief test were compared to their answers to the Smartie task, the 6 year olds showed a significant association between the verbal task and the Ignorance part of the nonverbal task.

Table 7.1: Actual results for all the children tested giving their name, age, response to the Smartie test for ToM (Sm) as correct (+) or incorrect (x) and their responses for Ignorance and Knowledge out of 4 trials for each condition. The children are split into school classes denoted by the dotted line.

Name	Age	Sm	Ignorance	Knowledge
Dean	3	+	1	3
Laura	3	x	-	-
John	3	x	1	4
Emily	3	x	1	1
Alice	3	+	0	3
Alex	3	+	2	4
Oliver	3	x	1	3
Vicki	3	x	1	4
Lia	3	+	(2/9)	(2/9)
Jon	3	x	2	2
……	……	……	……	……
Nicola	4	+	0	4
Laura	4	+	3	4
Craig	4	+	0	2
Luke	4	x	2	2
Sean	4	x	2	4
Emily	4	+	0	2
Rebecca	4	+	0	3
Daniel	4	+	1	3
Martin	4	x	4	4
Ryan	4	x	4	2
Liz	4	+	1	4
Chris	5	+	0	3
Beola	5	x	2	4
Bethan	5	x	0	3
Adrian	5	x	1	4
Daniel	5	+	2	0
……	……	……	……	……
John	5	+	0	4
Eedie	5	+	0	1
Laura	5	+	0	4
Hannah	5	+	0	1
Kim	5	x	4	0
Wayne	6	+	3	2
Charles	6	+	0	4
David	6	+	3	2
Sean	6	+	3	4
……	……	……	……	……
Phillip	6	+	4	2
Charlotte	6	+	4	4
Laura	6	+	4	4
Daniel	6	+	4	3
Nicola	6	+	3	2
Christina	6	+	4	2

Figure 7.2: The data are summarised according to the children's ages showing the association between responses to the nonverbal false belief task and the Smartie test (Sm) when comparing this with the Ignorance (I) condition or the Knowledge (K) condition. A (+) denotes a correct answer and a (X) an incorrect one.

3 year olds

		Sm	
		+	X
I	+	0	0
	x	4	5

		Sm	
		+	X
K	+	3	3
	x	1	2

4 year olds

		Sm	
		+	X
I	+	1	2
	x	6	2

		Sm	
		+	X
K	+	5	2
	x	2	2

5 year olds

		Sm	
		+	X
I	+	0	1
	x	6	3

		Sm	
		+	X
K	+	3	3
	x	3	1

6 year olds

		Sm	
		+	X
I	+	9	0
	x	1	0

		Sm	
		+	X
K	+	5	0
	x	5	0

Table 7.2: Mean percentage of children giving correct responses to the nonverbal false belief and the Smartie test for ToM (Sm) in children grouped according to their age. Correct responses for the false belief experiment for both Ignorance and Knowledge were deemed to be 3 or 4 out of 4 correct replies. The mean score for this experiment is also given (I_m; K_m).

Age	Sm	Ignorance	Knowledge	I_m	K_m	n
3	40.0	0.0	66.7	1.1	2.8	9
4	63.6	27.3	63.6	1.6	3.1	11
5	60.0	10.0	60.0	0.9	2.4	10
6	100.0	90.0	50.0	3.2	2.9	10

Table 7.3: Mean percentage of correct responses children gave to the nonverbal false belief experiment and the Smartie test for ToM (Sm) in children grouped according to their class. Correct responses to the false belief experiment for both Ignorance and Knowledge were deemed to be three or four out of four correct replies. The mean score for this experiment is also given (I_m; K_m).

Class	Sm	Ignorance	Knowledge	I_m	K_m	n
3-4	40 0	0.0	66.7	1.1	2.8	9
4-5	56 3	18 8	66.8	1.4	3.0	16
5-6	88 9	44 4	44 4	1 4	2.4	9
6-7	100 0	100 0	50 0	3.8	2.8	6

To determine whether the children gave significantly correct answers to the false belief experiment, a binomial sign test with a probability of 0.25 was conducted on the proportion of children achieving a certain answer (e.g. 3 children aged 5 gave 3 or above out of 4 correct replies, 2 got 4 out of 4 correct, etc.) and the probabilities were combined using Fisher's test.

Ignorance

When analysed by class, the result for the three year olds remains the same as no 4 year olds in their class were tested. In class 6-7, no 7 year olds were tested. Therefore, the results for class 3-4 will not be given since they are the same as those for 3 year olds, and class 6-7 will simply be referred to as class 6. Only the 6 year olds and the class of 6 year olds gave significantly correct responses to Ignorance: 3 year olds(Chi^2=4.282; df=18; $p>0.05$); 4 year olds(Chi^2=15.096; df=22; $p>0.05$); 5 year olds(Chi^2=7.436; df=20; $p>0.05$); 6 year olds (Chi^2=34.124; df=20; $P<0.05$); class 4-5(Chi^2=17.736; df=32; $p>0.05$); class 5-6(Chi^2=12.404; df=18; $p>0.05$); class 6(Chi^2=26.516; df=12; $p<0.01$).

A binomial test was conducted using a probability of 0.05. The results were treated as correct (3 or 4 out of 4 correct) or incorrect (2 or less out of 4 right) (see tables 7.2. and 7.3. for a mean percentage of the results analysed in this way). A probability of 0.05 was used since it is increasingly unlikely that the children would choose the correct drawer 3 or 4 times out of 4 trials. Given one trial, the probability is 0.25 that they will choose the correct drawer; the probability of choosing a correct drawer 3 times out of 4 trials is 0.047 and 4 times in 4 trials is 0.004. These probabilities were obtained from the tables in Siegal and Castellan (1988).

The three year olds and the class of three year olds were not able to give statistically significant responses to the Ignorance condition; all other classes and age groups were able to do so. 3 year olds(Chi^2=28.100; df=18; $p>0.05$); 4 year olds(Chi^2=56.300; df=22; $p<0.05$); 5 year olds(Chi^2=42.000; df=20; $p<0.05$); 6 year olds(Chi^2=82.000; df=20; $p<0.05$); class 4-5(Chi^2=78.100; df=32; $p<0.05$); class 5-6 year olds(Chi^2=40.900; df=18; $p<0.05$); class 6(Chi^2=61.3; df=12; $p<0.05$).

Knowledge

The 4 year olds gave correct responses at a significance level of $p=0.06$ (Chi^2=33.676; df=22; $p<0.06$). However, the 3, 5 and 6 year olds did not give significantly correct answers: 3 year olds(Chi^2=23.808; df=18; $p>0.05$) 5 year olds(Chi^2=20.347; df=20; $p>0.05$); 6 year olds(Chi^2=27.5; df=20; $p>0.05$).

The class of 4-5 year olds gave significantly correct answers (Chi^2=48.34; df=32; $p<0.05$) but the children in the other two classes did not: class 5-6(Chi^2=22.152; df=18; $p>0.05$); class 6(Chi^2=15.596; df=12; $p>0.05$).

A binomial test was conducted using a probability of 0.05 as described in the section on Ignorance. The children in all the age groups and school classes were able to give results that were significantly above chance levels. 3 year olds(Chi^2=62.700; df=18; $p<0.05$); 4 year olds(Chi^2=87.300; df=22; $p<0.05$); 5 year olds(Chi^2=64.500; df=20; $p<0.05$); 6 year olds(Chi^2=82.900; df=20; $p<0.05$); class 4-5(Chi^2=135.000; df=32; $p<0.05$); class 5-6(Chi^2=65.400; df=18; $p<0.05$); class 6(Chi^2=45.300; df=12; $p<0.05$).

Differences in response to the Ignorance and Knowledge conditions

A matched t test was conducted to determine whether there were any differences between the responses the children gave to the Ignorance and Knowledge conditions. The prediction in this case is that since Knowledge means the child need only, at the lowest level of understanding, understand that the peg is still associated with the reward just as she did in the training phase, there should be a significant difference between the responses given to Ignorance and Knowledge if there is no understanding of theory of mind (see rationale).

Three and 4 year olds showed a significant difference in their responses, giving far more correct responses to Knowledge than Ignorance. Five and 6 year olds showed no significant difference. These results are as predicted and accord well with the fact that significant responses are seen in the 6 year olds for Ignorance, and the 4, 5 and 6 year olds when analysed using a probability of 0.05.

A similar pattern was seen when the children were analysed according to class: the 4-5 year olds and the class of 6 year olds showed a significant difference, but the 5-6 year olds showed no significant difference between the two conditions: matched t tests: 3 year olds(t=3.780; df=8; p<0.01); 4 year olds(t=3.024; df=10; p<0.01); 5 year olds(t=1.800; df=9; p>0.05); 6 year olds(t=0.558; df=9; p>0.05); class 4-5(t=3.643; df=15; p<0.01); class 5-6(t=1.095; df=8; p>0.05); class 6(t=2.739; df=5; p<0.05).

The Smartie test

The responses given to the Smartie test were tested using a 1 tailed binomial test with a probability of 0.5 (see figure 7.1.). The 6 year olds and the classes of 5-6 and 6 year olds gave significantly correct results, all other groups did not give significant responses: 3 year olds(p=0.377); 4 year olds(p=0.172); 5 year olds(p=0.377); 6 year olds(p=0.001); class 4-5(p=0.402); class 5-6(p=0.020) class 6(p=0.016).

Association between the Smartie test and the nonverbal false belief experiment

Tests were conducted to see if there was an association between the Smartie test for ToM and the nonverbal false belief test. Since the response to the Smartie test could be either correct or incorrect, the responses to the pegged box were categorised in the same way to make them comparable. Obtaining 3 or 4 out of 4 trials was considered a correct response. A binomial test where p=0.025 [(Smartie task: p=0.5) X (nonverbal false belief task: p=0.05)] was conducted to determine how many children gave a correct response to both the ToM tasks (see figure 7.2.).

Only the six year olds, the class of five to six year olds and the class of six year olds were able to give significantly correct results for the Smartie task and the Ignorance condition where p<0.05. All age groups and all four school classes were able to give significantly correct responses to both the Smartie test and the Knowledge condition where $p<0.05$.

Ignorance: 3 year olds($p<0.05$); 4 year olds($p=0.243$); 5 year olds($p<0.05$); 6 year olds($p<0.001$); class 4-5 year olds($p<0.05$); class 5-6 year olds(0.001); class 6 year olds($p<0.001$).

Knowledge: 3 year olds($p=0.001$); 4 year olds($p<0.001$); 5 year olds($p<0.001$); 6 year olds($p<0.000$) class 4-5 year olds($p=0.001$); class 5-6 year olds($p=0.001$); class 6 year olds($p=0.001$).

The Sally-Ann test and the Smartie test

Using the data from the previous chapter on the Sally-Ann test, the two false belief tests are compared. The responses the children gave to the Ignorance part of the nonverbal false belief test are then compared to their responses to the Sally-Ann test. A significant number of the 6 year olds and the class of 6 year olds were able to give correct scores to both these false belief tests. The class of 5-6 year olds had a majority of children (5/8) who were able to give correct responses to both tests; the 4, 5 and class of 4-5 year olds showed no obvious trends and the majority of 3 year olds chose incorrectly for both tests (see figure 7.3.): 3 year olds($p=0.090$); 4 year olds($p=0.344$); 5 year olds($p=0.363$); 6 year olds($p=0.020$); class 4-5($p=0.212$); class 5-6($p=0.363$); class 6($p=0.031$).

Ignorance and the Sally-Ann test

All the children and all classes of children were able to give significant responses to both the Sally-Ann test and the nonverbal false belief test (see figure 7.4.). A probability of 0.025 was used (see previous chapter, section 7.4.2: [(Sally-Ann task: $p=0.5$) X (nonverbal false belief task: $p=0.05$)]. A binomial test was conducted using a probability of 0.05 and treating the results as correct (3 or 4 out of 4 correct) or incorrect (2 or less out of 4 right) for the false belief test. A probability of 0.05 was used since it is increasingly unlikely that the children would choose the correct drawer 3 or 4 times out of 4 trials. Given one trial, the probability is 0.25 that they will choose the correct drawer; the probability of choosing a correct drawer 3 times out of 4 trials is 0.047 and 4 times in 4 trials is 0.004. These probabilities were obtained from the tables in Siegal and Castellan (1988).
3 year olds($p=0.020$); 4 year olds($p=0.009$); 5 year olds($p=0.000$); 6 year olds($p=0.000$); class 4-5($p=0.000$); class 5-6($p=0.000$); class 6($p=0.000$).

Figure 7.3: The responses children gave to the Sally-Ann (SA) and the Smartie (Sm) tests are shown with the results grouped according to the children's ages or school class.

3 year olds

		Sm	
		+	x
SA	+	2	1
	x	2	4

4 year olds

		Sm	
		+	x
SA	+	2	2
	x	1	1

5 year olds

		Sm	
		+	x
SA	+	3	1
	x	3	1

6 year olds

		Sm	
		+	x
SA	+	8	0
	x	1	0

class 4-5

		Sm	
		+	x
SA	+	5	3
	x	3	3

class 5-6

		Sm	
		+	x
SA	+	5	0
	x	3	0

class 6

		Sm	
		+	x
SA	+	5	0
	x	0	0

Figure 7.4: The responses children gave to the nonverbal false belief test (Ignorance - I) and the Sally-Ann test (SA) where the results are grouped according to the children's ages or school class.

3 year olds

		I	
		+	x
SA	+	0	3
	x	0	5

4 year olds

		I	
		+	x
SA	+	1	3
	x	0	2

5 year olds

		I	
		+	x
SA	+	1	4
	x	0	5

6 year olds

		I	
		+	x
SA	+	8	0
	x	0	1

class 4-5

		I	
		+	x
SA	+	3	4
	x	0	7

class 5-6

		I	
		+	x
SA	+	3	2
	x	0	3

class 6

		I	
		+	x
SA	+	5	0
	x	0	0

In summary, when the children's scores are analysed using a binomial test where p=0.25, the children pass the nonverbal false belief test at a slightly older age (5-6 years) than the results from the published literature would suggest (3-5 years). However, treating their results using a binomial test where p=0.05 where it is assumed that it becomes increasingly harder to give 3 or 4 correct answers in a row indicates that children can pass the nonverbal false belief task from 4 years old.

The older 5 year olds and the 6 year olds can pass the Smartie task and the Sally-Ann test. These are the same children who gave significantly correct results to the nonverbal task using a binomial test where p=0.25. The 6 year olds showed a significant association between passing the Smartie task and the Ignorance part of the false belief test. It seems that the nonverbal false belief test is a valid way of testing for comprehension of false beliefs. The fact that the younger children can begin to comprehend the Ignorance part of the task may be because they are developing an awareness of false beliefs and the practice (a total of 8 trials on the false belief task compared to 1 for the Smartie task) helped them begin to understand what they were being tested on. The results of these tests are summarised in table 7.4.

Table 7.4: The significant results for the children are summarised according to their age or class and the kind of test that was conducted. In Ignorance and Knowledge, the first column gives the significant results for the children when their responses were analysed with a binomial test where p=0.25. The second column in bold type under the legend Ignorance and Knowledge denotes the significant results for a binomial test where p=0.05. The column under Sm (indicating the Smartie task) denotes the significant results for a binomial test with p=0.5.

The association between giving the correct response to the Smartie test and to either the Ignorance (SmI) or the Knowledge (SmK) condition is shown where p=0.025. The results of the matched t tests conducted between the responses for Ignorance and Knowledge is shown under the column headed Difference.

For all probability values given, the results were deemed correct only if the child scored 3 or above correct. The class of 3-4 year olds holds the same subjects as the age group of 3 year olds, hence the results are the same for in both groups, although tests were only conducted for the age group of 3 year olds. A significantly correct result is denoted by (+) and nonsignificant result by (-). Brackets are used to indicate an almost significant result at p<0.05.

Sm=Smartie task, I=Ignorance; K=Knowledge; SmI=association between giving the correct response to Ignorance and the Smartie task; SmK=association between giving the correct response to Knowledge and the Smartie task; Difference=the differences between the correct responses for Ignorance and Knowledge.

Age	Sm	Ignorance		Knowledge		SmI	SmK	Difference
3	-	-	-	-	+	-	+	+
4	-	-	+	(+)	+	-	+	+
5	-	-	+	-	+	-	+	-
6	+	+	+	-	+	+	+	-
Class								
3-4	-	-	-	-	+	-	+	+
4-5	-	-	+	+	+	-	+	+
5-6	+	-	+	-	+	+	+	-
6	+	+	+	-	+	+	+	-

7.3.2. Autistic adults

A normal approximation to the binomial with a probability of 0.25 was used to determine the criterion for a score that was significantly above chance. This was deemed to be 9/16 or above as a combined score for both Knowledge and Ignorance, or rule 1 and 2 combined in the conditional task; and 5/8 correct responses for either Ignorance or Knowledge in the false belief task, or rule 1 or 2 of the conditional task.

To demonstrate an understanding of ToM, the subjects needed to give scores that were above or bordering on the significance level and show no significant difference between scores for either Knowledge or Ignorance. Six out of 11 were able to give a score for Knowledge of 5 or more out of 8 trials. No subjects were able to do this for Ignorance (see table 7.5.); one subject obtained a combined score that was significant, but this was because he had obtained 7/8 on the Knowledge task and when asked, he stated that the bean was always in the drawer beneath the peg.

In the conditional task, again no subjects were able to give significant results for rule 1, but 7 were able to give significant results for rule 2; 3 subjects had a combined score which was significant. This suggests that the subjects are sticking to the rule that the reward is in the drawer currently marked by the peg, no matter whether the task required social knowledge or the ability to follow 2 rules (see table 7.5.).

The subject's approximate mental ages using the BPVS ranged from 13 years 10 months to 2 years 6 months, with most subjects falling in the lower age range. We were able to give 6 subjects the Smartie test and 2 the Sally Ann task (see table 7.5.). Only one subject (Mark A.) was able to answer both correctly.

In summary, it thus seems likely that the nonverbal task is a valid analogue of conventional verbal tasks as it produces the same results, namely that the autistic subjects fail even though their mental age ranged up to 13 years old. Not all the autistic subjects had sufficient language to be able to complete the Smartie task and the Sally Ann test, but out of the five adults that were able to understand the Smartie task, only one gave a correct response (Mark A., who was mentioned above).

Table 7.5: The raw data for all the adult autistics are given showing their mental ages calculated by the BPVS, the results of the Smartie test (Sm), the Sally Ann task (SA), their scores for Ignorance (I) and Knowledge (K) for the nonverbal false belief task; their scores for the conditional task where R1 is rule 1 and R2 is rule 2. An asterisk indicates which scores are significantly above chance; (+) indicates a correct answer; (X) indicates an incorrect one and (-) means there was no response.

	BPVS	Sm	SA	I	K	R1	R2
Clive	10 11	x	x	2/8	5/8*	5/16	12/16*
Peter	2 6	-	-	0/8	4/8	9/22	1/11
Stevie	2 6	-	-	0/8	5/8*	1/8	5/8*
Mike L	8 11	x	-	1/8	7/8*	0/8	5/8*
Mike B	5 4	-	-	1/8	3/8	3/8	2/8
Mark A.	13 10	+	+	4/8	7/8*	3/16	13/16*
Terry	6 8	x	-	2/8	2/8	3/8	6/8*
Roger	4 10	-	-	3/8	2/8	2/8	4/8
Laddie	2 10	x	-	0/8	1/8	2/8	2/8
Julia	(Deaf)	-	-	0/8	7/8*	0/8	6/8
Lynn	2 10	-	-	0/8	7/8*	0/8	5/8*

7.3.3. Chimpanzees

The chimpanzees differed in the number of trials it took before they could be moved on to the experimental phase. There is little difference between three of the chimps (from Twycross) but Pepe (from Dudley) had nearly twice as many trials as the others (see table 7.6.).

This may reflect a difference in intelligence and/or a difference in social stimulation and the captive environment (see chapter 3 on general methods).

The number of days over which the trials were spaced does not reflect individual differences greatly other than in Pepe's case, and again, lack of previous social stimulation may have impaired his initial willingness to respond (see table 7.6.). As mentioned in the methods, he would not do the experiment for anything less than sugary sweets which had to be varied daily. However, once he was given these sweets on a regular basis, he became much more motivated, particularly during the experimental phase.

The difference in the number of days it took to conduct the experiment does not reflect the ability of the other 3 chimps since they were all motivated almost all of the time. Rather, the differences reflect the

* There are two alternative ways of analysing these results. First, the subjects may have been choosing between two boxes only, rather than four, namely the box marked by the peg, and the one which had been marked by the peg. In this case the probability of choosing correctly would be 0.5. When the chimps' results were analysed using a normal approximation to the binomial with a probability of 0.5, and Fisher's test for combining the probabilities, the subjects did not choose significantly above chance on either the Ignorance ($Chi^2=0.526$; df=8; p>0.05) or the Knowledge ($Chi^2=0.645$; df=8; p>0.05) part of the test.

Binomial test with a probability of 0.5: Ignorance: Pepe (p=1.000); Beckie (p=0.998); Flynn (p=0.967); Josie (p=0.612).

Binomial test with a probability of 0.5: Knowledge: Pepe (p=1.000); Beckie (p=0.951); Flynn (p=0.990); Josie (p=0.557).

Secondly, the subjects may have been following a behavioural rule and choosing the correct box with the same frequency as they had during the training trials. The subjects' responses were then analysed using the conditional probability that each subject picked the correct box in the transfer phase given the way in which they performed during the training phase. When the probabilities for each animal were combined using Fisher's test, the subjects did not pick the correct box in either condition significantly above chance levels: Ignorance ($Chi^2=3.08$; df=8; p>0.05); Knowledge ($Chi^2=3.75$; df=8; p>0.05).

Binomial test using the probability that the subject chose correctly during the training phase (each subjects' own probability for passing or failing the test is given and is denoted as the 'training p'): Ignorance: Pepe (training p=0.285; p=0.435); Beckie (training p=0.337; p=0.687); Flynn (training p=0.330; p=0.330); Josie (training p=0.474; p=0.468).

Knowledge: Pepe (p=0.481); Beckie (p=0.220); Flynn (p=0.540); Josie (p=0.414).

Therefore, when a probability of 0.25 is used, one chimpanzee passed both conditions in the transfer phase, and one chimp passed one condition in the transfer phase. None of the subjects chose correctly either when a probability of 0.5 was used, or when each animal's own probability of giving the correct response during the training phase was used.

keepers' specification about the length of time that was allowed for the experiment and this in turn determined the number of days. It proved impossible to set a time specification per day due in part to the animals' motivation, but chiefly to the keepers' considerations.

The correct responses the animals gave are also given in table 7.6. In line with the predictions specified in the rationale for this experiment, the correct responses for Ignorance and Knowledge hardly differ at all.

Ignorance and Knowledge

When the chimps were analysed together using a normal approximation to the binomial with a probability of 0.25 and Fisher's test for combining the probabilities, they did not do significantly better than expected on either the Ignorance or the Knowledge part of the task; Ignorance(Chi^2=12.576; df=8; p>0.05); Knowledge(Chi^2=12.974; df=8; p>0.05). The unit of analysis in these combined tests was always the individual's score.

However, when the chimps' scores were treated individually, Josie scored significantly above chance on both the Ignorance and Knowledge conditions, and Beckie scored significantly above chance levels on the Knowledge condition.

Binomial test with a probability of 0.25: Ignorance: Pepe (p=0.287); Beckie (p=0.286); Flynn (p=0.093); Josie (p=0.001).

Binomial test with a probability of 0.25: Knowledge: Pepe (p=0.244); Beckie (p=0.024); Flynn (p=0.238); Josie (p=0.001). *

Differences between Ignorance and Knowledge

There was no significant difference between the responses given for the control or the experimental conditions (matched t=0.775; df=3; p>0.05) using a matched t test. A summary of the significant results are outlined in table 7.7.

Table 7.6: The correct response the chimps gave are indicated where T is the number of correct responses to the training session and Ignorance and Knowledge are the correct responses to these two conditions. The total number of days the experiment lasted for each chimp is given as well as the number of training Trials per chimp. Consequently T is correct responses out of the total number of Trials, and Ignorance and Knowledge are correct responses out of Trials/2 (see methods for more details).

Chimps	Days	Trials	T	Ignorance	Knowledge
Pepe	17	232	66	33/115	33/117
Beckie	5	104	35	15/51	20/53
Flynn	12	85	28	15/43	13/42
Josie	13	97	46	23/49	23/48

Learning

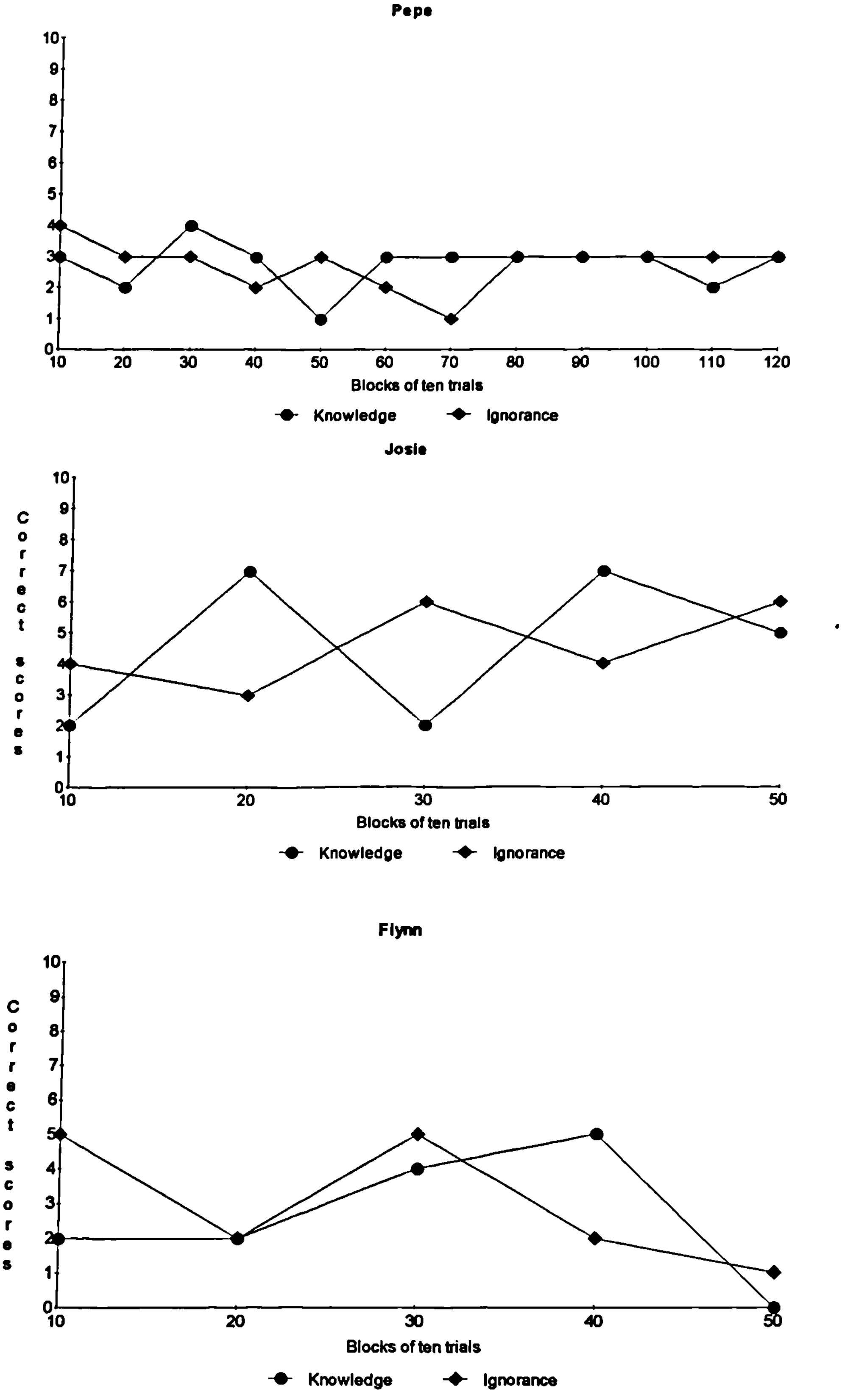
Were the chimps learning how to respond to the task? One would expect an element of learning if they had theory of mind. There ought to be a learning curve as they understand what it is they are being asked to respond to. This should be a short curve. If the learning curve does not appear until a relatively large number of trials have been conducted, then one might assume that the chimpanzees were learning the task as if it were new and unrelated to the training (see section on Rationale behind the nonverbal false belief task). They might be picking up on some other kind of cue and hence were being conditioned into responding correctly. In either case, neither of these scenarios proved to be true. There seems a slight trend for Josie and Beckie to learn the correct responses (see figure 7.5); statistics were used to investigate whether these trends were significant or not.

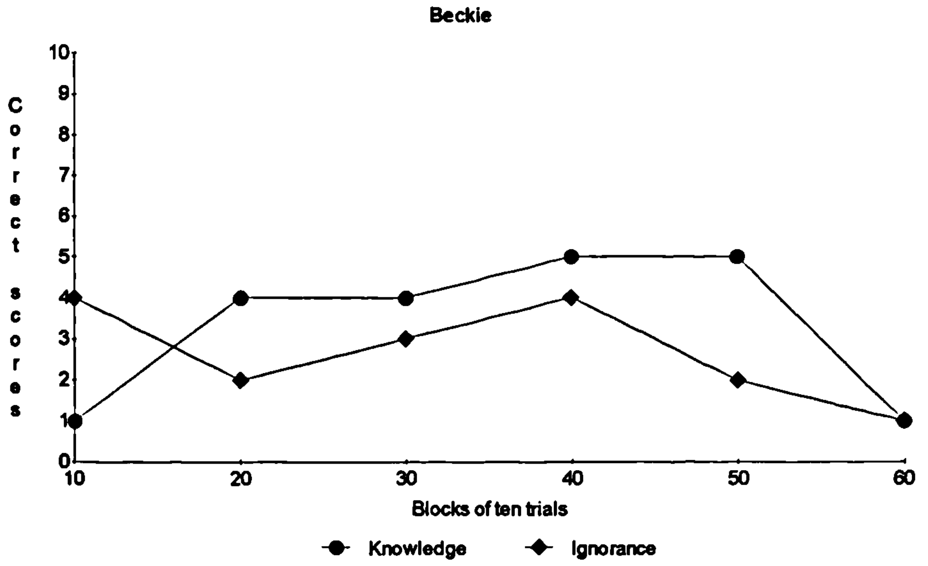
The Kolmogorov-Smirnov test was used which assumes a constant response rate. H_0 is that there is no difference between the chimp's observed and expected responses. H_1 states that there will be a difference between the observed and the expected responses as the subject improves in its ability to learn the right response. The expected responses were assumed to be the average correct result. Each chimp was analysed individually with the cumulative frequency taken for all the trials given to them in the experimental phase. The number of trials were divided into blocks of 10. There was no significant difference between the observed and the expected results at p= 0.05 for any of the 4 chimps. Therefore, H_1 can be rejected and thus the chimps did not show a learning curve: Pepe (D=0.202; p>0.05); Beckie (D=0.276; p>0.05); Flynn (D=0.303; p>0.05); Josie (D=0.24; p>0.05).

Table 7.7: Summary of the significance levels of the results given in the above section showing the results for tests conducted on individual animals and all subjects together where the unit of analysis was the individual. In each case the result is given for Ignorance and Knowledge analysed separately as well as together. A + denotes a significantly correct response, - shows a nonsignificant result and brackets are used to indicate whether a result is bordering on significance at the p=0.05 level.

Chimps	Ignorance	Knowledge
Together	-	-
Pepe	-	-
Beckie	-	(+)
Flynn	-	-
Josie	+	+

Figure 7.5: An graph of each individual's response to the experimental part of the false belief task in blocks of ten trials is shown.



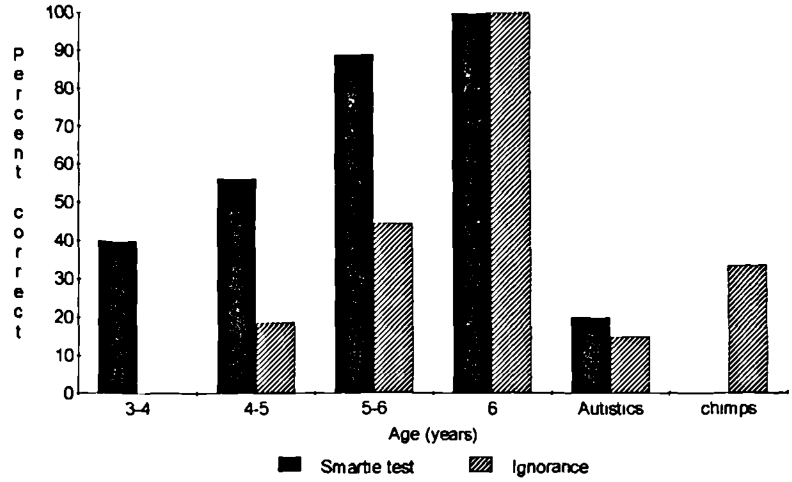


7.3.4. A comparison between the children's and the autistic adults' response to the Smartie test and all the subects' responses to the Ignorance condition in the nonverbal false belief test.

When the mean correct responses for the Smartie task and the Ignorance condition in the nonverbal false belief task are compared, the results serve to highlight the fact that six year old children are capable of solving both tasks. However, younger children and people with autism have a greater difficulty with the Ignorance part of the nonverbal false belief task than the Smartie task.

The results also suggest that the chimpanzees score better than autistic adults and 4-5 year old children at the Ignorance condition of the nonverbal false belief test (see figure 7.6).

Figure 7.6. A graph showing the mean correct responses given to the Smartie test and the Ignorance condition in the nonverbal false belief task.



7.3.5. The proportion of correct and incorrect responses produced by the children, the autistic adults and the chimpanzees

The results for the children, autistic adults and chimpanzees were analysed a different way by examining not just the correct scores, but the alternative choices they made. For each subject the proportion of times they picked a drawer that had not been labelled by the peg (other), how many times they picked the drawer labelled by the peg initially (first peg position) and how often they chose the drawer that was labelled by the peg after it had been moved (final peg position) were calculated for both the Ignorance and Knowledge conditions. For example, a child who had chosen the drawer labelled by the peg to begin with (first peg position) 3 out of 4 times would score a proportion of 0.75.

The proportions for each group of subjects were summed and a mean percentage of scores obtained (see figures 7.7. and 7.8. and table 7.8.). The results for the children, adults and chimpanzees are displayed together in figure 7.9. Matched t tests were then conducted on each group of subjects, comparing their scores for the final peg position in Ignorance and Knowledge and then comparing their scores for the first peg position in Ignorance and Knowledge.

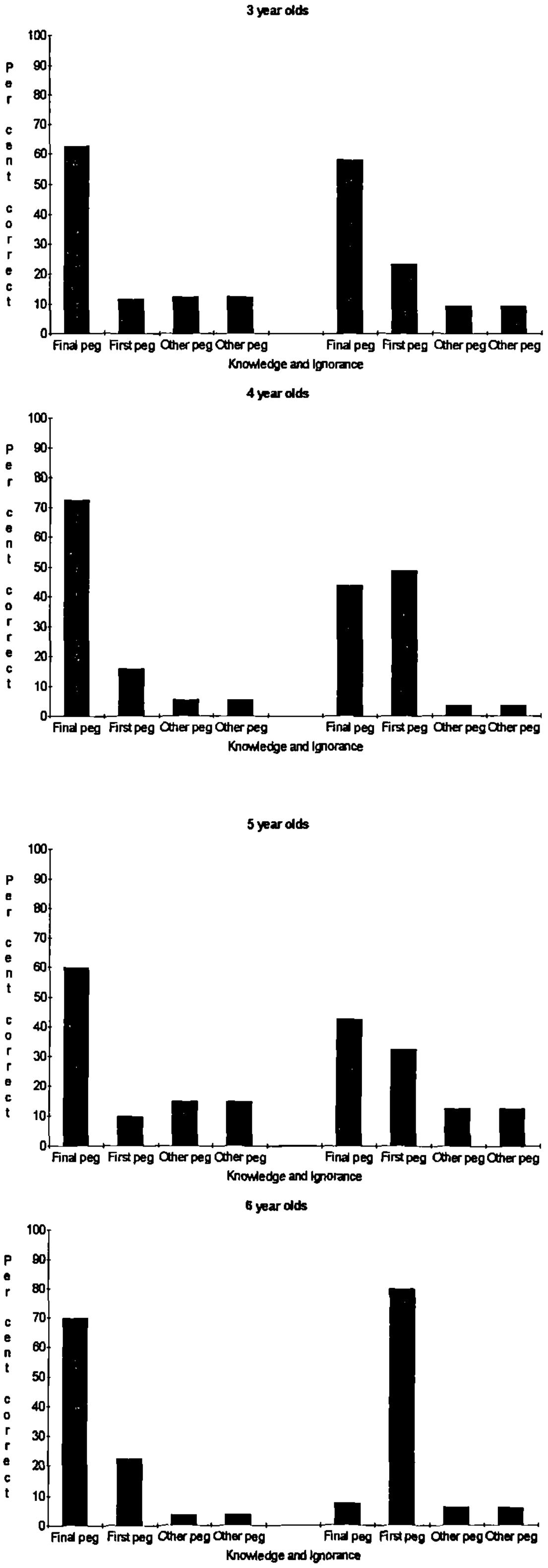
The final peg position is the correct choice for the Knowledge condition and the first peg position is the correct choice in the Ignorance condition. The two drawers that were not labelled by the peg were treated as one choice (other) since they could not be differentiated in terms of where the peg was or had been placed. However, to give a clearer picture of the choices being made by the subjects, the category of 'Other' is split into two where the results are displayed in the graphs. The assumption made is that when subjects chose a drawer that was not labelled by a peg nor had been labelled by a peg, they were equally likely to choose either of the other two drawers.

Children

Only the six year olds showed a significant difference between the final peg position and the first peg position in Ignorance and Knowledge. 3 year olds(Final peg: $t=0.303$; $df=8$; $p>0.05$; First peg: $t=1.470$; $df=8$; $p>0.05$); 4 year olds (Final peg: $t=2.1114$; $df=10$; $p>0.05$; First peg: $t=2.204$; $df=10$; $p>0.05$); 5 year olds (Final peg: $t=1.561$; $df=9$; $p>0.05$; First peg: $t=1.868$; $df=9$; $p>0.05$); 6 year olds (Final peg: $t=2.871$; $df=9$; $p<0.05$; First peg: $t=2.418$; $df=9$; $p<0.05$).

Examination of the graphs in figure 7.7. and table 7.7. show that the 3 year olds are choosing the drawer labelled by the peg regardless of whether the condition is Ignorance or Knowledge, and hence they are using a simple rule of thumb - choose drawer-labelled-by-peg. The four year olds correctly chose the drawer labelled by the peg in its final position for Knowledge, but in Ignorance they chose randomly between the drawers that are labelled by the peg in its final position or a drawer that had been labelled by the peg. They chose one of the other drawers only 11.4% of the time. Therefore they realise that in Ignorance, the 'rule of thumb': choose 'drawer-labelled-by-peg' no longer applies, and that the clue is the peg, but they have no real understanding of which drawer they should pick, or why. The 5 year olds chose the final peg position more than any other drawer in both conditions. In Knowledge they choose it 60.0% of the time, more than the other choices available to them. In Ignorance, they still chose the final peg position more than they chose the other drawers, although there is little difference between their responses for the final peg position and the first peg position. The 6 year olds have clearly understood the task.

Figure 7.7: A graph showing the mean percentage of times the children chose either the drawer where the peg had been put finally, where the peg was put first, or one of the other two drawers that were not labelled by the peg in the Knowledge (left hand side of the graph) and the Ignorance (right hand side of the graph) condition.



Autistic adults

There is no significant difference between the amount of times these adults chose the final peg position in either Ignorance or Knowledge (t=0.173; df=10; p>0.05) nor the amount of times they chose the first peg position in either of the two experimental conditions (t=0.026; df=10; p>0.05). It is clear that they were following the 'rule of thumb': choose 'drawer-labelled-by-peg' regardless of experimental condition, and had not understood that where the peg had been might be a clue to where the reward is (see figure 7.8. and table 7.7.).

Chimpanzees

One chimp, Josie was able to pick the final peg position in Knowledge and the first peg position in Ignorance (see figure 7.10. and table 7.8. and 7.9.). Beckie appeared to have understood the Knowledge part of the task, but not the Ignorance part and thus had no comprehension of false beliefs. Flynn did not give correct responses the Knowledge part of the task, but his responses indicated that he understood that the first peg and the final peg positions were important. He correctly chose the first peg position more than any of the other peg positions in the Ignorance part of the task, but it is unlikely that he demonstrates a comprehension of false beliefs for there was only a difference of 5% between his choices for the first and the final peg position in this part of the task. Benjie, either through inability or because he was not trying, was not able to choose the correct peg positions.

Three of the chimpanzees (Beckie, Flynn and Benjie) showed no significant difference between the amount of times they chose the final peg position in either Ignorance or Knowledge (matched t=0.831; df=3; p>0.05) nor the amount of times they chose the first peg position in either of the two experimental conditions (matched t=1.307; df=3; p>0.05). The fact that these subjects were choosing any of the drawers, rather than simply the two drawers associated with the peg is good evidence to show that a probability of 0.25 is the appropriate basis on which to analyse their choices.

Figure 7.8: A graph showing the mean percentage of times the autistic adults and the chimpanzees chose either the drawer where the peg had been put finally, where the peg was put first, or one of the other two drawers that were not labelled by the peg in the Knowledge (shown on the left hand side of the graphs) and the Ignorance (shown on the right hand side of the graphs) condition. N=11 autistics and n=4 chimpanzees.

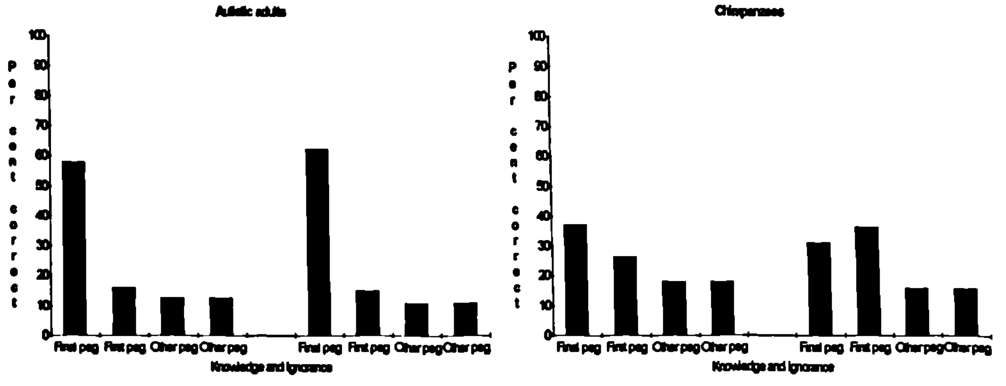


Figure 7.9: A graph showing the mean percentage of times the children, the autistic adults and the chimpanzees chose either the drawer where the peg had been put finally or where the peg was put first in the Knowledge and the Ignorance condition. The graph on the left deals with the subjects' choice of final peg position in both the Knowledge and the Ignorance conditions, whilst the graph on the right deals with the subjects' choice of first peg position in the two conditions.

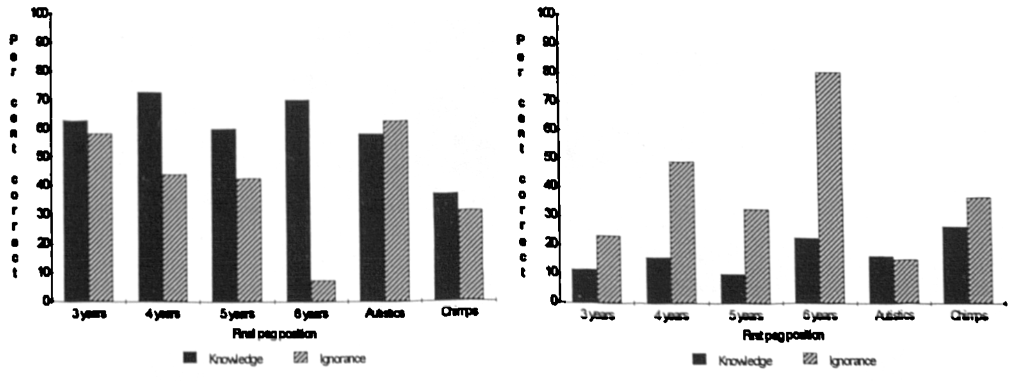


Figure 7.10: A graph showing the percentage of times each of the chimpanzees chose either the drawer where the peg had been put finally, where the peg was put first or one of the other two drawers not labelled by the peg in the Knowledge (shown on the left hand side of the graph) and the Ignorance (shown on the right hand side of the graph) condition.

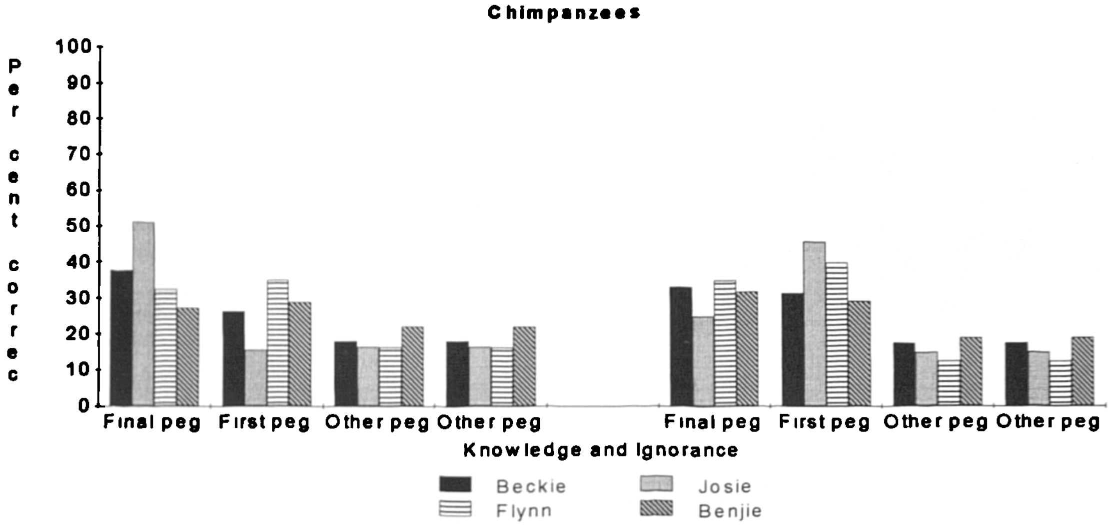


Table 7.8: The mean percentage of times children, autistic adults and chimpanzees chose either the drawer where the peg had been put finally, where the peg was put first or one of the other two drawers not labelled by the peg in the Knowledge and the Ignorance conditions.

Knowledge

	Final peg	First peg	Other
3 years	62.8	11.7	25.0
4 years	72.7	15.9	11.4
5 years	60.0	10.0	30.0
6 years	70.0	22.5	7.5
Autistic adults	58.1	16.3	25.6
Chimpanzees	37.1	26.5	36.4

Ignorance

	Final peg	First peg	Other
3 years	58.1	23.3	18.6
4 years	43.9	48.8	7.3
5 years	42.5	32.5	2.5
6 years	7.5	80.0	12.5
Autistic adults	62.8	15.2	22.1
Chimpanzees	31.3	36.6	32.1

Table 7.9: The percentage of times each of the chimpanzees chose either the drawer where the peg had been put finally, where the peg was put first or one of the other two drawers not labelled by the peg in the Knowledge and the Ignorance condition.

	Knowledge			Ignorance		
	Peg position					
	Final	First	Other	Final	First	Other
Beckie	37.7	26.4	35.9	33.3	31.4	35.3
Josie	51.1	15.6	33.3	25.0	45.8	29.2
Flynn	32.5	35.0	32.5	35.0	40.0	25.0
Benjie	27.2	28.9	43.9	31.9	29.2	38.9
Expected	25.0	25.0	50.0	25.0	25.0	50.0

7.4. Conclusion

7.4.1. Does the nonverbal task test for ToM?

Although not all the children were able to give significantly correct answers to Knowledge, all age groups had similar scores. Only the 6 year olds were able to get significantly correct results for Ignorance. When the results were analysed giving each child an incorrect or correct score for their responses to all 4 trials with a probability of 0.05, all the children were able to give significantly correct responses to the Knowledge condition, and all the children from the age of 4 upwards were able to give significantly correct scores to the Ignorance part of the task.

The younger children, in particular the 3 year olds, gave significantly correct results to Knowledge because they treated this condition as if the peg still signified an association with the sweet. The peg did still signify an association with the sweet, but at this low level of understanding, they did not take into account person A's knowledge. Therefore, they were unable to understand why the peg did not signify an association with the 'sweet in Ignorance and consequently they gave incorrect responses to this condition, so much so, that a significant difference was seen between the results for the two conditions.

There was a significant association between giving the correct response to the Ignorance part of the false belief test and the Smartie test for the 6 year olds, and for the class of 5-6 year olds and the class of 6 year olds. This indicates that the older 5 year olds were able to give correct responses to both tasks, although the younger 5 year olds were not. There was a significant association between giving the correct response to the Smartie test and the Knowledge condition for all age groups and school classes. However, the crucial association was between Ignorance and the Smartie test and this was not seen except in the older children as stated above.

In conclusion, it seems that the nonverbal false belief test is a valid analogue for the verbal false beliefs. The fact that the younger children can begin to comprehend the Ignorance part of the task may be because they are developing an awareness of false beliefs and the practice (a total of 8 trials on the false belief task) helped them begin to understand what they were being tested on. This is further borne out by the fact that none of the autistic adults showed an understanding of ToM. None of them could give significantly correct responses to the Ignorance part of the condition. There was a marked discrepancy in their scores for the two conditions. They performed better on the Knowledge condition, with 6/11 giving results that were significantly above chance. This suggests that they treated the latter condition as the control (see rationale) and used it as a simple association between peg and reward. These subjects were also given much more help than either the chimps or the children in terms of positive reinforcement since they were allowed to keep looking for the bean, and in facial expressions and exaggerated pointing and looking gestures. This leniency on our part (by allowing the autistic subjects more cues) has made the results more robust for, despite the exaggerated gestures, the autistic people were still unable to pass this test.

It is fair to say that many of the autistic people could not have been expected to do well at this task since they had low mental ages, but 6 were above 4 years old according to the BPVS and still were not able to understand the test.

Even on a rule based conditional task, they demonstrated their dislike of changing the initial rule and thus 7/11 were able to give significantly correct responses to rule 2 which was simply a continuation of the former rule (the association between peg and drawer) but none of them could choose the correct drawer for rule 1.

7.4.2. Do chimpanzees have ToM?

One chimpanzee, Josie, was able to produce significant results on both the Ignorance and the Knowledge condition. Where the incorrect choices were also taken into consideration, Josie did appear to be choosing the correct drawer on a nonrandom basis in both the Ignorance and the Knowledge conditions. The other three chimps appeared to be choosing the drawers on a more random basis. Benjie produced few correct responses. The results from both Beckie and Flynn indicated that although the chimps had no comprehension of false beliefs, they were able to respond correctly to the Knowledge part of the task. They also reacted as if they understood that what was important were the final and the first peg positions. Unlike the autistic subjects, the chimpanzees responded more appropriately. This could be because they are not bound by an overwhelming desire for 'sameness' as the autistic subjects are. If this is the case, the chimpanzees were then able to respond when the rules changed, and they may have recognised that there is something about the task that is a social problem. Indeed, when the mean correct responses from all the chimpanzees to the Ignorance part of the nonverbal false belief task are compared to the responses made by autistic people and children, the chimps score more highly than the autistics and children younger than 4-5 years old.

Several points need to be raised. First, the chimps had a large number of trials compared to the children, but they had the bare minimum it took in the training phase to achieve a response significantly above a chance level, rather then pressing on until they had achieved an 80 or 90% success rate. This low level of trials was then repeated in the experimental phase. Obviously the children did not have and did not need as many trials as the chimps. This could be because they are more intelligent; or better able to use tools; or because they have had more practise at 'games' whereas none of these chimps had had any previous experience of either tests or 'games'. However, although the chimps scored above a chance level in the training session, it might have been better to train them to an 80 to 90% success rate before proceeding with the experiment. This is standard practice in most animal learning experiments.

Secondly, I believe that learning does play a role even in the comprehension of theory of mind tests. The task differs in the experimental phase from the training session and one needs to learn what it is one is being asked to do and to concentrate on. No matter how long the false belief task (but not the conditional task) had been continued with the autistic people, it is unlikely that they would ever have given the correct responses because they were not paying attention to the salient cues. They did not look at our eyes and thus did not see where we were looking. Once the subject understands what they are being required to pay attention to in what is, after all, an arbitrary and artificial situation, if they have ToM, they ought to respond correctly. Therefore, for no species would I expect a transfer that was immediate, i.e. within the first trial for the children, or the first 10 for the chimps. However, two of the chimpanzees did appear to show a trend towards a learning curve, which would indicate that they were learning what they needed to attend to.

Finally, it is recommended that in future, this test is repeated giving the animals a longer training session and with a larger sample size, and with subjects of different ages. The latter would determine whether, if chimps are capable of passing this test, there is a developmental effect, i.e. that chimps below a certain age would not pass the test, but those over that age would be capable of passing the test.

In conclusion, it seems that the task outlined in this chapter may be a useful nonverbal way of testing for the comprehension of false beliefs. As predicted, the autistic adults and children who could not pass a verbal false belief task, were not able to pass the nonverbal false belief test either. One chimpanzee responded to the nonverbal false belief task in a way that might lead us to conclude that she had a comprehension of false beliefs.

8. Intentionality in chimpanzee and bonobo play: the play face as a means of metacommunication?

Aim

The aim of this study is to determine whether chimpanzees and bonobos use metacommunication (in the sense of intentional communication) about play behaviour. Play behaviour is often characterised by a 'play face'. The suggestion is that the ability to use this signal in certain contexts only, could indicate that the animal understood second order intentionality. Second order intentionality in this situation would imply that the subject was taking the mental perspective of the target (its play partner) into account; if the subject had a non-conditioned and mentalistic comprehension of the target's perspective, the subject would comprehend that its own facial expression can reveal its motivation to others.

8.1. Introduction

Playful behaviour can be distinguished from other behaviour since playful activities are often exaggerated, repetitive, incomplete and out of their usual sequence when compared to corresponding nonplay activities. These sequences are often marked by specific 'play signals' and involve behaviours removed from their usual motivational contexts (Smith 1982). Smith (1982), in his thorough review of the function of play, states that it occurs "to provide indirect practise for certain skills when direct or optimal practice is unlikely or unsafe."

In early development there are many similarities between chimps and children. The play face appears at around 5 months in chimps, and humans acquire smiling behaviour slightly earlier. Chimps begin to orientate towards objects at 4-6 months whereas a human object-centred stage begins at 6-8 months. At the end of this stage there is a shift in focus from inanimate object play to peer play at 10-11 months in humans, and 7-8 months in chimps. At this early stage chimps are more concerned with assimilative and possessive use of objects, such as taking them and using them in threat displays, whereas human infants use the object's features and will play, for example, ball games with balls (Russon 1990).

The major difference in chimp and human play is that by the time children are 2, they are capable of pretend play (but see Hayes 1951 for an anecdote about the chimp, Vicki). Pretend play is a feature which is also lacking in many autistic children (Baron-Cohen 1987, Rutter 1978, Ungerer & Sigman 1981, Wing et al 1977, Wulff 1985).

In animals, the function of the play face, or other cues, such as the play bow in canids, is to signal that 'this is play' so allowing rough and tumble play to take place (Bekoff 1976a; b). Bekoff (1972; pers. comm.), after Bateson (1955), argues that the play face may be an example of metacommunication in the sense that intentional communication about communication (the play behaviour) is taking place. This is the definition of metacommunication I would like to use in this chapter. It is, as yet, debatable whether play signals do have a mental component to them.

Play signals are deemed to be communicative as they change the behaviour of the target on perception of a signal from another animal (Marler 1967). According to Bekoff (1972) the play face or play bow is a ritualisation of specific signals to carry a message which conveys a mood that what is to follow is play. Play signals are context dependent; they signal an animal's intention and influence the mood of conspecifics. However, Bekoff appears to be talking about intending to commit an action, rather than intentionality in the sense of the ability to represent another's mental state, although he does not deny that play signals may have an underlying mental component (Bekoff pers. comm.).

Very few studies have been conducted on metacommunication in play behaviour other than Bekoff's work on canids (1972; 1974; 1995) and Adang (1984) who discusses 'teasing' behaviour in young chimps. These 'quasi-aggressive episodes' did not include a play face and where they did, which was in less than 2% of teasing behaviour, conspecifics reacted with a play face and looked tense. In Adang's words, this play face accompanied by quasi-aggressive behaviour created "an impression of derision". His interpretation is that teasing is best viewed as a form of social exploration and is performed by youngsters in order to learn and expand their social limits. This is an adaptive explanation and says nothing about the underlying mental components. Suffice to say that Adang's work bears out Bekoff's claim that play signals are context and mood dependent.

Observing concealment of the play face may indicate that metacommunication is taking place (Tanner and Byrne 1993). Tanner and Byrne (1993) observed a captive female lowland gorilla who repeatedly hid or inhibited her play face by covering her face with one or both hands. Play was usually delayed following this behaviour even if other play signals were simultaneously being made by the gorilla. In contrast, a play face indicated that play would follow within a few seconds. This form of behaviour may have been indicative of deception, metacommunication or at the very least, an awareness of facial expression and the consequences that could ensue.

The play behaviour of four young chimpanzees and two young bonobos was examined to determine how they communicated with each other during different types of play behaviour. It is almost impossible to determine (with any degree of certainty) whether a mental component underlies play behaviour through observational studies alone. However, examining play behaviour will give a greater understanding of the context in which communication about play takes place between the subjects. Documenting patterns of behaviour and communication is the first step towards designing experiments which may shed more light on whether these animals are intentionally communicating about their behaviour.

8.2. Method

Subjects

Four young chimpanzees (Josie, Flynn, Vickie and Jomar) and two bonobos (Kichele and Jasongo) were used in this study. Flynn and Josie were housed together, as were Vickie and Jomar, and Kichele and Jasongo. A distinction was made between play behaviour exhibited by Vickie and Jomar to each other and to a same aged gorilla (Mambie) who was housed with them for several hours each day. In addition, 2 juvenile spider monkeys and the 2 adult bonobos were included but were discarded from the observations. The adult female bonobo was pregnant and did not play very much and although the adult male played with the youngsters a great deal (and far more than the adult chimps played with the juveniles) he still did not spend as much of his time playing as the young bonobos so I have not included data from him in the analysis. The spider monkeys were not studied as they rarely played and made no play faces (although some monkeys do show play signals such as douc and Himalayan langurs (Fagen 1981)).

Focal animals were observed for an hour at a time and data were collected on an ad lib basis whenever the focal became involved in a play episode. The duration of each play bout was recorded and whether it was self play or conspecific play. If it was conspecific play, it was noted who initiated play, how it was initiated, what behaviour the agent had been involved in prior to the play episode, and whether initiation was successful or not.

For both conspecific play and self play, it was noted down what actions the agent carried out and what objects they played with in the order they occurred. As a superscript, it was noted whether a particular action occurred in conjunction with the full play face, a minor play face or no facial play signals (see table 8.1. for a list of play behaviours).

Rough-and-tumble play was defined as grappling with another animal which included biting, kicking, tickling and throwing. Non-rough-and-tumble conspecific play included holding, touching, hugging and chasing games or simply playing where bars, ropes or tree climbing were incorporated into play. Non-rough-and-tumble self play included playing on bars, ropes and in trees. Object play was play either with a conspecific or by themselves which included playing with balls, boxes or hay.

Ten hours of focal samples were obtained for each animal spread equally throughout the day.

Table 8.1: A table giving the list of play behaviours, other behaviour, and the abbreviations used in the data collection.

Play Behaviour

G = gaze
Ho = hold hand/foot of consp.
To = touch
C = chase
F = flee
W = walk
R = run
SW = slow walk
SR = slow run
Br = play on bars
Tr = play in tree
R = play on rope
B = play with ball
H = play with hay
O = play with other object
RT = rough-and-tumble
Hi = hit
Bi = bite
Ki = kick
Ti = tickle
Tw = throw
Ju = jump
Hs = headshake
X^P = full play face
X^- = minor play face

Other behaviour

W = walk
R = run
Cl = climb
Fe = feeding
Re = resting
P = play
Al = allogroom
At = autogroom
C = chase
F = flee
T = threaten
Mt = mount
S = submit
D = display
P = present
C = copulate
Mb = masturbate
I = infant inspection
x = target of above behaviours

8.3. Results

8.3.1. The use of the play face

The results indicate that the play face was shown more often during conspecific than self play, although there was little difference in the play face rate between rough-and-tumble and non-rough-and-tumble conspecific play. Very few play faces were made during object play either with peers or alone. Jomar signalled to the gorilla, Mambie, by showing more play faces per play bout, but Vickie showed a similar play face rate to both Mambie and Jomar. Table 8.2. shows the number of play faces shown during different types of play and this data is illustrated in figure 8.1.

Table 8.2: The number of play faces seen in rough-and-tumble, non-rough-and-tumble and object play during conspecific and self play in chimpanzees and bonobos where RT=rough-and-tumble; CP=conspecific play; SP=self play and Ma=play with Mambie, the gorilla. (Table 8.5. shows the total time spent playing in all subjects).

		Non RT	RT	Object	Total	Total rate per min of play
Chimps						
Flynn	CP	6	29	0	35	1.612
	SP	13		6	19	0.282
Josie	CP	3	22	0	25	0.874
	SP	6		1	7	0.241
Vickie	CP	10	57	0	67	2.827
	Ma	45	162	0	207	2.377
	SP	7		0	7	0.197
Jomar	CP	9	7	0	16	1.032
	Ma	42	134	0	176	5.014
	SP	23		2	25	0.112
Bonobos						
Kichele	CP	25	198	0	223	2.770
	SP	0		0	0	0.000
Jasongo	CP	53	250	0	303	3.098
	SP	1		3	4	0.037

The rate at which the subjects used the play face was calculated per minute for each individual bout of conspecific play that was initiated by the subjects studied. Play recorded during the observation period which had been initiated by Kakouwet or Diatou was not included since focal sampling had not been carried out on these two animals (both these bonobos were adults and hence they played less often than the younger bonobos).

The chimps had a slightly lower play face rate during conspecific play than the bonobos. Both species showed a similar play face rate during conspecific play with rough-and-tumble, and conspecific play without rough-and-tumble behaviour as each other; both species showed a slight increase in the play face rate during rough-and-tumble play (see table 8.3 and figure 8.2).

The rate of play faces shown during self play was much lower than the play face rate during conspecific play; again both species had a similar play face rate. Both species showed fewer play faces during self play with objects, rather than self play where the animals were running, or swinging on bars and trees (see table 8.4. and figure 8.2.).

Figure 8.1: The number of play faces seen in rough-and-tumble (RT), non-rough-and-tumble and object play in chimps and bonobo conspecific play.

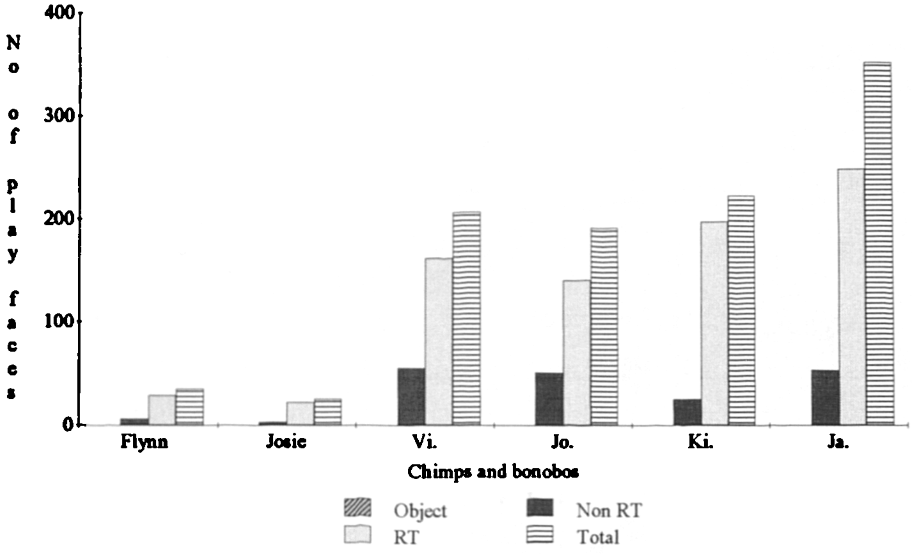


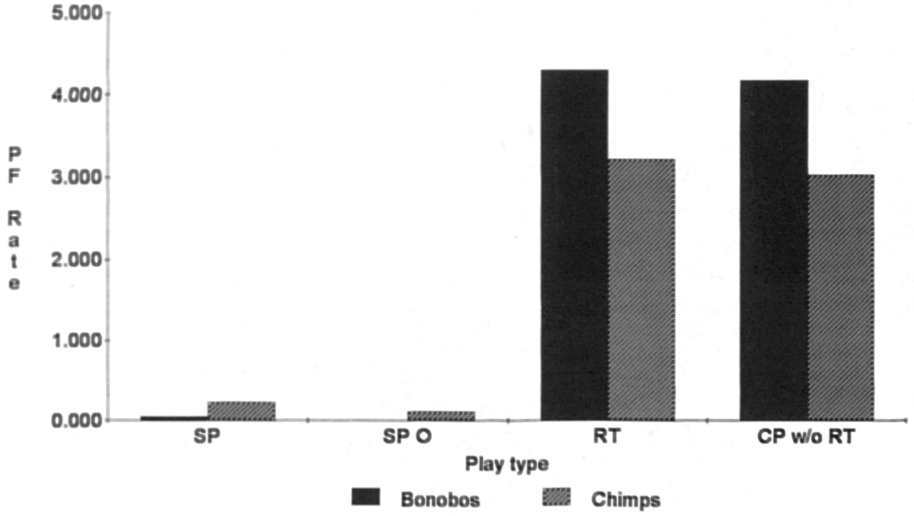
Table 8.3: The rate per minute spent playing during which chimps and bonobos gave a play face during conspecific play with rough-and-tumble play (RT) and without (w/o RT) the inclusion of rough-and-tumble play in each play episode.

	Bonobos		Chimps	
	RT	w/o RT	RT	w/o RT
Mean	4.277	4.150	3.195	3.006
Median	3.750	4.000	2.144	3.155
Min	0.000	1.111	0.000	1.715
Max	16.000	8.547	15.038	4.000
STD	3.325	2.297	3.249	0.821

Table 8.4: The rate per minute spent playing during which chimps and bonobos gave a play face during self play (SP) and self play with objects (SP O) in each play episode.

	Bonobos		Chimps	
	SP	SP O	SP	SP O
Mean	0.046	0.000	0.228	0.107
Median	6.667	0.000	0.952	1.818
Min	6.667	0.000	0.000	0.000
Max	6.667	0.000	8.000	3.750
STD	0.552	0.000	0.783	0.498

Figure 8.2: The rate of play faces (PF) per minute given by chimpanzees and bonobos during self play (SP), self play with objects (SP O), conspecific rough-and-tumble play (RT) and conspecific non-rough-and-tumble play (CP w/o RT) in each play episode.



8.3.2.Time spent playing

The bonobos spent the most time playing, then the young chimps, and the older chimps spent the least time playing. The bonobos spent roughly the same amount of time playing on their own as they did with each other, but the chimps spent more time overall in self play (see tables 8.5. and 8.6.).

There was no significant difference in the time spent in conspecific compared to self play in either species: chimps (matched t=0.920; df=3; p>0.05); chimps playing together and not with the gorilla (matched t=1.098; df=3; p>0.05); bonobos (matched t=8.456; df=1; p>0.05).

8.3.3. Initiation strategies used to elicit play

A variety of initiation strategies were used to elicit play. Most were common to both species, but there were some exceptions. Examples of strategies used by bonobos but not chimps are head shaking, throwing of objects and jumping (see figure 8.3.). Vickie and Jomar would stand on their hind legs and stamp their feet as a means of eliciting play with Mambie. They did not do this to each other, nor were other chimps seen to demonstrate this behaviour. Mambie would stamp his feet when he wanted to elicit play behaviour. Some behaviour was combined. For example, the play face and gaze would often be combined with another more physical type of behaviour, touching, chasing and biting or hitting being the most successful strategies used by the bonobos. A successful initiation strategy was one that preceded a playbout that lasted over 30 seconds since this is less than the mean length of a bout of conspecific play. Gaze was used as a strategy in its own right by bonobos, but not as much by chimps.

Table 8.5: The total time spent in conspecific play compared to self play (in minutes) in chimpanzees and bonobos collected during the total sample (10 hours per individual). Where specific peers are mentioned abbreviations are as follows: Ma=Mambie gorilla; Jom=Jomar; Vi=Vickie; Ja=Jasongo; Ki=Kichele; Ka=Kakaouwet; Di=Diatou; CP=conspecific play and SP=self play. Josie and Flynn have no choice in play partners as the two of them are housed together on their own.

		CP	SP	Total
Chimps				
Flynn		21.7	67.4	89.2
Josie		28.6	29.0	57.6
Vickie		110.8	35.5	146.3
	(Ma only)	87.1		
	(Jo. only)	23.7		
Jomar		50.6	222.5	273.2
	(Ma. only)	35.1		
	(Vi. only)	15.5		
Bonobos				
Kichele		80.5	99.7	180.2
	(Ja only)	51.5		
	(Ka. only)	26.4		
	(Di. only)	2.5		
Jasongo		97.8	112.2	210.
	(Ki. only)	67.2		
	(Ka. only)	30.0		
	(Di. only)	0.7		

Table 8. 6: The results from table 8.3. are shown in the form of the mean time a play episode lasted (in seconds) where CP=conspecific play, SP=self play and STD= standard deviation.

		CP		SP		Total	
		Mean	STD	Mean	STD	Mean	STD
Chimps							
Flynn		76.8	134.6	51.9	56.7	56.3	77.3
Josie		95.4	154.0	38.7	47.5	54.9	95.1
Vickie		77.3	123.6	73.5	110.4	76.4	120.4
	(Ma only)	85.7	129.0				
	(Jo. only)	57.0	106.5				
Jomar		56.2	68.7	77.6	91.7	72.2	87.2
	(Ma only)	63.9	73.5				
	(Vi. only)	44.2	58.5				
Bonobos							
Kichele		35.0	39.5	68.0	87.8	47.8	64.9
	(Ja only)	32.2	36.5				
	(Ka only)	42.8	47.5				
	(Di. only)	30.4	11.8				
Jasongo		52.9	61.0	62.3	102.6	57.5	84.3
	(Ki. only)	65.0	71.8				
	(Ka only)	38.3	39.1				
	(Di only)	19.5	3.5				

Like the bonobos, chimps would combine the play face and gaze with other more physical approaches, chasing, touching and biting or hitting being the most successful (see figures 8.3. and 8.4.). In both species, there were far more unsuccessful attempts at eliciting play than successful ones, and even though chasing was one of the most common strategies, it was also the least successful. The issue here, though, is the probability of an act initiating play (i.e. the proportion of occurrences which resulted in play). In these terms, chase is one of the least successful initiation strategies; the play face and/or gaze is one of the most successful for chimps and touch for bonobos.

Figure 8.3: A histogram showing the frequency and success of various strategies for initiating play in bonobos. A successful initiation attempt was deemed to be one that resulted in a play episode lasting over 30 seconds.

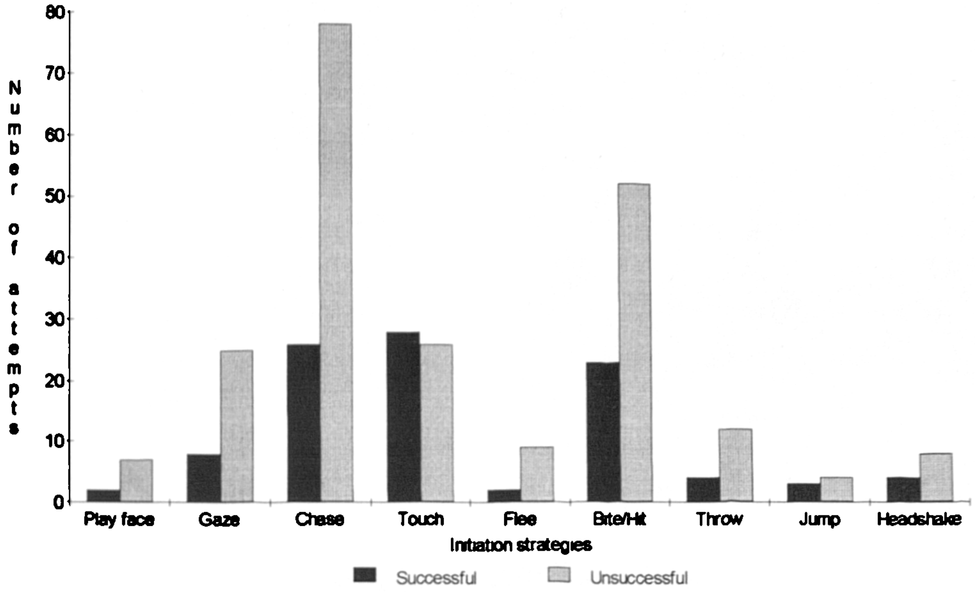
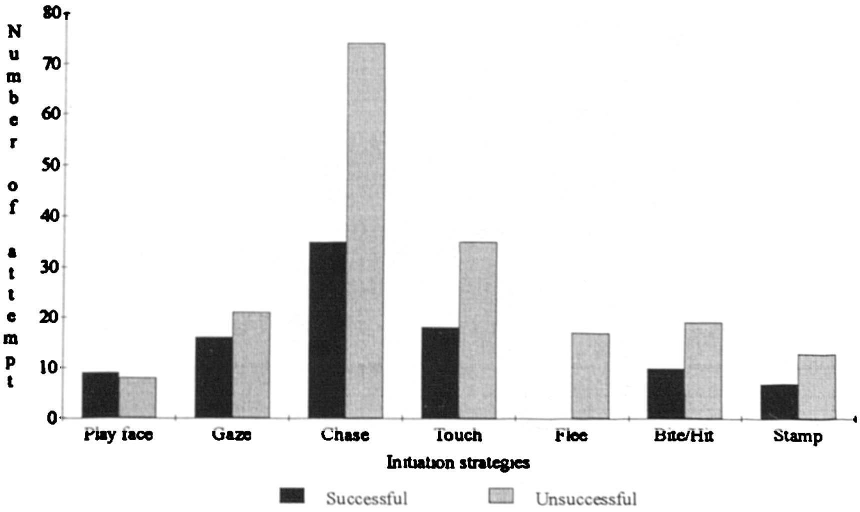


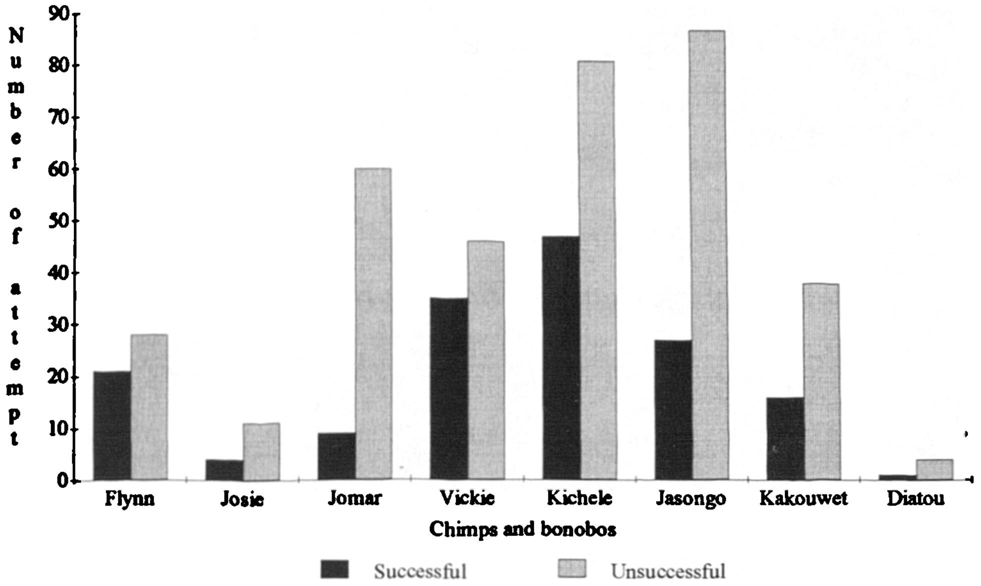
Figure 8.4: The frequency and success of various strategies for initiating play in chimps. A successful initiation attempt was deemed to be one that resulted in a play episode lasting over 30 seconds.



In all cases, it was the dominant animals (Flynn, Vickie and Kichele) who were the most successful at eliciting play. This produced a significant difference in the two chimp pairs, but not the bonobo pair: Flynn and Josie (Chi^2=5.8; df=1; p<0.02); Vickie and Jomar (Chi^2=7.689; df=1; p<0.01);

Kichele and Jasongo ($Chi^2=2.439$; df=1; $p>0.05$) Two out of three of the subordinate animals (Jomar and Jasongo) showed approximately as many unsuccessful attempts to elicit play as the dominant animal they were paired with. The adult bonobos did not elicit a great deal of play, mainly because they did not play much, but they were not included as focal subjects.

Figure 8.5: A histogram showing which of the chimps and bonobos were most successful at initiating play. A successful initiation was one that resulted in a play episode lasting more than 30 seconds.



8.4. Conclusion

8.4.1. The use of the play face

Both species of chimpanzee used the play face at a similar rate to each other. The subjects showed a much higher play face rate during conspecific than self play, This increased during rough-and-tumble play (although the difference between the play face rate during rough-and-tumble play and conspecific non-rough-and-tumble play was slight). The play face rate was lowest (and non-existent in bonobos) during self play with objects. Neither species used the play face at all during conspecific object play. These results suggest that both species of chimpanzee were making the play face as a means of signalling when they were playing with conspecifics. The fact that the play face rate did not increase significantly during rough-and-tumble play may indicate that the animals were familiar with each other and therefore they did not need to increase their rate of signalling to indicate that their behaviour was only play and not true fighting.

It is possible to suggest that the chimps are not making the play face simply because they are enjoying themselves. If this were the *only* reason for giving the play face - that it was an involuntary response to physical circumstances, then one would expect the number of play faces to be the same in conspecific as self play. If the chimps enjoyed themselves more during conspecific than self play, then one would expect conspecific play to occur more frequently and for longer, and that rough-and-tumble, and object conspecific play would all elicit the same number of play faces. These results are not seen. That chimps might enjoy themselves most during rough-and-tumble play does not invalidate the need to use the play face as a means of communication, whether it be an intentional or innate form of communication. In other words, if the chimps gain pleasure from rough-and-tumble play this is a proximate mechanism for an ultimate function, namely, communication.

The chimps used a different play initiation strategy with the gorilla sometimes; Jomar (male) showed more play faces to him. Communication is likely to be a problem between species as well as between relatively unfamiliar conspecifics. However, the fact that Jomar and not Vickie used more play faces with the gorilla may have been because he was trying to encourage the gorilla to keep playing with him. Jomar was less successful at initiating play and spent less time playing with the gorilla than Vickie.

Overall the results show that the play face is used during conspecific play and not during self play. There are two ways in which this can be viewed: (1) metacommunication is taking place. This explanation implies that the chimpanzees have second order intentionality, in other words, they are taking the mental perspective of their play partner into account. (2) An alternative explanation is that the chimps show the play face during rough-and-tumble play as an innate or learned response. Learning to show a behaviour does not necessarily preclude a mentalistic understanding, but I am assuming that it does for the purpose of the argument proposed in point 2. I do not think it is possible to distinguish between the two hypotheses at present.

8.4.2. Time spent playing

Neither species showed a significant difference between the time they spent in conspecific and self play; the bonobos divided their time equally between these two types of play behaviour, but the chimps spent more time in self play. This result accords well with the fact that although there was a trend towards showing the play face more during rough-and-tumble play in chimpanzees than any other play, the difference was not significant. Both of these results indicate that the chimpanzees compared with the bonobos are perhaps less interested in social play (they spend more time in self play).

8.4.3. Initiation strategies used to elicit play

The most aggressive ways of initiating play were both the most and the least successful: chasing, biting and hitting in bonobos, and chasing in chimps. In terms of probability of initiating play, gaze and/or the use of the play face in chimps, and touch in bonobos were the most successful (but was surprisingly rare). This indicates that the apes were aware of the importance of gaze to facilitate communication. Without attracting their play partner's 'attention, communication about play could not take place. When children first learn to point (see chapter 5 on joint attention) they do not look at their mother before they begin to point. But by the time they are 16 months old they look first before pointing in order to attract her attention. It seems that chimpanzees are aware of the need to obtain shared attention before communication, and in addition, they are aware of the visual effect of the play face because they use other gestures, such as touch, to attract their play partner's attention to their facial expression (Tomasello, Gust and Frost 1989). This so called 'awareness' in both the chimps and the human infants may be a learnt response, i.e. making eye contact before making requests is a better way of obtaining what they want.

The dominant animals were more successful at initiating play in both species, but this difference was only significant in chimps. This effect is of dominance rather than sex, since Flynn and Vickie were the best at initiating play compared to their partners. Two out of the three subordinate animals showed as many unsuccessful attempts at eliciting play as the dominant animals. Although the dominant animals may have been unsuccessful simply because they were dominant and frightened the others, this is a rather unlikely conclusion since they were also the most successful. I think it is more probable that, in general, more unsuccessful attempts at play are made than ones that are successful, and that, although it is a truism, dominant animals are successful because they are dominant.

In general, it is difficult to draw any firm conclusions because of the small sample size. Ideally subjects ought to be matched for confounding problems such as age and sex. Although sex is matched in all three cases, it would be better if there had been more chimps so that there were several pairs with a dominant female and several with a dominant male. Age is not matched, since Flynn and Josie are older than the other four.

In conclusion, it is not possible to say whether metacommunication is taking place in the sense that intentional communication about behaviour is occurring. However, it is clear that chimpanzees and bonobos do show more play faces during conspecific play than any other type of play and that they show no play faces during conspecific play with objects or (in the case of the bonobos) during self play with objects. The chimpanzees altered their attention-getting strategies for initiating play with the gorilla, and one of them (Jomar) increased the rate he made play faces to the gorilla during a play bout . The bonobos may have shown more play faces than is usual because they were relatively unfamiliar with each other and hence had to exaggerate their facial expressions. It seems that both chimpanzees and bonobos do alter their facial expressions, but it is far too early to conclude whether they are capable of altering their behaviour due to a mental understanding of their play partner.

9. Discussion

This chapter is divided into four main sections. The first asks whether the nonverbal theory of mind tests conducted on the animal subjects are comparable to verbal theory of mind tests carried out on children. The second section asks whether these tests do in fact test ToM in children. The third section deals with the results from the chimpanzees, bonobos and spider monkeys. This section is very general and covers results from the whole thesis. The final section focuses more specifically on JA, and belief-desire psychology. It deals with whether chimpanzees and bonobos have ToM.

9.1. Are nonverbal ToM tests analogous to the verbal ToM tests used by the child psychologists?

The first data chapter, chapter 4 dealt with the comprehension of causality. Three experiments were conducted which were based on experiments initially carried out by Leslie (1982). The most successful experiment was the first one which was most similar to Leslie's. The results from the chimpanzees and bonobos (but not from spider monkeys) were analogous to Leslie's indicating that this experiment is a useful nonverbal infant paradigm with which to test causal understanding in nonhuman animals.

The three experiments in the JA study were analogous to experiments conducted by child psychologists and investigated the crucial stages in JA: gaze following, the use of dyadic and triadic JA and the use of protoimperatives. Within the framework of this study it is reasonable to classify behaviour recorded during these experiments (which appeared to be the same as behaviour shown in analogous studies by human subjects) as JA. Whether this leads to the conclusion that mental understanding is being observed is a more complex issue. The same debate must be applied and the same assumptions made about the human subjects of these experiments (see following section).

The results from chapter 6 on desire indicate that the nonverbal test for desire comprehension is a weak version of the verbal test for the same ability since all human age groups tested did well on the nonverbal fulfilled desire section of the test, even though the 3 year olds and the class of 3-4 year olds did badly on the verbal desire test. However, as a test for nonhuman primates, there are some difficulties with the test since it relies on understanding a pictorial representation of desires. This is something that the children had experience of, but not the chimpanzees.

The nonverbal false belief test seems to be a valid way of testing false belief comprehension since the older children showed a significant association between giving the correct answers to the Smartie test for false beliefs and the Ignorance condition in the nonverbal false belief task. Again, the nonverbal test seems to be understood at a slightly younger age than the verbal test. The autistic adults performed as predicted: however, even those adults who were able to complete the Smartie test and the Sally-Ann test, were not able to give the correct response to the Ignorance condition in the nonverbal false belief task.

9.2. Do the verbal ToM tests really test ToM?

The central difficulty with theory of mind is that we know that we operate according to our own beliefs and desires and we assume that other people do so too. This is the well known philosophical problem of other minds. However, according to folk psychology (see chapter 2) it is a reasonable assumption to make. Indeed, we can, to a great extent, verify our assumptions by asking others what they are thinking and how they feel. The problem as far as children are concerned is twofold. Once children can speak, we assume that they mean and understand the same things as we do when we use the same words, and secondly, at a prelinguistic age, we assume that the child is able to understand theory of mind implicitly, or else has developed a precursor to theory of mind because we think that he or she will develop into an adult with theory of mind like our own.

As far as prelinguistic children are concerned, Wellman (1993) believes that by the time a child is two years old, she will have an understanding of others as intentional agents in the sense that she knows others have internal mental experiences of external objects (such as situations or actions). The evidence he provides for this is flimsy. He says that children initially start pointing without an understanding of what it means to point, but by the time they are 18-24 months, they realise that pointing is a way of treating objects as if they are the focus of intention and they understand that they and others attend to the world. This is because they use eye gaze towards the target person before they point (to make sure that they have the target's attention), and they do not cease pointing until they have received what they want - either an expression which indicates that the target has seen what the infant wants the target to see, or the object of her desire.

What may be happening is that the infant has learnt the best way to attract an adult's attention. In the same way that infants' head-turns can become conditioned (see Moore and Corkum in press), the infant may have learnt that obtaining mutual gaze before pointing is the quickest route to gaining the desired response from the target. Both JA behaviour and the 6 month old's responses to cause and effect (or lack of cause and effect) sequences may be hardwired behaviour. This hardwired infrastructure could be present in the human child acting as a scaffold for the later development and fuller comprehension of theory of mind. Experiments up until now have not been able to distinguish whether children at this early age have an implicit understanding of theory of mind, or are simply learning a behavioural rule. The ability to learn this behaviour may very well be an innate capacity in the infant. In addition, even if the infant really does understand that she is attending to the world, and that others do too when they direct their eye gaze to certain objects, we should not use this as an excuse to assume that the infant is capable of any higher mental understanding. For example, there is evidence that autistic subjects can understand 'seeing' (Baron-Cohen 1989a; 1991; Leslie and Frith 1988) but it does not follow that they understand that 'seeing leads to knowing' (Perner, Frith, Leslie and Leekam 1989; Goodhart and Baron-Cohen 1994; Pratt and Bryant 1990). Autistic children are not notably impaired at JA during their first year of life; it is only from 9 months to 2 years that abnormalities can be seen. Hence it is not wise to draw any firm conclusions about the mental ability of infants younger than 9 months of age as well as those over 18 months of age (Leslie and Roth 1993).

Further evidence for the development of theory of mind cited by Wellman (1993) is that infants use the expressions on their mother's face as a cue for how the infant should behave. If the mother has a disgusted expression on her face when handling a toy, the infant will avoid that toy. Similarly, if she shows a delighted expression, the infant will play with the toy. This shows no evidence that the child has an understanding of her mother's intentional state. The ability to react in the same manner as one's parents to objects and events is a trait that is biologically important and it has been shown that young rhesus macaques will avoid snakes after (but not before) they have seen their parents' fearful reaction to snakes (Mineka, Davidson, Cook and Keir 1984)

Even when children begin to speak, this is no guarantee that they have understood the full meaning and implications of the words they are using. Children brought up in a given culture will use the language of that culture, and it seems that they have an innate capacity to pick up words and use them in certain ways as they develop (Pinker 1994). The fact that infants in their second year have the capacity to use language in a rudimentary way and begin to refer to their desires and those of others, does not mean that they comprehend that others have internal mental representations of their desires.

Thus conducting JA experiments and analysing the number of words that young children use which refer to beliefs and desires (Wellman and Bartsch (quoted in Wellman 1991)) are not watertight ways of proving that young children have either theory of mind, or the precursors to theory of mind. Nevertheless, two points need to be made here. First, JA seems to be an ability which it is vital to acquire in order to understand beliefs and desires. The part of JA which Baron-Cohen refers to as SAM (shared attention mechanism) is amodal and it has been shown that blind children have an understanding of SAM and an ability to use JA by touch rather than sight (Landau and Gleitman 1985). However, the subjects in this study were significantly older than infants normally used in JA studies and were articulate. This highlights the assumption made by the child psychologists, namely, that if a child has JA attention at a certain age, it is assumed that she will have that same ability when she makes the same gestures at a much younger age.

The second point is that we assume that all other humans physically see the world in the same way that we do. This is simply not true. Happé (submitted) has conducted experiments on autistic children. She has shown them visual illusions (such as the Ponzo and the Pogendorff illusions) which we readily succumb to. The autistic children have no difficulty with these illusions, suggesting that they may actually see the world in a radically different way from ourselves. How we perceive the world is linked to our understanding of beliefs and desires. According to Wellman (1993) 4 year olds understand that not only can we comprehend false beliefs, but that we can be prey to false perceptions of the world.

I think it is fair to say that the experiments designed to test desire and false belief comprehension are adequate, but that they lack precision. For example, Wellman distinguished between 3 year olds who have, he believes, an understanding of belief, and even false belief, but do not realise that beliefs are central to people's actions. For example, Bill takes his umbrella with him to work because he believes it is raining. Actually, there is a strong wind and some pebbles were scattered against the window. Bill thus wrongly believes that it is raining, but this does not change his decision to take his umbrella with him. A 4 year old but not a 3 year old would understand this scenario. They realise that beliefs are inextricably central to human action. Where the argument lies here is exactly what is meant and understood by beliefs. The demarcations between desire comprehension and belief comprehension are also unclear. Sodian and Frith (1993) argue that because 3 year olds and some 4 year olds are not capable of showing deception, they have no true comprehension of belief. For instance, although 3 year olds can hide 'treasure' they cannot cover up their tracks unless given, in the words of the experimenters, "massive prompting" (Sodian, Taylor, Harris and Perner 1991).

Just as we shouldn't *a priori* expect children to have theory of mind, nor expect their comprehension of ToM to be the same as ours even if their behaviour is the same, so we should not expect animals to have ToM that is exactly like our own. Even if they do have ToM (or a version of it),we should not assume that they would indicate their ability by using the same behaviour as us.

Questioning ToM tests in this way shows us that we cannot always assume that children have theory of mind. What we can say is that they show a high degree of mental complexity. Likewise, from the results in this thesis and from work already published in the literature, we can say that the mental complexity of nonhuman primates is also highly advanced, but that it is not as advanced as children's. We cannot directly assume that a) the way that nonhuman primates see the world is the same as our own, and b) that their ToM, if they have it, is the same as our own. In the next section, I will deal with how the animals that were examined in this thesis fared on the ToM tests that were adapted for them from standard tasks used by child psychologists.

9.3. How do chimpanzees, bonobos and spider monkeys fare on the nonverbal ToM tests?

The results from one of the three experimental films described in chapter 4, seemed to indicate that chimps and bonobos may be able to understand cause and effect. These subjects reacted in the same way in which children did in a similar study (Leslie 1982) which concluded that human babies could comprehend causality. In my own experiments, many of the monkeys, however, would not even watch the television. This could be because they lack the relevant type of attention and were simply not interested. Nevertheless, one could counter this by saying that had they been aware that there was something strange about the images shown, they might have shown more interest. One conclusion is that it is unlikely that they do have a comprehension of causality. This is backed up by the results from the monkeys that did watch the screen: they showed no significant difference in the length of their looking times when given film clips showing scenes with and without a cause.

Chapter 5 on joint attention showed that monkeys do not show triadic JA or protoimperatives at all. They showed almost no shared attention, and when there was an object that was of interest to all members of the group, they tended to look at it at the same time (dyadic JA). None of the monkeys were able to follow line of sight although they may be capable of doing so using peripheral vision. Since triadic JA was not observed and dyadic JA tended only to occur with an object of general interest, it is likely that there is little if any mental comprehension underlying their use of eye gaze. When monkeys look at an object, it is highly probable that they do so because the object is interesting to them, rather than because other members of the group are also looking at it. However, it is possible, that they use peripheral vision to monitor eye gaze in social situations. Furthermore, direct gaze may constitute threatening behaviour, and may thus be absent, or rare in monkeys in non-threatening contexts.

Chimpanzees and bonobos, in contrast, did show all forms of JA apart from protodeclaratives. During the observational study, they showed no protoimperatives and the bonobos showed no triadic gaze, although their level of shared attention was higher than that of the chimps. In general, most of the chimpanzees and the bonobos who used JA towards one another did so at a level that was statistically significantly above chance. However, 4 out of the 11 chimps did not use JA to one another. In the experimental study when there were novel stimuli they showed protoimperatives. There was no evidence of showing or sharing new toys in chimps - which is perhaps to be expected given their normal species-specific behaviour. Nonetheless, the fact that this behaviour is absent in this species is interesting in itself; 2 chimps, though, did demonstrate a sophisticated monitoring of each other's eye gaze and intentions. It is not clear whether the comprehension of intention was goal directed or a ToM type of intentionality in this case. Both species were able to follow eye direction spontaneously and accurately.

Chapter 6 was an experiment to determine whether chimps and children could comprehend nonverbal desires. The children were able to give the correct results to this test from age 3 upwards. At this early age they were not able to answer a verbal test for desires correctly. All children, from 3 to 6 years old, found the unfulfilled desire comprehension part of the test equally difficult. Two of the chimps gave responses that were appropriate 7/10 times, however, they needed to have chosen the correct response 8/10 times for their results to have been statistically significant. The other 2 chimps responded at chance levels, although in my subjective opinion, Flynn was not giving the test the benefit of his full attention because he was being aggressive towards me. In summary, one could say that this test appears to be a weak test for desire comprehension, i.e. one that is understood at a slightly earlier age than the verbal desire test. However, there are several reasons why chimpanzees might have failed this task: (1) they were not given sufficient training time, (2) they did not understand the pictures, (3) they were confused by the subject of the pictures (4) they could not understand the mental nature of desire in conspecifics. All the chimps did best at the training picture and the unfulfilled desire picture; this may have been because these pictures showed chimps wanting or not wanting food.

Chapter 7 examined the comprehension of false beliefs using a nonverbal test. Only one chimp was able to respond correctly to each condition (treated separately) significantly above chance.

Chapter 8 examined metacommunication during play. The aim of this chapter was to determine whether the play face was used more often during conspecific play than any other type of play and whether it thus served as a signal that 'this is play'. The rate at which the play was shown did indeed increase during conspecific play. Frew play faces were shown in self play by comparison. No play faces were seen during self play with objects; the greatest number of play faces were seen during conspecific rough-and-tumble play, but the difference between the play face rate during rough-and-tumble conspecific and conspecific play was marginal. The number of play faces was altered and was, as predicted, context and mood dependent. The type of play initiation strategies were altered when the juvenile chimps played with a baby gorilla, and one chimp increased his play face rate during play bouts with this gorilla. However, these results cannot distinguish between the possibility that the chimps were giving more play faces during conspecific play due to a learnt response, or that their facial gestures may or may not have been learnt but that the animals still had an understanding of ToM and thus knew that they needed to communicate: 'this is play'.

9.4. Do chimpanzees have ToM?

I will now deal with three issues that have arisen from my research: JA, desire and belief comprehension. It is clear that chimps can and do use dyadic and triadic JA and protoimperatives and are able to follow line of sight. However, they do not use JA in their everyday lives as much as humans do. If people were kept in similar conditions to chimps, or chimps in similar conditions to people, then JA would decrease and increase respectively, but I do not feel it would become equal. Chimps do not seem to make protodeclarative gestures (as they have been defined by some child psychologists: see introduction for chapter 5) spontaneously. Some chimps may be able to gesture in this way, especially if they have had prolonged contact with people, but it does not appear to be a common or usual form of behaviour. This probably ties in with chimps' lack of teaching and the way that their culture is learnt through emulation rather than imitation (Tomasello in press). Chimp culture has almost to be reinvented every generation. These lacunae in their mental competence may stem from the fact that they rarely show each other unobtainable objects, nor *how* to do things. This in turn may arise because they do not respond to another creature as if they knew that the other did not know. There is no need to point out a star to a friend if you have no conception that your friend has not seen it. Neither is there any reason to teach your friend how to probe for termites if it hasn't crossed your mind that they've never fished for termites before. However, chimps have been known to facilitate learning (how to crack nuts, in this instance, by presenting their youngsters with stone hammers and correcting the infants' grip: Boesch 1991). There are other examples of more direct teaching in the literature that have mainly been witnessed in language using chimps and bonobos.

What I would like to suggest is not that chimpanzees have no ToM, but that they do not have ToM as we have defined it. Neither do young children although it is clear that in both cases they have a highly complex mental outlook and understanding of the world. The way in which we have defined ToM is abstract in the sense that it is set up around the mental understanding of the average adult. Anyone or any animal that does not have that same understanding of ToM but does have some mental understanding of events and conspecifics has what may be termed "weak" ToM.

Chimpanzees may understand another's mental state, but they do not seem to know that they know, i.e., they have no full blown self-awareness and they are rarely able to act upon their knowledge of other minds. As Whiten (1994) says, "seeing is very much on the behaviour surface, wanting and intention less clearly so, and false belief much less so - the conditions for this last state not even requiring the person acquiring the belief to twitch a muscle." Until an organism has a truly representational ToM, skills below this level (i.e. that of comprehending false beliefs in others) are classed by Perner (1991) as a "mentalistic theory of behaviour." It is possible that a chimp or a child could have what Perner refers to as secondary representations and what Leslie (1987) would refer to as metarepresentations, i.e., the ability to attribute a mental state to another. (Note that they would not have the ability to metarepresent in Perner's terminology unless they could represent a representation in another as a representation. He believes that only those who can comprehend false beliefs could do this, but it would be possible, I would argue, for an animal to comprehend false beliefs but not metarepresent in the sense in which Perner means).

If the above assumption is correct, it might explain the fact that chimps can use JA, but have not been shown to use protodeclaratives in these experiments. This would also explain their apparent inability to fully grasp what was being required of them in the desire experiment. Here they were asked to understand a representation of a chimp desiring a banana and superimpose that understanding upon *their* desire to choose the drawer with the sweet in. Hence the fact that they were better able to respond to the false belief test. The choice here was concrete. The person in front of them did not know where the peg was and they had to understand this in order to obtain the reward. There were no abstract concepts involved; comprehension of the task was not removed by one step. Yet because of the limitations of their intelligence, it took them a number of trials to learn the training phase. If the chimps had been given more trials during the training phase, the 3 chimps who did not pick the correct choice significantly above chance might have given scores that were statistically significant in the experimental condition.

I would now like to try to give an overview of how chimpanzee ToM as I have outlined above might fit into a more comprehensive picture of ToM in particular, and cognition in general throughout the animal kingdom. First of all I want to do this by returning to a more basic classification of mental awareness: Crook's levels of consciousness.

I split levels 4 and 5 into two to give greater predictive power. To deal with level 5 first which was linguistic self consciousness: part 1 stated that the animal communicates using referential communication and part 2 stated that they should be able to use pronouns symbolically and reflectively. These are both out of my remit because I did not focus on communication and have not dealt with the sign language using apes who may manage to fulfil part 2 of level 5. For the same reason, I cannot attribute consciousness to a nonhuman since this requires knowing whether they have empathy in the sense of analogical sympathy (understanding how another feels in a nonemotional situation) and concordance (both the subject and the target are using referential communication; Crook 1983). However, I have argued that chimps are capable of fulfilled empathy and analogical sympathy even if they may not be specifically aware of what they are doing or feeling (O'Connell 1995). Level 4: awareness of social agency, was split into a) animals react to each other on the basis of their behaviour; no mental states are required; and b) animals react to each other on the basis of their knowledge of each others' mental states. At least second order intentionality is needed. I think it is too early to be able to say for sure whether chimps can fulfil level 4.b. As Whiten (1994) and Heyes (1993) say, the identification of mindreading is unlikely to lie in the one-shot experiment. However, I would say that given the evidence presented in this thesis, chimps may be capable of level 2 intentionality, but it is not clear whether they are capable of level 3 and/or the comprehension of false beliefs, and if they are, whether this is an explicit realisation on their part (although an *explicit* realisation, to my mind, seems unlikely). Whatever their ability, it does seem to differ dramatically from both our own full blown comprehension of mindreading and from the way that monkeys behave.

There are two broad approaches to ToM generally. One is the Continuum approach, which, as its name suggests, is the view that there is a continuum in the ability to understand theory of mind. This could be treated in an evolutionary way: as one traces the phylogenetic tree from those creatures which evolved first to those that evolved last, intelligence increases. This does not imply that mammals are superior to any other orders, rather, those animals on the outermost twigs of their particular branch are liable to possess the greatest mental capacity. The other approach is the Us and Them theory. This states that only humans possess theory of mind and intelligence; other animals do not possess ToM and their cognitive processes are very different from ours. In effect, there is a great divide between humans and other species.

The most recent of the Continuum theories has been proposed by Whiten (1994). He suggests that the recognition of a mental state as an intervening variable shares similarities with intervening variables proposed by behavioural scientists such as thirst. The mental state, like the intervening variable (IV) thirst, must lie in the centre of a web of observed conditions and predicted outcomes. He proposed that mindreading is only likely to evolve in a creature with a certain degree of intelligence and potential for flexibility of action as otherwise, predicting conspecific's further actions and generating appropriate responses can be handled by a small set of linear sequences. He adds, "This analysis of what mental states "are" to the mindreader suggests that any attempt simply to dichotomise mentalism and behaviourism is likely to dissolve into gradations. If mentalism can be boiled down to a kind of complex behaviour/context pattern recognition, the process of recognising a mental state can, in principle, always be described alternatively in terms of the pattern of behaviour/context on which it rests: It is just that as the pattern becomes more complex, it becomes uneconomic to do so. Simple mentalism would thus appear to grade into complex behaviourism." It is only (at the nonverbal level) when animals react in the same way to a battery of tests that one could begin to assume that there is a mental component present.

What I would like to argue for is an approach that is in between the two. This may sound unfeasible so I want to try and clarify my position with an analogy from taxonomy. Biologists have long known that species are not distinct entities. Within a species there is wide individual variation; one species can evolve into a new one or form races or sister species. Taxonomists fall generally into two camps: those who believe that there is no such thing as a species and those who argue that, despite overlaps and complications of the sort mentioned above, animals can still be classified into discrete groups which can be labelled by any one with some knowledge of the subject, no matter what their cultural background is. An example which does not fall into either category is that of a ring species. One such species is the lesser black-backed gull and the herring gull. Analysis of these two species in Britain would lead us to assume that they are two different species. However, if one follows the population of herring gulls round the North pole to North America, via Alaska to Siberia and back to Europe, the herring gulls become more like the lesser black backed gull until finally, the gulls in Britain are so different, they cannot breed with the herring gulls (Dawkins 1993). This is analogous to the Continuum theory. Intelligence, like the gulls, is graded, but when one compares creatures from opposite ends of the phylogenetic spectrum, the difference is large.

A further example which does not show *a continuum in a neat* ring like the herring gulls and the black-backed gulls comes from looking at hybrids. Most hybrids are sterile, but it is possible to develop crosses between two species which are fertile, for example, cabbishes, or rabbages. This vegetable is a cross between a cabbage and a radish. It, like most hybrids, shares properties with both its parents which derive from their genes and thus, their chemical composition and many of these properties can be seen in tangible ways, for example, their physical features and their taste. Yet, despite the similarities to the parent species, the rabbage is an entity in its own right. It has its own properties, which might not have been predicted simply from a knowledge of its parents' genome, and it can breed independently. The hybrid is similar yet different to its parents. It is neither one parent species nor the other, and yet its characteristics are not inconsistent with either.

This, I would argue, is analogous to the mental understanding of chimpanzees, and possibly other great apes. They share many similarities with us and with other animals, yet they are very different to us. There is both gradation and discontinuity between us, them, and other animals. Similarly, we are animals ruled by our culture, environment and biology. None of these factors can be separated out and treated in isolation. We share a biological nature with chimps, but we can transcend that, just as chimps share a biological nature with monkeys, but they can transcend a monkey code of conduct by showing empathy, by teaching, and through their protoculture, mirror self-recognition, symbol acquisition and "weak" theory of mind. Chimpanzees live in a less mentally complex world where the workings of other minds, though present, are only dimly understood. However, until further experiments are conducted, we still remain in the dark regarding our understanding of whether chimpanzees are fully capable of behaving intentionally.

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Appendix I

Mental rehearsal in chimpanzees

Aim

To determine whether chimpanzees mentally rehearse physical problems.

I.i. Introduction

Insightful learning was first described by Köhler (1925) who gave sticks to his chimps and placed fruit rewards on the other side of the bars. One chimp, Sultan, had sticks that were too short to reach the fruit. Eventually he gave up trying to rake in the fruit, but when he played with the sticks later, he fitted two together. He then jumped up and used the sticks to solve the puzzle.

Byrne (1977;1975) has shown that even if people appear to solve problems by insight, they are actually thinking about the problem unconsciously. He asked people to think aloud whilst solving problems. Unable to complete one part of a problem, they would start another part, but then would realise how to solve the whole problem. The solution appeared to have been gained by insight, but their train of thought indicated that they had been thinking about the solution.

This ability requires the subject to draw on any remembered past experiences, to be able to generalise and to have the capacity for abstract thought processes (Byrne 1995). These are capacities that are likely to be of use for theory of mind, especially in the comprehension of role reversal (Povinelli, Nelson and Boysen 1992; Povinelli, Parks and Novak 1992), the use of the imagination to show empathy (O'Connell 1995), and to comprehend the beliefs and desires of other (Harris 1989; 1991) . It is not yet clear whether chimpanzees have this ability: namely, to think about problems and 'mentally rehearse' them in order to obtain the correct solution.

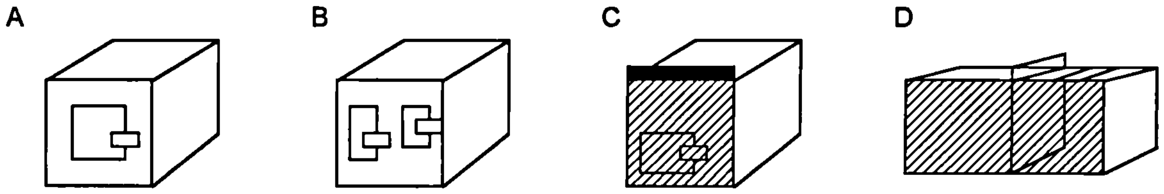
I.ii. Method

The subjects of this experiment were 2 chimps: Josie and Flynn.

Four puzzle boxes were used which were made out of wood and perspex by me (see figure I.i.). Three were cubes, one was a rectangle; they were held together by nails and glue. Each box had at least one hinged door which opened outwards and was fastened by a bolt. Box A only had one door. Box B had 2 doors and when baited with a large reward, the bait could only fall out of the larger drawer (the chimps' hands were too big to fit through the doors). Drawer C had a perspex front with a wooden handle on the top. Behind the perspex and set three inches back into the box, was a hinged door. In order to open the box, the chimp had to pull the perspex cover up, insert their hand into the box and open the door inside. The box then had to be tipped up, keeping the inner door open and the perspex cover lifted up so that the reward could fall out. One side of Box D was made of a perspex cover which could not be removed. The box was divided into two by a wooden partition which could be raised or lowered, but not taken out of the box and which could be viewed through the perspex. On the top of the box was a hinged door. The reward was visible to the chimp where it was located on the opposite side of the box from the door. In order to obtain the reward, the chimp had to lift up the partition, tilt the box so that the reward fell on to the other side, push the partition down, open the lid and tip the box upside down to let the reward fall out.

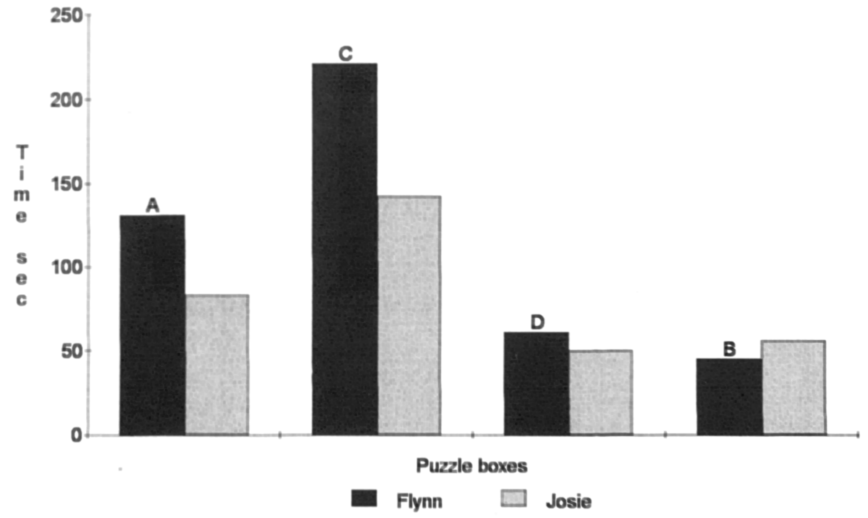
Chocolate was used as a reward; a whole chocolate biscuit bar was put into box B. The chimps did not see the boxes being baited. Box A and C were given to the chimps without them ever seeing any of the boxes before. The director, Ms Badham, who could handle the chimps, gave the boxes to the chimps and waited with them until they had opened them. Her presence prevented them from destroying the boxes, but she did not aid them in any way. Each chimp was given the boxes out of sight of the other chimp. Box B and D were placed outside their cage in a position where they could see them both from their day and their night pens. These boxes were left there for 48 hours. The chimps were then given them to open. In each case the chimps were timed to see how long it took them to open the boxes and extract the food.

Figure I.i: The puzzle boxes that were used in the mental rehearsal experiment, Each box has at least one small hinged door (indicated by a smaller square or rectangle on the front of the box: boxes A, B and C; or on the top of the box: box D) with a bolt (the smallest rectangle in each figure placed horizontally across the 'hinged door'); box C and D have perspex covers (indicated by the shading).



I.iii. Results

Figure I.ii: A graph showing the time in took in minutes for two chimps, Josie and Flynn to open the puzzle boxes. Box D and B were left outside their cages for 2 days before they were allowed to open them.



It took Flynn 2 minutes and 11 seconds to open box A, and Josie 1 minute and 23 seconds. Box C took Flynn 3 minutes and 41 seconds and Josie 2 minutes and 22 seconds. Both chimps were able to open the boxes they had been given 2 days to look at in a shorter time: box B took Flynn 45 seconds and Josie 56 seconds; box D took Flynn 1 minute and 1 seconds and Josie 50 seconds (see figure I.ii.).

I.iv. Conclusions

Flynn and Josie were given the easiest box to open first and then a more complex one. After a time lag, they were given the most complex box and the second most difficult box in the series last. This is my subjective judgement of the ease of difficulty of opening the boxes; the reason they were given the boxes in this order was so that it could not be said that the chimps were simply learning to open them faster.

From the results, there is a definite difference in the speeds with which the animals opened the boxes; they were much faster opening boxes they had viewed for 48 hours than those they were given straight away. This difference is more pronounced when comparing boxes of similar difficulty, i.e. box A and B and box C and D.

The original methodology for this study was to have two groups of chimps, one of which would be given A and C straight away, whilst the second group would be given B and D. The first group would then be allowed to look at D and B before being given them and the second group would be given C and A after a time lag. Unfortunately, although this had been agreed with the director, she decided I was only allowed to have a sample size of two chimps. This experiment thus needs to be repeated properly and an equivalent type of study conducted on children. However, despite these problems with the results, they do at least suggest that there is a possibility that chimpanzees are capable of mental rehearsal when solving problems in the physical domain. Nevertheless, without conducting the experiment in the way outlined above, the possibility that the chimpanzees were simply learning how to open the boxes more quickly cannot be ruled out.

An alternative approach would be to determine whether chimpanzees could solve social problems mentally.

Appendix II

An attempt to examine empathy experimentally

Aim

To replicate Blair's (1994) experiment (with suitable alterations) conducted on psychopathic and nonpsychopathic murderers in order to determine whether chimpanzees have physiological responses that are similar to those seen in normal humans and nonpsychopathics murderers.

II.i. Introduction

Normal human beings show an empathic response to distress cues (Bandura and Rosenthal 1966; Fabes, Eisenberg and Eisenbud 1993; Krebs 1975) which can be measured physiologically as electrodermal activity and has been found to be a reliable measure of emotional arousal (Greenwald, Cook and Lang 1989). Psychopaths are incapable of showing empathy where an empathic reaction is measured physiologically, although they do have an appropriate fear response (Blair 1994).

II.ii. Method

A hand reared chimp (Josie) was seated in a small chair in front of a television set and made to keep still (this was vital in case any arousal responses were due to her movement). A video tape was played showing a variety of stimuli, 11 of which were distress cues (such as a child or a chimp crying) and 9 neutral stimuli (such as nonemotive chimp behaviour). Eight of the distress cues showed empathic but not emotive stimuli (the latter consisting of attacks between chimps). The first 5 clips at the beginning of the tape were neutral; the first 3 were to be used to settle the chimp down and obtain a base line reading. All other stimuli were shown in random order and each one was shown for 20 seconds. The video material came from archive film owned by the BBC (I did attempt to obtain film from other sources such as the Environmental Investigation Agency, but with no luck), and the tapes were edited using BBC on-line editing facilities.

Skin conductance responses (SCR's) were to be recorded from 2 sites on the medial phalanges of the left hand using 1 cm Beckman Ag-AgCl electrodes filled with Johnson and Johnson K-Y Lubricating jelly. The electrodes were connected to a constant voltage Biosystems SCL 200 system and data was to be recorded by hand, the unit of measurement being in micromho's (a unit of skin conductance). The electrodes were attached using a piece of ribbon by the director, M. Badham who had handreared Josie. They were also attached to her toes, the skin of her leg and her face.

II.iii. Results

Unfortunately it was not possible to obtain a reading in micromho's.

II.iv. Discussion

A reading was probably not obtained because of the thickness of chimpanzee skin, no matter what part of the body the electrodes were attached to. There are two options here for further research. Either a more powerful Biosystem could be used (not yet invented) or the electrode could be implanted into the animal's dermis. This seems to be unethical, especially since the results of such an experiment would not directly benefit either chimps or humans.

Had the experiment 'worked' in that a response was obtained to the distress but not the neutral stimuli, what could one conclude? In these circumstances I think it would be fair to say that chimpanzees have a physiological arousal to distress cues that is similar to a human response. We could have termed this response 'empathic' although we could not have proved whether the animal had an implicit or explicit awareness of what we could call empathy or sympathy (meaning compassion in this case: Wispé 1986).