SOCIAL LEARNING AND IMITATION IN HUMAN AND NONHUMAN PRIMATES

Deborah M. Custance

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(a)

I, Deborah Mary Custance, hereby certify that this thesis has been composed by myself, that it is a record of my own work, and that it has not been accepted in partial or complete fulfilment of any other degree of professional qualification.

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I was admitted to the Faculty of Science of the University of St. Andrews under Ordinance General No. 12 in October 1990 and as a candidate for the degree of Ph.D. in October 1990.

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This thesis is dedicated in loving memory to my father, Gareth Alfred James Custance (1937-1994).

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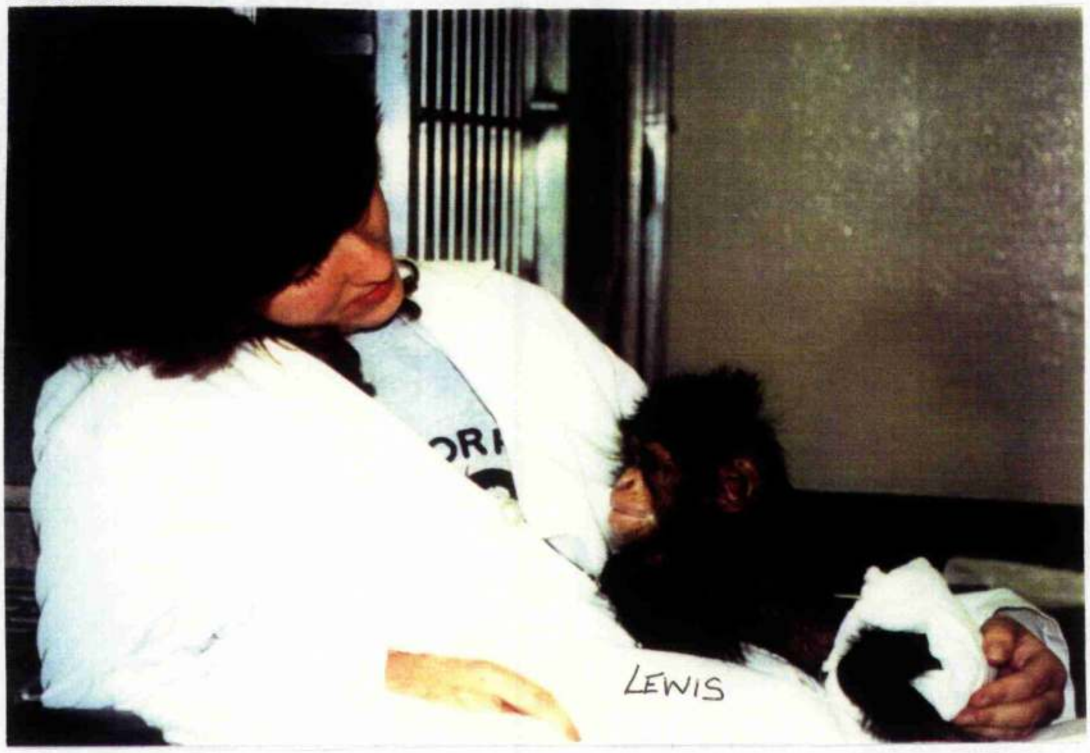


ABSTRACT

Most people assume that monkeys and apes can imitate, but recently, several researchers have suggested there is little convincing evidence of imitation in any nonhuman species. The purpose of the present thesis is to compare the imitative abilities of human and non-human primates.

Some of the most convincing evidence for imitation comes from anecdotal reports of imitative behaviour in great apes. A survey of the literature was performed and a database of imitative episodes in chimpanzees, gorillas and orangutans was compiled (using a similar approach to Whiten & Byrne's 1988a tactical deception database). Each report was subjected to a strict evaluation, and it was deemed that 23 reports from chimpanzees, 3 from gorillas and 4 from orangutans provided relatively convincing evidence of imitation.

An experiment was conducted to test if chimpanzees *can* imitate as the anecdotal data suggests. Two chimpanzees were taught to reproduce 15 arbitrary gestures on the command "Do this". Next they were presented with 48 novel items. They imitated 13 and 20 novel gestures respectively. Using a rigourous coding system, two independent observers correctly identified a significant number of the chimpanzees' imitations ($P < 0.0001$). These results show that chimpanzees are capable of the complex intermodal visual-motor co-ordination and control necessary for imitation.

The second experimental chapter explores whether monkeys, apes, and/or humans imitate in the context of a functional task. Six capuchin monkeys (*Cebus apella*), eight chimpanzees (*Pan troglodytes*) and 24 children were presented with an analogue of a natural food processing task. The subjects were divided into two groups and each saw a different method for opening an artificial fruit. The children showed quite extensive imitation; the capuchin monkeys showed little to none; while the chimpanzees showed marginal imitative abilities. This constitutes the first experimental evidence of functional object imitation in a nonhuman specie.

CONTENTS

Preface

For over one hundred years comparative psychologists have grappled with the question of whether or not non-human species can imitate. Imitation is thought to be an intelligent ability which requires complex cognitive processing (see Bruner 1972, Whiten & Ham 1992, Heyes 1993, and Tomasello *et al.* 1993). Yet, there has been little agreement on how to define imitation or what constitutes a proper experimental methodology for demonstrating the ability. Recently, several researchers have argued that there exists, as yet, little convincing evidence of true imitation in non-human animals (Galef 1988, Mitchell 1989, Whiten & Ham 1992).

It is commonly assumed that at least one group of animals, the primates, can imitate very well.

"*Scimmiottare* in Italian, *singer* in French, *macaquear* in Portuguese, *nachaffen* in German, *majmuna* in Bulgarian, *obez'janstvovat* in Russian, *majmol* in Hungarian, *mapowac* in Polish, and "to ape" in English - each of these verbs is derived from a linguistic root that in particular languages label primates. Across different languages and cultures, these verbs consistently mean "to imitate." The convergence across different cultures of the terms denoting monkeys and imitation reflects the common view that monkeys are excellent imitators (Visalberghi & Fragaszy 1990, p.247).

Whiten and Ham (1992) have shown that scientific textbooks have concurred with this view. Yet, even the imitative ability of monkeys (e.g., Beck 1974, Fragaszy & Visalberghi 1989, Visalberghi 1987) and apes (e.g., Tomasello 1990) has been brought into question. The purpose of the present dissertation is to consider whether or not non-human animals, and especially nonhuman primates, can truly imitate.

Chapter 1

HISTORICAL BACKGROUND

In order to understand the controversy related to the definition of and the experimental approach to the study of imitation, it is important to consider the work of some of the first comparative psychologists. Four researchers, Romanes, Thorndike, Baldwin and Morgan, profoundly influenced the nature and direction of the scientific enquiry into social learning. I shall, therefore, discuss each of their work in turn (see Galef 1988, Mitchell 1987 and Whiten & Ham 1992, for similar reviews).

Galef (1988) explains why early comparative psychologists were interested in imitation:

"The major impetus for the 19th-century discussion of imitation arose out of disagreement among leading scientific figures of the period concerning the origins of the higher mental faculties of man. Darwin and Wallace, co-formulators of evolutionary theory, differed profoundly over the possibility of employing the principle of evolution, of descent with modification, to understand the development of the human mind. As a contemporary, George Romanes (1884), stated the issue:

> "... the great school of evolutionists is divided in two sects; according to one the mind of man has been slowly evolved from the lower types of psychical existence, [e.g., Darwin, Romanes, Baldwin and Morgan] and according to the other the mind of man, not having been thus evolved, stands apart, *sui generis* from all other types of existence [e.g., Wallace and Thorndike]." (p. 9)

... there was some consensus as to evidence that would decide the issue: indication that animals had humanlike emotions such as shame, remorse, jealousy, and benevolence, that could use tools or act deceitfully, that they were able to solve complex problems or imitate complex acts" (p.4).

The debate was often couched in terms of whether or not animals possessed the power of reasoning. Can they, like humans, intelligently reflect upon their present or future actions?

G. J. ROMANES

Romanes was a student of Darwin's, and as such, he was one of the staunchest proponents of the so-called Reasoning Theory. He argued that human mental faculties have gradually evolved, and that more simple and phylogentically earlier forms of reasoning can still be found in other species. Darwin encouraged Romanes to attempt to establish a similar legacy in the field of comparative psychology as Darwin himself had achieved in the biological sciences.

Unfortunately, Romanes lacked Darwin's rigourous scientific approach. Romanes's "scientific" evidence of intelligence and imitation in animals consisted exclusively of anecdotal reports of their behaviour. Many of the anecdotes he discussed came from newspapers and letters sent to him from devoted pet owners. He performed no controlled experimental studies of his own. Today, the importance of Romanes's work lies mainly in the fact that it came to represent the standard against which the majority of future researchers rallied.

Romanes did not provide a formal definition of imitation, "to him the word was a perfectly ordinary everyday expression" (Whiten and Ham 1992, p.240). He claimed an imitative ability in species as diverse as honey bees, cats, dogs and monkeys. His general approach was to relate an anecdote about the remarkable feat of someone's pet, and then to discuss the underlying cognitive process involved in terms of a rich internal dialogue.

For the purpose of illustrating Romanes' method let us consider an anecdote he discussed in which his coachman's cat had learned to operate the thumb-latch on a door:

"Walking up to the door with a most matter-of-course kind of air, she used to spring at the half-hoop handle just below the thumb-latch. Holding on to the bottom of this half-hoop with one fore-paw, she then raised the other to the thumb-piece, and while depressing the latter, finally with her hind legs scratched and pushed the door-posts so as to open the door. Precisely similar movements are described by my correspondents as having been witnessed by them.

"Of course in all such cases the cats must have previously observed that the doors are opened by persons placing their hands upon the handles, and, having observed this, the animals forthwith acts by what may be strictly termed rational imitation. ... The whole psychological process, therefore implied by the fact of a cat opening a door in this way is really most complex. First the animal must have observed that the door is opened by the hand grasping the handle and moving the latch. Next she must reason, by "the logic of feelings" - If a hand can do it, why not a paw? Then, strongly moved by this idea, she makes the first trial" (Romanes 1882, pp.420-422).

Romanes has ascribed a highly intelligent imitative ability to his coachman's cat; through observation it learned not only what actions to reproduce but it also came to appreciate the causal properties of the mechanisms of the door. Romanes did not actually observe the whole process by which the cat learned to open the door. He argues it is highly improbable that the cat learned it through chance or trial and error because the whole operation was too complicated. Yet, Thorndike (1901) was to show that cats can learn to operate very complicated latches through a process of gradual operant conditioning rather than reasoning. If the complete ontogeny of a behaviour is not observed, one cannot be completely sure what learning process is involved (Mitchell 1987, Whiten and Ham 1992).

Romanes sums up his views on imitation as follows:

" ... it may be said in general that, as the faculty of imitation depends on observation, it is found in greatest force, as we should expect, among the higher or more intelligent animals - reaching its maximum in the monkeys where, as is well known, it passes into ludicrous extremes" (1883, p. 224).

Elsewhere he notes:

" ... it is remarkable as well as suggestive that it [imitation] should be confined in its manifestations to monkeys and certain birds among animals and to the lower levels among men. As Mr. Darwin says:

> "The principle of imitation is strong in man, and especially, as I myself observed in savages. In certain morbid states of the brain, this tendency is exaggerated to an extraordinary degree; some hemiplegic patients and others, at the commencement of inflammatory softening of the brain, unconsciously imitate every word that is uttered, whether in their own or in a foreign language, and every gesture or action which is performed near them."

"The same sort of tendency is often observable in young children, so that it seems to be frequently distinctive of a certain stage or grade of mental evolution, and especially in the branch of *Primates*. Other animals, however, certainly imitate each other's actions to a certain extent" (1882, pp. 477-478).

Romanes' high opinion as to the imitative ability of nonhuman species based solely on anecdotal or observational data was soon to be challenged.

E. L. THORNDIKE

Thorndike (1901) was one of the first researchers, among many, who dismissed Romanes's work as unscientific. Thorndike advocated a strictly experimental approach to the study of animal intelligence and imitation. Some of his most famous experiments have direct relevance to Romanes's anecdotes about cats operating door latches.

Thorndike designed a lattice-sided wooden box with a door in the front that could be locked with a series of different latches. An experimentally naive cat was placed in the box, and Thorndike recorded its general behaviour and how long it took to operate the latch mechanisms and escape from the box. He found no evidence of the kind of reasoning powers Romanes had attributed to cats. Instead, the cats tended to scrabble wildly when placed in the box and hit upon the solution by chance.

Thorndike tested for imitation using a similar method. He defined imitation as, "learning to do an act by seeing it done" (Thorndike 1898, p. 50). He used a box divided into two compartments, separated by a wire-mesh screen. The larger area had a door in the side that could be opened by clawing or biting at a length of string stretched over the top of it. First, an experimentally naive cat was habituated to the smaller observation compartment. Next, an experienced cat acted as the model and opened the door by pulling on the string, thus gaining access to a bowl of fish placed outside. Finally, the observer cat was placed in the test compartment. Thorndike took notes on the degree of similarity between the actions used by the model and observer, and he timed how long it took the observer to escape. Neither measure indicated an imitative ability in the cats: the observer cats did not exhibit similar action patterns to the model, nor did they escape any faster than non-observers.

Thorndike conducted similar tests with dogs and chicks. He concluded that:

" ... a dog, or cat, or chick who does not in his own impulsive activity learn to escape from a box by pulling the proper loop, or stepping on a platform, or pecking at a door, will not learn it from seeing his fellows do so. They are incapable of even the inference (if the process may be dignified by that name) that what gives another food will give it to them also" (Thorndike 1901, p.74).

Thorndike's response to the suggestion that animals might be capable of some kind of "reasoning" was positively scathing.

"I may add that my observations of all the conduct of all these animals during the months spent with them, failed to find any act that even *seemed* due to reasoning. I should claim that this quarrel ought now to be dropped for good and all, - that investigations ought to be directed along more sensible and profitable lines. I should claim that the psychologist who studies dogs and cats in order to defend this reason theory is on a level with a zoologist who studies fishes with the view to supporting the thesis that they possessed clawed digits" (Thorndike 1901, p.75).

There are several problems with Thorndike's experiments. First, the subjects could not see all the mechanisms or workings of the latches, since many of them were located on the outside of the box. It was impossible for any animal placed inside the box to figure out the significance of the door-opening mechanisms, assuming that it might possess such powers of reasoning. Also, it is not surprising that all that Thorndike observed from the cats was random scrabbling, since as Morgan (1896) points out, the "conditions are abnormal and cramped" (p. 187). Anyone who has tried to place a cat into a confined space knows that such conditions are not at all conducive to calm cognitive processing. The task itself promotes mindless random action. Therefore, despite Thorndike's conviction, the book is certainly not closed on imitation in cats after his rather limited experimental investigations (see John *et al.* 1968; Chesler 1969).

However, Thorndike's basic experimental method was to become the blueprint for the majority of the proceeding century of research. Most future experimental investigations followed Thorndike's example and compared the time it took observers and non-observing controls to solve technical problems. The problem with Thorndike's methodology is that it does not adequately distinguish imitation from other social learning processes such as, stimulus enhancement, exposure and contagion. It was not until very recently that viable alternatives to Thorndike's method have been devised (Galef 1988, Whiten and Ham 1992).

In addition to his experimental investigations, Thorndike made important contributions to the theoretical debate about the nature of social learning. He identified a number of different (psuedo-imitative) processes which can also cause individuals to behave in a similar manner.

"Thorndike is the first to offer a clear alternative to the view that various types of "semi-imitative phenomena" he described are simple forms of the "general imitative faculty which we find in man". Thorndike's distinction between pseudo-imitative and imitative behaviours suggests that the process of social learning seen in man and in animals may be different in kind rather than in degree, that there is not a single imitative capacity that appears in various guises in animals possessing nervous systems of varying complexity" (Galef 1988, p. 10).

I discuss some of the different pseudo-imitative processes in Chapter 2.

J. M. BALDWIN

Baldwin (1896) proposed one of the first comparative-developmental "stage" theories of imitation. He had a very broad conception of imitation which he divided into two main categories: 1. organic, and 2. conscious or mental imitation.

Baldwin argues that "there is an essentially imitative quality to all adaptation by process of selection, because this involves a certain replication of previous states: thus "we may say that all organic adaptation in a changing environment is a phenomenon of biological or organic imitation" (p. 278)" (Whiten & Ham 1992, p.241). According to Baldwin (1896), conscious imitation develops from organic imitation, which serves "for the accumulation of material for conscious and voluntary actions" (p. 351). Conscious imitation is divided into two further sub-categories: simple and persistent imitation. "Simple imitation is a form of suggestion, in which the organism merely responds to stimulation by producing something similar to it and does not improve upon the similarity between model and copy. Persistent imitation involves an improvement in the similarity between the model and the copy based on the organism's comparison of them, and is voluntary" (Mitchell 1987, p. 187).

One example of simple imitation that Baldwin discusses is vocal imitation in young children:

"The child repeats it prattle over and over, ... simply from vigour, not from desire, nor from effort, least of all with deliberation. The sounds he makes are accompanied by sensations in his vocal organs, and what he hears he makes again, and so on, simply because his machinery works that way - works easily and gives him the pleasure of exercise and rhythm" (Baldwin 1896, p. 378, cited by Mitchell 1987, p. 187).

The vocal imitation described by Baldwin above, actually involves the child imitating or repeating its own vocalizations rather than another individual's. Such behaviour is not usually considered as imitation.

A second example of simple imitation described by Baldwin is that of a parrot reproducing human vocalizations. He states that:

" ... my parrot has just learned to say "Hulloa" imitatively. He learns to pronounce this word just as an intelligent child would learn to do it; but he cannot vary, modify, or inhibit it, nor exercise selection in the manner of his doing it" (Baldwin 1902, p.28, cited by Mitchell 1987, p. 187).

Baldwin treated the vocal imitation performed by the parrot and child as if they were based on the same process. Yet, they actually seem very different in nature: the parrot learned to eventually produce a rather hard-wired imitation of the modelled vocalization, while the child repeated his own vocalizations and was not adapting to some external agent.

Baldwin argues that persistent imitation is unique to humans. It constitutes a deliberate attempt to match a modelled behaviour through goal-directed trial and error. The imitator constantly monitors his or her own responses and modifies them so that they more closely resemble the model. The imitator, "detects differences between what he sees or hears and what he produces by hand or tongue, and finds these differences unpleasant to him. Then he makes effort to reduce the difference by altering his movements, and what is more remarkable, he succeeds in dong so" (Baldwin 1896, p.378).

Baldwin distinguishes between two kind of persistent imitation: external and internal. External persistent imitation involves immediately attempting to reproduce modelled sounds or actions. Internal involves the imitator performing some kind of internal refection or processing upon the observed and mentally encoded behaviour. Hence, an example of internal persistent imitation would be delayed imitation where the resultant behavioural replication is based on a long term memory of the model's actions. What distinguishes Baldwin's persistent imitation from the simple vocal imitation performed by parrots is the degree of control the imitator has over his or her responses. The imitator is deliberately or consciously directing his or her behaviour to reproduce the model.

Baldwin's conceptualization of imitation was to have far reaching effects on future theory. Many of his ideas are clearly reflected in the writings of Piaget (1951). The one area of his theory which has not survived the test of time is that of "organic imitation". "Although the breadth of this conception of imitation was soon challenged by Morgan (1900, pp. 179-183), imitation could never again be seen as an inherently narrow and easily circumscribed phenomenon" (Whiten & Ham 1992, p. 241).

C. L. MORGAN

Morgan's (1900) approach to imitation was similar to Baldwin's except that he rejected the concept of organic imitation. Morgan agreed that not all behavioural similarity directly implies complex cognitive processing. Like Baldwin, he proposed a stage theory in which he described three stages of imitation: 1. instinctive or biological, 2. intelligent, and 3. reflective.

Morgan's instinctive imitation is equivalent to "contagious" behaviour which

Thorpe (1963) defined as a process where, "the performance of a more or less instinctive pattern of behaviour by one will tend to act as a releaser for the same behaviour in another or in others" (p. 133). Morgan describes an example in which, "A chick sounds the danger note; this is the stimulus under which another chick sounds a similar note, and we say one imitates the other" (p. 190). Although instinctive imitation is not particularly cognitively complex, Morgan points out that, " if the young inherit a tendency to imitate certain actions of their parents, and if there is among the members of a gregarious species such instinctive imitation as shall tend to keep them gregarious, we have here a social factor in animal life of no slight importance" (Morgan 1900, p. 190-191).

When Morgan discusses intelligent imitation he actually outlines two quite different processes. The first is equivalent to Thorpe's "stimulus enhancement" in which an observer's attention is drawn to an object by the activities of another individual. The observer then learns to direct appropriate behaviour toward the object through its own efforts. The second is similar to Morgan's persistent vocal imitation where a bird or young child learns to match a modelled vocalisation via trial and error. Both of these processes are "intelligent" in the sense that the observer actively learns through socially directed trial and error how to perform a novel modelled behaviour, rather than the response being relatively preprogrammed or hard-wired as in contagion.

Morgan's discussion of an observation made by Romanes' sister of a capuchin monkey opening a trunk with a key, constitutes an excellent exposition of stimulus enhancement. He comments that:

"The monkey need not regard the key and lock as the related parts of a puzzle to be practically solved, need not have any free idea of the difficulty it presents, need not in unlocking the trunk clasp the true nature of the difficulty or have any conception of its solution. Every several act of the capuchin, the seizing the key, the directing it here or there, and so on, is already supplied with the impulse, directs and combines these pre-existing impulses to a new end. And since that which directs the attention is the act of another, we call the procedure imitative. ... And success in opening the trunk is reached by the capuchin, not, it would seem through any real appreciation of the essential kernel of the practical problem, but through the chance results of many varied efforts" (Morgan 1900, p. 188).

Morgan proposes that vocal imitation in young children and birds is achieved through a process of trial and error and the gradual modification of familiar vocalizations. According to Morgan, for some reason these organisms seem to find it inherently rewarding to match modelled sounds. He states that:

"Intelligence ... aims at the reinstatement of pleasurable situations, and the suppression of those which are the reverse, the sound-stimulus, the motor effects in behaviour, and the resultant sound production, coalesce into a conscious situation, which appears to be pleasurable or the reverse, according as the sound produced resembles or not the initiating sound-stimulus. If we assume that the resemblance of the sounds he utters to the sounds he hears is itself a source of pleasurable satisfaction (and this certainly seems to be the case), intelligence, without the aid of any higher faculty, will secure accommodation and render imitation more and more perfect. And this appears to be the stage reached by the mocking-bird or the parrot" (Morgan 1900, p. 192).

Morgan stated, at least more clearly than Baldwin, how simple vocal imitation might be achieved. The affective dimension plays a key role. By deriving pleasure from closely matching vocalisations and displeasure from mismatching them, an organism receives a kind of internal feedback that directs trial and error learning. If an organism finds matching certain kinds of behaviour inherently rewarding this suggests it has an innate predisposition for imitation.

Morgan assumes that imitation found in birds and young humans is based on the same cognitive mechanism. Yet, human vocal imitation does not appear to be hard-wired like birds', in fact during human ontogeny it becomes increasingly flexible (Kaye 1982). The hard-wired nature of bird imitation implies that they are based on different rather than similar underlying mechanisms. Thorndike (1911) states that, "we cannot, it seems to me, connect these phenomena with anything found in the mammals or use them in advantage in a discussion of animal imitation as the forerunner of human" (Thorndike 1911, p. 77). Human and bird vocal imitation, therefore, would seem to constitute an example of evolutionary convergence, not homology (Moore 1992).

Morgan's reflective imitation involves an intentional or deliberate attempt to reproduce another's actions in order to achieve some particular goal. Morgan puts it as follows:

"But the child soon goes further [than intelligent imitation]. He reflects upon the results he has reached; he at first dimly, and then more clearly realizes that they are imitative; and his later efforts at imitation are no longer subject to the chance occurrence of happy results, but are based on a scheme of behaviour which is taking form in his mind, are deliberate and intentional, and are directed to a special end more or less clearly perceived as such. He no longer imitates like a parrot, he begins to imitate like a man" (Morgan 1900, p. 193).

Intelligent imitation is a kind of socially directed trial and error learning; while reflective imitation is a rational, goal-directed process.

Morgan's "analysis of progress from simple to complex levels of imitation was the forerunner of more elaborate schemes of developmental and evolutionary stages that have followed in this century, including those of Piaget (1951), and most recently, Mitchell (1987)" (Whiten & Ham 1992, p.241). One problem with his treatment of the different kinds of imitation is that he provides no clear behavioural indices by which one might distinguish one from the other. Morgan's definition of reflective imitation provides no insight into how to experimentally isolate the process. He defines it in terms of mental concepts without indicating specific kinds of behaviour that might be related to it. Distinguishing between different kinds of imitative or imitative-like processes is a problem which still challenges researchers today.

Chapter 2

DEFINING IMITATION

One problem which has plagued research into imitation is the lack of agreement over how to operationally define it. Galef (1988) comments that:

" ... historical diversity in approaches to study of imitative behaviour has produced incompatible conceptual frameworks for analysis of imitative phenomena. One man's example of learning by imitation is another's paradigmatic case of "pseudo-imitation" and each can cite historical precedent for treating phenomena of interest as he does" (p. 4).

Mitchell (1987) makes a similar point when he writes:

"The imitation of the behavior of one organism by another is intriguing to different authors for different reasons. Behavioral imitation has been viewed as a means of socialization, biological adaptation, identification, and communication of shared emotional states, and as evidence for elementary referential capacities, complex inferential abilities, and self-awareness (Baldwin, 1896; Morgan, 1900/1970; Guillaume, 1926/1971; Mead, 1934/1974; Miller and Dollard, 1941; Piaget, 1945/1962; Thorpe, 1963; Mussen, 1967; Danto, 1981; Uzguris, 1981, 1983). Such diverse interpretations of the significance of imitation suggest that the concept of imitation is used broadly. Different authors apply the term "imitation" for different purposes, and their consequently differing conceptions of imitation tend to be meaningful within a particular theoretical framework (Uzguris, 1983, p.1)" (p. 184).

I shall distinguish between two of the main approaches to defining imitation in comparative psychology and assess their strengths and weaknesses. But first it is important to draw some general (and relatively uncontroversial) distinctions between different kinds or categories of imitation.

GENERAL CATEGORIES OF IMITATION

There are two main kinds of imitation: vocal and action. Vocal imitation involves the reproduction of sounds; while action imitation involves the reproduction of physical actions. Vocal imitation is well documented in several species of birds (see Slater 1986 for a review), while action imitation has proved much more difficult to document in non-human species. It has been suggested that the reason why action imitation seems to be rarer than vocal imitation is because it requires particularly complex cognitive processing (Palameta 1989; Whiten & Ham 1992). The present dissertation is primarily concerned with action imitation, although Chapter 8 features a brief discussion of the possible differences in the cognitive processing related to action and vocal imitation.

Two kinds of action imitation can be distinguished: object-related and independent body movement (I.B.M). Object-related imitation involves reproducing actions directed toward objects, substances, or surfaces. I.B.M. imitation involves reproducing non-object related actions, such as jumping or waving. Both object-related and I.B.M. imitation can be either arbitrary in nature (i.e, not directly causally related to a reward) or functional (i.e., reward-directed). Arbitrary object-related imitation may occur during play or exploration. Functional object-related imitation may occur in problem solving situations, such as food-processing or tool-use. Arbitrary I.B.M. imitation may occur in play or be a means by which one individual identifies with another. Jolly (1985) provides an example in which a young boy identifies with his elder brother by imitating an idiosyncratic facial expression. Functional I.B.M. imitation may be observed in relation to gestural communication. Figure 2.1 is a schematic representation of the different categories of imitation discussed so far.

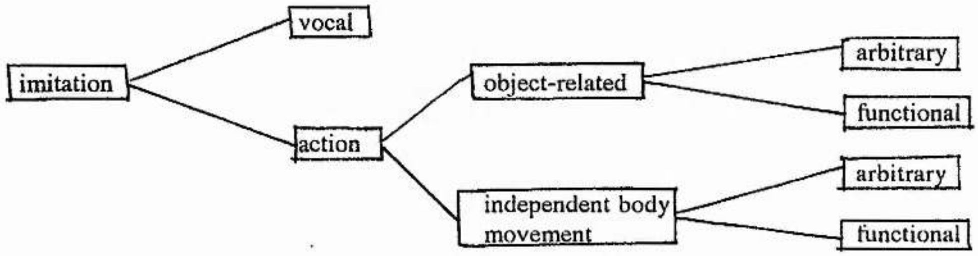


Figure 2.1: Schematic representation of different major categories of imitation

TWO APPROACHES TO DEFINING IMITATION

There are two main approaches to defining imitation in comparative psychology. Some researchers reserve the term imitation so that it refers exclusively to what they identify as the most complex mimetic process (e.g. Thorndike 1901, 1911; Thorpe 1963; Galef 1988; Whiten & Ham 1992). (I am using the term "mimetic" after Whiten and Ham (1992)), as a supergenerative for any process that leads to behavioural similarity.) An alternative approach is to provide a general definition for imitation so that it encompasses the majority of mimetic processes. These different processes are then arranged into incremented stages or levels ranging from the least to the most cognitively complex (e.g.Baldwin 1896, 1902; Morgan 1900; Piaget 1951; and Mitchell 1987.)

Stage Theories of Imitation

Morgan's stage theory of imitation was discussed in chapter 1. For Morgan, "demonstrations of imitative learning in animals were seen as providing important evidence of an evolutionary origin of the higher mental faculties in man" (Galef 1988, p. 5). Morgan applied his incremented system of imitative stages to animals and humans equally. There are scientists, such as Piaget (1962) and Guillaume (1926), who devise stage theories of imitation which relate only to human development. Piaget's theory in particular has been modified by many comparative psychologists in order that it might serve as a general comparative-developmental model (Parker 1977; Chevalier-Skolnikoff 1977; Parker & Gibson 1990).

It is not enough in itself for a stage theory to simply observationally identify the order in which mimetic processes appear in an infant's development. Nor is it sufficient to simply demonstrate that only lower stages of imitation are found in so-called "lower-order" species, while higher stages are found exclusively in "higher-order" species. A system of stages or levels implies that they are causally linked to one another. A stage theorist must be able to suggest a viable mechanism which explains why each stage is developmentally or evolutionarily dependent on earlier stages. If a theorist can not provide such a mechanism, then one might as well treat the stages as separate, although similar, processes.

One of the main problems with many stage theories is that it is often far from obvious how the stages or levels are logically linked. For example, in Morgan's theory - why should stimulus enhancement (stage 2) be in any way logically related to or dependent upon contagion (level 1)? Why, in Piagetian theory, should contagion (level 2) develop from reflexes (level 1)? The fact that certain processes appear in a specific order during human ontogeny does not mean they need necessarily be directly causally dependent on one another. That may explain why some neo-Piagetian researchers have found that certain non-human species manifest higher stages of sensory motor skills without manifesting some of the stages which precede them in human infancy (e.g., Chevalier-Skolnikoff 1977).

Mitchell (1987) attempts to present a more cohesive theory by synthesizing four major stage theories: Morgan (1900), Baldwin (1896), Piaget (1962) and Guillaume (1926). Mitchell (1987) describes five levels of imitation. Level 1 is equivalent to physical mimicry such as when the striped markings of the harmless hoverfly are said to "imitate" the warning stripes of stinging bees and wasps. Level 2 encompasses the concept of contagion through to a more generalised social facilitation and the imitation of familiar acts. Level 3 is equivalent to Morgan's intelligent imitation. Level 4 is similar to Morgan's reflective imitation. Level 5 is, as far as I know, unique to Mitchell. "At this level the organism changes its imitation in relation to its knowledge of another organism's perception" (p. 209). Mitchell argues that, "Hierarchically higher levels are logically inclusive of, and develop from, lower levels, and therefore *require* the process of lower levels" (p. 202).

However, even in Mitchell's theory it is not always clear how each of these different processes are causally linked to one another. It is far from obvious that level 2 (contagion) develops from level 1 (physical mimicry). These processes actually appear to be the result of two different lines of evolutionary selection: one line has led to physical similarity between different organisms (level 1), while the other has led to a relatively hard-wired predisposition to reproduce certain behaviours (level 2). The only, rather superficial, link between them seems to be that they are both the result of evolutionary selection.

Neither is it clear why level 4 (reflective imitation) need necessarily be preceded by level 3. These processes are based on two very different mechanisms. Level 3 is based on trial and error learning, while level 4 is based on having conscious control over one's actions. Mitchell suggests no viable mechanism that could explain how conscious control develops from the ability to learn through trial and error. One of the strengths of Piaget's (1962) theory of sensory-motor development is that it does at least specify such a mechanism. Yet, even Piaget's system of assimilation and accommodation does not altogether satisfactorily account for the proposed transition from sensory-motor to mental representational abilities.

Mitchell's fourth and fifth levels of imitation offer an example of two processes which must be logically linked. In "level five, the imitator is aware that another organism may perceive the similarity between the model and the copy (i.e., is aware of another's awareness) and so adapts the copy in relation to the other's perception, to have the other recognize the copy as either an imitation or as the model" (p. 212). One must be consciously aware of the imitative nature of one's actions (level 4) before one can attribute the same kind of consciousness or awareness to another (level 5). In order for Mitchell's theory to be fully valid all his stages must be similarly linked.

Mitchell also suggests no clear operational protocols that might be capable of establishing whether a certain level of imitation has occurred. He emphasises the importance of taking into account an individual's ontogeny stating that, "knowledge of the ontogeny of an organism's imitations allows one to distinguish most accurately the level of an imitation" (p. 206). Yet, it is not clear how such knowledge is of much assistance when trying to establish whether an organism is capable of fourth or fifth level imitation. The existence of preceding levels does not logically imply the existence or development of higher levels. Mitchell needs to suggest diagnostic characteristics for each of his levels. Without offering appropriate operational criteria it is impossible to follow Mitchell's advice and elucidate "the relationship between organisms' psychological processes and their actions" (p. 212).

I have discussed Mitchell's (1987) theory in detail, and I have pointed out some of its main shortcomings. The reason for such a detailed analysis is to consider the important issues related to comparative-developmental theories of imitation. One feature which is common to many of them is that they fail, as Mitchell has done, to propose a viable mechanism by which each stage provides the necessary conditions for the development of the preceding one. Many comparative-developmental theories outline processes which need not actually be hierarchically or causally linked. I am, by no means, suggesting that the comparative-developmental approach to imitation should be abandoned. It is very important to generate hypotheses related to what factors might be necessary for the development, or evolution of, imitation. Yet, if these hypotheses are generated from within a stage theory, the theory itself should be logically cohesive.

Imitation as a Distinct Process

Thorndike (1911) was the first comparative psychologist to argue that, "The presence of some sorts of imitation does not imply that of other sorts" (p. 76). A number of researchers follow his lead and treat imitation as a distinct process which they attempt to conceptually and operationally distinguished from other less complex mimetic processes. One result of this has been that the last century of research has thrown up a bewildering array of terminology (Whiten & Ham 1992). Two kinds of terminological confusion have hampered progress: 1. several researchers have used different labels to define essentially the same process, and more seriously, 2. some researchers have not clearly defined certain terms (see the discussion of emulation).

Two recent reviews (Galef 1988, and Whiten and Ham 1992) have made valuable contributions by identifying and systematizing the plethora of terms related to social learning. There would be little point in reproducing their fine and detailed analyses. Instead, I have defined, below, only those processes which have proved particularly difficult to distinguish from imitation: individual learning, social support, contagion, exposure, stimulus-, local- and reward- enhancement, impersonation, and emulation. I have also defined two kinds of action imitation: precise-form imitation and program-level imitation.

Individual learning can be mistaken for imitation "*when two or more individuals independently acquire the same behaviour through encountering and being shaped by similar learning environments*" (Whiten & Ham 1992, p.248). For example, imagine a situation in which two monkeys are presented with a jar that can only be opened by twisting the lid in an anti-clockwise direction. Now imagine that each monkey independently learns how to open the jar. Since the jar can only be opened one way, at least some aspect(s) of the action-patterns used by the monkeys will be similar, even though they solved the problem by individual learning rather than imitation. Therefore, a prerequisite for distinguishing imitation from individual learning is that it must be shown that the observation of a model had a direct positive influence on the consequent behaviour of an observer.

Thorndike's (1898, 1911) method (which was described in Chapter 1) is capable of distinguishing individual learning from imitation. Recall that, Thorndike presented a control and experimental group with the same problem. The control subjects were tested individually, while the experimental subjects were given the opportunity to observe a model. If the experimental group solved the problem significantly faster than the control group, one could conclude that the model exerted some kind of favourable influence on the observers. One could not, however, conclude that the observers necessarily imitated the model. **Social support** *is a process in which B may be "more likely to learn behaviour like A's in the mere presence of A and its learning* *environment, because A affects B's motivational state.* For example the presence of conspecifics can reduce fear" (Whiten & Ham 1992, p. 252). Therefore, the fact that an animal learns a behavior more quickly if it is in the presence of a model does not constitute proof of imitation.

Thorndike recognizes that a simple comparison of the time it takes observers and non-observers to solve a problem is not sufficient in itself to prove imitation. Hence, he includes what he admits is a rather subjective measure of observationally assessing the degree of similarity between the observers' the model's actions. Yet, in **contagious behaviour** it is entirely likely that the observer responds to a model with an almost identical action. We have already discussed contagion in relation to Morgan's instinctive imitation. Armstrong (1951) states that *contagion, "consists of the reproduction by one animal of the instinctive behaviour pattern of another"* (p. 46). An example of a contagious behaviour is when one person yawns and thereby triggers an involuntary response of yawning in a second individual (Provine 1989). In a contagious yawn the observer produces almost exactly the same action as the model of slowly inhaling then exhaling breath. Since, contagion consists of two or more individuals producing almost exactly the same form of behaviour contingent with one another, it is not surprising that it has proved difficult to distinguish from deliberate imitation.

Yawning is a fairly obvious contagious behaviour. It is not always easy to decide what actions might trigger a contagious response. For example, if two people tap their feet at the same time, or rub their noses, or stretch - could these be contagious responses? Foot tapping, nose rubbing and stretching are all part of the normal repertoire of human behaviours, and it seems likely that they could be contagiously induced. Yet, if one individual, A, was to pat her head with one hand while simultaneously rubbing her stomach with her other hand, and a second individual, B, did the same thing, no-one would treat this as anything but deliberate imitation. Hence, Thorpe (1963) sought to operationally control for contagion by defining imitation in terms of reproducing novel or improbable acts for which there is no instinctive tendency.

Moore (1993) champions Thorpe's approach and produces a strong argument in favour of it. He admits that:

"At first glance this restriction seems unethological, since species-typical responses are central to the learned behaviour of most species ... We know, however, that humans can imitate almost any movement of which they are physically capable. THORPE's definition therefore asks in effect what other animals (if any) show imitative learning of comparable complexity" (Moore 1993, p. 235).

Thorpe's definition does exclude some examples of so-called imitative behaviour which seem to be suspiciously similar to contagion.

"For example, the "relatively-arbitrary" responses copied by EPSTEIN's (1984) pigeons (*Columba livia*) were species-typical food-getting reactions - approach, pecking and eating movements. Similarly, the pigeon's wheel-rotation response in PALAMETA's (1989) savings study was simply a food peck, as the author acknowledged. ... Observation did not teach these birds to peck; it simply taught them what to peck" (Moore 1993, pp. 235-236).

Thorpe's definition has many advantages as Moore points out, but there are drawbacks.

Thorpe's definition is too restrictive and even places severe constraints on what we usually take to be clear examples of imitation in humans (Mitchell 1987). Insisting that what is imitated must be novel restricts one's discussion to *imitative learning* and ignores the everyday notion of imitating familiar actions. "In the everyday sense, a person can imitate another doing some everyday act like waving, yet the imitator is not "learning to wave" in so far as some sort of waving is already in their behavioural repertoire" (Whiten & Ham 1992, p. 251). Although waving one's hand may already be part of someone's repertoire there is no reason to assume that it can be subject to a contagious reaction. Similarly, imagine that several acts such as touching one's nose, touching the top of one's head and turning through 180 degrees are demonstrated to a monkey, and with no training on those specific actions it reliably responds in a similar manner. In the monkey's everyday spontaneous behaviour it must often turn around, touch its nose and touch the top of its head, yet there is no reason to assume that its responses are examples of contagion rather than imitation of familiar actions. Thorpe's definition should be amended to consider whether there is any reason to assume that a subject would possess an instinctive tendency to repeat certain familiar acts on cue, and only if there is, should the response *not* be considered as imitation.

Rowley and Chapman (1986) provide an example of a novel, non-species-typical action pattern which can be explained by exposure just as well as by imitation. **Exposure** *is a process in which, "By simply being with (or following) A, B may be exposed to a similar learning environment and thus acquire similar behavior"* (Whiten and Ham 1992, p. 252). Rowley and Chapman observed that two galahs who had been cross-fostered with Mitchell's cockatoos developed the same flight pattern as their foster parents. Usually galahs exhibit a fast, level flight pattern, but the two foster birds adopted a more cockatoo-typical slow and undulating style of flight. Rather than directly imitating the behaviour of their foster parents the young galahs may have been forced to modify their normal fight patterns simply in order to fly at the same pace as their slow moving foster flock. The constraints of the galahs' social environment may have shaped their behaviour.

Stimulus enhancement is probably the process most often confused with imitation in practice (Whiten and Ham 1992). Stimulus enhancement was discussed earlier in relation to Morgan's "intelligent" imitation. *It is a process "in which a performer's action merely focuses an observer's attention on critical environmental features, increasing the speed with which the observer subsequently learns a similar behaviour pattern through its own efforts"* (Whiten 1989, p. 61). "A subdivision may be helpful in some contexts, between ***local enhancement***, as defined by drawing attention to a particular locale in the environment, and *stimulus enhancement*, where attention is drawn to an object or part of an object, irrespective of its location" (Whiten & Ham 1992, p. 249). For example, Fragaszy and Visalberghi (1989) conducted an experiment in which a capuchin monkey (*Cebus*) was able to watch a skilled monkey use a stick to poke a peanut out of a horizontal tube. "Although the observer monkey subsequently directed more behaviour towards the stick and tube, copying of the pattern of poking behaviour was not discernible, leading the authors to conclude that only stimulus enhancement was involved" (Whiten 1989, p.61).

The tendency in comparative psychology has been to focus almost entirely on imitation. Stimulus enhancement may actually be a much more important learning process in the everyday lives of the vast majority of species. Whiten (1992) suggests stimulus and local enhancement might be processes by which many animals learn what to eat and where to find it. Galef (1990) states:

"3- to 12-month-old vervet monkeys (*Cercopithecus ascanius*) tend to feed in synchrony with their mothers, to eat only the food items she does and, consequently, never even sample some foods that could be deleterious (Hauser 1988). Similarly, mother and infant chimpanzees share food (Silk 1978) as do mother and infant rhesus macaques (Kawamura 1959) and gorillas (Watts 1985)" (p. 79).

Galef argues that it does not necessarily always follow that because infants co-feed with their mother, this is in fact a crucial factor in the development of their food choice in later life. We need to conduct more research into the possible relevance of co-feeding. Although the current document follows the more common route of concentrating almost exclusively on those processes thought to be cognitively more complex than stimulus enhancement (i.e., emulation, impersonation and imitation), it is acknowledged that more research is needed on what animals actually learn from their social group rather than whether or not they can imitate in a human-like manner (Box 1992).

We also need more research to establish just how sophisticated stimulus enhancement can become; whether an animals' attention is drawn in a very general way to objects, or whether it can be drawn to specific parts of objects. Also, it is important to consider what precise aspect of the model's performance draws the attention of an observer. Palameta and Lefebvre (1985) found that observer pigeons only learned to peck through a paper lid on a dish of seed if they saw a model peck through the lid *and* consequently eat. Pigeons who saw a model peck through the lid but receive no food, and those who saw a model eating seed through a pre-existing hole did not learn to peck through the lid themselves. Pecking and piercing are species-typical behaviours in pigeons, so that contagion or individual learning can explain the existence of this behaviour in the observers. Yet, only special observational conditions sufficiently enhanced the test apparatus so that behavioural transmission occurred. Experimentally dissecting the different aspects of a task in the way Palameta and Lefebvre have done would seem a potentially valuable approach to social learning, without imitation necessarily being the complete focus of the researcher's attention.

IMITATION

Precise Form Imitation

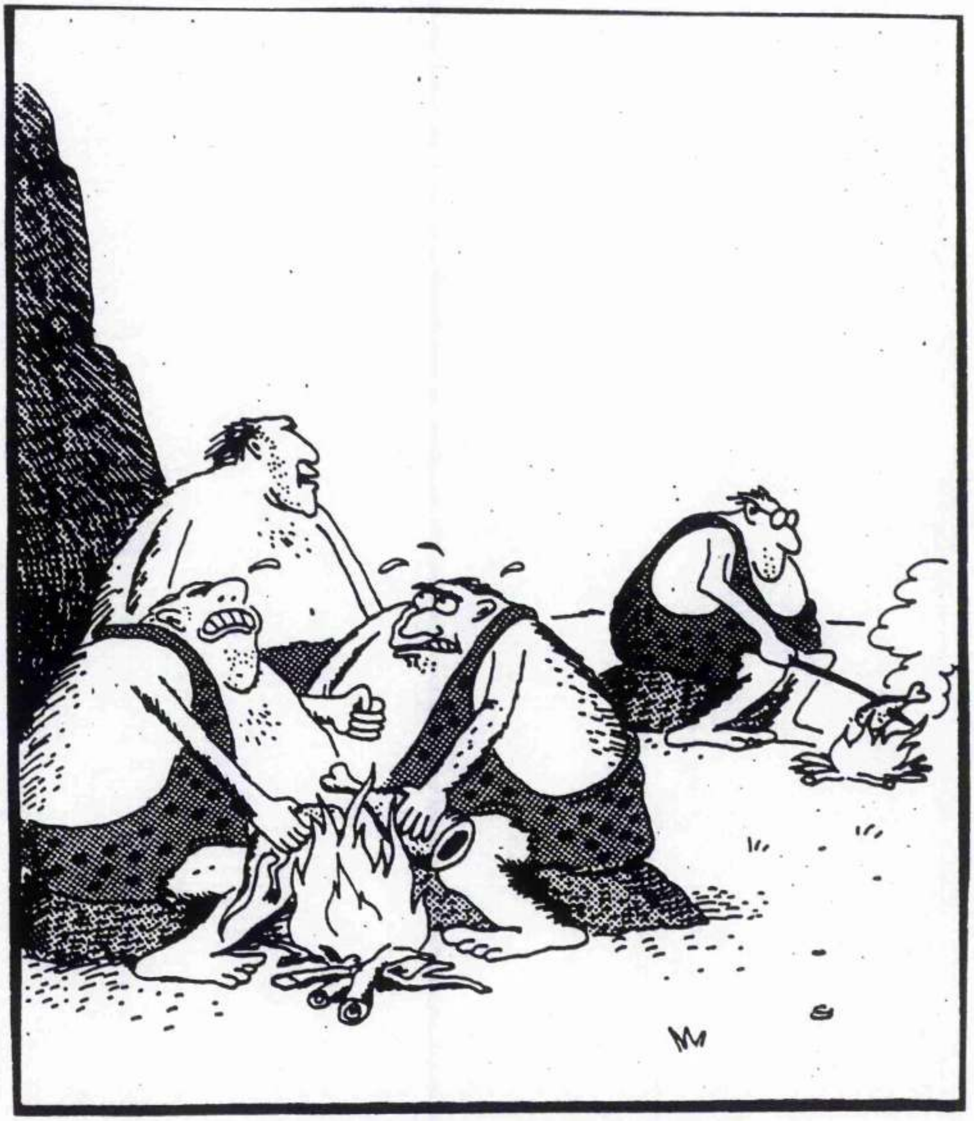
After having outlined some of the different mimetic processes it should be clear just how difficult it is to distinguish imitation from them. Some researchers have attempted to distinguish imitation by emphasising that what is learned from observing a model is at least some part of the precise or intrinsic form of a non-instinctive behaviour or action-pattern (e.g., Galef 1988, Tomasello 1990, Whiten & Ham 1992). For example, there is no reason to assume that twisting at objects is an instinctive or contagious behaviour in primates. So, if a model were to twist at a jar-lid in order to open it, what an imitator might learn directly from observing the model (rather than from his or her own efforts) is that he or she should also use a twisting motion. Precise-form imitation does not require the observer's technique to be a carbon copy of the model. The model may hold the jar upright in her left hand and twist at the lid with her right hand, while the observer holds the jar on its side in her right hand and twists at the lid with her left hand. The important point is that it is unlikely that the observer would have twisted at the lid in the first place (or at least not without extensive trial and error) unless he or she had seen the model do so first. Whiten and Ham (1992) comment that, "no imitation of A by B will be perfect, ... imitative copying of the form of another individual's act may vary between the faithful and the poor and encompass only a subset of the elements potentially copyable" (pp. 250-251). One advantage of defining imitation in terms of precise actions is that it is the basis for one of the most promising methodological approaches to studying imitation (see the discussion in chapter 3 on the multi-act approach).

Although the approach of defining imitation in terms of reproducing precise actions distinguishes it from the other mimetic processes, it also considerably narrows the scope of the term. There are other aspects to imitative behaviour beyond reproducing precise action patterns. Precise-form imitation ignores, to a certain extent, the tradition of studying imitation, because it is thought to represent an example of intelligent behaviour. It is possible to exactly replicate another's actions in a rather *unintelligent* manner. Tomasello *et al.* (1993) discusses a process called **impersonation** or mimicry in which an observer "*reproduces the precise form of the adult's behavior but does not understand its goal* ... for example, the infant might make twisting motions on the [jar] lid as the mother did, but without applying pressure, not knowing that the goal is to open the jar" (p. 497). In contrast, Byrne (in press, c) discusses a process he calls program-level imitation which is much more akin to the traditional approach of studying imitation in animals (and especially non-human primates) in order to gain an insight into the evolution of human intelligence.

Program-level Imitation

In program-level imitation the information transferred by observation is not necessarily the precise form of the actions used by a model, but rather, *the observer either capitalizes on a model's apparently original idea or learns the general program of the logical structure of another's actions*. Consider the Larson cartoon in figure 2.2: if the observer cavemen were to almost immediately go and find sticks, skewer some meat, and place it in the flames, it would not be the replication of precise actions that would be important (in fact, they need never have observed the whole procedure), it would be that they were able to, "intelligently grasp what the actions of another means"

(Kohler 1925). The word "program" is used because what the cavemen have gained from observing Zog is the general program of behaviour which is needed to safely cook their meat. The program might be something like: "find a stick, skewer meat, grasp protruding end of stick, hold meat-ladden end in fire." The exact actions used by Zog, (e.g., the grip he used to hold the stick, or precisely how he pushed the stick through his meat), are not important in comparison to the general logical program.



"Hey! Look what Zog do!"

Figure 2.2: A "Farside" cartoon by G. Larson which depicts potential social learning in early hominids

One important stipulation for program-level imitation is that the behaviour must be sufficiently complex to rule out other more simple learning processes. The Japanese macaques of Koshima Island appeared to capitalize on the original behaviour of a young female called Imo (Itani & Nishimura 1973, Kawai 1965, Imanishi 1957). The monkeys were provisioned with pieces of sweet potatoes scattered on a sandy beach. It took the monkeys a long time to rub the gritty sand off the potatoes before they could eat them. A juvenile female, Imo, began to wash her potato pieces in the sea. In time, other monkeys followed Imo's example until eventually nearly all of them were potatoes-washing. The specific action patterns used to wash the potatoes were not particularly significant in comparison with the general behavioural strategy itself. Yet, program-level imitation need not have been responsible for the transmission of sweet potato washing. There were in fact several ways in which the monkeys could have learned the behaviour. Simply seeing monkeys down by the water's edge could have drawn the attention of others. Upon approaching the water the observers would have been more likely to learn through trial and error the advantages of washing their food (local enhancement). Fragaszy and Visalberghi (1990) found that macaques and capuchins learn to dip food in water through individual exploration relatively easily. "To obtain clear evidence of program-level imitation a complex, multi-stage task is necessary, but unfortunately the natural lives of most animals and the experiments usually devised to test imitation are lacking such complexity" (Byrne in press, c).

One class of behaviour which certainly appears to be sufficiently complex to be learned by program-level imitation is the skilled food-processing of mountain gorillas (Byrne & Byrne 1991, in press). The gorillas' food processing often involves hierarchical stages with several subgoals which must be completed before reaching the main goal (i.e., eating the edible part of a plant). It is possible for the logical structure of a task to be copied without it always being necessary to reproduce every detail of the exact action pattern used by the model. One example discussed by Byrne is nettle-leaf processing. First, the gorillas collect a handful of nettle leaves. Second, the particularly virulent petioles are detached from the more innocuous leaf blades. The gorilla then folds the leaves so that the least stinging surface is presented to the sensitive lips. Finally, the nettle leaves are placed in the mouth and eaten. Byrne argues that it is possible for the gorillas to learn the separate stages of this complicated program without them needing to exactly reproduce precise action patterns.

One problem with program-level imitation is that it is very difficult to distinguish from hierarchical tasks which are acquired through individual learning. Squirrel monkeys execute several processing subgoals before they are able to eat semi-poisonous caterpillars (Boinski & Fragaszy 1989). Many of the caterpillars have urticaceous spines which are removed by the monkeys rubbing them vigorously with the tuft of fur at the end of their tail. The monkeys then eviscerate the caterpillars by placing the head capsule in their mouth, with one or both hands holding the body. The body segment immediately posterior to the head capsule is bitten such that the body, but not the gut tract, is severed from the head capsule. The body is pulled away, leaving the gut tract attached to the head capsule, which is discarded. The monkey then eats the eviscerated body. There are several stages involved in the squirrel monkeys' handling of spiny caterpillars, but there is little evidence that it is learned by imitation. Juvenile squirrel monkeys seem to learn how to handle caterpillars through painful trial and error. They were observed handling spiny caterpillars with their bare hands and then for several minutes afterwards rubbed their hands together. Another ate a furry caterpillar without preparing it and was violently sick. These mistakes could be the result of unsuccessful imitations, but this seems unlikely since the authors report that infants do not closely or preferentially observe adults while they are eating. Even so, the infants learned these foraging skills quite rapidly, so that at four and a half months of age the foraging patterns of infants were indistinguishable from adults.

The main argument that Byrne uses to support the notion that young gorillas are learning to process difficult plants via imitation is that they acquire the behaviour so quickly that it is unlikely to be the result of individual learning. Judging by the rapidity with which squirrel monkeys learn to process caterpillars, it might be possible that nettle processing is learned without direct imitation. Byrne points out that the young gorillas watch adult food processing very closely. Although close observation is a necessary condition for imitation it is not sufficient in itself to prove that imitation has taken place. Perhaps the only way to gain an insight into the learning process involved in mountain gorilla food processing is to closely observe the details of its ontogeny. For example, do young gorillas only begin folding nettle leaves immediately after they have closely observed an adult's technique? Unfortunately, even such ontogenic data is likely to be far from clear cut. Although program level imitation is an important concept, the sometimes blunt tool of science makes it difficult to study - especially in feral apes.

Byrne and Byrne (in press) were fortunate to be able to collect some very revealing data from a female gorilla, Picasso, and her son who had only just migrated into an area with nettles. Neither gorilla followed the standard program of folding the nettle leaves before eating them. If nettle eating were learned through trial and error and the similarity of the gorillas' processing program was simply the result of the logical structure of the task itself, one would expect Picasso and her son to eventually learn the standard method. The fact that neither individual learned the program supports Byrne's contention that this is learned through program-level imitation. It also suggests that there is a sensitive phase in mountain gorilla development in which essential food processing skills are acquired. If a gorilla does not get exposed to the processing of certain foods during that time, the required skills are unlikely to be learned later in life.

Precise form imitation and program-level imitation are not mutually exclusive processes (Byrne in press, c). One can imagine social learning processes positioned along a continuum. At one end every minute detail of a behaviour is encoded and reproduced regardless of its direct relevance to the task (impersonation). At the other end nothing is learned by the observer. Sometimes, all that is encoded is to what object the model directs its attention (stimulus enhancement). At other times, quite general and flexible programs of complex behaviour are learned (program-level imitation).

There might be situations in which noting the actions used by an observer is essential in order to distinguish imitation from other less complex mimetic processes. In other situations, the complexity of the modelled behaviour itself and the speed with which it is learned by an observer will be sufficient in itself to establish program-level imitation, without the precise details being a particularly important factor. Each case must be considered individually: there is no single, simple formula for establishing the occurrence of imitation.

Emulation and Reward Enhancement

Tomasello (1990) was the first comparative psychologist to use the term emulation. It is not always clear what he means by the term. In some instances it seems equivalent to program-level imitation, and in others it seems to be a specific species of enhancement in which *a reward is enhanced through observation (reward enhancement)*. In order to help grasp emulation's possible meaning(s), let us consider it in relation to an instance of social learning exhibited by a group of chimpanzees which Tomasello (1990) discussed in terms of them emulating rather them imitating a model.

Tomasello, Davis-Dasilva, Camak, and Bard (1987) conducted a study on observational learning of a tool task by chimpanzees. An adult female chimpanzee, Lil' One, acted as the model and was taught to use a T-bar to rake in food placed on a platform outside her cage. Lil' One used two distinctive two-stage techniques to reach the food. If the reward was placed against the far raised edge of the platform, she would tap it away holding the T-bar with two hands and then rake it in using one hand. If it was placed against a side edge, she would place the bar beyond the food using two hands and then draw it in using one. Seven young chimpanzees were presented with the same problem and after ten trials none of them had independently solved it. They were then divided into two groups. One group of four individuals was able to observe Lil' One solve the problem, while a control group of three chimpanzees never observed her.

The observers clearly benefited from watching the model, since three out of four successfully used the T-bar within six trials of watching Lil' One, while only one out of the three control subjects solved it and then not until her eighteenth trial. Even so, Tomasello *et al.* argue that the observers had not imitated the model since none of them reproduced either of her two-stage techniques.

The authors state that the learning process was not simple stimulus enhancement, since all of the subjects, irrespective of watching the model, manipulated the T-bar to a high degree. It was not the tool as an object that was made more salient, but in the words of Tomasello *et al.*, "the tool in its function as a tool" (p. 182). "The chimpanzees ... seemed to be learning from their observation not just that some objects are of special interest, but rather that some objects have a special utility in their use as tools" (p.183). Tomasello *et al.* do not actually use the term "emulation" to describe the learning process that takes place. The learning process they describe seems very similar to "program-level" imitation in which the observers acquired the program - "use T-bar to rake in food".

In his 1990 review of cultural learning, Tomasello discusses the young rake-using chimpanzees' behaviour specifically in terms of emulation. He seems to have changed his tune in regards to the cognitive process involved. Instead of discussing it in terms of learning the function of the T-bar as a raking tool, he describes the process as a kind of enhancement. When observing functional object-directed behaviour, such as tool-use or food processing, the objects themselves can become enhanced (stimulus enhancement), or the reward (reward enhancement), or a combination of these factors. Such an analysis can be used in respect to Palameta & Lefebvre's (1985) study with pigeons. It was not until the observer pigeons saw behaviour directed toward the paper-lid (stimulus enhancement) in combination with seeing the model eat the food (reward enhancement) that they were sufficiently motivated to direct species-typical piercing and pecking behaviour toward the test apparatus. Galef (1988) comments, "It is ... possible that piercing-and-eating models are better stimulus enhancers than either eating models or piercing models and that differences in the stimulus-enhancing capacities of the various types of models were responsible for differences in rate of behaviour acquisition by their observers" (p.22). Hence, in Tomasello *et al.*'s tool task it was not until the chimpanzees saw Lil' One manipulate the rake in combination with her acquiring the reward that they were sufficiently motivated to direct the T-bar toward the food. The observer chimpanzees could have then worked out through their own efforts, since there is a species typical propensity to use tools in chimpanzees, how to use the T-bar in order to reach the food. According to Tomasello (1990), it was the chimpanzees' tool using ability which was intelligent, the actual *social learning* process involved was not much more complicated than what was found in pigeons.

Of course, Tomasello (1990) is perfectly entitled to change his mind and interpret the young rake-using chimpanzees' behaviour in a different way. The problem is that he is not consistent in his use of the term "emulation". Even within his 1990 review, he sometimes uses the term as if it were a kind of enhancement and other times he uses it as if it were equivalent to program-level imitation. For example, he explains the Mahale and Bossou chimpanzees' leaf-clipping display (Nishida 1980,1987, Sugiyama 1981) in terms of emulation but then suggests they are using the program - "make noise with leaves" (see p. 301).

Fortunately, a rather more comprehensible definition of emulation is at last provided in Tomasello *et al.* (1993). The authors state:

> "Also not qualifying as clear cut cases of cultural learning are the attempts of infants to attain goals after adults have attained them (e.g., Kaye 1982), but using their own methods of execution - what Wood (1989) calls emulation. The problem is that what is often happening in such cases is that the child is learning about the affordances of an object or situation, not about the adult's goal or perspective. Thus, an infant might see an adult open a jar and then do the same, using established behavioural strategies, because it now sees that the jar affords opening" (p.497).

When emulating, the observer need never actually see the model manipulate an object, he or she need only see the end-result of the model's manipulations. Imagine a monkey, A, who comes across a previously inaccessible hard-husked fruit that has been opened earlier by another monkey, B, striking it on a rock. On discovering that the pulp of the fruit is good to eat, A could then direct its attention to other unopened fruits and learn through trial and error that hitting them on rocks breaks them open. Although A never saw B manipulate the fruits, simply finding the results of B's activities was sufficient to lead A to independently learn how to open them.

Tomasello has assumed that emulation is less cognitively complex than imitation and, therefore, less worthy of study. Yet, on considering the Larson cartoon (Figure 2.2), if the cavemen were to reconstruct the logical program of Zog's meat-cooking technique without actually having seen the whole procedure, this would constitute emulation. Such an ability would seem to be just as, if not more, cognitively complex than imitation. Emulation is certainly a process which needs more detailed empirical investigation.

Now that the different mimetic processes have been defined, we need to consider in greater depth how to distinguish them in practice. Chapter 3 considers different methodological approaches to studying imitation.

Chapter 3

METHODOLOGIES FOR STUDYING IMITATION

Three types of evidence of imitative-like behaviours can be distinguished: anecdotes, systematic or controlled observations, and experiments. Anecdotes are uncontrolled or chance observations of the spontaneous behaviour of subjects. Systematic observations consist of researchers devising observational techniques and criteria prior to the recording of data. Experiments involve the proposal of specific hypotheses which are tested by manipulating and controlling different variables in a given situation. These three types of evidence can be collected in the wild or captivity.

ANECDOTES

Since Romanes' almost entirely uncritical use of anecdotes and Thorndike's subsequent crushing criticisms, psychologists have tended to avoid all anecdotal data. Yet, there is a danger that the pendulum has swung too far away from this potentially valuable source of evidence. As Moore (1992) points out:

"While no one should countenance a return to ROMANES' (1882) standards of evidence, it would seem equally unwise to reject for ideological reasons the informed observations of, say, HAYES & HAYES (1952), KOHLER (1926) or PIAGET (1951/1945). A less extreme position is therefore appropriate" (p. 236).

Moore proposes five criteria by which we might evaluate the merit of individual anecdotes. In chapter 5, an amended set of criteria based on Russon and Galdikas (1993) and Moore (1992) are presented and used to evaluate the reports which appear in an observational database of imitative-like behaviour in nonhuman primates.

Anecdotes from Captivity

There have been a great number of anecdotes of imitative behaviour in captive animals. Perhaps one of the reasons that so many anecdotes originate from subjects raised in human homes is that such conditions promote intimate knowledge of an animal's personal history and consequently the observer is more likely to recognize certain actions as novel. Also, some of the anecdotes from human-reared subjects have involved the reproduction of specifically human behaviours, which reduces the likelihood of them being based on an innate predisposition for the modelled behaviour. For example, Hayes and Hayes' home raised chimpanzee, Viki, imitated her human foster mother, Kathy Hayes, applying lipstick. Viki not only applied the lipstick to her own lips while standing in front of a mirror, she even smoothed the cosmetic with her finger just as Kathy Hayes was apt to do. This is a detailed description of a non-species typical behaviour observed by researchers who knew the subject's entire learning history. Detailed anecdotal reports, such as this, are surely worthy of consideration and should not be dismissed just because the observer had not anticipated the event.

Anecdotes from the Wild

Many reports of apparent imitation which come from the wild have involved the emergence (or recognition) of local traditions in groups of animals (e.g., Hinde & Fisher 1951 - blue and great tit milk bottle top opening; Kawai 1965 - Japanese macaque sweet potato washing; Goodall 1973 - Gombe chimpanzee leaf-sponging; Gandolfi & Parisi 1973 - Po River rat mollusc diving). Some of these observational reports are so detailed that they bare no resemblance to the kind of anecdotal data discussed by Romanes (1882). They often fall somewhere between anecdotes and systematic observations. One such report comes from Hauser's long term observational study of wild vervet monkeys. In a time of severe drought Hauser

(1988) noticed a female vervet monkey dipping an acacia pod in the hollow of a tree in order to reach the exudate within. The behaviour spread rapidly, with four monkeys dipping pods within 9 days, and another two dipping within 22 days. Hauser immediately recognised the potential significance of the behaviour in relation to social learning and took detailed notes.

"Given continuity of observation, details of the first incorporation of the act into each animal's repertoire provided evidence that different individuals acquired the technique by different routes. One appeared to deduce what to do from observing the end product (the model finally eating dipped pods), whereas another watched the model prepare and consume the pods "and then performed the whole behaviour"" (Whiten & Ham 1992, p. 255).

Although Hauser's observations are very detailed, this still does not constitute a strict systematic study because the observational methods were not devised prior to the onset of the novel behaviour. Hauser had no control over the monkeys' access to the pods and tree hollows, prior to, or during the manifestation of the dipping technique. Therefore, he could not be absolutely sure how each monkey learned the behaviour. As Whiten and Ham (1992) comment:

"it must remain possible that some parts of the developing actions escaped observation and these might have been subject to other processes like trial-and-error learning; unless such a case study is seamlessly continuous, convincing field evidence for imitation remains elusive" (p. 256).

Of course, the very nature of field work means that it is very difficult for a researcher to be sure that he or she has observed the entire ontogeny of a naturally occurring behaviour. Fortunately, other complementary methods of investigation are also at the scientist's disposal. Some researchers have investigated different aspects of naturally occurring behaviours by exposing captive subjects to analogous but controlled conditions (e.g., Galef 1980; Sherry & Galef 1984).

SYSTEMATIC OBSERVATIONS

One problem with the systematic observation of a behaviour like imitation is that it is so apparently rare in animals few researchers can devote their time to studying it alone. One way to overcome this problem is to use a modified 1-0 data collection method in which recordings of imitative behaviours are part of, or piggy back, other on-going data collection. One can also facilitate observations by deliberately arranging the situation so that a novel behaviour is more likely to emerge and then the details of any social transmission can be recorded.

Systematic Observations in the Wild

In chapter 2, I discussed two observational field studies which have considered whether certain food processing behaviours were imitative: mountain gorilla nettle eating (Byrne and Byrne 1991; in press) and squirrel monkey caterpillar processing (Boinski and Fragaszy 1989). Both studies involved the collection of detailed observational data on the general food processing skills of the subjects involved. One aspect of their analyses was concerned with whether imitation could have played a part in the development of these specific food processing techniques. The possible role of imitative learning was assessed inferentially, rather than by trying to directly judge whether specific behavioural episodes were imitative. Byrne inferred that imitation was involved in the ontogeny of gorilla food processing from the fact that infants paid close attention to feeding adults and that they learned the standard patterns for a great number of complex food processing techniques in a relatively short period of time. Boinski and Fragaszy, on the other hand, concluded that the squirrel monkeys were not imitating because of the lack of close attention they paid to feeding adults, combined with observations of apparently painful trial and error learning.

Although observational data on standard behaviours in feral subjects can strongly suggest the presence of imitative learning such data are rarely clear cut. One possible strategy is to build up strands of evidence until they strongly support one hypothesis over another. Byrne and Byrne (in press) say of standardized mountain gorilla food processing:

"For this pattern to result from trial and error implies that for gorilla food plants the constraints of the environment are so tight that one and only one logical sequence is learnt by individual experience in the first three years of life, with no room for idiosyncratic variation [in the program rather than precise actions used]. This appears wildly unlikely, but cannot be entirely ruled out."

Further complementary evidence could perhaps be supplied from carefully controlled field or laboratory experiments. Such an enterprise would be extremely difficult with mountain gorillas since there are none in captivity and they are so rare in the wild that intrusive field experiments are not feasible.

Systematic Observations from Captivity

One of the main advantages of captive observational studies is that the researcher has much more opportunity to control different aspects of the test environment than in the wild. The researcher can introduce specially designed novel objects that she or he can be sure the subjects have never encountered before (of course such objects could be presented to feral subjects). The researcher can also control the amount of access each subject has to the test apparatus, and hence, can potentially observe every aspect of any resultant behavioural acquisition and transmission. Studies which exert so much control fall somewhere between systematic observations and experiments. Many examples of this approach exist. For example, Visalberghi (1987) presented two naive captive groups of capuchins with stone slabs and nuts and systematically recorded the emergence of nut-cracking. Although nut cracking did not in fact spread in either of the two groups of monkeys, if it had, Visalberghi could have recorded every detail of its social transmission. Recording the behaviour on video has the added advantage of being able to perform micro-analyses of the subjects' actions (e.g., Fragaszy & Visalberghi 1989; 1990).

EXPERIMENTS

It has been argued that there are so many subtle interconnected mimetic processes that they can only be distinguished from one another in the controlled setting of a laboratory experiment (Galef 1988). (Of course, I have been arguing that with careful use of observational protocols and criteria systematic observations and even anecdotes can be used in the study of imitation.) Box (1984) comments that:

"although there are advantages of carrying out controlled laboratory experiments with reference to answering particular kinds of question about socially mediated learning, there are also inherent methodological constraints. It is a general difficulty, as in all learning situations, that if an animal does not perform a task, we cannot assume that it has not the ability to learn it. It may be that the individual has not attended to it, or that its behaviour is inhibited for some reason. Another methodological difficulty includes the fact that although an animal may have learned a task, it does not always show that it has done so at the time. There may be a considerable delay, as in many real-life situations. In an ideal world, and as with research into the behavioural biology of all natural processes, it is particularly useful to carry out coordinated and complementary programmes of investigation in the laboratory and the field" (p. 218)

One can even conduct experiments in the field with free ranging subjects.

Field experiments

Traditionally, we think of experiments occurring in the rather artificial conditions of a laboratory. Yet, insightful experiments on social learning can be conducted in the field with wild populations of animals. One ingenious field experiment was conducted by Whiten (1988). Whiten observed that juvenile olive baboons often watch skilled adults processing root corms, but because of their weakness and lowly rank they have very little power to pull up, secure and then process corms themselves. Therefore, Whiten dug up some corms and when there were no high ranking individuals nearby he dropped the food in front of a juvenile and recorded its subsequent behaviour. Whiten found that despite previous extensive observation of the adults' technique the juveniles appeared wholly ignorant of how to best process corms. Their manipulations of the food appeared to be little more than trial and error.

Of course, if the young baboons had immediately correctly processed the corms, one could not have been certain they did not either possess an innate predisposition to do so, or had previously learned the technique after all. One would need a control group who had never observed the adults' technique and never had access to corms. Although field experiments can be useful for probing deeper into naturally occurring behaviours, it is extremely difficult to control for all the interconnected variables.

However, one could present specially designed novel test objects to wild subjects. One or two well-habituated individuals could be trained to act as models so that they manipulate the object in a certain predetermined way. The experimenter could then record the details of any diffusion of the target behaviour through the group. Cambefort (1981) conducted an ingenious field experiment in which separate groups of Chacma baboons (*Papio ursinus*) and vervet monkeys (*Cercopithecus aethiops*) were presented with buried food caches which were marked with small flags. In both species it was the juveniles who learned first how to locate the food, but the overall pattern of social transmission was very different between the two species (see Figure 2.3).

There are, of course, ethical considerations related to the degree to which humans should properly intrude upon the day-to-day lives of wild animals. One must carefully weigh up the pros and cons of any given situation. In the past, some very successful and important research has involved the direct manipulations of wild animals, (e.g., Goodall (1986) habituated the Gombe chimpanzees by provisioning them with bananas; Kortlandt (1967) used a stuffed leopard to provoke chimpanzees to use sticks and stones as weapons; Cheney and Seyfarth (1980) conducted vocal play-back experiments with vervet monkeys). Nevertheless, some of these field experiments have proved very disruptive to the animals involved; for example, food provisioning at Gombe seemed to lead to increased intraspecific and interspecific (i.e., between chimpanzees and baboons) aggression.

Experiments in Captivity

Saver Method

Thorndike (1898; 1911) was one of the first researchers to devise formal experiments for studying imitation. His basic method, dubbed the "saver" method by Moore (1992), has basically served as the blueprint for the proceeding century's experimental work. Most of the other experimental approaches constitute slight variations on the saver philosophy. The saver method "compares the learning rates of groups that have or have not observed others perform some target response" (Moore 1992, p. 234).

Most of the experimental innovations on Thorndike's method have constituted little more than changing exactly where the observer is placed in relation to the model. Thorndike had originally placed the subject in a separate compartment while the model demonstrated the target response. The Kline single cage method places the subject in the same area as the model (see Whiten & Ham 1992). The Warden and Jackson Duplicate Cage (1935) places the subject in an area next to or opposite the model, with both areas containing identical apparatus.

The problem with the saver method is that it does not control for other mimetic processes which, like imitation, can facilitate the acquisition of novel behaviour. Thorndike's (1898) and Kline's (e.g., Haggerty 1909) methods do not control for local or stimulus enhancement. For example, imagine that Thorndike's observer cats in his problem box experiment did learn to open the door more rapidly than non-observers. Such a result could be explained in terms of the observers' attention being drawn to the opening mechanism by the model, thereby facilitating learning by trial and error.

Thorndike tried to compensate for the insensitivity of the saver method by using a subjective measure of judging the degree of similarity between the model's and observer's actions. However, he could not rule out the possibility of similar actions occurring by chance. Tomasello *et al.* (1987) face the same problem in their tool task experiment with chimpanzees (see chapter 2). If the young observer chimpanzees had used two-stage techniques similar to the model, one could not ultimately rule out the possibility that they learned the techniques through their own trial and error. After all, the model learned the technique through her own efforts, so why not the observers? Therefore, even noting whether the observer used a similar action pattern to the model in a saver experiment, the method does not control for stimulus enhancement combined with individual learning.

Warden and Jackson (1935) claim that their duplicate cage approach does control for stimulus enhancement. They argue that since the observer does not manipulate the exact same physical apparatus as the model, but their own identical separate set, stimulus enhancement is controlled for and only imitation can account for any facilitation of learning. Whiten and Ham (1992) comment that:

"as Galef (1988) has recently emphasized, although this may rule out local or stimulus enhancement (in the precise sense referring to the unique object manipulated by the demonstrator), it does not do so in the more general sense where stimulus enhancement is taken to refer to the entire class of objects sharing the stimulus characteristics of the object manipulated by the demonstrator ... If an observer monkey's attention was directed in this fashion toward its duplicate chain apparatus, as seems plausible, the faster acquisition of chain-pulling that Warden and Jackson recorded still does not count as evidence for imitation as opposed to stimulus enhancement" (pp. 253-254).

Multi-act Method

Galef (1988) advocates an alternative to the saver method which concentrates on the precise form of the actions used rather than relative speeds of behavioural acquisition. The multi-act approach, as I shall call it, was first devised by Dawson and Foss (1965). Dawson and Foss trained three budgerigars (*Melopsittacus undulatus*) to perform as models. Each model was taught to use a different action to solve the same problem of removing a paper lid from a dish of bird seed. Model A lifted the lid off with its beak, Model B nudged the lid off with its beak, and Model C removed the lid with its foot. Stimulus enhancement was controlled for because the same set of stimuli (i.e., a paper lid on a dish of food) was manipulated by all the subjects. Individual learning was controlled for because the critical measure was whether the three groups of observers performed similar action patterns to their respective models. The birds did tend to use the same appendage as their respective models but no difference was found in the detail of beak movements used by groups A and B. Since only five subjects were tested, Dawson and Foss' experiment could provide only weak preliminary evidence of imitation in budgerigars. Galef *et al.* (1986) replicated the experiment with more subjects and found similar but only very fragile evidence of imitation. Galef (1988) encourages "the adoption of their paradigm for use with other species and behaviours in future work on the question of the occurrence of true imitation in animals" (p. 23). As you will see Ham (1990) took up the challenge with stump-tail macaques (see chapter 5), and the second original experiment reported in this document does likewise with children, chimpanzees and capuchin monkeys (see Chapter 8).

One word of caution though, the multi-culture approach does not automatically control for contagion. Imagine a situation in which three chickens act as models for three groups of observers. Model A flaps its wings, model B scratches at the ground and model C pecks at the ground. It would not be very surprising if the observers in group A flapped their wings more than the other two groups, group B scratched at the ground more, and group C pecked at the ground more. Although the observer chickens might exhibit behaviour similar to their respective models, contagion can explain these results just as well as imitation. Wing flapping, ground scratching and pecking are all part of a chicken's normal behavioural repertoire, and it seems very likely that these actions can be contagiously induced. Moore (1992) explains Epstein's (1984) multi-act experimental results with pigeons in terms of contagion rather than imitation (see chapter 2). Therefore, in designing a multi-act experiment one must ensure that the demonstrated actions are unlikely to be capable of inducing a contagious reaction.

Arbitrary Actions Series

The arbitrary action series approach controls for stimulus enhancement, individual learning and contagion. This approach requires subjects to reproduce novel non-object directed arbitrary actions which must be imitated within the first few demonstrations. Such a task controls for stimulus enhancement because there are no objects involved. It controls for trial and error learning because the subject must reproduce each novel action within the first few demonstrations and hence there is little opportunity for an adjustment of response in accordance with differential feedback from the experimenter. It controls for contagion because a wide variety of actions are presented. Meltzoff *et al.* (1992) argues that the greater the number of actions reproduced, the more unlikely it becomes that contagion is the underlying mechanism. Hayes and Hayes (1952) were the first scientists to conduct an experiment on arbitrary action imitation in a nonhuman subject. Their three year old home-raised chimpanzee, Viki, was required to imitate a series of 70 arbitrary actions. I shall discuss Hayes and Hayes' work in greater detail when I describe my own original modified version of their study (see Chapter 9 of this document).

Both of the experimental methods which have been recommended so far (i.e., the multi-act and arbitrary action series approaches) relate to precise-action imitation. Chapter 2 includes recommendations for the kind of test that would be needed to test for program-level imitation. The experimental task would need to involve either very complex and/or improbable action patterns and, the observer would also have to reproduce the behaviour much faster than one would predict if it was learned through individual learning or a kind of enhancement. As yet no clear experimental tasks of this kind have been reported (Byrne in press). (Although Haggerty 1913 may represent a possible candidate, see chapter 4).

After having discussed how to define and study imitation in practical terms, we are now in a position to consider the evidence for imitation across the animal kingdom.

Chapter 4

IMITATION IN APES

Great Apes are of special interest in regards to imitation. Humans are, of course, a kind of ape and imitation is very pronounced in humans. Meltzoff (1988) goes so far as to suggest imitation is one of our defining characteristics and he re-dubs *Homo sapiens* as "*Homo imitans*". One might, therefore, expect those species most closely related to humans to be likely to manifest a similar ability in imitation. Byrne (in press, a) states that, "among the apes it is now certain that humans are much more closely related to some species than others." Whiten (1993) further explains:

> "The two species of chimpanzee represent our closest living relatives in the animal kingdom. Current estimates put the date of evolutionary divergence between our ancestors and those of these apes at only 4-7 million years ago. This may be contrasted with the split between our line (i.e. the ape lineage) and that of the Old World monkeys, which occurred as long as 20-30 million years (Sibley and Ahlquist 1984; Hasagawa *et al.* 1989). The ancestors of the other Great Apes (the orangutan and the gorilla) and the Lesser Apes (gibbons), split off in between" (p. 373).

Therefore, if one is interested in identifying appropriate subjects for comparative studies in imitation, the Great Apes and especially chimpanzees would appear to be very suitable candidates.

In the present chapter, I shall discuss the observational and experimental evidence for imitation in each of the Great Ape species (examples are included from *Gorilla gorilla*, *Pongo pygmaeus*, and *Pan paniscus*, but the majority of reports come from *Pan troglodytes*). I shall not discuss Lesser Apes simply because I have not been able to find any reports of imitation in these primates: although, one should bare in mind that "absence of evidence is not evidence of absence" (Byrne & Whiten 1990, p. 5). In Chapter 5, I shall consider the evidence for imitation in monkeys.

UNCONTROLLED OBSERVATION OF IMITATION IN GREAT APES

There are a great many anecdotes or uncontrolled observations of apparent imitation in Great Apes (see chapter 3 for definitions of anecdotes or uncontrolled observations, controlled observations and experiments). Reports of these observations can be found scattered throughout scientific and popular (factual) literature. I have made a search of this literature and compiled a data-base of anecdotal reports of imitative-like behaviour in non-human primates. A similar data-base was compiled by Byrne and Whiten (1986/1990) on tactical deception in primates. They used anecdotes that came from "highly experienced primatologists, each with years of familiarity with the species concerned, and training in behavioural recording" (Byrne 1993). Whiten and Byrne (1988) argue that single anecdotes can never be more than "a jumping off point for more systematic work" (p. 243). They suggest that, "no single observation can be regarded as definitive evidence in support of a hypothesis ... There are two major reasons for scepticism. One is that in many cases the relevant evidence involves very fine distinctions in behavior ... Second, a single instance may in many cases simply represent a coincidence" (p. 243). Instead, the authors recommend that only multiple records be considered. Byrne (1993) states that, "The lesson is this: careful and unbiased recording of unanticipated or rare events, followed by collation and an attempt at systematic analysis, cannot be harmful. At worst, the exercise will be superseded and made redundant by methods that give greater control; at best, the collated data may add to theory".

Even Whiten and Byrne's careful treatment of anecdotes have been highly criticised with some commentators arguing that anecdotes are intrinsically "unscientific" (e.g., Berstein 1988, Thomas 1988). There is a very genuine fear that such work will lead other researchers to revert to the sloppy use of anecdotes that abounded at the turn of the century. Burghardt (1988), however, indicates that our modern day aversion to anecdotes may be over-zealous. He points out, "Lloyd Morgan (1894), who with his "canon" supposedly brought down the anecdotal method, actually called for more careful, critical use of anecdotes and his own books abound in them" (p. 248).

One way to avoid Romanes' uncritical approach is to evaluate each anecdote using strict criteria. In the present imitation catalogue each observation was judged using six criteria which are partially based on the work of Moore (1992) and Russon and Galdikas (1993):

"Perhaps reports should simply be considered on their individual merits, with greatest weight given to

(1) first-hand accounts by

(2) competent observers who

(3) demonstrate adequate knowledge of the species in question" (Moore 1992, p. 236).

Moore (1992) and Russon and Galdikas (1993) also argue that the observers should:

(4) describe the context of the episode and the precise actions performed by the subject in detail and,

(5) be acquainted with the relevant details related to the ontogeny of the apparently imitative behaviour.

(6) Finally, of course, the details of the behaviour and its ontogeny should indicate that imitation was indeed the learning process involved and that no other less complex process can adequately explain the subject's behaviour.

Washburn (1908) discussed two further potential pitfalls in anecdotal data, both of which are related to observer bias. The observer may:

(I) have "a personal affection for the animal concerned, and a desire to show its superior intelligence" (p. 5)., and

(II) have "the desire, common to all humanity, to tell a good story" (p. 5).

Burghardt (1988) argues that these two potential flaws in anecdotal data (I and II above) are particularly intractable. Yet, if the observer is vigilant and shows him or herself willing to point out weaknesses or flaws in the subject's imitation, this might go some way towards counteracting the two kinds of observer bias described by Washburn.

One difficult problem related to assessing an anecdote is how to objectively judge who qualifies as a "competent observer" (see criterion 2 above). Washburn (1908) suggests that the observer should be, "scientifically trained to distinguish what he sees from what he infers" (p. 5). Yet, it is possible that "the careful observations of experienced pet-owners, unfamiliar with behaviourist theory but knowing their animals well" (Byrne, in press a and b) can also be of merit. The best way to illustrate this point is to consider an actual observation made by an experienced pet-owner. Let us closely examine the observation made by Kearton (1927) of his pet chimpanzee, Mary (see report 18 in the data-base).

In order to assess Kearton's competence as an observer, I propose to consider how well the anecdote satisfies the other four criteria listed above, and to what extent Kearton avoids Washburn's two types of observer bias. Kearton's report is clearly a first hand account (criterion 1). Also, one can be confident that Kearton possessed a great knowledge of chimpanzees, since Mary was the second chimpanzee he had raised in his home (criterion 3). Since Kearton had raised Mary from an early age, we can assume that he was very knowledgeable of her past experiences (criterion 5). Kearton was particularly careful in describing the context in which the observation took place. He wished to demonstrate to a sceptical onlooker, a certain Mr. Jones, that Mary was not forced to learn "tricks", but performed a number of human-like activities through a combination of natural intelligence, curiosity and imitation. Kearton set up the situation of presenting Mary for the first time with a bucket and spade on the beach, in order to demonstrate her natural ability to Mr. Jones. Hence, he described the demonstration and Mary's actions in great detail (criterion 4).

It is true that Kearton was trying to demonstrate to Mr. Jones that Mary was possessed of natural intelligence (observer bias I), and since he was writing a children's book, telling a good story was one of his main aims (observer bias II). Yet, Kearton did not only point out Mary's strengths, he also pointed out her weaknesses. He comments that despite several demonstrations Mary did not learn to turn the sand out of the bucket to form individual structures, she simply filled the container then tipped the sand out and filled it again. The fact that Kearton does not fail to mention Mary's shortcomings, helps to convince one of the unbiased nature and accuracy of his report. All these factors combined should convince the reader that Kearton was indeed a competent observer, even if he was not a trained scientist. Each anecdote in the data-base has been evaluated in this way, in order to judge the relative competency of the observers.

Let us now consider the content and structure of the data-base itself. It is not always easy to decide what is an observation versus an experiment. For example, Hayes and Hayes (1952) demonstrated hammering a stake into the ground and then rubbing it with sandpaper, with the expressed intention of trying to elicit an imitative response from their chimpanzee, Viki. Although these acts were deliberately demonstrated they have been treated as observations rather than experiments because no formal controls or measures were used. The behaviour was simply demonstrated and then Viki was allowed to respond. Later tests with Viki do seem to constitute experiments and hence these do not appear in the database. In one experiment Viki was systematically taught to imitate novel arbitrary actions on command. In a second study her imitative problem-solving ability on specially designed tasks was compared with young children and a young laboratory- (rather than home-) raised chimpanzee. Experiments are distinguished from observations by assessing the degree to which controls and formal measures are used on specific tasks.

Observations were included in the data-base if: (a) the original authors interpreted the behaviour as imitative, (b) the description of the subject's behaviour indicates that imitation (or at least a complex form of social learning) was involved, but the original authors offer no explicit interpretation and (c) the original authors clearly state that no evidence of imitation was found despite attempts to promote its occurrence.

At the head of each report a number of relevant facts were noted:

(1) the reference,

(2) whether the subject was observed in the wild or captivity,

(3) the interpretation provided by the original author (I = imitation; D.I. = delayed imitation; O.L. = observational learning (with no single social learning process stipulated); 0 = no interpretation given),

(4) the present author's interpretation of the observation (I = program-level and/or exact action imitation; D.I. = delayed imitation; E = emulation; D.E. = delayed emulation; S.E. = stimulus enhancement; R.E. = reward enhancement; C = contagion; Exp = exposure; I.L. = individual learning; O.C. = operant conditioning, such as when an experimenter inadvertently shapes or molds the response; ? = an independent judgement was not possible.)

(5) which of the six criteria for evaluating the validity of anecdotes were not satisfied,

(6) the species of the subject,

(7) the name of the subject.

The details of the observation itself follow these preliminary notes. Each report was, as far as possible, quoted in full. Only if the report was particularly long was it paraphrased with the most relevant sections quoted in the original words. After each report the present author provides a brief explanation of her interpretation of the subject(s)' behaviour. The observations from each species of primate are clumped together with the chimpanzees appearing first, followed by gorillas and then finally orangutans. Table 4.1, at the end of the database, summarizes each report.

OBSERAVATIONAL REPORTS OF IMITATIVE-LIKE BEHAVIOUR IN GREAT APES

CHIMPANZEES

No Criteria Failed

1. Grip on a Nut Cracking Stone

Reference: Boesch (1991) Condition: wild

Authors' explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"On 18 February 1987, Ricci's daughter, 5-year-old Nina, tried to open nuts with the only available hammer, which was of irregular shape. As she struggled unsuccessfully with this tool, alternatively changing her posture, hammer grip and the position of the nut, Ricci, was resting. Eventually, after 8 min of struggle, Ricci joined her and Nina immediately gave her the hammer. Then, with Nina sitting in front of her, Ricci, in a very deliberate manner, slowly rotated the hammer into the best position with which to pound the nut effectively. As if to emphasize the meaning of this movement, it took her a full minute to perform this simple rotation. With Nina watching her she then proceeded to use the hammer to crack 10 nuts (of which Nina received six kernels and a portion of the other four). Then Ricci left and Nina resumed cracking. Now, by adopting the same hammer grip as her mother, she succeeded in opening four nuts in 15 min. Although she still had difficulties and regularly changed her posture (18 times), she always maintained the hammer in the same position as did her mother. She whimpered whenever encountering difficulties, to attract her mother, but Ricci did not return to her even when she threw a temper-tantrum after unsuccessfully attempting to open a fifth nut for 3 min. In this example, the mother corrected an error in her daughter's behaviour and Nina seemingly understood this perfectly, since she continued to maintain the grip demonstrated to her" (p. 532).

2. Assumed Hunched Carriage of a Crippled Female

Reference: de Waal (1982) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"Krom means "crooked". Her body is distorted and she has a hunched up way of walking. This can sometimes lead to amusing scenes. The young apes, who think up new games all the time, once had an "ape Krom" craze. For days on end they would walk behind her, in single file, all with the same pathetic carriage as Krom" (p. 80).

3. Wrist Walking

Reference: de Waal (1982) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"Luit has an injured finger and foot ... Luit does not walk on his hand for days afterwards. (Instead he supports himself on his wrist. Amazingly, all the young apes imitate him and suddenly begin stumbling around on their wrists.)

4. Bathing a Doll

Reference: Gardner & Gardner (1969) Condition: captive

Authors' explanation: D.I. Criteria failed: 0

Alternative explanation: D.I.

Species: *Pan troglodytes* Name: Washoe

"The following is a typical example of Washoe's delayed imitation. From the beginning of the project she was bathed regularly with us, she always had dolls to play with. One day, during the tenth month of the project, she bathed one of her dolls in the way we usually bathed her. She filled her little bathtub with water, dunked the doll in the tub, then took it out and dried it with a towel. She has repeated the entire performance, or parts of it, many times since, sometimes also soaping the doll" (p. 666).

5. Cheek-Suck instead of Conventional Play-face

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"Another example of the way in which social behaviour may be imitated occurred when a two-year-old infant, during play sessions, consistently sucked in her cheeks instead of showing the normal play-face. After a few weeks other infants with whom she frequently played also began sucking-in their cheeks during play sessions. The face itself was not novel, as it appears in most infants from time to time; the context in which it can be used, however, was new. Within the next few months the habit gradually disappeared" (p. 167).

6. Wrist Shaking

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* Name: Gilka

"Whilst we have not yet witnessed the diffusion of a new form of gestural or postural expression through the whole group, we have seen a novel behaviour being imitated by a few other individuals. One example concerns "wrist-shaking", in which the hand is shaken extremely rapidly to and fro. ... Not until 1964, at Gombe, was a chimpanzee observed to make this gesture; it suddenly appeared in a juvenile, Fifi (on whom we had made very regular observations throughout the previous year), when she was threatening an older female. A younger individual, Gilka, was with Fifi at the time. The following week Fifi was seen to repeat the gesture; the same week Gilka showed the pattern. Subsequently Gilka used the gesture very frequently indeed, in a variety of contexts; whereas Fifi also continued to wrist-shake, but infrequently and usually only in aggressive contexts. During the ensuing year the gesture was used by both individuals less and less often, and finally appeared to vanish from their repertoires" (pp.166-167).

7. Lying on Back Dangling Infant With One Foot While Tickling

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* Name: Fifi

"Flo's daughter Fifi was about six years old when her infant brother was born. Fifi showed much interest in the new baby, Flint ... Some aspects of her behaviour in these respects were almost certainly the result of direct imitation of Flo's behaviour. Thus when Flo played with Flint, she frequently lay on her back, dangled him above her with one of his wrists firmly clasped in her foot, and ticked him. This pattern was not seen in any other mother; but when Fifi played with Flint, she frequently held and tickled him in precisely the same manner. ... Seven years later Fifi had her own first infant. ... she repeatedly lay on her back and dangled Freud from one foot whilst she ticked him, a pattern we have still not seen in other mothers. ... After giving birth, Fifi continued to travel about frequently with her mother, who was still almost constantly accompanied by Flint. And it is of particular interest that Flint not only showed a great fascination for his nephew Freud, but also played with him, often by lying on his back and dangling the infant from one foot" (pp. 165-166).

8. Leaves Used to Wipe Bottom

Reference: Goodall (1973) Condition: wild

Author's explanation: I

Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"Leaves are also used to wipe dirt or blood from the body. On two separate occasions a two-year-old male, after watching his mother pick up handfuls of leaves to wipe diarrhoea residue from her bottom, picked leaves to wipe his clean bottom. In neither case had he himself defecated" (p. 158).

9. Wrist Mopping Gesture

Reference: Goodall (1973)

Condition: wild

Author's explanation: I

Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"During the second month of his first termite season, when an infant was eight months old, he incorporated "mopping" into his gestural repertoire. Mopping is a movement that is rarely if ever seen out of the termiting context and occurs when a number of the insects are crawling about on the surface of the nest. The adult gently places the back of hand and wrist over the termites and gently rotates the hand laterally. This motion causes the termites to become entangled in the hair, or they may bite onto it. The chimpanzee then picks them off with his lips. At first this infant just makes banging-down movements onto objects with the back of his wrist, but after a week he also showed a slight outward rotation of the hand, He did not show the behaviour in context, but mopped almost anything, branches of trees, the ground, rocks, his mother's leg. Occasionally he also mopped at the surface of a termite nest, but was never seen to direct the gesture onto a termite" (p. 156).

10. Wiping Stain on a Dress

Reference: Hayes (1951)

Condition: captive

Author's explanation: D.I.

Criteria failed: 0

Alternative explanation: D.I.

Species: *Pan troglodytes*

Name: Viki

"Sometimes she saw us using materials to which she would not have access until hours later. Nevertheless, by "delayed imitation," she must try her skill. One night she watched me dab furiously with a wash-cloth, trying to remove spilled milk from my skirt. The garment was left hanging in the bathroom, and Viki was shortly put to bed; but the next morning she took down the skirt, wet the wash-cloth, and rubbed at the spots" (p. 182).

11. Using Sandpaper on a Wooden Stake

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* Name: Viki

"The experimenter then rubbed the stake with a piece of sandpaper (which Viki had never used before). She promptly copied this procedure, keeping the abrasive side of the paper against the wood. The motion picture record of this and other instances of imitation is available" (p.451).

Hayes (1951) notes that, "Long after we had finished our movie, she was sanding. In fact, she went indoors and spent several hours sanding our furniture" (p. 182).

The following is my transcript of the above incident from Hayes and Hayes' (1951) film of the incident:

Kathy Hayes has hammered the wooden stake firmly into the ground. She then takes a piece of sandpaper of approximately six inches square. She partially wraps it around the stake and rubs it up and down while Viki pays very close attention. Hayes drops the sandpaper and departs. Viki immediately picks it up and holds it up to her face, perhaps in order to smell it. She then holds the stake in her right hand and rubs the sandpaper up and down the length of the stake as shown. There is a jump in film, presumably because before Viki was sat partially obscuring her actions. Now she is sat facing the camera with the stake directly in front of her. She holds the top of the stake steady with her left hand and continues to rub the sandpaper up and down its length.

12. Applying Lipstick

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* Name: Viki

"Before she was two years old, however, some of her play was much too complex and precise to be so explained [as stimulus enhancement]. For instance, she appropriated a lipstick, stood on the wash-basin, looked in the mirror, and applied the cosmetic - not at random, but to her mouth. She then pressed her lips together and smoothed the color with her finger, just as she had seen the act performed. A similar performance occurred involving face powder" (p. 451).

NB: Of course the note about face powder fails criterion 5.

13. Sharpening Pencils

Reference: Hayes and Hayes (1952) Condition: captive

Authors' explanation: D.I. Criteria failed: 0

Alternative explanation: D.I.

Species: *Pan troglodytes* Name: Viki

"Many of Viki's recent imitations have occurred some time after the original demonstration. For instance, when she saw an experimenter sharpen some pencils, she could not imitate immediately; but within a minute she got a pencil from the next room, returned with it, put it in the sharpener, and turned the crank.

14. Washing Clothes

Reference: Kearton (1925) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan*?? Name: Toto

"One day, as Mr. Percival and I came out of the house, we saw a group of native "boys" sitting on the ground, washing clothes. Taking his place in the circle, accepted apparently without question as an additional helper and hard at work, sat Toto. He was entirely absorbed in the task, washing a cloth with soap in a bowl of water, wring it out in exact imitation of the way the natives worked, then wetting it with a cupful of clean water and wringing it out again" (pp. 80-82).

15. Cleaning Teeth

Reference: Kearton (1925) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan*?? Name: Toto

"This began one day when he sat outside the tent and watched one of the boys cleaning his teeth. The native did not use a brush as we do, but a little wooden stick with a frayed and fibrous end, which did its work exceedingly well. Toto picked this up when the boy had laid it down and, like the perfect imitator that he was, put it into his mouth, drawing it to and fro as the boy had done."

Later Kearton gave Toto a toothbrush:

"He found the method of the white man considerably more difficult than that of the native. He had, ... , a fairly large mouth; but that, instead of making the matter easier, rather added to his difficulties, because he was uncertain into which part of his mouth the brush should be put. First of all he brushed his tongue, and it tickled. Then he tried to eat it.

"Steady old fellow," I said, "Watch what I do," and taking my own brush I held it up to attract his attention. Toto imitated me at once, holding the brush so that it scraped his nose and making him sneeze" (pp. 46-47).

16. Smoking a Pipe

Reference: Kearton (1925) | Condition: captive

Author's explanation: I | Criteria failed: 0

Alternative explanation: I

Species: *Pan*?? | Name: Toto

"One day he watched me in silence for a long while as I sat smoking. Then he came towards me and reached up to touch my pipe.

"It's an evil habit, Toto," I said laughing, "You'd better keep off."

But soon I found he was serious. He wanted to smoke. So I gave him an old pipe, wondering what he would do with it. He went back to his chair, put the stem between his teeth, and leaned back luxuriously, closing his eyes. For a time he seemed content, and for some days after that wherever he went he carried the pipe as if it was his most precious possession. Then he realised that I used to put brown grass into the bowl of mine and set fire to it, and he wanted to do the same with his. I let him try. The matches proved a difficulty, but at last he learnt to strike them and to light the top of the tobacco. But he did not realise the secret of the art of smoking and he was puzzled when the flame in the pipe died directly, while mine continued to send forth clouds of smoke.

It was constantly a problem for him and often I felt he was longing for me to show him how it was done. I tried to do so, but my drawing in of breath must have looked to him merely a matter of making faces; so that I roared with laughter when he began to imitate my expression" (pp. 53-54).

17. Extracting Teeth with Pliers

Reference: Kearton (1927) | Condition: captive

Author's explanation: D.I. | Criteria failed: 0

Alternative explanation: D.I.

Species: *Pan troglodytes* Name: Mary

"Almost anything that she sees me do she will try to do. The other day, for example, she had trouble with one of her teeth, and I had to get a pair of forceps and pull it out. It must have been a painful experience, I am afraid, but, in spite of the pain, it interested her. The next day she discovered the pliers, and went off with them. I found her in the garden, half an hour later, with another member of "My Happy Family" - Tommy, my fox-terrier. She was holding the dog down with one hand, while with the other hand she pulled at one of the dog's teeth with the pliers!" (pp. 14-15).

18. Digging on Beach with Bucket and Spade

Reference: Kearton (1927) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* Name: Mary

"Peter [a young boy] was ready enough, and he at once picked up a spade and began some furious digging, making a moat and throwing the sand into a castle. ...

"Leave it to Mary now," I said, "Catch, Mary. Here's your spade." ... She picked it up and looked at it. A little uncertain as to its purpose, she tried to eat the handle; but either she found it hard or else the flavour did not please her, for she soon put it down and then took it up again by the blade.

"Like this, Mary," Peter cried, and he showed her how a spade should be held. With this personal lesson she seemed to grasp the idea at once, though she worked left-handed - as indeed she often does - and soon she was sitting on the ruined top of Peter's castle, holding the spade with both hands and thrusting its blade into the loose sand. ... And in a minute or two Mary had got the knack of digging and was lifting large quantities of sand at each stroke.

"That was our first success, but I was soon reminded once more of the difficulty one always has with a small child. A child can easily be taught to dig, in the same way that we had taught Mary, but it cannot so easily be taught to dig with any purpose: to build a castle, for instance. A child's first idea of digging is simply to lift a spadeful of sand and scatter it one side or the other. It was exactly the same way with Mary. Try as we would, we could not get her either to finish Peter's castle or to build one for herself. And, after all, it wasn't necessary, for she enjoyed her own method of digging quite as much as any other.

"It was the same also with the sand pies. Copying Peter, she began to put sand into a bucket: but she entirely failed to gasp the principle of patting it firm and turning it out as a "pie". Nevertheless, she obviously thought it the greatest fun to dig sand and fill her pail, and now and then she shouted with glee as she dug deep with the spade" (pp. 84-85).

19. Painting with Paintbrush and Whitewash

Reference: Kohler (1925) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes*

"On the playground a man has painted a wooden pole in white color. After the work is done he goes away leaving behind a pot of white paint and a beautiful brush. I observe the only chimpanzee present, hiding my face behind my hands, as if I were not paying attention to him. The ape for a while gives much attention to me before approaching the brush and paint because he has learned that misuse of our things may have serious consequences. But very soon, encouraged by my attitude, he takes the brush, puts it in the pot of color and paints a big stone which happens to be in the place, beautifully white. The whole time the ape behaved completely seriously. So did others when imitating the washing of laundry or the use of a borer" (p. 157).

NB: Of course the imitation of washing the laundry and using a borer fails criterion 5.

20. Threading a Needle and Sewing

Reference: Sheak (1917) Condition: captive

Author's explanation: I Criteria failed: 0

Alternative explanation: I

Species: *Pan*?? Name: Sallie

"We once had a very intelligent chimpanzee called Sallie. A negro connected with the menagerie had a needle and thread with which he mended his clothes. Sallie watched the operation very intently. A little later she was noticed with a string trying to find an eye in a nail. She was given a small darning needle, and a heavy cotton thread, and at once threaded the needle, just as she had seen the negro do. After that she could not be deceived. When given a nail or a piece of wire, she would look for an eye, and if there was none, she would throw away the counterfeit. She would begin by wetting the end of the thread in her mouth, would place the eye of her needle in line with her eye, pull the thread from behind forward, then pull the thread the remainder of the way with her lips. She often tried to tie a knot too; but in this she was never successful. She always tried to make the knot in the thread up next to the needle. After a number of [un]successful attempts at this, she would go to work on her dress, and sew, and sew, and sew, pulling the thread clear at every stitch. Sometimes she would amuse herself in this way for half an hour" (pp. 308-309).

21. Attempts to Open a Watch Case

Reference: Shepherd (1915) Condition: captive

Author's explanation: I Criteria failed: 6

Alternative explanation: I & E

Species: *Pan*?? Name: Peter

"As a test of imitation, I took out my watch and pressed the stem, slowly, and opened the watch three times while Peter watched my actions with attention and apparently with interest. Then I reached it to him: he held it and pressed on the stem correctly several times, as if to open it. However, he did not press hard enough, and the watch did not open. He thereupon attempted to open it with his finger nails. The keeper stated to me that the ape had not received any training on that act" (p. 393).

Since Peter failed to open the watch it does seem true that he had never been taught to open a watch-cases before. Peter reproduced the correct precise-action but he did not seem to have grasped the functional relevance of pressing the stem. Indeed, it is not clear how one could learn from observation alone how the stem is logically or functionally related to opening the watch-case. When Peter tried to prise open the case with his fingers he showed that he had certainly learned about the "affordances of the object" (paraphrase of Tomasello *et al.* (1993)), i.e., that it opened, but he was using his own behavioural strategy which would indicate he was emulating.

22. Vomiting

Reference: Temerlin (1975) — Condition: captive

Author's explanation: I — Criteria failed: 0

Alternative explanation: I

Species: *Pan troglodytes* — Name: Lucy

"When I started vomiting Lucy rushed in, distressed and concerned as usual, but she also seemed perplexed. I vomited briefly and then went into the bedroom to lie down. Lucy followed me, watched me undress and get into bed, touched me gently as if to reassure herself that I was all right, and then made a bee-line for the bathroom. She stood by the toilet and tried to make herself vomit. She opened her mouth wide, stood on two legs, leaned over the toilet and made gagging sounds as though trying to imitate my vomiting. I do not understand this behavior but since she was distressed by my vomiting before she imitated it, I speculated that identification can be a defense for chimpanzee children as well as for human beings" (p. 151).

23. Learning to Spit

Reference: Yerkes & Yerkes (1929) — Condition: captive

Author's explanation: I — Criteria failed: 0

Alternative explanation: I

Species: *Pan paniscus* Name: Chim

"A boy of twelve who was playing with Chim in the New Hampshire pasture one day began to spit to see whether Chim would imitate him. Chim watched with keen interest and perfect attention. Almost immediately he tried to spit. His efforts were amusing if not effective. The following day in the observation room he was seen off in a corner practising spitting, having achieved in the meantime a fair degree of proficiency. As this performance was promptly discouraged the story stops here" (p. 51).

Reports that Fail Only Criterion 6

24. Swirling "Nest" Building Style

Reference: Fouts *et al.* (1989) Condition: captive

Author's explanation: I Criteria failed: 6

Alternative explanation: C & S.E.

Species: *Pan troglodytes* Name: Loulis

"He [Loulis] learned to build a sleeping nest with blankets in Washoe's unique way. Washoe builds a nest by taking her blanket and swirling it around herself on the floor, and sometimes she wraps herself in it. Then she collects toys and other objects and places them in her nest. For many months, Loulis simply watched Washoe, or played by himself, although occasionally he helped her by giving her a toy. Then, Washoe began to hold Loulis as she built her nest. Loulis learned Washoe's nesting methods and when given his blanket at night, he swirled it around himself as she did" (p. 291).

Captive chimpanzees often exhibit crude nest-making behaviours. For example, Mignault's (1985) chimpanzees "often placed a long object (the hose for example) in a semi-circle in front or around them and, after that, they would take different objects and place them between themselves and the semi-circle" (p. 754). Berstein (1962) found two captive chimpanzees made circular nests reminiscent of those made by wild individuals. It would, therefore, seem that chimpanzees have an innate predisposition to engage in certain nest-making behaviours or rituals.

25. Playing With Infant's Penis

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 6

Alternative explanation: S.E.

Species: *Pan troglodytes* Name: Fifi

"Flo often played with Flint's penis when he was small, tickling it with either her hands or lips. Other mothers show this behaviour very rarely. When Fifi was playing with Flint at that time, she very often played with his penis" (p. 165).

26. Grooming Infants Ears

Reference: Goodall (1973) Condition: wild

Author's interpretation: I Criteria failed:6

Alternative interpretation: S.E.

Species: *Pan troglodytes* Name: Fifi

"Flo was observed to have a particular fondness for grooming the ears of her offspring. Often she held Flint down whilst he struggled to escape as she intently picked around one or the other of his ears. Fifi also frequently paid attention to Flint's ears when she was grooming him ... Seven years later Fifi had her own first infant. During the first few months of his life ... Fifi very often groomed her son's ears" (pp. 165-166).

27. Dorsal Carrying of Infant

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 6

Alternative explanation: I.L., C

Species: *Pan troglodytes* Name: Fifi

"When Flint was about five months old, Flo initiated dorsal riding. On two different occasions about a week apart, we saw her push him up onto her back as she set off; both times he immediately slid down into the normal ventral position. Some two weeks later, Flint was first observed to travel for at least 40 yards on his mother's back. (The pair had been under very frequent observation every day during these months.) Later, on that same day, Fifi expended considerable effort in manoeuvring Flint until she had draped him over her shoulders. Flint was certainly not assisting his sister, and it is almost certain that Fifi was imitating her mother's behaviour" (p.166).

Dorsal carrying in chimpanzees is a species-typical behaviour that could possibly be induced by contagion.

28. Striking a Tree Trunk

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 4,6

Alternative explanation: C

Species: *Pan troglodytes*

In reference to opening tough seed pods or fruits with a hard rind:

" ... he may watch her [his mother] closely, beg from her, and sometimes make ineffectual attempts to imitate her method of coping with the situation.

"One such food is the hard-shelled strychnos fruit about the size of a tennis ball, which the adult opens by banging against the trunk of a tree or rock. Infants under four years of age are seldom able to crack the rind and obtain morsels only begging from others. After watching her sibling opening such a fruit, a two-year-old then hit her own wrist against the tree trunk" (p. 155).

It is possible that vigorously and repeatedly striking any object increases the likelihood of inducing a contagious striking action in an observer.

29. Preparing Termite Probing Tools

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 4,6

Alternative explanation: I.L., S.E.

Species: *Pan troglodytes*

"An infant between one and two years of age often picks a small twig whilst his mother is working at a nest and, apparently playfully, strips off the leaves, thus imitating the manner in which an adult prepares a tool for use" (p. 156).

It could be that having had its attention drawn to twigs the infant engages in a species-typical kind of play.

30. Leaf Used as Olfactory Probe

Reference: Goodall (1973) Condition: wild

Author's explanation: O.L./I Criteria failed: 4,6

Alternative explanation: I.L.

Species: *Pan troglodytes*

"Quite frequently a chimpanzee will use a grass stem or a stick as an "olfactory aide" or investigation probe, in order to touch something he cannot reach or fears. A thin twig may be pushed into a hole in a piece of rotten wood. The chimpanzee withdraws it, sniffs the end, and then either moves away or else breaks open the wood. ... One juvenile female, after sitting with a group of adults staring at a dead python, pushed a long dead palm frond, hand over hand, until the tip touched the python's head. She withdrew her implement, sniffed the end, and then repeated the process twice" (p. 158).

Using objects as olfactory probes may be a relatively common behaviour that is easily independently learned or invented by chimpanzees. Menzel (1971) reports that his young captive chimpanzees poked at strange and alarming objects (e.g., a rubber snake) with sticks.

31. Leaf Grooming

Reference: Goodall (1973) Condition: wild

Author's explanation: O.L./I Criteria failed: 4,6

Alternative explanation: C, S.E., I.L.

Species: *Pan troglodytes*

"Sometimes, particularly when a chimpanzee is involved in a social grooming session, he will reach out and seize a leaf or several leaves. Peering closely at the leaves and often lip-smacking, he holds them with both hands and makes clear-cut grooming movements with one or both thumbs. Sometimes he will remove minute specks with his lips. After a few moments he will drop the leaves and resume other activities. ... Infants watch this behaviour closely. A one-year-old female watched as an adult male leaf-groomed. When he dropped his leaves, she picked one leaf and sucked it, then picked another and carefully scratched down it with one index finger. Infants of about one-and-a-half years have already begun to show adult leaf-grooming behaviour" (p. 161).

Once an infant has seen grooming directed toward a leaf (stimulus enhancement) it is likely this would contagiously induce similar grooming patterns to be directed toward this now salient material.

32. Charging Displays

Reference: Goodall (1973)

Condition: wild

Author's explanation: I

Criteria failed: 4

Alternative explanation: S.E. and C

Species: *Pan troglodytes*

"Youngsters often watch, though from a discreet distance, when adult males perform charging displays. Subsequently, when the excitement is over, the youngsters may execute a display of his own. A three-year-old male, for example, hurried to his mother's embrace as the alpha male of the community, Humphrey, gave pant-hoots preceding a charging display. The infant then watched as Humphrey charged across an open space, slapping the ground with his hands and stamping with his feet. He ended his display by jumping up and pounding with his feet on an empty 44 gallon drum at the observation area. When Humphrey had moved away, the infant left his mother, ran a short distance with much stamping of his feet on the ground, and then paused near the drum. After a moment he walked up to it, again paused, and then hit it gently twice with knuckle of one hand. A three-year-old female also watched from the security of her mother's arms as an adult male displayed, charging along and stamping on the ground. When he had gone, she left her mother, walked to the place where he had displayed, and several times stamped the ground.

"The watching of and imitation of displays is by no means confined to infants. A male of about eight years of age was up in a tree when an adult displayed through the observation area past a group of chimps, dragged a large branch, and went from sight. A few moments later the youngster displayed; he followed almost precisely the same route and also dragged a branch" (p. 164).

Stamping one's feet and slapping the ground are species- typical display behaviours for chimpanzees and are thus likely to be susceptible to contagion. The fact that the observers directed their display behaviour toward the same object as the model could be the result of stimulus enhancement.

33. Termite Fishing Actions

Reference: Goodall (1973)

Condition: wild

Author's explanation: 0

Criteria failed: 4,6

Alternative explanation: I.L., S.E.

Species: *Pan troglodytes*

"Two infants of one-and-a-half years old, after watching their mothers working, picked up short thick pieces of stem and jabbed them at the surface of the nest. In neither case was there a hole there. One of these infants held her "tool" in the manner of an adult, between thumb and forefinger. The other used the "power grip" ... holding her piece of stick rather as a human infant may initially hold a pencil or spoon" (pp. 156-157).

The grips described by Goodall are species-typical in chimpanzees and the jabbing actions directed toward the surface of the termite mound could be the result of individual exploratory play. The fact that the infant paid attention to the twigs and the mound may have been the result of stimulus enhancement.

34. Photographs Flattened Between Pages of a Book

Reference: Hayes and Hayes (1952) Condition: captive

Authors' explanation: D.I. Criteria failed: 6

Alternative explanation: D.E.

Species: *Pan troglodytes* Name: Viki

"On another occasion she saw photographs being flattened between the pages of a book. When she saw the pictures again, about 6 hr. later, she began to put them in a book. (She later generalized this game not only to scraps of paper but also to bulkier objects.) (p. 451).

Viki could have playfully reproduced the same end result of objects lying between the pages of a book (emulation), rather than imitating a novel program or action pattern. No complex program had to be learned (it seems possible that Viki could have worked out for herself how to place objects in a book, especially as she had had prior experience of books) and Hayes and Hayes did not say if any novel exact actions were reproduced. Yet, the fact that Viki was motivated to reproduce this (as far as she was concerned) non-functional activity is still significant (see discussion of imitative and emulative play in chapter 7).

35. Hammering Wooden Stakes into the Ground

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: I Criteria failed: 6

Alternative explanation: S.E. & E

Species: *Pan troglodytes* Name: Viki

"By the time she was three years old, we were sufficiently familiar with these incidents to predict their occurrence and be prepared to record them with a motion picture camera. In one such case, she was allowed to watch the experimenter pound a wooden stake into the ground with a hammer. When the experimenter stepped aside, Viki attempted to duplicate this new use of a familiar tool" (p. 451).

The following constitutes my transcript of the above incident which is taken from the authors' film:

Kathy Hayes crouches holding a thin, straight wooden stake of about 1.5 ft. in length and a hammer. She holds the stake upright in her left hand and taps at its top end with a hammer which she holds in her right hand. She strikes the stake six times so that it seems to be only rather shallowly driven into the grassy turf. During the demonstration Viki playfully runs back and forth without paying much apparent attention. Kathy Hayes lays down the hammer and steps out of the camera's field of view.

Viki immediately grasps the top of the stake in her right hand and it wobbles from side to side. She grasps the hammer in her left hand and strikes at the top end of the stake. She holds the hammer downwards so that the top end of the head strikes at the stake rather than the face as shown. She then pulls the stake out of the ground. She drops the hammer and runs towards the camera picking up a second stake. Viki runs back to the hammer and holding both stakes together with her feet she orients them correctly toward the ground and strikes once at the top points with the hammer. The hammer is still held incorrectly with the top of the head striking at the stakes. She then hits the ground twice with the hammer. She picks up one of the stakes and orientates it correctly and strikes at the top end of it twice with the hammer as before.

Kathy Hayes returns and demonstrates the technique again. She strikes at the top point of one stake with fifteen very rapid taps. Throughout the demonstration Viki hops back and forth and shows more apparent attention than before. Hayes leaves and Viki strikes once at the upright stake using the second stake as a "hammer". She then picks up the hammer in her right hand while holding the upright stake steady with her left hand. She holds the hammer rather awkwardly and strikes once at the top of the stake with the face of the hammer. She then playfully strikes twice at ground. She pulls the stake out of the ground and holding both stakes together she seems to try to drive them into the ground by leaning her weight on them. Viki's actions are very playful and rather uncoordinated throughout.

Viki had learned to use a hammer before but not to drive wooden stakes into the ground. Therefore, it would appear she was using a familiar behaviour to achieve a novel result which constitutes emulation rather than imitation.

36. Screwdriver Used to Prise Off Friction-Lids

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: D.I. Criteria failed: 6

Alternative explanation: Delayed S.E. and E

Species: *Pan troglodytes* Name: Viki

"A delay was introduced into one of the situations set up for motion picture recording: Viki was allowed to watch us use a screwdriver to pry off the friction-type lids of several empty paint cans. She was then taken away and brought back 1 hr. later. She set to work immediately, and after some effort succeeded in opening two cans. (She was already familiar with various other containers and had often used a screwdriver as a lever; but this combination was new to her" (p. 451).

Hayes and Hayes' (1952) film reveals that Viki uses a different and rather less effective levering technique to the one demonstrated. The demonstrated action was to grip the screwdriver with the back of the hand uppermost and with the screwdriver point facing away as the lid was levered off. Viki gripped the screwdriver with the back of her hand facing down and she hugged the can to her while the screwdriver point faced toward her as she levered at the lid.

Since Viki had used screwdrivers to lever things before, all she needed to learn from observation was where exactly to place the tip of the screwdriver (stimulus enhancement) and that the can could be opened (emulation).

37. Stacking Boxes

Reference: Kohler (1925) Condition:captive

Author's explanation: I? Criteria failed: 6

Alternative explanation: E, S.E., R.E.

Species: *Pan troglodytes* Name: Rana

Kohler set three chimpanzees (Grande, Chica and Rana) with the problem of stacking boxes to reach fruit hung overhead. Grande solved the problem as the others watched.

"A new objective is hung up; Rana now puts one of the boxes flat underneath the objective and the second one immediately on top of it (also flat); but the arrangement is too low, and the animals prevent each other from improving it, as they now all want to build on their own, and at the same time. Knowing Rana, I am inclined to assume that this is a case of imitation of what she has just seen, or, at any rate, what she saw was of great help to her" (p. 137).

Once Rana had seen the boxes being manipulated (stimulus enhancement) in combination with retrieval of the food (result enhancement), she may have much more motivated to use the boxes in her attempt to reach food.

38. Ladder Making

Reference: Menzel (1972/1973) Condition: captive

Author's explanation: I Criteria failed: 6

Alternative explanation: E

Species: *Pan troglodytes*

One member of a social unit of 8 wild-born chimpanzees learned to gain access to elevated points such as viewing windows and trees by using a pole as a bridge between two points. All the chimpanzees had used poles for "vaulting" by standing them vertically and then rapidly climbing up to jump from the top to an elevated point. Prior to May 1970 they had not been observed deliberately propping poles against structures to climb up them. One male chimpanzee, Rock, in early May of 1970 used a pole as a ladder to climb up to an elevated observation area. The pole was removed and for "at least a week, Rock made no attempt to transport new poles to the scene, although at least 15 poles were available in other parts of the compound" (p. 91).

About one week after Rock's discovery of ladder construction, all the chimpanzees were found one morning in the "forbidden" elevated observation area. That day five chimpanzees including Rock were observed positioning and using ladders. "Once this behavior developed the chimpanzees set up their ladders at almost any point along the walls and fences of their enclosure, against trees, etc." (Menzel 1973, p. 451). Altogether 7 out of the 8 chimpanzees used poles in this fashion.

The chimpanzees also learned to erect ladders on elevated platforms and climb past protective electric fences into trees. "Rock was clearly the "inventor" and others learned it only over a period of several months, if at all" (Menzel 1973, p. 451). Eventually, one year after the first ladder use a female, Gigi, learned to use long poles to climb over the fence of the enclosure and escape. Rock was absent at the time but the day after the first escape all the other chimpanzees were performing the same behaviour."

The chimpanzees need not actually have observed a pole being erected and climbed in order for them to learn the technique. Simply climbing up a pole that was already in place may have been sufficient for other chimpanzees to learn the advantages of such an arrangements. The chimpanzees could then learn for themselves how exactly to position the poles. In fact, Menzel *et al.* describe some of the chimpanzees going through extensive trial and error as they tried to erect "ladders".

39. Cushion Making Courtship Display

Reference: Nishida (1987) Condition: wild

Author's explanation: none given Criteria failed: 4

Alternative explanation: C & O.C.

Species: *Pan troglodytes* Location: Mahale

"Recently, another style of courtship display was discovered among Mahale chimpanzees. Typically, a male sitting on the ground or in the tree, faces an estrous female and makes a crude bed or cushion (often bending two to four shrubs down to the ground), which he sits on. Then he stamps his foot. This behavior may be derived from the branch shaking in courtship, which is commonly observed in the chimpanzees of Gombe and Mahale. Interestingly, this pattern has not been observed for K-group's chimpanzees, but has been recorded only for about 10 (mostly immature) males of M-group. Therefore, it is plausible that this is a newly acquired behavior pattern that has been transmitted neither to all the members of M-group not [sic.] to the local population; Thus, it might be "incipient" culture. Newly invented behavioral patterns can be "exported" to other groups when females acquire them because, in the chimpanzee, females, more than often males, transfer ... the cushion-making display has not been seen in any females of M-group" (p. 466).

Nestmaking is a species typical behaviour in chimpanzees (Berstien 1962) that could be triggered contagiously. A male chimpanzee's courtship display involves sitting with the legs apart to reveal his penile erection and making soft grunts presumably to gain the female's attention. Foot stamping may be another way to draw attention of a female. If one individual has an idiosyncratic tendency to make nests in the sight of estrous females this might contagiously trigger nest-making in excited male onlookers. If this gains the attention of estrous females along with foot stamping these are likely to become reinforced behaviour patterns.

40. Nut-cracking

Reference: Sumita *et al.* (1985) Condition: captive

Author's explanation: I Criteria failed:0

Alternative explanation: E., S.E. & C.

Species: *Pan troglodytes*

Two adults and a sub-adult chimpanzee learned to use rocks to break open hard shelled walnuts. The authors proposed that there were three stages involved in the adult's' acquisition of nut-cracking. First, there was trial and error behaviours in which somewhat random actions were performed upon the nuts, stone anvil and hammer. Second, the behaviour "patterns consisted of striking motions and the placing of nuts on the anvil, and they tended to appear shortly after demonstrations had been observed ... In Stage 2, the method of tool use was understood through imitation of the striking motions of the demonstrated behavior. This process can conceivably be based on mental combination. Even after the method was understood, a nut was not cracked unless the proper skills were learned. In Stage 3, while testing various ways of actually hitting the nut, a subject learned the proper technique and finally achieved success. ... The infant did not follow the staged process of understanding method and learning skills as the adults did, but reached the solution through goal-directed trial-and-error" (p. 180).

The increase of striking motions shortly after observation may have been a contagious response. Placing the nut on the anvil can be explained as stimulus enhancement. With no control group to gauge the development of nut-cracking without a demonstration one cannot determine whether imitation was involved.

Reports that Failed Criterion 5

41. Learning the ASL Gestures for "Drink", "Blanket" and "Apple"

Reference: Fouts *et al.* (1989) Condition: captive

Authors' explanation: I? D.I.? Criteria failed: 5,6

Alternative explanation: O.C.

Species: *Pan troglodytes* Name: Washoe & Loulis

"When she was an infant in Reno, Washoe's human foster family taught her signs by modelling, molding, and signing on her body the way human parents teach deaf infants [three references]. She used all these methods with her own [foster] infant, Loulis. ...

"Sometimes the first observation of a new sign involved direct imitation. For example, Loulis first used DRINK during a meal after Washoe used this sign in answer to a human caregiver who had asked WHAT about a drink. As Washoe was signing DRINK, Loulis watched her and signed DRINK, himself. ...

"It is important to remember that Washoe and Loulis were not under constant observation. Funds available in those critical early days permitted only four hours per day of scheduled observation by trained observers. In only a handful of cases could we be sure that we had observed the events surrounding the first use of a sign by Loulis. In most cases Loulis' signs appeared to be delayed imitations of signs that he had seen Washoe or another signing chimpanzee using in similar contexts (Fouts, Hirsch & Fouts, 1982). ...

"Washoe herself has learned new signs from Moja, Tatu, and Dar. Because the Gardeners could not find the BLANKET sign in the sign language manuals then available, Washoe was taught to use the noun/verb COVER for blankets ... Later in Reno, Moja, Tatu, and Dar were taught BLANKET, which differs in place, configuration, and movement from COVER ... After these younger chimpanzees joined her, Washoe came to use both signs for blankets. From Moja, Washoe acquired a more precise form of the sign APPLE, and used it for apples, only. She continued to use the earlier form of her sign for several different kinds of fruit" (pp. 289- 291).

For an explanation of how such behaviour might be inadvertently shaped by human caregivers see Gardner and Gardner's note at the end of report number 44.

42. ASL Gesture for Toothbrush

Reference: Gardner & Gardner (1969) Condition: captive

Authors' explanation: D.I.? Criteria failed: 5,6

Alternative explanation: O.C.

Species: *Pan troglodytes* Name: Washoe

"Some of Washoe's signs seem to have been originally acquired by delayed imitation. A good example is the sign for "toothbrush" ... (used to brush teeth after every meal. She would go to rush away from the table and would be stopped with signing "first, toothbrush, then you can go.") One day, in the tenth month of the project, Washoe was visiting the Gardener home and found her way into the bathroom. She climbed up on the counter, looked at our mug full of toothbrushes, and signed "toothbrush" (p. 667).

NB: "Toothbrush" was signed with the index finger used as a brush to rub the front teeth.

Washoe's behaviour is not described in sufficient detail to be able to independently evaluate whether this is imitation. If she only vaguely touched her mouth or teeth in response to seeing the toothbrushes this could because she quite naturally associated these objects with her teeth and mouth. If she clearly bared her teeth and held one index finger in front of them moving her hand stiffly up and down, as the standard ASL sign requires, then this would be precise-action imitation.

43. ASL Gesture for Flower

Reference: Gardner & Gardner (1969) Condition: captive

Authors' explanation: D.I.? Criteria failed: 5,6

Alternative explanation: O.C.

Species: *Pan troglodytes* Name: Washoe

"The sign "flower" may also have been acquired by delayed imitation. From her first summer with us, Washoe showed a great interest in flowers and pictures of flowers accompanied by the appropriate sign. Then one day in the fifteenth month she made the sign, spontaneously, while she and a companion were walking toward a flower garden" (p. 667).

NB: Flower was signed with the tip of the index finger(s) touching one or both nostrils (the correct ASL form was the tips of one tapered hand touching one nostril then the other.

The authors note:

"It is difficult to decide which signs were acquired by method of delayed imitation. The first appearance of these signs is likely to be sudden and unexpected; it is possible that some inadvertent movement of Washoe's has been interpreted as meaningful by one of her devoted companions" (p. 667).

44. Weaver Ant Nest Processing

Reference: Goodall (1973) Condition: wild

Author's explanation: 0 Criteria failed: 5,6

Alternative explanation: Previous I.L., S.E.

Species: *Pan troglodytes*

"Weaver ants (*Oecophylla longinoda*) construct a nest by joining a clump of leaves together with sticky silk; they are eaten by chimpanzees during about two months of the year. An adult chimpanzee will pick an entire nest and then make a rapid downward movement with one hand or foot which serves to sweep off any ants crawling on the surface and probably also partially to crush those within. He then breaks open the nest and feeds on the insects. One infant, about three years of age, was not observed to attempt to feed on weaver ants during the season. The following year I saw her, after watching an older playmate feeding on these insects, hurry to a hanging nest, pick it very quickly, make a few frantic-looking sweeping movements, race from the spot, make a few more sweeping movements, and then drop the entire nest without eating any of the ants" (p. 155).

The young chimpanzee may have attempted to eat weaver ants before and had been bitten by the insects. Hence, the frantic sweeping movements could have been the result of previous trial and error learning. The fact that she did not eat the ants may have been because she was either too nervous of being bitten or not sufficiently motivated.

45. Ant-dipping

Reference: Goodall (1973)

Condition: wild

Author's explanation: O.L./I

Criteria failed: 5,6

Alternative explanation: ?

Species: *Pan troglodytes*

"Ants of two species are eaten usually with the aid of quite large sticks. When raiding an underground nest of *Anomma nigricans* (the "safari ant"), the chimpanzee plunges his stick down into the nest (usually from an overhead branch), waits for a moment, withdraws the stick, which he eats. Once, when a five-year-old saw a few of these ants moving over the surface of the ground, she broke off a stick, pushed it down into the sandy soil, stepped back, and then pulled out her tool. Since there was no nest at that spot, her behaviour was unrewarded" (p. 157).

The chimpanzee may have already learned to ant-dip but was using this familiar action in an inappropriate context.

46. Levering Upon an Ant Nest

Reference: Goodall (1973)

Condition: wild

Author's explanation: O.L./I

Criteria failed: 5.6

Alternative explanation: S.E.

Species: *Pan troglodytes*

"Another ant species of ant *Crematogaster sp.*, constructs a hard-walled nest on the branches of trees. Chimpanzees may push sticks into these nests and pick off the ants. One mother carefully examined an intact nest, selected a stick, and using it as a lever, tried unsuccessfully to push it between the nest and the branch. After watching, her five-year-old daughter also found a stick and tried to use it in the same way" (p. 157).

It is possible that the daughter had already learned to lever objects with sticks. Once her attention was drawn to the stick in combination with the nest, she may have been independently trying to lever the nest, irrespective of her mother's actions.

47. Rapid Spread of Nut-Cracking

Reference: Hannah & McGrew (1987) Condition: semi-wild

Authors' explanation: I Criteria failed: 5,6

Alternative explanation: S.E., R.E., E

Species: *Pan troglodytes*

Sixteen ex-captive chimpanzees were released on an island in Liberia. One female began to crack nuts with a stone and on the same day three others successfully cracked nut. Within two months, 13 of the chimpanzees were nut-cracking. None had cracked nuts in captivity and 10 individuals who had been on the island prior to the "inventor" had not showed the behaviour. Several of the chimpanzees exhibited idiosyncratic methods for cracking nuts.

The other chimpanzees may have had their attention drawn to the nuts and stones and then independently learned the details of nut-cracking.

48. Grooming Hand Clasp

Reference: McGrew & Tutin (1978) Condition: wild

Authors' explanation: "some sort of social learning"

Alternative explanation: O.C.

Criteria failed: 5

Species: *Pan troglodytes*

"During these observations we witnessed a behaviour pattern which to our knowledge has not been described before in chimpanzees. This we have called the grooming-hand-clasp ... It occurred fourteen times, always at the beginning of, or during, an otherwise normal bout of social grooming. Each of the participants simultaneously extends an arm overhead and then either one clasps the other's wrist or hand, or both clasp each other's hand. Meanwhile, the other hand engages in social grooming of the other individual's underarm area revealed by the upraised limb, using typical finger movements. In doing this, the two chimpanzees sit facing each other on the ground in a symmetrical configuration. Either both raise their right arms and groom with their left, or vice-versa. With one exception ... the participants engage in dyadic and mutual (as opposed to polyadic or reciprocal) social grooming" (p. 238).

It is possible that if one individual, A, has the idiosyncratic tendency to grasp and raise another individual, B's, arm during mutual grooming bouts, that B may find this posture comfortable and hence raising his arm is rewarded or reinforced. As more individuals are exposed to A's grooming hand clasp an increasing number of chimpanzees may be more likely to raise their arms in mutual grooming situations. If the behaviour was transmitted in this way, it would be self-perpetuating and would spread at a geometric rate.

NB: The grooming hand clasp has also been observed in the chimpanzees of Kibale Forest, Uganda (Ghiglieri 1984).

49. Key Used to Unlock Cage Door

Reference: Menault (1869), p.370 Condition: captive

Author's explanation: 0 Criteria failed: 5,6

Alternative explanation: S.E.

Species: *Pan*??

"It first of all fixed its eyes on the door of the room in which it was imprisoned; but this door was locked, and the key hung on a nail. The ape was not discouraged by this obstacle. Raising himself on the points of his toes, he tried to possess himself of the key, but the nail hung too high for him to reach it. After several useless attempts, in which the animal showed as much perseverance as sagacity, it comprehended that the key was placed at such a distance that it would never be able to reach it even with the tips of his fingers. It then placed a chair against the wall, mounted, and unhooked the key. That done, it got down, inserted it very cleverly into the lock, and unfastened the door" (p. 370).

Although the chimpanzee's behaviour seemed very intelligent, it could have previously learned how to use keys to unlock doors.

50. Leaf Clipping

Reference: Nishida (1980; 1987) Condition: wild

Author's explanation: not stated Criteria failed: 5

Alternative explanation: S.E. & C

Species: *Pan troglodytes*

"Another behavioral pattern peculiar to Mahale chimpanzees is the "leaf-clipping display." A chimpanzee picks one to five stiff leaves, grasps the petiole between the thumb and the index finger ... repeatedly pulls it from side to side while removing the leaf blade with the incisors, and thus bites the leaf to pieces ... In removing the leaf blade, a ripping is conspicuously and distinctly produced. When only the midrib with tiny pieces of the leaf blade remains, it is dropped and another sequence of ripping a new leaf is often repeated. This occurs most commonly (23 of 41 observations) in sexual contexts, such as "herding" behavior, or as a courtship display. Otherwise it occurs when the chimpanzee seems frustrated (Nishida 1980b)" (p. 466).

Perhaps clipping leaves is a fairly easy behaviour for chimpanzees to learn through individual learning (as I child, I often pulled leaves apart in my hands so that I was left holding just the central spine). If the chimpanzees perform the behaviour when they are generally bored or frustrated - and courtship and aggressive situations must often be very frustrating - leaf-clipping may be very likely to appear. If it then has the advantage of drawing the attention of a female or assailant, it could possibly become a reinforced pattern of behaviour. If several chimpanzees regularly engage in leaf clipping, it is possible that leaves will become enhanced objects for any observers who are then more likely to explore leaves and independently learn the advantages of clipping them.

51. Reproduced the letters "W" and "T" with Pencil and Tablet

Reference: Shepherd (1915) Condition: captive

Author's explanation: I Criteria failed: 5

Alternative explanation: ?

Species: *Pan troglodytes* Name: Peter

"I held out a writing tablet and a pencil to Peter. He at once seized them and began scribbling, i.e., making irregular marks, on the tablet. I make, in his sight, the letter T; a very plain T, with simple one vertical and one horizontal stroke of the pencil. The ape make a rather poor T, the first time shown. He also make a W when I showed him once. Peter seemed to like to use the pencil and tablet" (p. 393).

NB: Of course the question is begged: is this the same chimpanzee, called Peter, that Witmer (1910), (see report 54), tested? If this is the same chimpanzee, it is possible he was taught to reproduce certain letters as a circus trick.

52. Branches Used to Pull Down Tree Limbs

Reference: Sugiyama & Koman (1979) Condition: wild

Authors' explanation: I

Criteria failed:5,6

Alternative explanation: I.L. and S.E.

Species: *Pan troglodytes*

A group of chimpanzees were unable to climb into a fig tree because the trunk was too wide. One male, Aiwa, beat at a low branch with sticks that he stripped of twigs and thorns. After an hour's effort he managed to bounce upon the branch he was standing on and catch the higher limb. An observer, Bafu, unsuccessfully tried to hook or beat the branch down. A third male, Tua, tried to hook the branch and also "swung the main branch, stretched his hand up like Aiwa and touched a fig leaf but failed to catch it" (p. 520). Finally, Tua reached the branch by weighing it down with a heavy stick. As Tua climbed up the other chimpanzees swarmed up in his wake.

The authors comment that, "The third exponent, Tua, tried not only the first animal's methods but also a new method of his own invention. This indicates that the chimpanzees were not only able to imitate a previous method but also to devise and improvise in their daily life" (p. 523).

It is possible that Bafu had previously learned to use sticks to hook objects. Aiwa could have drawn his attention to the branch and he then independently tried to solve the same problem in a familiar way.

53. Reproduced the letter "W" with Chalk on a Blackboard

Reference: Witmer (1909)

Condition: captive

Author's explanation: I

Criteria failed: 5

Alternative explanation: ?

Species: *Pan troglodytes*

Name: Peter

"I drew forward a blackboard, the writing surface of which he could easily reach when standing upon the table. He took a piece of chalk eagerly, and before I had make any mark upon the board, began to scrawl in a corner of it. I took the chalk from him and said, "Peter, I want you to do this," and rapidly make the letter W in four strokes. Peter's attention had not been fully given while I made the letter. He took the chalk and scrawled beneath in much the same manner as he had done before. I picked upon another piece of chalk and said, now look, this is what I want you to do," and traced another W over the one which I had just drawn. Peter watched the operation intently, then with the chalk in his hand, he quickly made the four movements and drew a fairly perfect letter beneath the W which I had traced. After a brief interruption due to the excitement of the spectators at this performance, Peter's interest in the board still remaining as appeared from his continued scrawling, I asked him to try again, and he made at some distance from the first letter another W, somewhat less perfectly formed" (pp. 193-194, cited in Candland 1993, p. 203).

Peter was a circus chimpanzee and could have been taught to imitate certain letters as part of his act.

Reports that Fail Criteria 4

54. Use of Bowls and Spoons

Reference: Fouts *et al* (1989) Condition: captive

Authors' explanation: none given Criteria failed: 4,6

Alternative explanation: S.E.

Species: *Pan troglodytes* Name: Loulis

"In addition to signs, Loulis acquired other skills from the cross-fostered chimpanzees. He learned to use bowls and spoons as feeding implements, just as Washoe, Moja, Tatu, and Dar used them" (p. 291).

The behaviours are not described in sufficient detail.

55. Various Human Activities

Reference: Furness (1916) Condition: captive

Author's interpretation: I Criteria failed: 4

Alternative explanation: ?

Species: Pan

"Simple actions such as digging with a spade, or trowel, sweeping, screwing in a screw she learned entirely by imitation" (p. 289).

The behaviours are not described in sufficient detail.

56. Various Human Activities

Reference: Hayes (1951) Condition: captive

Author's interpretation: I Criteria failed: 4

Alternative explanation: ?

Species: *Pan troglodytes* Name: Viki

"Viki showed her first evidence of imitation at sixteen months of age, when she began crudely copying my household routine - dusting, washing dishes, pushing the vacuum cleaner about. In a very short time, however, we began to wish that Viki were not quite so enterprising. For instance, one day she claimed the grater from my lemon-pie-making residue, helped herself to a lemon from the refrigerator, and grated it all over the living-room rug.

"As Viki grew, such imitative play became more frequent until every tool we used, every little action, was apt to result in her attempts at duplication - hair brushing, finger filing, eyebrow tweasing, the use of a saw, a drill, a bottle opener, a pencil sharpener" (pp. 181-182).

None of Viki's specific behaviours are described in sufficient detail.

57. Various Human Activities

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: S.E., I Criteria failed: 4,6

Alternative explanation: S.E.

Species: *Pan troglodytes* Name: Viki

"Most of Viki's imitation occurs in play. At about 16 mo. of age she began to imitate such bits of household routine as dusting furniture and washing clothes and dishes. Her early efforts were quite crude and could perhaps be ascribed to stimulus enhancement" (p. 451).

The behaviour is not described in sufficient detail, although the assessment of the behaviour as stimulus enhancement is instructive.

58. Cleaning Windows with a Spray Nozzle Detergent

Reference: Hayes & Hayes (1952) Condition: captive

Authors' explanation: D.I. Criteria failed: 4

Alternative explanation: E

Species: *Pan troglodytes* Name: Viki

"Delayed imitation often results when Viki watches an activity through the screen door of her room. She once saw the window being cleaned with a solution from a bottle with a spray gun built in the cap. When she was admitted to the living room about 15 min. later, she went directly to the bottle and sprayed its contents on a window" (p. 451).

There are not enough details given to evaluate whether Viki learned how to use the spray-lever mechanism immediately indicating imitation or through trial and error.

59. Various Human Activities

Reference: Kearton (1927) | Condition: captive

Author's explanation: I | Criteria failed: 4

Alternative explanation: ?

Species: *Pan troglodytes* | Name: Mary

" ... simply by imitation, she has learnt to do a great many things which probably no chimpanzee ever did before. For instance, she can paddle a boat on the lake in my grounds: she enjoys smoking a cigarette or a pipe, striking a match and lighting it herself: and she can unlock a box with a key, choosing the right key off a bunch. These things she has learnt, not by being taught as tricks, but simply by watching me do them, and then puzzling out the correct actions herself" (pp. 13-14).

None of these behaviours and especially Mary's first attempts to perform them are described in detail.

60. Various Human Activities

Reference: Rothman & Teuber (1915) | Condition: captive

Author's explanation: I | Criteria failed: 4

Alternative explanation: ?

Species: *Pan*??

"Certain of our chimpanzees quickly learned to open doors and to insert keys into locks on seeing these things done. They learned also to use a lever to regulate the water supply, and in imitation of their keeper tried to scrub the floor and sweep with a broom".

The precise behaviour of the chimpanzees, especially when they first encountered these objects, are not described and so it is impossible to judge whether the learning process is true imitation.

61. Various Human Activities

Reference: Sheak (1923) | Condition: captive

Author's explanation: I | Criteria failed: 4

Alternative explanation: ?

Species: *Pan*?? Name: Joe

"He learned to wipe his nose with a handkerchief, brush his hair with a hairbrush, clean his clothes with a whisk broom, drink out of a cup, eat with a spoon as well as any human child, bore holes with a brace and bit, use a hand saw quite dexterously, take screws out of the guard rail with a screw driver, drive nails with a hammer, and to play on a toy piano and on a mouth harp" (p. 55) cited in Yerkes & Yerkes 1945).

Sheak tells us that no special effort was made to teach the chimpanzee, but that "he was a close observer and persistent imitator".

Even it no special effort was made to teach the chimpanzee, it could still have learned these behaviour via social learning processes other than true imitation.

62. ASL Gestures for "Orange" and "Tree"

Reference: Terrace (1979) Condition: captive

Author's explanation: I Criteria failed: 5

Possible explanation: O.C.

Species: *Pan troglodytes* Name: Nim

"In many instances it was possible to teach a new sign through imitation alone. Laura, for example, taught Nim to imitate her orange sign after looking at a picture of an orange. Dick taught Nim to sign tree by pointing to a tree and signing tree. Nim showed his understanding of the sign by signing tree himself and then running around the tree or jumping up into one of its branches" (p. 139).

Orange: closed fist held up to the chin

Tree: raised lower arm while grasping elbow of other hand across body

Nim could have learned the form of the signs through the experimenters inadvertently shaping his response (see Gardner and Gardner's (1969) comment at the end of report number 44).

Reports that Fail Criteria 1, 2 or 3

63. Fire-making

Reference: Buttehofer 1893, cited in Harris 1968.

Condition: wild

Criteria failed:1,2,3,5

Author's interpretation: 0

Alternative interpretation: ?

Species: *Pan*??

"The cleared ... spaces ... are used by the chimpanzees to build immense bonfires of dried wood ... When the pile is completed one of the chimpanzees begins to blow at the pile as if blowing the fire. He is immediately joined by others, and, eventually, by the whole company, and the blowing is kept up until their tongues hang from their mouths, when they sit around on their haunches with their elbows on their knees and holding their hands to the imaginary blaze. In wet weather they frequently sit this way for hours together"" (p. 254).

This anecdote fails nearly all the criteria outlined earlier, it is included principally for historical interest!

64. Finger Motions in Typing

Reference: Cameron (1969)

Condition: captive

Author's explanation: I

Criteria failed:2,3,5

Alternative explanation: ?

Species: *Pan*??

"There were three chimpanzees; I came to know them well. ... There was one genuinely startling moment: I was working beside the window, grinding out from the typewriter whatever contemporary nonsense was required ... when I glanced round and there were the monkeys in a row, by the doorway, beating out a ragged tattoo with their fingers on the floor; a very reasonable imitation" (pp. 164-165).

Cameron was a journalist visiting Albert Sweitzer's camp in Africa. The chimpanzee were camp residents who befriended Cameron. He admits he knows very little about chimpanzees and therefore his report must be treated with great caution.

65. Leaf Sponging

Reference: Goodall (1973) Condition: wild

Author's explanation: O.L./I Criteria failed: 1,5,6

Alternative explanation: S.E. and R.E., E

Species: *Pan troglodytes*

"The Gombe Stream chimpanzees use leaves as a "sponge" to sop up rain-water from a hollow in a tree trunk or branch that they cannot reach with their lips. Before use the tool is modified: the chimpanzee briefly chews the leaves, thus crumpling them and increasing their absorbency. All the adults who have been observed drinking from such water bowls have used leaves in this way. Some infants, however, have merely dipped their hands into the bowl and licked the water from their fingers. F. Plooij [personal communication] watched as one mother began to use a sponge. Her two-year-old daughter moved up to sit closely behind her, but was unable to get a good view of the activity from this position. Since the mother was sitting on the only branch projecting from the main trunk at that place, the infant made a two-minute journey (with pauses) involving locomotor manoeuvres difficult for her, until she reached a place from which she could watch her mother's behaviour. She looked intently for half a minute and moved away until her mother left the water bowl. The infant then returned and for six minutes repeatedly dipped her hand in the water and licked her fingers. Another infant of similar age watched her mother drinking with leaves and then used the sponge which had been left in the bowl. Infants between three and four years of age have successfully demonstrated the adult technique" (pp. 157-158).

Neither infant immediately repeated the adult technique. They simply observed closely and had their attention drawn to the reward (i.e., the water) and the stimuli (i.e., hollows in trees and chewed leaves).

66. Vigorous Scratching Before Grooming

Reference: Goodall (1973) Condition: wild

Author's explanation: I Criteria failed: 1,6

Alternative explanation: C

Species: *Pan troglodytes*

"The mother, Madam Bee, was victim of a paralytic disease during which she lost the use of one arm. At the time her two daughters were about eight and one and one-half years old, respectively. As a result of her affliction, Madam Bee has developed an unusual social grooming technique. Normally when a chimpanzee grooms a companion, he parts the hair with one hand; and with the other, and often with lips as well, picks at small flakes of dried skin, and so on. When a chimpanzee is grooming his own arm he usually first scratches down the limb quite rigourously before proceeding to part the hair and pick out particles with his hands and lips. Madam Bee very often shows the vigorous scratching on her companion's body that is typical of self-grooming. Today her eldest daughter shows normal social grooming techniques; but the younger one, now about seven years old, often scratches her mother vigorously before grooming her [M. HANKEY and A. PUSEY, personal communication]" (pp. 173-174).

In the context of grooming, Madam Bee's daughter was used to being scratched. It seems likely that vigorous scratching is a contagious behaviour and the youngster was much more likely to start scratching when she came to groom her mother.

GORILLAS

Failed No Criteria

67. "Exercise"

Reference: Anon (1992)

Condition: captive

Author's interpretation: I

Criteria failed: 0

Alternative interpretation: I

Species: *Gorilla gorilla*

Name: Michael

Penny Patterson was advised to do a number of exercises to alleviate a back ache. Michael begins to put his hands behind his head and hold his elbow up and forward. This action is interpreted as his way of referring to Patterson's behaviour and is indicated in the text by the word "exercise" printed in bold face.

"Penny begins by doing a "chicken wings" exercise, first raising her hands above her head, then lowering her arms and tucking her elbows behind her hips. Mike grasps his head with his two hands ... Next, Penny does the "taffy pulling" exercise.
M: Cough, cough.
P: Did you swallow something wrong? (voice only).
No response. Penny moves on to knee bends.
M: Exercise. [Both hands held behind head with elbows pointing forward.]
P: Yes!
Mike continues to cough and grunt the following day when Penny exercises, and she realizes he is imitating the straining sounds she makes" (PP. 7-8).

The gorilla's response is sufficiently improbable that even with human reinforcement there is good reason to accept his behaviour as imitative.

Failed Criteria 6

68. Digging a Trench

Reference: Anon (1992)

Condition: captive

Author's interpretation: 0

Criteria failed: 6

Alternative interpretation: D.I.

Species: *Gorilla gorilla* Name: Koko

"The second day of construction, the workmen dug an L-shaped trench in the south-east corner of the new play-yard area ... After all the workmen left for the day, Koko wanted to go outside to the existing play-yard for a closer look. Using one of Michael's PVC pipes, Koko worked on an "excavation" project of her own ... A few minutes later Ron discovered that Koko had dug a miniature, scale-model L-shaped trench in the south-east corner of the existing play-yard."
[This report was accompanied by a photograph of Koko's trench. It is a very shallow scraping in a rough L-shape.]

Koko need not imitate the actual program or exact action used to dig a trench. All she need do is try to match the finished product.

69. Failed to Imitate Various Activities

Reference: Yerkes (1927) Condition: captive

Author's interpretation: Negative Criteria failed: 6

Alternative interpretation: E

Species: *Gorilla gorilla* Name: Congo

"Nothing I ever did by way of manipulating objects; whether sticks, boxes, hammer and nails, pencil and paper, pipe, or the parts of my own body, as for example by opening my mouth, grimacing, making gestures, etc., had obvious effect on the form of her response. ... In the several stick, box, and lock problems which I attempted to help Congo with, she gained more I think by watching the result of series of acts than by following the acts themselves and attempting to reproduce them" (p. 497).

Yerkes also gave Congo his pipe which she had seen him smoke very often. According to Yerkes, she bit the bowl as if it were a nut. When she was given a broom she simply fingered the end lightly and pushed it away.

<u>Failed Criteria 4 or 5</u>

70. Turning Pages of "Book"

Reference: Tanner (1990) Condition: captive

Author's interpretation: 0 Criteria failed: 4

Alternative interpretation: S.E.

Species: *Gorilla gorilla* Name: Bouba

"Edalee (Bouba's zoo keeper) also bought books for her to look at through the bars. On Jan. 4, 1979, she reported, "I had newspaper, with red printing and has pictures, torn and folded into small "books". I took mine, turned the pages and read it, then pushed one through the bars to Bouba. She began studying it, opening the pages and holding it correctly" (p.8).

There are not enough details related to exactly how the gorilla held the booklet to distinguish her behaviour from stimulus enhancement.

71. Pulling a Strange Face

Reference: Tanner (1990) Condition: captive

Author's interpretation: I Criteria failed: 4,5

Alternative interpretation: ?

Species: *Gorilla gorilla* Name: Bouba

Tanner (1990) quotes from a letter by Lisa Kaschak, Bouba's present day keeper:

"One day after waiting an hour for her to move to her holding area, I became exasperated and made a face at her. Instantly she responded making the same face at me" (p. 9).

Without a description of the actual facial expression there is no way to evaluate the gorilla's response.

72. Making a Strange Gesture

Reference: Philips (1989) Condition: captive

Author's interpretation: I Criteria failed: 4

Alternative interpretation: ?

Species: *Gorilla gorilla* Name: Koko

""Can you do this?" I puff out my cheeks, then slap them, making a rather rude noise. She does the same" (p. 9).

Without a description of exactly what Koko did in response it is difficult to evaluate her behaviour. It seems that she may have perfectly reproduced the action, but further elaboration of the account is needed.

73. Making a Strange Gesture

Reference: Hillar (1984) Condition: captive

Author's interpretation: I Criteria failed: 4

Alternative interpretation: ?

Species: *Gorilla gorilla* Name: Koko

""If I knock on my head, my tongue sticks out!" I knock on my head and stick out my tongue. Koko copies me and laughs" (p. 9).

Further elaboration of exactly how Koko responded is needed in order to evaluate her behaviour.

74. Facial Expression

Reference: Gordon (1992) Condition: captive

Author's interpretation: I Criteria failed: 4

Alternative explanation: ?

Species: *Gorilla gorilla* Name: Koko

"Ndume (a male gorilla) characteristically bares his lower teeth in an expression of annoyance. Koko's frequent imitation of Ndume's facial expression seems to be one way of referring to him" (p.7).

More details are necessary before one can independently evaluate this reported behaviour.

75. ASL Gestures for Fake, Eat, Gimme and Drink

Reference: Gordon (1992) Condition: captive

Author's interpretation: I

Criteria failed: 5

Alternative interpretation: ?

Species: *Gorilla gorilla*

Name: Ndume

Ndume was a male gorilla who was raised in a zoo and lent to the Gorilla Foundation for breeding purposes with the expressed agreement that he would not be directly taught any sign language. The following are notes from one of the caretaker's diary on Ndume.

"December 19, 1991
While Penny is feeding sweet potato to Ndume through the window Ndume gestures **fake** (index finger brushes across nose) and **points** to a workman outside.

December 20, 1990
Penny is feeding Ndume. Ndume pokes back the greens she offers and turns slightly away from the bean spouts, and gestures **fake**.

January 26, 1992
Ray is wearing a sweat-shirt bearing the Gorilla Foundation logo, which consists of two gorilla silhouettes facing each other, one with hand to mouth in the eat sign ... Ndume leans close to examine the sweat-shirt, then twice imitates the eat gesture depicted in the logo, touching his nose rather than his mouth.

March 25, 1992
Penny comes to Ndume's window to deliver some fruit and a special drink of soup. Ndume gestures gimme (beckoning) drink (thumb of fisted hand to mouth) [His spontaneous use of this gesture in this context is particularly interesting. No one has made any effort to teach Ndume the sign drink, but he has seen Michael signing drink many times and in response to his signing usually offered a drink or lettuce browse, and his companion frequently says the word drink as well].

April 10, 1992
Penny is outside bringing Ndume's morning snack. Penny assumes that Leigh Anne is inside with Ndume and calls to her at the window that the food is ready. Getting no response Penny asks Ndume is she is in there. Ndume gestures fake and points to the garage. Loretta, the worker who has been on duty with Ndume, is in the garage at that moment, and Ndume is alone.

June 1, 1992
Penny has two pieces of old clothes for the gorillas. With one item in each hand, and also a carrot (for herself) in her right hand, Penny holds them out to Ndume and asks, "Which one do you want?" Ndume does not reach for either piece of clothing, or the carrot, but puts his hand to his mouth in a slightly sideways eat gesture" (pp. 6-7).

Gardner and Gardner (1969) note in relation to ASL signs that "It is difficult to decide which signs were acquired by method of delayed imitation. ... it is possible that some inadvertent movement of Washoe's has been interpreted as meaningful by one of her devoted companions" (p. 667). Exactly the same process may have occurred with Ndume.

ORANGUTANS

Failed No Criteria

76. Siphoning

Reference: Russson & Galdikas (1993)

Condition: rehabilitants Criteria failed:0

Author's interpretation: I

Alternative interpretation: I

Species: *Pongo pygmaeus* Name: Supinah and Siswoyo

The camp assistants regularly syphoned fuel from large drums to five gallon jerry cans.

"They insert one end of the hose into the fuel in the drum through the drum hole, suck on the second end of the hose to start fuel flowing, then quickly insert this second end of the hose into a jerry can to collect the flow." Two adult female orangutans were observed re-enacting some parts of the procedure involved in siphoning. (They were only allowed to attempt to syphon from empty containers).

One of the females, Supinah, unscrewed the caps on an empty fuel drum and jerry can. She inserted one end of a hose in the drum and she placed the other end in her mouth. She "closed her lips around it, and bellowed her cheeks out". She then removed the hose from her mouth and the drum, explored the different objects and repeated the procedure bellowing out her cheeks a second time.

"On the second occasion Siswoyo, the second female, entered the lean-to, sat on top of a fuel drum holding a hose she found, pushed and twisting one end against the top of the drum at its hole, but the hole was still capped." She then tried to pry the lid off the drum with a stick before she was shooed away by camp staff.

"Supinah's reproduction showed nonfunctionality (the drum was empty) and errors (the hose was not inserted into fuel, she did not clearly suck, and the timing between sucking and inserting the hose was flawed); nonetheless, its visible forms and sequence are appropriate and replicate those used by humans who siphon effectively. Siswoyo's reproduction showed errors (e.g., she tried to insert the hose into a hole before one existed). Both had prior experience with these objects, but it was limited because extensive manipulation of fuel drums is tolerated only when drums are empty: to our knowledge, neither has effectively siphoned. Complete acquisition by individual experiential learning thus seems implausible. Acquisition through social reinforcement is implausible because humans do not encourage siphoning fuel for obvious reasons" (p.151).

77. Fire-making

Reference: Russon & Galdikas (1993)

Condition: Rehabilitant

Criteria failed: 0

Author's interpretation: I

Alternative interpretation: I

Species: *Pongo pygmaeus*

Name: Supinah

The cook staff at the research camp used several methods to make a fire:

"The wet sticks with fuel were kept in a metal container nearby, and they commonly scooped small amounts of fuel with a plastic cup also kept nearby; to start a new fire, they often touched a burning stick to a fuel-soaked one; to make fires burn faster, they blew on them or fanned them with a round metal lid (held vertically in one hand and waved briskly back and forth horizontally toward the fire)."

"On entering the cooking area, Supinah picked up a burning stick, blew on its burning end, and briefly bit gingerly at it hot tip. She next went to the metal container, removed the plastic cup and round metal lid sitting on top ... scooped fuel from the container with the cup, and plunged the burning end of her stick into the fuel. [Russon thought the container contained water, and so let Supinah continue.] Plunging the stick into the fuel extinguished it. Supinah removed her stick and looked at it, dipped it back into the fuel, removed it and looked at it again, then got a second burning stick, and touched its burning tip to the extinguished tip of her first stick. Next, she poured the fuel from her cup back into the container ... placed the cup on the ground, picked up the container, poured new fuel from it into the cup ... stopped when the cup overflowed, and put it back into the cup of fuel ... picked up the round metal lid, and fanned it repeatedly over the stick in the cup; in fanning she held the metal lid in one hand, in vertical position, and waved it back and forth horizontally in front of the cup and stick ... After this she removed the stick from the cup and blew at its [still extinguished] tip ... Her activities continued for another 10-15 min; she brought in six more sticks, some of them burning, set the plastic cup of fuel onto the embers (smoke or steam billowed), and stirred the embers with a long stick. She finally threw this last stick into the embers, dropped the cup abruptly [as if it were hot], poured most of the liquid out, and left" (pp. 152-153).

78. Weeding

Reference: Russon & Galdikas (1993)

Condition: rehabilitants

Authors interpretation: I

Criteria failed: 0

Alternative interpretation: I

Species: *Pongo pygmaeus*

Name: Siswoyo

"Mr. Murisam, a long-time member who took care of young orphans, was cleaning weeds from the edges of paths in camp. A flurry of weeding had been undertaken around the camp over several days in preparation for important visitors. Weeding is an occasional and sporadic activity but when it does occur, it occurs frequently and several staff participate. Mr. Murisam's technique involved chopping weeds off at the root with a hoe and then pushing the cut weeds into a neat row behind him along the center of the path for later removal.

"When Russon arrived, Siswoyo was 3 m behind Murisam on the same path, also removing weeds from the side of the path. Siswoyo mainly used a foot-long stick and chopped the weeds but sometimes pulled them out with her hands. She put her chopped weeds into a neat row behind herself, in the center of the path. The incident ended when Russon interrupted to ask Mr. Mursiman about Siswoyo's weeding; he reported that she followed his weeding; and then started weeding" (pp. 154-155).

79. Painting

Reference: Russon & Galdikas (1993)

Condition: rehabilitants

Authors' interpretation: I

Criteria failed: 0

Alternation interpretation: I

Species: *Pongo pygmaeus*

Name: Supinah

Galdikas's son, Fred, was painting a set of book-shelves on the front porch of their house.

"Supinah took one of the paintbrushes and put it in her mouth; this made her mouth white, and Galdikas pulled the brush out. Supinah next took the brush and painted the floor of the porch, holding the brush appropriately and painting effectively. Galdikas took the brush away after 10 s and had staff remove Supinah's paint, which they did by dipping a rag in a can of paint thinner and scrubbing the floor in wide, sweeping arcs. About 5 seconds later Supinah took the paintbrush and painted the floor again, for about 1 min, in similar wide sweeping arcs. At this point Fred and the staff were painting the side and back of the shelves, stroking up and down. Supinah then turned to the house wall behind her and started painting there, also stroking up and down, for about 20 brush strokes.

Five seconds later Supinah rushed into the open bathroom nearby. A staff member stopped her, but Galdikas gave her a sliver of soap and a pail of water [assuming this was what she wanted in the bathroom]. Supinah ignored the soap [which was unusual] and instead grabbed the paint-thinner-soaked rag earlier used to wipe her paint from the floor. She dipped this rag into the pail of water, wrung it out, and wiped the floor with it. She dipped, sloshed, and wrung the rag again, and then grabbed for a paint can. Supinah then dipped her rag into the pail of water a third time and wiped it on the freshly painted set of shelves [this got paint on the rag]. She dipped the paint-covered rag in the pail of water again and wiped the floor with it [this got paint on the floor]. She repeated her manoeuvre with the rag and shelves twice, in between wiping the rag over spilled paint on the floor near the shelves. Five minutes later, as Galdikas went into the house, Supinah dropped the rag into the pail of water and abruptly moved away.

Supinah's painting and wiping replicated action just demonstrated. We judged her painting exceptional; no orangutans had ever been seen painting before this flurry of painting around camp, and only 1 other had done anything remotely similar. ... Individual learning is implausible because paint and brushes were uncommon in camp and not available to her. Shaping through social reinforcement is unlikely. As seen here, her painting is at best tolerated but more commonly stopped" (p. 155).

Failed Criteria 5 or 6

80. Bridges

Reference: Russon & Galdikas (1993)

Condition: rehabilitants

Authors' interpretation: I   Criteria failed: 6

Alternative interpretation: E

Species: *Pongo pygmaeus*

"Several years ago, the rehabilitant orangutans and their feeding station were moved across the river from the camp. On one occasion, a new assistant was sent across the river to feed them. After he arrived, 1 orangutan proceeded to sink his boat, and another charged him. The assistant could not swim, so he dragged a log over to the weeds at the river's edge, threw it across to the other side, scrambled over it back across the river, and pulled the log up behind him. Within minutes, 2 of the 8 rehabilitants watching began dragging everything they could find to the water's edge. A sub-adult succeeded in crossing on a thick vine, and soon others were crossing as well. Eventually, some rehabilitants crossed at will by making bridges. When all the logs were thereafter removed, the rehabilitants resorted to using vines" (p. 155).

Once the orangutans had seen an object spanning the river and being climbed across, they could have worked out the details of the technique (such as the appropriate materials to use and how to position them) for themselves.

81. Hanging Hammocks

Reference: Russon & Galdikas (1993)

Condition: rehabilitants

Authors' interpretation: I   Criteria failed: 6

Alternative interpretation: E

Species: *Pongo pygmaeus*   Name: Unyuk and Supinah

Hammock's were hung by wrapping each of the two rope ties several times around the trunk of two trees and tying them secure with a hitch-like knot. Several orangutans had been observed trying to re-hang hammocks. Both orangutans in the two reports wrapped one length of rope around a tree but did not successfully tie the rope into place, so the hammock soon collapsed.

The orangutans could have been trying to reproduce the end product of a properly tied hammock through their own
efforts.

82. Baling out a canoe

Reference: Russon & Galdikas (1993)

Condition: captive — Criteria failed: 5

Authors' interpretation: D.I.

Alternative interpretation: I.L.

Species: *Pongo pygmaeus* — Name: Supinah

Canoes are sunk to prevent orangutans from taking them.

"Staff remove water from dug-outs by rocking them side to side, sloshing water over the gunwales, or by baling with scoops or hands. ...

" ... A dug-out canoe was tied to a piling beneath the dock; it was visible, half-full of water and accessible in knee-deep water. Supinah climbed down form the dock into the dug-out, untied its rope from the piling, then guided the dug-out out from under the dock. After several moments she climbed out of the dug-out, holding it by its rope; she stood in the water beside it and began to rock it from side to side. Her rocking sloshed water over the gunwales, and the dug-out was three-quarters empty of water within minutes. At one point Supinah paused in rocking the dug-out, looked at the water remaining in it, resumed rocking, and sloshed more water out. When most of the water was sloshed out, she climbed into the dug-out and baled out more water with the lightly cupped palm of her hand. She next pulled against the dock pilings, and the dug-out glided the rest of the way out from under the dock; she then reoriented the dug-out toward the center of the river (parallel to the dock) and pushed off. As the dug-out neared the raft with the cooks and laundry, she looked toward it and hopped on, by-passing the guard on the dock above. The cooks screamed and fled, leaving Supinah alone on the raft with their soap and laundry" (p. 156).

The observers could not be certain that they had seen all of the orangutan's past

FIGURE 4.1: THE ORANG-OUTANG MIMICKING A MAN. (Menault 1896).

manipulations of sunken boats. It is possible, (although it seems unlikely) that Supinah learned this technique through her own efforts.

Failed Criteria 1 - 3

83. Various Human Activities

Reference: Cuvier cited in Menault (1869)

Condition: captive   Criteria failed: 1,2,3?,4,5?

Author's interpretation: I

Alternative interpretation: ?

Species: *Pongo pygmaeus*

""These animals," says Frederic Cuvier, "acquire without difficulty all the actions to which their organisation is not opposed. This results from their confidence, docility, and their great facility of comprehension. After the first attempt they understand what is required of them; that is to say, having performed the action shown them, they know they must repeat it themselves in the same manner. Thus they drink from a glass, eat with a fork or spoon, make use of a dinner-napkin, wait at table behind their master's chair like a servant, and, it is said, can assist him with wine"" (p. 356).

There is not enough detail given of specific episodes to independently decide whether true imitation has occured or not.

84. Walking with the Same Gait as an Old Man

Reference: Flourens cited in Menault (1869)

Condition: captive   Criteria failed: 2? 5?

Author's interpretation: I

Alternative interpretation: I

Species: *Pongo pygmaeus*

""One day," says M. Flourens, "I paid him a visit, accompanied by an illustrious old gentleman, who was a clever, shrewd observer. His somewhat peculiar costume, bent body, and slow, feeble walk at once attracted the attention of the young animal, who, while doing most complacently all that was required of him, kept his eyes fixed on the object of his curiosity. We were about leaving, when he approached his new visitor, and, with mingled gentleness and mischief, took the stick which he carried, and pretending to lean upon it, rounding his shoulders, and slackening his pace, walked round the room, imitating the figure and gait of my old friend. He then gave him back the stick of his own accord, and we took our leave, convinced that he also knew how to observe"" (p. 359).

This anecdote is included purely for historical interest. The behaviour of the ape is described in detail and there is even a delightful sketch engraving of the incident (see Fig. 4.1). It is extremely difficult to evaluate the competency of the observer and it does seem that the incident is primarily being told to entertain rather than inform.

85. Preacher's Gesticulations

Reference: Menault (1869) Condition: captive

Author's interpretation: I Criteria failed: 1-5

Alternative interpretation: ?

Species: *Pongo pygmaeus*

"M. Coubasson had brought up a young ape of this family. The animal was so attached to the missionary, that wherever he went it seemed desirous of following him. Every time the "father" had some religious service to perform, he was obliged to shut the orang-outang in a room. One day, however, the animal made his escape, and followed his master into the church. There he quietly mounted to the top of the organ above the pulpit, where he remained until the sermon commenced. Then he slipped down slyly to the front, and looking steadfastly at the preacher, began imitating his gestures in so droll a manner, that all the congregation were seized with an irresistible desire to laugh. The father, surprised and confounded at this levity, severely reprimanded his inattentive audience. The rebuke was ineffectual. The congregation still appearing diverted, the preacher, in the warmth of his zeal, redoubled his efforts to engage their attention. The monkey imitated so cleverly the vehemence of this oratorical action, that the congregation could no longer restrain their mirth, but burst out into continual peals of laughter. The father, now thoroughly vexed and angry, threatened his hearers with the wrath of Heaven. At length a friend indicated with his finger the cause of this unseemly mirth, and the preacher began to laugh himself. The attendants then with some difficulty removed the ape which had thus abused his powers of imitation" (pp. 359-360).

This anecdote is included purely for historical interest.

Table 4.1: Summary Table of Observational Database

CHIMPANZEES

Reference	Report	Process	Criteria failed
1. Boesch (1991)	Adjusted grip on a stone hammer to exactly match model	I	0
2. de Waal (1982)	Assumed the same hunched walk of a partially crippled female	I	0
3. de Waal (1982)	Walked on wrists in the same way as injured male	I	0
4. Gardner & Gardner (1969)	Soaked, soaped and dried a doll in the same way she had been bathed	D.I.	0
5. Goodall (1973)	One infant sucked in her cheeks as a play gesture and her play-mates did likewise	I	0
6. Goodall (1973)	A juvenile used a novel "wrist-shake" threat gesture and her companion copied it	I	0
7. Goodall (1973)	A sister and brother exhibited their mother's idiosyncratic posture of dangling infants from their feet to tickle them	I	0
8. Goodall (1973)	An infant wiped his clean bottom with leaves after seeing his mother use leaves to wipe away diarrhoea	I	0
9. Goodall (1973)	An infant playfully wiped the back of wrist on many different surfaces after seeing adults pick up termites in this way	I	0
10. Hayes (1951)	After a night's delay, wiped at a stain on dress with a cloth	D.I.	0
11. Hayes & Hayes (1952)	Wrapped a piece of sandpaper around a stake and rubbed it up and down in just the way it had been demonstrated	I	0
12. Hayes & Hayes (1952)	Applied lipstick to lips and smoothed it with a finger just as her human owner was apt to do	D.I.	0
13. Hayes and Hayes (1952)	After a delay, placed a pencil in a sharpener and turned the crank	D.I.	0
14. Kearton (1925)	Soaked, soaped and wrung out laundry in the same manner as his human companions	I	0
15. Kearton (1925)	Used a piece of wood to scrape over his teeth in the same way as an African boy. Tried to imitate the actions used for cleaning teeth with a tooth-brush	I	0
16. Kearton (1925)	Toto learned to pack a pipe with tobacco, strike a match and hold it up to the tobacco. He even imitated the facial expression related to inhaling	I	0

Reference	Report	Process?	Criteria Failed
17. Kearton (1927)	Tried to extract a dog's tooth with a pair of pliers the day after she had had one of her teeth removed in this way	I	0
18. Kearton (1927)	Learned to dig with a plastic spade and fill a plastic bucket with sand	I	0
19. Kohler (1926)	Painted a stone with a brush and whitewash after seeing a workman paint a fence post	I	0
20. Sheak (1917)	Reproduced many of aspects of sewing: threading a needle, tying a knot in the end of the thread and pulling the needle and thread through cloth.	I	0
21. Shepherd (1915)	Tried to open watch case by lightly pressing stem and them hooking fingernails under rim	I & E	0
22. Temerlin (1975)	Leaned over tiolet bowl and reproduced the sounds her master had made when vomiting.	I	0
23. Yerkes & Yerkes (1929)	After seeing a boy spit for the first time, pulled all kinds of faces in his attempt to spit. The next day he was seen practicing in a corner and he soon become quite proficient	I	0
24. Fouts et al. (1989)	Made a swirling nest using a blanket and various object in same way as mother	C & S.E.	6
25. Goodall (1973)	Often played with infant's penis, like her mother	S.E.	6
26. Goodall (1973)	Often groomed infant's ears, like her mother	S.E.	6
27. Goodall (1973)	Shortly after her mother started to dorsally carry her infant, a young female tried to carry him on her back	C	6
28. Goodall (1973)	Hit wrist on a tree after brother had been striking a hard fruit against the trunk.	C & S.E.	6
29. Goodall (1973)	Infants strip twigs in the same way adults prepare termite probes.	I.L.	6
30. Goodall (1973)	An infant exhibited the common practice of using a stick or a piece of grass to investigate a strange object.	I.L.	6
31. Goodall (1973)	Infants closely observe and learn the adult practice of " leaf-grooming".	C & S.E.	6
32. Goodall (1973)	Young chimpanzees display along the same routes and with the same objects as adults.	C & S.E.	6
33. Goodall (1973)	Two infants poked twigs at the surface of a termite mound. One used the adult precision grip.	I.L. & C	6

Reference	Report	Process?	Criteria Failed
34. Hayes & Hayes (1952)	Placed photographs between pages of a book 6 hours after seeing human foster parents doing so	D.E.	6
35. Hayes & Hayes (1952)	After seeing a stake hammered into the ground, struck at the top of the stake with the hammer	S.E., E	6
36. Hayes & Hayes (1952)	After an hour's delay, used a screwdriver to remove the friction lids from cans	D.S.E, D.E.	6
37. Kohler (1925)	Stacked boxes to reach fruit	S.E., R.E., E	6
38. Menzel (1972;1973)	Leaned poles against trees or walls in order to climb up to inaccessible areas	E	6
39. Nishida (1987)	Young males make a crude nest and stamp their foot as a courtship display.	C & O.C.	6
40. Sumita et (1985)	Nut-cracking learned after observing human demonstrator	C, S.E., R.E.,E.	6
41. Fouts et al. (1989)	Without direct human intuition, learned many ASL signs	O.C.	5,6
42. Gardner & Gardner (1969)	Learned the ASL sign for "toothbrush"	?	5,4
43. Gardner & Gardner (1969)	Learned the ASL sign for "flower"	O.C.	5,6
44. Goodall (1973)	A young female used a standard sweeping action for removing ants from the surface of a weaver ant nest	I.L.	5,6
45. Goodall (1973)	A juvenile pushed a stick into the ground near a line of safari ants but as there was no nest present she picked up no ants.	I.L.	5,6
46. Goodall (1973)	Used a stick to lever an ant nest	S.E.	5,6
47. Hannah & McGrew (1987)	Rapid spread of nut-cracking in semi-captive group	E	5
48. McGrew & Tutin (1978)	Local tradition of a mutual grooming hand clasp	O.C.	5,6
49. Menault (1869)	Used a key to unlock the door of its cage	S.E.	5,6
50. Nishida (1987)	Local tradition of a leaf-clipping courtship display	I.L. & S.E.	5,6
51. Shepherd (1915)	Reproduced a "W" and a "T" with pencil and paper	O.C.	5,6
52. Sugiyama & Koman (1979)	Tried to pull a branch down using a stick	S.E.	5,6
53. Witmer (1910)	Reproduced a "W" with chalk on a board.	O.C.	5,6
54. Fouts et al. (1989)	Learned to use a bowl and spoon	?	4
55. Furness (1916)	Dug with a spade and trowel, swept with a broom, used a screwdriver	?	4

Reference	Report	Process?	Criteria Failed
56. Hayes (1951)	Dusted, washed dishes, pushed a vacuum cleaner, grated a lemon	S.E., E	4,6
57. Hayes & Hayes (1952)	Sprayed window with squirt bottle	D.E.	4,6
58. Hayes & Hayes (1952)	Dusted furniture, washed clothes and dishes	S.E.	4,6
59. Kearton (1927)	Paddle a boat, strike a match to light and smoke a cigarette or pipe, unlock a box with a key, choose the right key off a bunch	?	4
60. Rothman & Teuber (1915)	Opened doors, inserted keys, used a lever to regulate water supply, scrubbed floors, swept with a broom	?	4
61. Sheak (1923)	Wiped nose, brushed hair, cleaned clothes with whisk broom, drank from a cup, ate with a spoon, bored holes with a brace and bit, used a saw,screwdriver and hammer, played with a toy piano and harmonica	?	4
62. Terrace (1979)	Learned ASL signs for "orange" and "tree"	?	4
63. Buttehofer (1893)	Constructed piles of sticks and sat around them as if they were a fire	?	1,3,5
64. Cameron (1969)	Tapped fingers on the floor in imitation of typing	?	2,3,5
65. Goodall (1973)	Closely observed and explored the objects related to leaf-sponging	S.E.	1,5,6
66. Goodall (1973)	An infant used the same vigorous scratching grooming method as mother	C	1,6

GORILLAS

67. Anon (1992)	Reproduced the actions and sounds made by human who was exercising	I	0
68. Anon (1988)	Dug an L-shaped trench after watching workmen do so	D.I.	0
69. Yerkes (1927)	Failed to imitate raking task and smoking a pipe	Negative	0
70. Tanner (1990)	Turning pages of a book	S.E.	6
71. Tanner (1990)	Pulling strange faces	?	4,5
72. Philips (1989)	Reproduced strange gesture of puffing out cheeks and protruding tongue	?	4
73. Hillar (1984)	Reproduced strange gesture of knocking head and slapping them	?	4

Reference	Report	Process?	Criteria failed
74. Gordon (1992)	A female (Koko) bared her lower teeth in the same way as a male (Ndume)	?	4
75. Gordon (1992)	A male gorilla (Ndume) began to use certain ASL signs without receiving specific instruction to do so	?	4

ORANGUTANS

76. Russon & Galdikas (1993)	Reproduced elements of spihoning liquid from a jerry can	I	0
77. Russon & Galdikas (1993)	Reproduced elements of fire-making	I	0
78. Russon & Galdikas (1993)	Dug up weeds and arranged them in a neat row	I	0
79. Russon & Galdikas (1993)	Reproduced the precise actions used in whitewashing	I	0
80. Russon & Galdikas (1993)	Constructed bridges out of logs and vines to cross a stream	E	6
81. Russon & Galdikas (1993)	Tried to tie fallen hammocks back to tree trunk	E	6
82. Russon & Galdikas (1993)	Rocked canoe from side to side to bale out water	I.L.	5
83. Cuvier cited in Menault (1869)	Various human activities	?	1-5
84. Flourens cited in Menault (1869)	Walked with the same gait as an old man	I	2,5
85. Menault (1869)	Entered a church and gesticulated like the preacher	?	1-5

Key

Processes

I = imitation

D.I. = delayed imitation

E = emulation

S.E. = stimulus enhancement

R.E. = reward enhancement

I.L. = individul learning

O.C. = operant conditioning

C = contagion

Exp = exposure

? = an independent judgement was not possible

Key

<u>Criteria</u>

1 = first hand account

2 = competent observer

3 = demonstrate adequate knowledge of the species

4 = describes the context and actions in detail

5 = aquainted with the relevant details of ontogeny

6 = details and ontogeny suggest that the behaviour is imitation

Comments on the Database

The observational database contains 21 anecdotes of imitation in chimpanzees, one from a gorilla and four from orangutans which pass all the criteria outlined in Chapter 4. Even though strict criteria are used to evaluate each of the anecdotes, such data must be still be treated very carefully. Byrne (in press) comments:

> "It should be emphasised that information collected, ... by the survey method can never provide precisely reliable *quantitative* data on the relative frequencies with which acts are used in different primate populations or species ...
>
> Obviously, there are immense differences in the number of hours for which different species have been studied."

For example, in the past, chimpanzees were more commonly kept as pets and raised in human homes than gorillas or orangutans. There have been several studies where researchers have raised chimpanzees (e.g., Kohts 1923; Kellogg & Kellogg 1933; Yerkes 1943; Hayes & Hayes 1952; Gardner & Gardner 1969; Rumbaugh 1977; Terrace 1979) but relatively few have raised gorillas (e.g., Patterson & Linden 1981) or orangutans (e.g., Miles 1986; Laidler 1980; Galdikas 1980).

The majority of the anecdotes that indicate true imitation have come from human-raised subjects (18 out of 26) in which they often reproduced specifically human activities. As mentioned in chapter 3, such conditions promote intimate knowledge of a subject's personal ontogeny of individual behaviours, and since the activities are human, it is relatively easy to determine whether they are based on innate predispositions. It seems likely that the fact that the majority of anecdotes have involved chimpanzees is an artifact of more chimpanzees than gorillas or orangutans being raised by humans.

The anecdotal database can be used to confirm the *presence* of imitation in different species. However, it can say very little about whether there is an *absence* of imitative ability in a given species. Just because there are no anecdotes of imitative behaviours in gibbons, for example, does not mean they can not imitate. All one can safely conclude is that no-one has observed and reported imitative behaviour in gibbons. Hence, Byrne and

Whiten (1990) point out that "absence of evidence is not evidence of absence" (p. 5).

The imitation anecdotes in the present database can tell us very little about the direct functional relevance of imitation in apes. Only one of the reports (no. 1) describes the imitation of a directly functional activity (Boesch 1991). In reports 5, 6, and 7 the function of the chimpanzees' behaviour is unclear. In all the other anecdotes of true imitation (chimpanzee reports 2-4 and 8-21, gorilla report 1 and orangutan reports 1-4) the behaviour of the apes appears to be some kind of playful imitative exploration. Chapter 8 features a discussion of the possible indirect functional relevance of imitative play.

It should be clear, after considering all the anecdotes in the database, how important it is to describe in as much detail as possible the ontogeny and the precise actions related to an imitative episode. Many of the anecdotes (i.e., chimpanzee reports 37-48, gorilla reports 4-8 and orangutan report 8) can not be independently evaluated because the observer did not describe in detail exactly what actions were performed by the ape(s). It is to be hoped that, anecdotal databases such as this one will encourage researchers in the future to pay very close attention to important unpredicted events (e.g., apparently deceptive or imitative episodes) and to produce very detailed descriptions.

Some of the observational reports in the database have been taken as evidence of social traditions. Such data is found in monkeys, apes and other species, and it should be considered as separate. The majority of reports in the database involve directly observed individual incidents of apparent imitation in single subjects. Social traditions involve a whole group or population of animals exhibiting a behaviour which deviates from species-level behavioural norms and can not be explained simply in terms of ecological variation. Often the actual acquisition of the tradition was not directly observed and therefore its status as a social tradition is determined by careful cross-group comparisons. As social traditions seem to represent a special kind of observational data they are discussed separately in chapter 7.

EXPERIMENTS ON IMITATION AND SOCIAL LEARNING IN GREAT APES

Chimpanzees

There have only been ten formal experiments that directly relate to imitation, social learning or social traditions in chimpanzees. Table 4.2 summarizes the data from experiments on social learning in Great Apes. Two of the listed experiments do not properly refer to imitation. Menzel *et al.* (1972) investigated questions related to social traditions or customs. Yerkes' (1934) experiment explored contagious behaviour.

One serious problem with three of the eight remaining experiments on imitation in chimpanzees is that the results and procedure are not described in sufficient detail. Two of these are Piagetian-style studies (Mathieu & Bergeron 1981; Mignault 1985) which tested the same four chimpanzees from the Universite de Montreal. Mathieu and Bergeron (1981) stated that their formal testing consisted of "tasks inspired by Piaget, systematized by Gouin-Decarie (1965), and Uzgiris and Hunt (1975) and, when needed, adapted to the chimpanzees" (p. 143). There was no further explanation of what was presented to the chimpanzees. The authors simply state that the chimpanzees were "capable of delayed imitation, behavior typical of stage VI" (p. 144) without describing any of the subjects' imitative behaviour. Mignault (1985) did describe what actions were shown to the chimpanzees, but she only briefly described one of their apparently imitative responses. The action of brushing the hair on a doll was demonstrated to the chimpanzees. Subsequently, one individual brushed the doll's hair while another brushed its hair and body. Since the chimpanzees were not given access to the doll and hair brush prior the demonstration, it is not clear that they would not have independently brushed the doll (Tomasello 1990). With such sparse data, neither Mathieu and Bergeron (1981) nor Mignault (1985) have sufficiently substantiated their claim that the chimpanzees were capable of imitation.

Hayes & Hayes (1952) conducted an experiment in which their home-raised chimpanzee, Viki, (at 17 to 34 months of age) was required to imitate a series of non-functional or arbitrary actions on the command "Do this!" (see chapter 3). Hayes and

Table 4.2: Experiments on social learning and imitation in great apes

Reference	Experiment	Process?
1. Menzel et al. (1972)	Young chimpanzees were placed in a series of six overlapping groups and exposed to two novel objects. Approach to the objects depended on the group rather than simply individual characteristics	S.T.
2. Yerkes (1934)	Chimpanzees ate rice paper after seeing a human do so	C
3. Mathieu & Bergeron (1981)	A Piagetian-style study of imitation	?
4. Mignault (1985)	A Piagetian-style study in which one individual brushed a doll with a hair brush	?
5. Hayes and Hayes (1952)	Required their chimpanzee, Viki, to imitate a series of arbitrary on the command "Do this"	?
6. Chapter 9	Two chimpanzees were presented with a task which was a modified version of Hayes and Hayes' imitation action series.	I
7. Tomasello et al. (1987)	Young chimpanzees emulated rather than imitated the solution to a raking task	E/R.E.
8. Nagell et al. (in press)	Young chimpanzees were presented with a raking task in which a specific action of turning the rake over was presented	?
9. Tomasello et al (in press)	Human- and mother- reared chimpanzees were presented with several different arbitrary object-directed actions to imitate. Only the human-reared subjects clearly imitated.	I
10. Chapter 10	Eight chimpanzees were presented with an analogue of a food-processing task. The test apparatus was a perspex foraging box which could be opened two different ways. A multi-act experimental design was used.	I
11. Chevalier-Skolnikoff (1977)	A Piagetian-style imitation series was presented to the gorilla, Koko.	?
12. Haggerty (1913)	After watching a conspecific use a stick to poke food out of a long horizontal, a female orangutan immediately attempted the same technique	?

KEY

I = imitation
E = emulation
R.E. = result enhancement
S.T. = social tradition
C = contagion
? = an independent evaluation was not possible

Hayes' first objective was to teach Viki the general meaning of the phrase "Do this", so that on command she would try to imitate any action demonstrated to her. They demonstrated a functionless act such as clapping their hands, or patting their head and if Viki responded immediately she was given a food reward, otherwise her response was moulded by the experimenters, "putting her through the actions of each new item many times (by manipulating her hands, etc.) before she began to perform them herself" (452).

> "Beginning with the twelfth, however, certain new items were imitated immediately, without preliminary tutoring - provided that she had previously done them in other situations. Number 12, for instance, was saying "Mama," which she had previously done in solicitation; and Number 13 was a "Bronx cheer," [blowing air through pursed lips] which she had made before only in play.
>
> Beginning with the twentieth task, at least ten were copied immediately, even though we were certain that she had never done them before under any circumstances. Examples are: stretching the mouth with two forefingers ..., whirling on one foot, and operating various new toys" (p. 452).

The authors noted that Viki had problems with some of the tasks. For example, she failed to imitate putting a card into an envelope because her actions were too clumsy, and blinking her eyes "seemed to be absent from her voluntary motor repertory - though she finally adopted the pseudosolution of putting a finger to her eye, which caused it to close" (p. 452). She also occasionally seemed to simply refuse to respond. Hayes and Hayes concluded that "Despite these difficulties, 55 of the tasks were finally learned, and she could then imitate our demonstrations of them with very little confusion among the various items" (p. 453).

Unfortunately Hayes and Hayes did not provide a comprehensive list of the seventy demonstrationed items. Nor do they describe any of Viki's initial responses in detail: that is, before they began to mould her actions. The first 11 actions definitely did not count as true imitations since Hayes and Hayes state these were all moulded. Viki had been explicitly taught to say "Mama", so her response to that item did not count as an imitation. The "Bronx cheer" is a noise chimpanzees tend to make when grooming (personal observation), hence Viki's response could have been a reinforced contagious reaction. There are, in fact, only two actions which are individually identified as being immediate true imitations (stretching the mouth with the forefingers and whirling on one foot). Yet, the precise form of Viki's first response was not described and as there seemed to be no objective measure of how accurate the reproduction had to be for the authors to count it as an imitation, it is impossible to independently judge whether these actions were in fact imitations. Although there is a photograph of Viki stretching her mouth with her index finger, (see Figure 4.1), it is possible that her first response had been subsequently refined through moulding and shaping, prior to the photograph being taken.

Figure 4.2: Viki imitating Keith Hayes pulling his mouth wide with his index fingers

The experimental design used in Hayes and Hayes's imitation series seemed to be basically sound (see chapter 3). Testing to see whether one can induce in a subject a predictable and controlled transition from the imitation of taught to untaught actions is a potentially powerful way to gain an insight into the cognitive processes underlying imitation. If such a transition occurs it suggests the subject is capable of performing a rather complex cognitive operation of translating visual information about another's actions into its own similar motor actions (Bruner 1972). Exactly how faithfully the reproduction is, and what kinds of actions prove particularly difficult to imitate may provide further insight into the process involved. Therefore, Hayes and Hayes' experiment begs replication (see chapter 9).

There have been only five experiments on imitation in chimpanzees that have been described in scientifically adequate detail. Two of these are the original experiments reported in chapters 9 and 10. The other three are Tomasello *et al.* (1987), Nagell, Olguin and Tomasello (in press) and Tomasello, Savage-Rumbaugh and Kuhn (in press).

Tomasello *et al.*'s (1987) raking task was described in chapters 2 and 3. It was argued that the experimental design was flawed because it could not adequately control for stimulus and reward enhancement in relation to explaining the facilitation of learning in the chimpanzees who observed the model. Also, even if the observers had used two-stage techniques which were similar to the model, there would have been no way to determine whether they were learned through imitation or individual learning.

Nagell *et al.* (in press) designed a second raking task. The main difference was in the design of the rake. The rake had a solid lip on one side and a broken or pronged lip on the other side (see Figure 4.2). The tool could be used in one of two positions: prong-side down or edge-side down. In the prong-side down position the food was difficult to pull in because it normally (but not always) slipped through the widely-spaced prongs. In the edge-side down position the food was easy to pull in as there were no gaps for it to slip through.

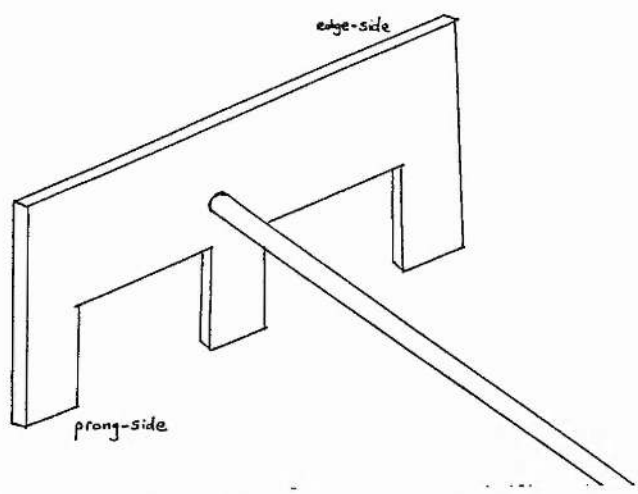


Figure 4.3: The raking tool used in Nagell et al. (in press)

There were 15, four to eight year old chimpanzee subjects and twenty-four two year old human subjects. The subjects were randomly assigned to one of three experimental conditions: No model, Partial model, or Full model. In all the conditions two food items or objects were placed out of reach of the subject on a platform. The subject was presented with a raking-tool in the prong-side down position and a human experimenter sat next to a second rake that rested on the platform. In the No model condition the subjects received no demonstration and were left to solve the problem for themselves. In the Partial model condition the human demonstrator's tool was presented already in the edge-side down position, but the subject never saw the target action of flipping the tool. In the Full model condition the demonstrator's tool was in the prong-side down position, and the tool was flipped in an exaggerated manner making a loud clanking noise against the platform before the food or object was pulled in.

In the chimpanzee No model condition one subject solved the problem using the pronged side of the rake. In the Partial model condition two chimpanzee subjects solved the problem with one consistently using the solid edge and the other using the pronged edge. In the Full model condition two chimpanzee subjects solved the problem with one wavering back and forth between using both sides and one first using the pronged edge and then swapping to use the solid edge. In the children two subjects in the No model group solved the problem nearly always using the pronged side. In the Partial model condition six children solved the problem, nearly always using the pronged side. In the Full model condition there were four successful subjects, one of whom consistently used the pronged side, while the others used an equal mixture of both sides. Nagell *et al.* argued that since there was no significant difference in the behaviour exhibited by the chimpanzees in the Partial and Full model conditions, the chimpanzees were emulating rather than imitating the model. There was a difference between the children's performance in the Partial and Full model conditions, and therefore, according to the authors, they did appear to have imitated.

I do not think Nagell *et al.*'s interpretation of the results is altogether justified. Figures 4.3 and 4.4 are reproduced from Nagell *et al.* and show the pattern of response in the three conditions for the chimpanzees and children. The general pattern of response for the chimpanzees and children is very similar in the No model and Full model conditions. The greatest difference is between the children and chimpanzees' Partial model pattern of response. One chimpanzee followed the children's pattern of consistently using the pronged edge of the tool. The second chimpanzee discovered the tool could be flipped and he consequently adopted this more efficient strategy. It seems that although some of the children in the Partial model condition may have at some time independently discovered how to flip the tool, they did not benefit from this knowledge. Unlike the second chimpanzee, they continued to use the less efficient method. It seems that the chimpanzees' behaviour was interpreted by the researchers as less cognitively complex because one subject in the Partial model condition exhibited independent intelligent problem-solving! Rather than emphatically concluding that the chimpanzees emulated rather than imitated, the results only seem to justify a judgement of "not proven".

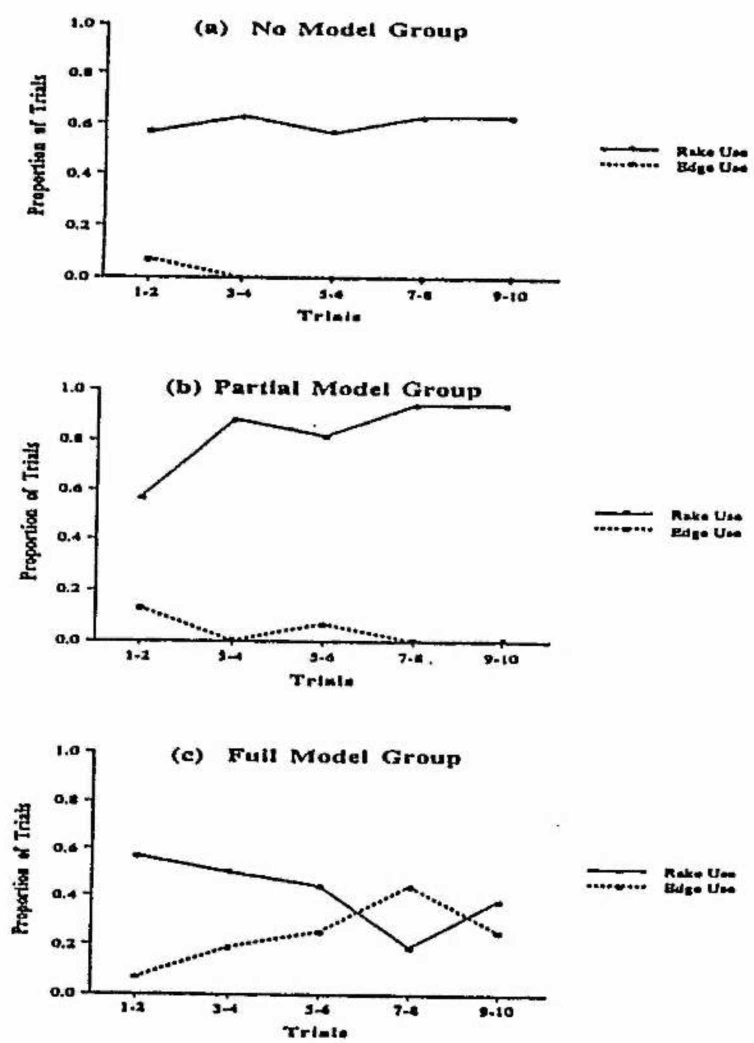


Figure 4.3: Mean proportion of type of tool use over trials in each experimental condition (children). (reproduced from Nagell et al. in press)

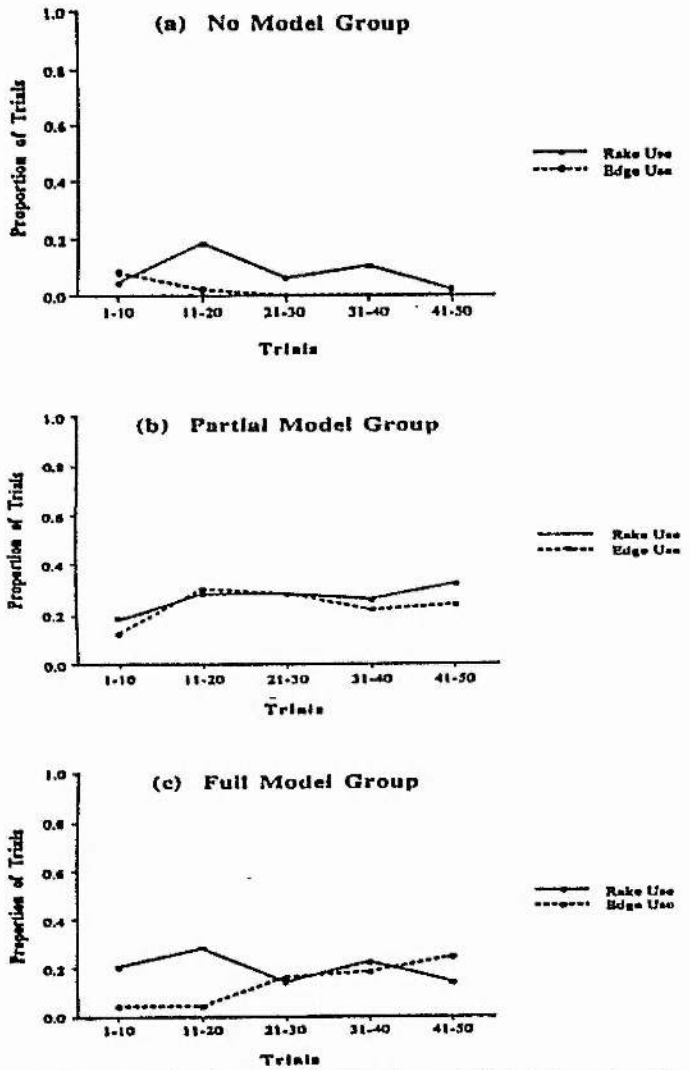


Figure 4.4: Mean proportion of type of tool use behavior over trials in each experimental condition (chimpanzees). (reproduced from Nagell et al. in press)

Tomasello *et al.* (in press) is one of only three methodologically sound and properly described experiments (see chapters 9 and 10 of the present document for the other two) which indicate that chimpanzees can imitate. They presented three human-raised chimpanzees, three mother-raised chimpanzees and 16, 18 to 31 month old children with 16 objects. The objects consisted mostly of tools and other hardware items (such as a lever, a clamp, a reel, a leash, a brush, a sifter, and a syringe). The subjects were presented with 12 objects for approximately four minutes of free-play with each item. The experimenter then retrieved the first object and with the instruction "Do what I do" she or he demonstrated a simple action, such as striking an empty paint can with a stick. Next, a more complex action was demonstrated with the object(s), such as opening the lid of the paint can with the stick. As a test of delayed imitation four objects were presented separately to the subjects for four minutes of free-play with each item. The objects were then retrieved and the experimenter demonstrated one complex action with each of them. The subjects were then not given access to the objects until two days later.

Tomasello *et al.* found that the mother-raised chimpanzees hardly imitated at all but they emulated much more than the children or the human-raised chimpanzees. The human-raised chimpanzees imitated just as well as the children on the immediate imitation task and, surprisingly, much better than the children on the delayed imitation task. The authors argued that there was a genuine difference in the imitative abilities of the human and mother-reared chimpanzees. They described a process called "enculturation" which they suggest "is necessary if the capacity of chimpanzees to imitatively learn from others becomes phenotypically expressed during ontogeny." They go on to say:

"What is developing in chimpanzees as a result of their enculturation is not just imitative abilities, but rather more fundamental social-cognitive skills. These rely on a variety of social experiences, not just the experience of matching the behavior of others. The most important experiences, in our view, are social interactions in which there is a joint focus of attention on some third entity such as an object (Savage-Rumbaugh, 1990; Tomasello, 1988). Human enculturators encourage and structure such interactions in a way that adult chimpanzees in their natural environment do not, and, in our hypothesis, this "scaffolding" and intentional instruction serves to "socialize the attention" of the chimpanzee in much the same way that human children have their attention socialized by adults (Vygotsky, 1978)".

Therefore, according to Tomasello *et al.* (in press), there is nothing fundamentally different in the basic cognitive capacities of chimpanzees and children in relation to imitation. The species divergence occurs later in development with the emergence of adult intuitive teaching or scaffolding abilities.

Tomasello *et al.* (1993) discuss the social-cognitive skills related to imitation in terms of mental perspective-taking in the sense of reading the purpose, goal or intention behind another's actions. They state that:

"True imitative learning in our definition involves the infant's (sic.) reproducing the adult's actual behavioral strategies in their appropriate functional contexts, which implies an understanding of the intentional state underlying the behavior" (p. 497).

In the "enculturation study" the actions performed on the objects were arbitrary or non-functional. In what sense, then, could the subjects have an understanding of the intentions underlying the demonstrator's actions? The only purpose behind the actions was to induce the subjects to imitate. It seems that even the non-enculturated chimpanzees had some idea about the experimenter's expectations:

"Mother-reared chimpanzees performed the target actions, or attempted to do so (by producing the means only), much more after the demonstration than they did during the freeplay period, demonstrating at the very least the effect of having watched the demonstration and, possibly, their understanding of the instruction in some very general sense. Further evidence for this interpretation is the fact that they clearly expected praise when they successfully imitated the demonstration (e.g., by looking to the experimenter expectantly), and they showed signs of guilt when they were not cooperating (e.g., by looking away and down)" (Tomasello *et al.* in press).

As the only purpose behind the demonstrator's actions was for the chimpanzee to imitate them, the non-enculturated chimpanzees do appear to have understood "the intentional state underlying the behavior" (Tomasello *et al.*'s 1993 definition of imitation). It may have been that the non-enculturated chimpanzees did not understand that they had to reproduce the *precise details* of the demonstrator's actions when they were given the command "Do what I do". Hence, the fact that they did not imitate *precise* actions may not have been because they were not capable of doing so, but rather they did not appreciate the *precise* meaning of the verbal command.

It does seem true that feral chimpanzee mothers do not socialize the attention of their infants (Plooij 1978). Nevertheless, young chimpanzees in the wild pay very close attention to the activities of adults. They have exhibited some fragmentary evidence of an imitative ability (Goodall 1973). It is possible human infants and chimpanzees possess a basic imitative ability independent of enculturation, but imitation only becomes easy to elicit and highly predictable after they have undergone some process of adult human socialization.

Experiments on Imitation in Gorillas

There has only been one experiment on imitation in a gorilla. Chevalier-Skolnikoff (1977) stated that she modified Uzgiris and Hunt's (1975) Piagetian based imitation series to compare the imitative abilities of stumptail macaques, one gorilla (Patterson's Koko) and human infants. No details are given of how the imitation series was modified. The subjects' responses are not described and hence it is impossible to independently evaluate their imitative abilities.

Experiments on Imitation in Orangutans

There has only been one published experiment on imitation in an orangutan. Haggerty (1913) presented two orangutans with a horizontal tube that contained a piece of food that could only be removed by poking it out with a stick. One of the orangutans, Betty, was taught how to solve the problem. The second orangutan, Nancy, was given five preliminary, five-minute trials. Although Nancy remained motivated she did not solve the problem. Then Betty "demonstrated" the solution five times while Nancy watched her. Finally, Nancy was presented with the problem again:

"At once she picked up the stick and went to the left end, where Betty had spent so much of her time. The stick was too long to put in that end, and she was given a stick a little shorter. This she immediately inserted and pushed the food out at the right end, where she got it. Five times within a few minutes she repeated the act.

What we have here would seem to be a case of "inferential imitation". Neither instinct, experience, nor accident availed to solve the problem. In her case we have an animal learning to do a thing otherwise than by doing it" (p. 154).

However, it is possible that Nancy's actions were the result of local and stimulus enhancement. Once her attention had been drawn to the end of the tube (local enhancement) and to the sticks (stimulus enhancement) she may have solved the problem through her own efforts. The only feature of Nancy's behaviour that argues against such an interpretation is the apparent speed with which she solved the problem after observing Betty. Haggerty claimed that she immediately took a stick and tried to insert it in the tube and was only prevented because for some reason the tool was too long (perhaps that end of the tube was near a wall or fence). The speed with which the problem was solved after demonstration is suggestive of program-level imitation. It seems clear that much more rigourous experimental work is needed on imitation in orangutans.

Chapter 5

IMITATION IN MONKEYS

UNCONTROLLED OBSERVATIONS OF IMITATION IN MONKEYS

Table 5.1 lists all the observational reports of imitative-like behaviour in monkeys that I could find in the scientific and popular (factual) literature. None of the reports pass all six of the criteria for judging uncontrolled observations of imitation outlined in chapter 4. Many of the reports involve observations of apparent social traditions in monkeys. Some of the most famous examples have come from Japanese macaques. Premack (1984) comments that, "Probably the single most impressive case of imitation on record concerns the changes in food technology of the Japanese macaques on Koshima Island" (p. 17, sited by Whiten & Ham 1992). Japanese potato-washing (Kawamura 1959) was discussed in chapters 2 and 3. It was suggested that processes other than imitation could account for the behavioural transmission that occurred. Whiten and Ham (1992) comment:

"Stimulus enhancement - in which the behavior of potato washers drew the attention of others to the potatoes, the water, and their conjunction - coupled with trial-and-error learning, possibly enhanced by caretakers, would appear sufficient to explain the phenomenon" (p. 257).

Similar interpretations can be given for the other Japanese macaque social traditions listed in Table 5.1. Wheat-washing involved monkeys casting handfuls of wheat and sand into the sea. The sand sank while the wheat grains floated and were scooped up sand-free. Wheat-washing could have been learned by stimulus enhancement and trial-and-error just as Whiten and Ham suggest potato washing was learned. Exactly the same interpretation could be made for the practice of rolling apples in the snow that Suzuki (1965) observed, except that the stimuli were apples and snow rather than water and wheat or potatoes. Swimming in the Koshima island macaques was reinforced by caretakers throwing pieces of food into the water (Kawai 1965). Hot-spring bathing (Suzuki 1965) involved Japanese macaques climbing into a

Table 5.1 Uncontrolled Observations of Social Learning in Monkeys

Reference	Species	Report	Process?	Criteria failed
Breugermann (1973)	Macaca rhesus	Female carried a coconut shell in the same way as her mother carried her baby brother	C	6
Carpenter (1887)	Macaca ??	Social tradition of opening oyster shells with stones	S.E., I.L.	4, 5
Corner (1955)	Macaca nemestrina	Trained by imitation to aid in botanical collections	O.C.	4, 6
Fletemeyer (1976)	Papio ursinus	Adult male threatens juveniles away from drugged food	O.C.	6
Gibson (1989)	Cebus apella	Found no evidence in her pet monkeys whom she owned for 11 years	Negative	6
Hall (1963)	Papio ursinus	Released pet dug in the same place as wild individual	C	6
Hamilton & Tilson (1985)	Papio ursinus	A group of baboons ate fish from a partially dried up pool	S.E., Exp.	6
Hauser (1988)	Cercopithecus aethiops	Acacia seed pod dipping spread rapidly in a group of monkeys	S.E.	5, 6
Itani (1958)	Macaca fuscata	Candy eating	I.L., C.	6
Kavanaugh (1980)	Cercopithecus aethiops	A group foraging in human farm land vocalize very quietly	O.C., C	6
Kawai (1965)	Macaca fuscata	Spread of "gimme" gesture and swimming	O.C.	6
Kawamura (1959)	Macaca fuscata	Spread of potato-washing	S.E., Exp.	6
Kinnaman (1902)	Macaca rhesus	Peeped under a tree	C	6
Marais (1969)	Papio ursinus	Dug water-cooling channels, broke open baobab fruit with stones, killed lambs to eat curdled milk in their stomachs	S.E.	5, 6
Romanes (1882)	Cebus??	Opened trunk with key	S.E.	4, 6
Sholholzer (1958)	Papio hamadryas	Two males soaked up water in a moat with their tails but did not spread through the group	Negative	6

Reference	Species	Report	Process?	Criteria Failed
Strum (1981)	Papio anubis	Co-operative hunting	O.C.	6
Suzuki (1965)	Macaca fuscata	Social traditions of rolling apples in snow and hot-spring bathing	S.E., Exp.	6
Visalberghi & Fragaszy (1990)	Macaca rhesus	Two rhesus smashed coconuts-open on the rocks but behaviour did not spread through group	Negative	6
Tinklepaugh & Hartman (1930)	Macaca rhesus	Ate afterbirth after mother did, ate raw meat after turtle companion did.	C	6
Witmer (1910)	Macaca cynomolgus	Opened a door with no trial and error	S.E.	6
Yamada (1957)	Macaca fuscata	Wheat washing	S.E.	6

KEY

Processes

Negative = negative finding for imitation
I.L. = individual learning
C = contagion
Exp. = exposure
O.C. = operant conditioning
S.E. = stimulus enhancement

Criteria failed

4 = episode not described in detail
5 = observer not aquainted with ontogeny of behaviour
6 = behaviour did not indicate imitation

natural thermal-spring on bitterly cold winter days. By simply accompanying other monkey bathers to the springs, naive individuals were more likely to explore and independently discover the warming properties of the water. The practice could, therefore, spread by exposure rather than imitation. In fact, since there were no complex programs of behaviour or specific action patterns involved in the Japanese macaque traditions, imitation (as defined in the present document) simple does not apply to them.

Marais (1969) reported some interesting, already established, apparent social traditions in Chacma baboons. One group was sometimes forced to obtain water from a hot-spring. The water was too hot to drink directly from the source, so some of the baboons would dig channels in the mud into which water flowed; after about an hour the water was cool enough to drink. Baboons often dig up roots and therefore this might have been the application of a species-typical behaviour in a new situation. Indeed Marais did notice juveniles engaging in rather ineffectual digging behaviours. Marais also noticed that only a few members of the group would actually dig the channels while all of the baboons drank the water when it was cool.

Marais (1969) also observed another group of baboons picking up baobab fruits which they would carry long distances until they reached a rocky area. They would then use stones to hammer open the fruit. Although, the baboons' behaviour appeared very intelligent and may have involved foresight in collecting the fruit and then carrying it to suitable rocky areas, it does not have to have been learned by imitation. Marais noticed some young baboons tried to bite the fruits open and only after considerable trial-and-error did some of them discover how to use the stones. This practice could therefore have spread by exposure and individual learning rather than imitation.

There are a few uncontrolled observations of apparent imitation that have come from captive subjects but none of these are convincing. Romanes' (1882) report of a capuchin monkey opening a trunk with a key was eloquently explained in terms of stimulus enhancement by Morgan (1900) (see chapter 1). Witmer (1910) described how a macaque opened a green-house door with no trial and error. She reached the latch by hanging from her hind-legs and opened it immediately, "making an intelligent attempt to imitate the persons whom she had seen going in and out of this door" (p. 225, cited in Hall 1963, p. 206). The monkey is just as likely to have had its attention drawn to the latch (stimulus enhancement) and the lack of trial and error could have been purely due to chance.

There are a number of observational reports in which monkeys have not seemed to learn from observing other individuals. Gibson (1989) comments that despite having owned a pet capuchin monkey for over eleven years she has never seen any act that even remotely resembled true imitation. There are also reports of surprising failures by monkeys to learn from conspecifics. Sholholzer (1958) saw two hamadryas baboons in Zurich Zoo use their tails to soak up otherwise inaccessible water from a steep-walled moat. Although many other individuals crowded around and tried to lick up drops of moisture from the skilled individual's tails, none of them attempted to independently dip their own tails. Visalberghi and Fragaszy (1990, pers. comm. Bernard) describe another advantageous behaviour which did not spread through a group. Two rhesus macaques on Cayo Santiago Island, Wk and his younger brother 436, learned to break open coconuts by hitting them against rocks. Dominant animals would sit and wait while either WK or 436 pounded a coconut and when it was cracked open they would take the broken pieces. The result was that coconut opening was quickly extinguished in the two brothers, but at no time did any of the other monkeys begin pounding open coconuts for themselves. Visalberghi and Fragaszy comment, "It seems likely that the requirements to obtain a particular orientation of nut to anvil, and to perform a specific act, were too complicated for the observers to learn this skill from watching WK and his brother" (p. 257).

The fact that there are no convincing uncontrolled observational reports in monkeys is not necessarily very revealing. Most of the observations of imitative behaviour involving apes came from human-raised individuals. It could be that monkeys do not imitate humans, but they do imitate one another. Negative results are always difficult to interpret. There are any number of reasons why an individual might not imitate on a given occasion (Box 1984). Controlled observations have the advantage of allowing a researcher to isolate important factors to a much greater extent.

CONTROLLED OBSERVATIONS OF IMITATION IN MONKEYS

Table 5.2 lists controlled observational studies of imitation in monkeys. In all these studies the observational protocols and criteria were decided prior to the onset of data collection. The researchers introduced specific novel objects or stimuli to a group of monkeys and systematically recorded their behaviour.

Chevalier-Skolnikoff (1989) used a Piagetian framework to evaluate the imitative behaviour of spider and cebus monkeys. Novel objects such as a plastic tub and a cloth were put in the monkeys' enclosure. The author claimed that the spider monkeys exhibited no more than stages 3 or 4 imitation which amounted to little more than stimulus enhancement. Chevalier-Skolnikoff interpreted some of the Cebus monkeys' behaviour as stage 5 or 6 imitation. In one incident a monkey intently watched another bang two objects together and then it picked up two other single objects and banged them together. As evidence of delayed imitation the author describes how one individual saw another place a tub into a moat. The first monkey proceeded to repeatedly lift the edge of the tub and duck its own head under it. Later the observer monkey did the same. Another monkey draped a cloth over a branch and removed all the wrinkles. When the cloth was re-introduced two months later a second monkey did the same. Half an hour later a third monkey also draped and smoothed the cloth.

The main problem with these observations is that there is no way to tell if the monkeys were in fact imitating one another or if they were performing similar behaviours independent of one another. Fragaszy (1989) comments:

> "One cannot simply assume intent to copy from whim. For example, that one monkey banged two nuts together after another had done the same is not the least convincing evidence of imitation - capuchins do this every day, with or without a model, and the behaviour is hardly new. The cases of capuchin monkeys carrying a cloth to a branch and smoothing it (considered delayed imitation) are just as likely to be completely independent actions. The author linked them, but did the monkeys? How are we to know? Additional information about the activities of animals outside the purported episode of imitation is needed.
>
> The point must be clearly understood that inference about imitation must rest upon clearer evidence than mere temporal proximity of similar actions" (p. 597).

The actions Chevalier-Skolnikoff describes are all species-typical capuchin behaviours. If

Table 5.2 Controlled Observation of Social Learning in Monkeys

Reference	Species	Report	Process	Criteria failed
Adams-Curtis (1987)	Cebus apella	Skilled juvenile manipulated a sequential mechanical puzzle, observers touched the object more but did not copy action patterns or sequence	S.E.	6
Beck (1972; 1973)	Papio hamadryas, & anubis repectively	Raking behaviour did not spread in a group of baboon, although they did touch the tool more after demonstration	S.E.	6
Beck (1976)	Macaca nemestrina	As above	S.E.	6
Boinski & Fragaszy (1989)	Cebus apella	Wild infant appeared to learn how to process caterpillars by trial and error	I.L., S.E.	6
Cambefort (1981)	Papio ursinus, Cercopithecus aethiops	Recorded pattern of propagation of using marker to find hidden food	S.E.	6
Chevalier-Skolnikoff (1989)	Cebus apella	Peeped head under plastic tub, draped cloth over branch and smoothed out the wrinkles	I.L., S.E.	5, 6
Fragaszy & Visalberghi (1989)	Cebus apella	Learned to use stick to poke out nut in tube but details of behaviour different from model	S.E.	6
Visalberghi (1987)	Cebus apella	Nut-cracking behaviour did not spread	Negative	6
Visalberghi & Trinca (1988)	Cebus apella	Did not learn to use a stick to poke a nut out of a tube by observation but did touch the stick and tube more	Negative	6
Westergaard & Fragaszy (1987)	Saimiri oerstedi	Squirrel monkeys did not learn to dip for yogurt after months of watching Cebus cagemates	Negative	6

KEY

Criteria

5 - Details of ontogeny of the specific behaviour was not known
6 - Behaviour did not indicate imitation

Processes

O.C.	- operant conditioning
C	- contagion
S.E.	- stimulus enhancement
I.L.	- individual learning
Negative	- behaviour suggests a process other than imitation

similar objects were introduced to any group of capuchin monkeys it is highly likely exactly the same activities would occur. That is why Thorpe (1963) insisted that an operational definition of imitation should include observations of novel or *improbable* acts.

There have been several controlled observations on social learning in capuchin monkeys (e.g., Visalberghi 1987; Adams-Curtis 1987; Visalberghi & Trinca 1988; Fragaszy & Visalberghi 1989). None of these have shown evidence of imitation. For example, Visalberghi and Trinca (1988) conducted a study in which a capuchin was able to watch a skilled conspecific use a stick to poke a peanut out of a horizontal tube. Although the observer directed more actions toward the stick and tube after observing the model (stimulus enhancement) exact copying of the poking behaviour was not evident from a micro-analysis performed on videotapes of the test sessions. The naive individual actually seemed to benefit more from individual learning. When she had solved an easier problem of using a stick to reach juice in a vertical tube and was then presented with the horizontal tube problem again, she solved it almost immediately. Adams-Curtis (1987) presented a four step sequential puzzle to a group of capuchins. One individual eventually solved the problem but despite several hundred subsequent "demonstrations", no other monkeys in the group solved it. "A detailed micro-analysis of the behavior of one of her frequent observers during several additional sessions indicted that the observer's contacts with the different parts of the puzzle were not different after he had just seen a solution than at other times. He continued to contact the parts of the puzzle in a way unrelated to the order of acts necessary to solve the puzzle" (Visalberghi & Fragaszy 1990, p. 259).

Beck (1973) found very similar results to those discussed above, in a tool-use study with a group of eight Guinea baboons (*Papio papio*). The baboons were presented with a pan of food placed outside their cage which could only be reached with a raking tool. One sub-adult male solved the problem and subsequently provided food this way for the rest of the group for almost a month. When the male was removed none of the other baboons solved the problem. They did, however, exhibit stimulus enhancement by manipulating the tool and directing it towards the pan more often than before. Beck found similar results with macaques (1974) and hamadryas baboons (1972).

Some of the controlled studies have included observations that have been suggestive of imitation, although the evidence is far from definitive. For example, when Beck (1972) presented the pan and raking task to a group of hamadryas baboons he observed:

"On the third successful trial ..., M2 [a sub-adult male] got the pan very nearly within reach after a 25 mins. and 15 secs. throwing sequence. F1 [a dominant female] rushed over quickly and M2 moved away leaving the tool lying between the pan and the cage. F1 reached for the pan but could not get it, picked up the tool and flipped it over to one side of the pan so that the hook was behind it. She pulled in the shaft a bit moving the tray just into her reach and secured the food. This seems to have been a clear case of imitation but in the total 104 successful trials, this was the only time that any member of the group other than M2 secured the food with the tool" (p. 284).

Of course, it could have been that F1's success was simply a lucky fluke rather than imitation. Similarly, Visalberghi and Fragaszy (1990) describe the behaviour of individual capuchins in Westergaard and Fragaszy's (1987) syrup probing task:

"... the first monkey to use a detached tool of her own fabrication (obtained by breaking a stick from a branch) exhibited the innovative behavior immediately after observing a cage-mate awkwardly stuff an attached branch into one of the holes of the apparatus. A second instance that suggested a role for observation in the acquisition of proficient probing concerned a mother (a proficient tool user) and her infant daughter of less than 1 year. The infant was often with her mother at the apparatus, and the mother frequently allowed her daughter to take sticks coated with syrup from her, and even to place her hand on the mother's hand during the probing action. In this case, observation and co-action were concurrent events. This infant was the first infant (out of three in the group) to acquire the tool-using behavior" (p. 262).

The authors go on to say:

"Although these are suggestive observations, they are not compelling evidence for imitative capacity. We are unable to rule out competing hypotheses, particularly the hypothesis that individual experience coupled with social enhancement processes can account for the observed behavior" (p. 262).

In fact none of the controlled observational studies provide convincing evidence for imitation in monkeys. More often these studies suggest that stimulus enhancement plays a more important role than imitation in the acquisition of novel behaviours.

EXPERIMENTS ON IMITATION IN MONKEYS

Table 5.3 lists all the experiments I could find in the scientific literature on social learning in monkeys. It was judged that none of these categorically establish an imitative ability in monkeys. Some of the studies did not claim to be specifically concerned with imitation; they investigated more general aspects of social learning. For example, Miller *et al.* (1959), Mineka *et al.* (1984), and Cook *et al.* (1984) were concerned with aspects in the acquisition of contagious and/or conditioned fear responses in monkeys. Presley and Riopelle (1958) conducted a study on the social facilitation of pain avoidance behaviour in rhesus monkeys. Hikami (1991) studied the social transmission of approach and avoidance behaviours. Takeda and Asano (1991) investigated socially transmitted curiosity in group-housed Japanese macaques.

Many studies have investigated the social facilitation of object or response discrimination. These kinds of tasks are simply not directly related to exact-action or program level imitation. For example, Feldman and Klopfer (1972) presented mother and infant, and unrelated juvenile lemurs (*Lemur fulvus*) with an object discrimination task. The researchers found the infants were more influenced by their mother than a known juvenile but the mother was more influenced by the juvenile. Although these results are important to general aspects of social learning, they are not directly relevant to the question of whether monkeys are capable of learning exact actions or complex programs of behaviour from observing others. Similar studies of observational response discrimination include Aronvitch and Chotin (1929), Darby and Riopelle (1959), Riopelle (1960), Wechkin (1970), Myers (1970), and Strayer (1976).

There have been studies which are more directly relevant to imitation as defined in the present document since they presented subjects with object-related manipulative problems (e.g., Kinnaman 1902; Warden & Jackson 1935). Unfortunately, the methodologies used in all these experiments (except for Ham 1990) were not capable of distinguishing imitation from stimulus enhancement. For example, Kinnaman (1902) tested the imitative ability of a male and a female rhesus macaque by allowing each of them to observe the other solving a

Table 5.3 Experiments on Social Learning in Monkeys

Reference	Species	Report	Process?
Aronvitch & Chotin (1929	Macaca rhesus	A male monkey was given opposed training to three companions on pushing one of two buttons to open a box. When they were placed in the same cage the male changed his response was to conform to the group	S.E.
Chamove (1974)	Macaca rhesus	Pairs of monkeys acted as demonstrator and models in discrimination tasks, they did not learn from one another	Negative
Cook et al. (1985)	Macaca rhesus	Learned fear of snakes by watching other fearful monkeys	C, O.C.
Darby & Riopelle (1959)	Macaca rhesus	Two cups but only one with food under it. Observer benefited from watching demonstrator especially if it made a mistake.	O.C.
Feldman & Klopfer (1972)	Lemur fulvus	Infant lemurs benefited from watching mother in discrimination tasks by not vice versa	S.E.
Haggerty (1909)	Cebus?? & Macaca rhesus	Various tasks, given 5 preliminary trials if failed allowed to watch a model. 16 cases of subsequent solution but only 5 within the first ten minutes	S.E.
Ham (1990)	Macaca arctoides	Two-act test with two groups, one saw a bar twisted the other saw it pulled. No difference found between the two groups of observers	Negative
Hikami (1991)	Macaca fuscata	Approach behaviour was easily transmitted, avoidance behaviour was not.	C
Kempf (1916)	Macaca rhesus	Behaviour of reaching through hole in cage wall to take food from a box did not spread	Negative
Kinnaman (1902)	Macaca rhesus	Various tasks e.g., pulling out a plug, pulling on a lever	S.E.
Miller et al. (1959)	Macaca rhesus	Showed fear response from watching another monkey and looking at a fearful monkey in a photograph	C
Myers (1970)	Macaca rhesus & arctoides	Two rhesus and two stumptails learned to respond correctly to multiple reinforcement schedule including non-emission of response. They did not learn switch variable interval when demonstrator did	O.C.

Reference	Species	Report	Process?
Parker (1977)	Macaca fuscata, Macaca fascicularis, & Cebus apella	Infant Japanese macaque, crabeating macaque and capuchin failed to imitate a human demonstrating facial expression and closed fist	Negative
Presley & Riopelle (1958)	Macaca rhesus	Observer learned faster than demonstrator to jump over barrier to escape electrified floor	C
Riopelle (1960)	Macaca rhesus	Four rhesus selected from 100 pairs of objects. Observer did better than demonstrator	S.E., O.C.
Shepherd (1910)	Macaca rhesus	Observer learned to rake in an object after demonstrator	S.E., E.
Shepherd (1910)	Macaca rhesus	Failed to learn by observation how to poke food out of a tube with a stick	Negative
Strayer (1976)	Macaca nemestrina	Pigtails' tested on a response alternation task Observer had better response delays than demonstrator but did not learn alternation aspect any faster	O.C.
Takeda & Asano (1991)	Macaca fuscata	Group members were much more likely to peep through a hole in a wall after dominant individual had done so than when a subordinate did	S.E.
Thorndike (1901)	Cebus??	Series of problems with puzzle box, subject did not learn from human or monkey demonstrator	Negative
Warden et al. (1940)	Macaca rhesus	Presented with a series of instrumentation problems in a duplicate cage. Observers benefited from watching a model.	S.E.
Warden & Jackson (1935)	Macaca rhesus	As above	S.E.
Watson (1908)	Macaca rhesus & Cebus??	Four monkeys were presented with various problems and none of them appeared to imitate	Negative

KEY

Processes

O.C. = operant conditioning
C = contagion
S.E. = stimulus enhancement
E = emulation
Negative = No evidence of social learning or imitation found

number of manipulative problems, such as opening a box, pulling out a plug to reach food, and pulling on a lever. In all the tasks, except for plug-pulling, Kinnaman concluded that the monkeys learned via instinctive imitation (i.e., contagion). In the plug-pulling task Kinnaman stated that the male:

"went immediately to the box, she following some four feet away. Knowing the trick perfectly he seized the end of the plug with his teeth and removed it. I set the box again; this time the female rushed to it seized the plug by the end as he did, and procured the food. This she repeated immediately eight times in exactly the same way" (p. 121).

The female could have simply had her attention drawn to the plug by the male's behaviour (stimulus enhancement) and then applied a species-typical behaviour of pulling on objects with her teeth.

Haggerty's (1909) experimental results can also be explained in terms of stimulus enhancement. In one test the subjects had to pull a string that was situated at the bottom of a tube in order to release a food reward. One subject had failed to solve the problem in five preliminary trials. It was then given the opportunity to watch another monkey solve the problem. The observer then immediately approached the tube, inserted its hand, pulled the string and hence released the reward. Since the tube was opaque, the observer could not actually see the model pull the string. Therefore, the only way the observer could have benefited from watching the model was through having its attention drawn to the tube (stimulus enhancement). The monkey had to discover for itself there was a string inside the tube that released food if it was pulled.

The only experiment that has been conducted with monkeys that could have distinguished imitation from other learning processes was Ham's (1990) two-act experiment with stumptail macaques. Two groups of monkeys watched one of two methods for manipulating a T-bar that was attached to the wall of a testing cage. One group saw the T-bar being pulled outward by a model and the other group saw the bar being twisted. Either of these actions caused the apparatus to automatically release a peanut. After watching the model the observer monkeys were allowed access to the apparatus. The T-bar was connected to a computer that recorded the number of pulls and twists performed by the subjects. There was no significant difference found between the numbers of twists and pulls performed by the two groups of observers.

There have in fact been a number of experiments that found no evidence of imitation in monkeys. The problem with negative findings is that there could be all kinds of reasons why an animal fails to learn (Box 1984). Kempf (1916) tested rhesus monkeys and found surprisingly little aptitude for imitating such a simple act as reaching through a small aperture in the cage wall to obtain food from a box. It could have been that the observers were too timid or nervous to explore what lay beyond the hole in the cage wall. Some studies have required the monkey to imitate humans, but it may be that they only imitate conspecifics (e.g., Parker 1977). In other studies the subjects were either kept in an unnatural social group (e.g., Thorndike 1901; Watson 1908) or separated from some or all of their social companions which may have inhibited their normal social learning abilities (e.g., Chamove 1974).

At the present time, there is no convincing evidence of imitation in monkeys. It would be wrong, however, at this stage to suggest that monkeys cannot imitate. There have not been enough methodologically sound studies on imitation in monkeys for us to be able to return any more confident a verdict than "not proven".

Chapter 6

IMITATION IN OTHER ANIMALS

The main focus of the present thesis is on imitation in primates. However, there is some evidence of imitation in non-primate species. Research into imitation in non-primates has proved important in relation to methodological issues and the nature of the cognitive processes involved in action imitation.

Some of the most convincing observational data on imitation in a non-primate has come from bottle-nosed dolpins (*Tursiops aduncus*). Taylor and Saayman (1973) reported a case in which a dolphin who was kept in a pool with a seal began to use the seal's swimming style of propelling herself around by her flippers instead of her flukes. The dolphin also appeared to try and adopt the same sleeping posture as the seal of lying belly up, which was difficult, to say the least, as dolphins breath through their dorsal hole. A second dolphin was seen:

"... after repeatedly observing a diver removing algae growth from the glass viewing port, ... cleaning the window with a seagull feather while emitting sounds almost identical to that of the diver's air-demand valve and releasing a stream of bubbles from the blow-hole in a manner similar to that of exhaust air escaping from the diving apparatus" (p. 290).

Lastly a young dolphin had seen a human observer through a viewing port blow out a cloud of cigarette smoke:

"The observer was astonished when the animal immediately swam off to its mother, returned and released a mouthful of milk which engulfed her head, giving much the same effect as had the cigarette smoke" (p. 291).

The milky smoke cloud incident seems extraordinary but it might have been a coincidence. The window cleaning behaviour could be explained in terms of emulation. Yet, the exact replication of the diver's breathing pattern suggests a strange instance of exact action imitation, as does the seal-like sleeping posture and swimming style. It seems clear that more formal research is needed on dolphin imitation.

Heyes and Dawson (1990) claim to have found an imitative ability in rats. Two groups of rats observed a trained conspecific push a vertical bar which was hanging from the ceiling of its cage in order to gain a food reward. One group saw the bar pushed to the left and the other saw it pushed to the right. The observers were situated in a cage directly opposite the model. When the subjects had seen the model push the bar 50 times the model was removed and the observer was placed in the compartment with the bar. In the test session the observers were rewarded for pushing the bar in either direction, yet they tended to push the bar in the same direction as the model. "On average, the observers of left pushing made 86% of their pushes to the left, and observers of right pushing made 29% of pushes to the left" (Heyes 1993, p. 1001). The rats' behaviour is particularly interesting because they compensated for the change in perspective and even though they were moved through 180 degrees from their observational position, they still pushed the bar in the same direction as the model.

It is not absolutely clear where Heyes and Dawson's rat data fits into the account of imitation that has been outlined so far in the present document. For example, the rats were not required to replicate the precise form of the actions used. A test of precise-form imitation might involve presenting the rats with one model that pushed the bar with its paw and another that pushed with its snout. The test of imitation would be whether the observers used the same method as demonstrated. Nor were the rats required to learn some complex program of behaviour (program-level imitation): after all, pushing at objects is very likely to be within a rat's normal behavioural repertoire.

The relevance of the rat data is in relation to the cognitive processes that are needed to compensate for differences in perspective. Several researchers have argued that action imitation is a particularly difficult cognitive ability precisely because an imitator must compensate for a difference in perspective between how he or she perceives the model's actions and his or her own response (e.g., Bruner 1972; Meltzoff *et al.* 1992; Whiten and Ham 1992). Despite the fact that the rats replicated a very simple action pattern, they still compensated for the difference in perspective between how they perceived the model's actions and their own. Even when the bar was re-positioned to the middle of the cage before the observers were given access to it, so that it moved towards different cage features compared to during the observation period, the observer rats still pushed it in the same direction as the model in relation to their own bodies (Heyes *et al.* 1992). The rats also seemed to be doing more than replicating the movement of the bar irrespective of the model's actions (a process called valence transformation by Hogan 1988), since they exhibited no directional preference when the bar was moved automatically during the observation period, i.e., without a rat pushing it (Heyes *et al.* unpubl.). These abilities suggest that rats "can manipulate and transform information in ways that have hitherto been assumed to be way beyond their capabilities (Heyes 1993, p. 1006).

There has also been some important research on imitation in birds. Chapter 2 features a discussion on experiments with budgerigars (Dawson & Foss 1965; Galef *et al.* 1986) and pigeons (Palameta & Lefebvre 1988). The rodent and bird work is particularly interesting because of the methodological rigour employed. For example, Palameta (1989) has conducted a two-act experiment with pigeons. A trough of bird seed was covered by a rotating disk. The disk had two holes. One hole had a stopper in it and was directly over the trough, the second hole was uncovered but above the trough so that the rotating disk needed to be pulled downward to reveal the food. Two pigeons acted as models for two separate groups of observers. Model A pulled the stopper out with its beak and model B rotated the disk by pecking downwards on the stopper. Palameta then glued the stopper into place and presented the apparatus to both groups of observers. The group that had watched model B pecked downward on the stopper more often and therefore solved the problem more quickly than the group that had watched model A. Palameta argued that the pigeon's behaviour constituted evidence of true imitation. However, pecking is very likely to be a contagious behaviour in pigeons, and although the effect of stimulus enhancement was kept constant, the facilitation in learning could be due to contagion rather than imitation.

Moore (1992) presented an African Grey Parrot, called Okichoro, with an arbitrary action series rather like that used by Hayes and Hayes (1952, see chapter 4). Okichoro imitated a total of ten non-functional actions, including waving, poking out his tongue, and nodding his head. Okichoro's imitations were unrewarded. A human demonstrator entered the parrot's room, announced an action, performed it, and left before the parrot could respond. A video monitor recorded the subsequent actions which Okichoro performed in solitude. Eventually, (sometimes after months of demonstrations), the parrot began to verbally announce the action and then imitate it. Moore argued that although there is a superficial similarity between imitation in parrots and chimpanzees, the processes are not identical. First, there was an incubation period of several months before a novel action was imitated by Okichoro, while there are several reports of immediate imitation in great apes (see chapter 4). Second:

"It is possible that there is also a functional difference between avian and mammalian imitation. The process often helps primates to acquire essential skills, and often involves tool use or tool making ... But the parrot's imitation appears to have nothing to do with skill learning or tool use; it may normally be related to social display" (Moore 1992, p. 257).

Moore's conclusion may be premature since Okichoro was not presented with a problem to solve via imitation. Careful observation of wild parrots may suggest that they do solve problems via social learning.

The faithful transmission of adaptive behaviours across generations is a rather obvious possible function of imitation. Chapter 7 considers the issue of nonhuman social traditions and culture.

Chapter 7

SOCIAL TRADITIONS AND CULTURE

SOCIAL TRADITIONS

In Tables 4.1 and 5.1 there are a number of reports of behaviours in monkeys and apes which have been referred to as local or social traditions. Kummer (1971) defined a social tradition as "behavioural modification induced by the social environment." Box (1984) explains that:

"... a strong case can be made that a pattern of behaviour does constitute a social tradition under conditions in which closely related (such as the same subspecies) but separate populations, living in very similar ecological conditions, are compared, and a behavioural deviation is found in one of the populations" (p. 222).

One must be very careful when considering already established behaviours to ensure that differences in separate groups of animals are not primarily due to ecological variation rather than social influence. Tomasello (1990) suggests that in most cases of apparent non-human social traditions it is practically impossible to exclude the chance that ecological factors are responsible for the behavioural variation. He considers the case of differences in termite-fishing techniques which McGrew and Tutin and Baldwin (1979) found across the Gombe (Tanzania), Mt Assirik (Senegal) and Okorobiko (Rio Muni) chimpanzees. Most notably only the Mt Assirik chimpanzees prepared their probing sticks by peeling the bark off first. Tomasello (1990) comments:

"it is impossible in principle for ecological analyses by themselves to answer definitively questions about learning processes. On the one hand, a failure to find ecological differences between groups does not mean there are none. Perhaps bark peeling is advantageous for one group but not another, for example, because of some of subtlety in the behavior of the particular termites on their range (they reside deeper, they grow larger, they have learned to be wary, their mounds are wetter inside, and so on ad infinitum) and this guides the individual learning of members of the two groups" (p.282).

Yet there are still a few behaviours in non-human animals which qualify as social traditions at least in Kummer's general sense of the term. The important point is not that the behaviour is learned through imitation, but that some kind of stable social transmission has occurred. Rather than considering established behavioural patterns, it is easier to identify a social tradition when novel practices are observed to spread through a group (Galef 1990).

Potato-washing in Japanese macaques constitutes one of the most famous cases of a social tradition in a non-human primate (see chapter 2 and chapter 5). The pattern of propagation indicates that the practice spread through social influence since juveniles learned from their same-age play-mates, mothers learned from their juveniles, and infants learned from their mothers (Kawai 1965). Yet, the actual learning process involved could be exposure or local enhancement, rather than imitation (Green 1975; Galef 1976). Nevertheless, it still qualifies as a social tradition because it was behaviour that was "induced by the social environment" (Kummer 1971).

Social traditions, so defined, have been observed in species other than primates. Perhaps the most famous example is the rapid spread of milk-bottle-top opening by British tits (*Paridae*). The birds learned to pierce through foil tops on milk-bottles left on people's doorsteps and eat the layer of cream beneath. The practice spread rapidly throughout many parts of Britain. Sherry and Galef (1984) presented 16 captive black-capped chickadees (*Parus atricapillus* - the American equivalent to British tits) with an equivalent problem, to study how the tits learned the behaviour. They found that chickadees who had their attention drawn to already open tops learned to pierce undamaged tops without directly observing the exact method used. Therefore, the bottle-opening tradition could have been transmitted by stimulus enhancement rather than imitation.

The Japanese macaques' and the Tits' social traditions arose directly from the fact that the animals were being (intentionally or unintentionally) provisioned by humans. It is more difficult to assess to what extent social traditions are present in wild populations of animals where humans have not significantly affected the learning environment (McGrew 1992). Hauser's (1988) report of vervet acacia pod dipping (see chapter 3) is the only example of a naturally occurring social tradition in non-human primates, where there were direct observations of the rapid spread of a novel behaviour with non-provisioned food. If the actual initial discovery and subsequent spread of a technical behaviour are not directly observed, one can not be sure that the members of a group did not acquire the practice through individual learning.

If an apparent social tradition does not involve manipulating objects or solving a technical problem, it is difficult to see how it could be transmitted by any process other than social influence. One such tradition is the Mahale chimpanzees' mutual grooming hand clasp described by McGrew and Tutin (1978), (see the database report number 48, chapter 4). The Mahale chimpanzees' strange grooming posture did not seem to be due to ecological factors. Although the chimpanzees at Gombe had occasionally been seen holding on to low-hanging branches with one hand while mutually grooming with the other, there was no difference found in the number of available low-hanging branches between Gombe and Mahale. As ecological factors could not explain the behaviour, it must have been transmitted by some kind of social learning. The mechanism of transmission did not necessarily have to be imitation, it could have been a kind of social moulding procedure (see comments accompanying the report in chapter 4 for greater detail). Nevertheless, as social influences appear to have been responsible for the spread of the grooming hand clasp, it does qualify as a social tradition (in Kummer's sense of the term).

McGrew (1977) comments:

> "No one would deny now that social traditions (in the sense of Kummer's [1971] "behavioral modification induced by the social environment") can and do exist in free-ranging nonhuman primate populations. It can be further postulated that when social traditions are passed between generations the process of socialization is involved. The unanswered questions lie in the area of proximal mechanisms of social traditions, i.e., how novel behaviors are acquired, disseminated, and transmitted (Beck 1974)" (p. 263).

The fact that it has been shown that social traditions exist in non-human species is very important in its own right. Social traditions show that animals can benefit from the innovative behaviours of others and these innovations can be maintained across generations. In terms of the practical benefits to an animal's inclusive fitness, it matters very little if the innovative behaviours are learned by imitation or some other social learning process. There is a danger that too strict a focus on imitation can blind researchers to the relevance of data relating to social traditions in terms of inclusive fitness (Box 1992).

NON-HUMAN CULTURE?

One hotly debated issue is whether the social traditions found in non-human species constitute evidence of non-human "culture". The concept of "culture" has proved as difficult to define as "imitation". Traditionally, culture has been defined in terms of being a purely human activity (e.g., Tylor 1871; Huxley 1958; Montagu 1968). Box (1984) comments:

"With very few exceptions (e.g., Harris, 1964), discussions of culture have excluded infrahuman species by definition. In a much quoted example by Tylor (1871), culture was described as "that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society." ... Further, Kroeber and Kluckhold (1952) list over two hundred descriptions of culture which reflect the anthropological bias which was understandably in the literature, given the lack of comparative evidence to the contrary" (p. 224).

When the Japanese macaque studies of culture in a non-human primate were published, (such as potato-washing (Kawamura 1954), wheat eating (Yamada 1957), candy eating (Itani 1958), hot-spring bathing (Suzuki 1965), swimming and a "gimme" begging gesture (Kawai 1965)), many anthropologists chose either to ignore them (e.g., Montagu 1968), dismiss them without proper discussion (e.g., Dobzhansky 1972) or to tighten up the definition of culture so that it even more stringently excluded non-human primates (e.g., Mann 1972). McGrew (1992) comments:

"The overall impression is that until recently anthropologists either long ignored the evidence for non-human culture, erected *ad hominem* criteria which avoided taking the phenomenon seriously or, having considered the problem felt it necessary to move the goal posts" (p. 73).

McGrew (1992) calls for an "operational definition of culture, that is, one that stipulates properties that are empirically observable and measurable" (p. 75). McGrew and Tutin (1978) took the first steps towards a working definition by "being as painstaking as possible in abstracting those qualities of culture that are thought to be crucial" (McGrew 1992, p. 76). They identify six conditions (innovation, dissemination, standardization, durability, diffusion, and tradition), which form a logical chronological sequence. McGrew (1992) adds two more conditions to these initial six (non-subsistence and naturalness). Table 7.1 is reproduced from McGrew (1992), it lists and defines the eight conditions for recognizing cultural acts.

None of McGrew's conditions stipulate that cultural acts must be disseminated by imitation. However, Tomasello *et al.* (1993) argue that the distinguishing mark of culture is that:

"cultural products share, among other things, the characteristic that they accumulate modifications over time. Once a practice is begun by some member or members of a culture others acquire it relatively faithfully, but then modify it as needed to deal with novel exigencies. The modified practice is then acquired by others, including progeny, who may in turn add their own modifications, and so on across generations. This modification across time is often called the "ratchet-effect," because each modification stays firmly in place until further modifications are made" (p. 495).

Tomasello *et al.* (1993) argue that only learning processes at least as complex as imitation, (which they define in terms of understanding the intentional state underlying a model's behaviour (p. 497)), can ensure the fidelity of transmission needed to support the ratchet effect.

Bruner (1993) argues that Tomasello *et al.*'s account of culture is too individualistic. He suggests that members of an existing culture indoctrinate new members in such a way that they promote and maintain cultural norms.

"For it is through cultural institutionalization that the most enduring "ratchet effect" is assured. Without such institutionalization, Kawamura's (1959) Japanese macaques do not pass on potato washing as a culture-wide tradition: it could easily disappear in a generation. For traditional cultural transmission requires not only an appreciation of "other minds." It also requires such intraspecific support as guilt and shame for non-compliance, as well as such punitively external ones as the compulsion of legal systems, the unavoidability of rites of passage assuring participation ..., incest taboos, and so forth" (p. 516).

It seems possible that cultural practices can be initially acquired through any social learning process. For example, the Thai people have a cultural practice whereby they avoid

Table 7.1 Criteria for recognizing cultural acts in other species (from McGrew 1992, p. 77)

Innovation	New pattern is invented or modified
Dissemination	Pattern acquired from another by innovator
Standardisation	Form of pattern is consistent and stylised
Durability	Pattern performed outwith presence of demonstrator
Diffusion	Pattern spreads from one group to another
Tradition	Pattern persists from innovator's generation to next one
Non-subsistence	Pattern transcends subsistence
Naturalness	Pattern shown in absence of direct human influence

crossing their ankles because it is considered offensive. It seems very unlikely that members of the Thai culture learn not to cross their ankles through imitation. Simply punishing a child for sitting with his or her ankles crossed would be sufficient to teach him or her through operant conditioning not to sit that way. A foreign visitor could learn the practice without she or he ever having "an understanding of the intentional state underlying the behavior" (Tomasello *et al.*'s 1993 definition of imitation). In fact, despite having lived in Thailand for three years as a child, *I* have no idea why Thai people find crossed ankles offensive. The important factor in learning cultural norms is not precisely how or by what mechanism these behaviours or practices are learned, but that they are maintained or institutionalized in the way Bruner describes.

Heyes (1993) also argues that, "research on imitation in non-human animals has no direct or special bearing on "the question of animal culture" (p. 1006). She notes that there is no reason why individuals who imitate should not, even during retention of a novel behaviour, adjust their behaviour in response to the environment regardless of the initial actions performed by a model. According to Heyes, if "behaviour acquired through imitation is not insulated from modification by the environment during retention" (p. 1005) then it can not form a firm enough basis for Tomasello *et al.*'s ratchet effect. Heyes (1993) concludes, "the psychological processes that support culture are those that insulate socially transmitted information from modification through individual learning, that prevent or discourage individuals from "testing" information acquired from conspecifics." It seems feasible that Bruner's process of intraspecific support is the essential element needed for culture rather than imitation.

Does this mean that the evidence for social traditions in non-human primates is of absolutely no relevance in relation to the evolution of human culture? First, it does seem to be a mistake to suggest that evidence of one or two socially transmitted behaviours in nonhuman primates means that in some sense they have a culture. The concepts of "social tradition" and "culture" are not equivalent. To illustrate this point, imagine two tribes of people who live in exactly the same environment and who behave in exactly the same ways except for one practice: all the members of tribe **A** cut their hair short, while everyone in tribe **B** lets their hair grow long. Based on the evidence of one idiosyncratic difference in behaviour, it seems sensible to conclude that the two tribes have basically the same *culture*, but they differ in respect to one *social tradition* or *custom*.

In our every day sense of the word, a culture constitutes a much more all-embracing phenomenon than simply consisting of one or two social traditions. Cultural systems or practices define a group or population, and they are a means by which the members of that culture define themselves and the world in which they live. When we talk about Western Culture the concept incorporates elements such as a shared history, art, religion, philosophy, literature, music, and technology. Social traditions or customs (such as, for example, the way Westerners shake hands when formally greeting one another) form a small part of the whole complex cultural system. It is no wonder, when the every day meaning of "culture" refers to a complex, interrelated, and socially maintained system of knowledge, beliefs and customs, that anthropologists have ignored or dismissed the evidence for one or two social traditions in animals.

I suggest, therefore, that much of the discussion of non-human culture and McGrew's eight cultural conditions relate to *social traditions*, not *culture*. However, since social traditions are a small element in the whole system of a culture, they are significant in relation to it. One problem in studying human culture is that it is so incredibly complex it is difficult to differentiate all the different elements involved. Studying non-human primates who seem to exhibit one component of culture, in their social traditions, may offer an insight into the evolution of the complicated edifice of human cultural activities. In other words, instead of arguing about the semantics of whether or not non-human primates can properly be said to have culture, we should re-focus the debate to ask exactly what we can learn from their behaviour about the evolution of human culture. (Exactly the same can be said of the debate over ape "language" projects. Instead of arguing whether signing or symbol use by apes should properly be called language, we should re-focus the debate on what the apes' behaviour can tell us about the evolution of human linguistic abilities (McGrew 1992).)

Chapter 8

UNDERLYING COGNITIVE MECHANISMS AND FUNCTIONS OF IMITATION

COGNITIVE PROCESSES UNDERLYING IMITATION

There are two ways of characterising the cognitive processes underlying imitation. One approach is to consider imitation in terms of problem-solving and reading the purpose or intention behind a model's actions (e.g., Tomasello *et al.* (1993). The other approach is to consider it on the level of mentalistic calculations of translating visual information into motor acts (Whiten & Ham 1992).

Tomasello *et al.* (1993) argue that imitation involves taking the psychological or mentalistic perspective of a model. The imitator must recognize the purpose or intention behind the model's actions. "Thus, to engage in imitative learning the child must understand the demonstrator in terms of his intentions toward things (i.e., as an intentional agent) in order to distinguish the relevant and irrelevant aspects of the demonstrator's behavior" (p. 503).

Cheney and Seyfarth (1990) discuss imitation in a similar way. They comment that:

"Visalberghi and Fragaszy [1990] ... suggest that monkeys may have difficulty in representing the task at hand and at recognizing the relation between actions and objects. Unlike chimpanzees, monkeys show little foresight and little ability to modify objects in *advance* of their use. Imitation may be uncommon at least in part because monkeys are unable to attribute purpose to others. Lacking a theory of mind, they may not recognize what others are trying to do.

"Chimpanzees and other apes seem more adept than monkeys at learning to use tools through observation, possibly because they are more adept at imputing purpose to others" (pp. 228-229).

Beck (1972) has also suggested that chimpanzees use tools more than monkeys, not because monkeys necessarily lack the ability to use tools, but because they are not able to learn from others about the advantages of tool use.

Whiten and Ham (1992), in contrast, suggest that the difficulty of imitation may lie in visual/motor perspective taking. They contrast action imitation with vocal, and assert that the former process is cognitively more demanding because a more complicated mental conversion is required.

They point out that:

"As Palameta (1989) notes, "in order to copy a novel movement, a bird cannot rely, as in song learning, on comparing it own product with the perceived act in the same sensory modality." More specifically, in song learning the bird does not have to represent what is in effect the model's representation of the act as it does in the case of visual imitation; instead, it need only adjust its own output until the sound of this matches what it originally heard (one level representation)" (p. 272).

Meltzoff, Kuhl and Moore (1992) argue that it is the cross modal nature of action imitation which makes it a more cognitively complex ability than vocal imitation. In action imitation our own and another's actions are not always perceived in the same sensory modality. For example, when imitating a facial expression, although we can see a model's face, we cannot see our own facial movement and directly compare them with the model. Therefore, it would seem that some kind of cross modal transfer is required in order to compare our visual perception of the model's facial expression with the kinesthetic perception of our attempted reproduction.

Many actions, of course, remain within the actor's field of view, such as hand actions. Yet, it has been argued that these are still more cognitively demanding to imitate than vocalizations because of the difference in perspective between how we perceive the model's performance and our reproduction of them. Whiten and Byrne (1988), after Bruner (1972), argue that all action imitation:

"involves the imitator in a particularly difficult mental transformation. Its perception of behaviour as seen in others must be translated into motor acts which even if it can see them, will from this new point of view look quite different to the novel behaviour originally observed in others" (p.65).

Whiten and Ham (1992) argue that the mental transformation involved in action imitation requires metarepresentational abilities.

"To imitate in the visual mode involves B copying an action pattern of A's that was originally organized from A's point of view (Bruner 1972). It is necessarily a different pattern from B's point of view, yet it has then to be re-represented in its original organizational form so as to be performed from B's point of view. The expression "re-represented" seems unavoidable and is used advisedly: it translates as second-order representation or metarepresentation (Leslie, 1987; see also Dennett 1988). To put the idea more graphically, we might say that B has to get the program for the behavior out of A's head: in other word, to engage in a type of mindreading" (p. 271).

Therefore, via a rather different route, Whiten and Ham (1992), like Tomasello *et al.* (1993) and Cheney and Seyfarth (1990), have related imitation to the ability to attribute mental states to others.

Yet, not all cases of action imitation involve a difference in perspective between the observer and model. Imagine a situation in which two individuals sit side by side and facing in the same direction. One of them, A, repeatedly performs the action of opening and closing her fist. The observer, B, can see her own and A's hand action from almost the same perspective and hence, just as with vocal imitation, B can compare "its own product with the same act in the same sensory modality" (Palameta's words in reference to vocal imitation). It is hard to see, based on the difference in perspective alone, how the above example of action imitation is any more demanding than vocal imitation. Especially when one takes into account that in vocal imitation, just as in action imitation, the imitator must convert perceived information (albeit, through the auditory rather than visual modality) into motor actions to physically produce vocal sounds.

THE FUNCTION OF IMITATION

Action imitation could also be a cognitively demanding process for reasons other than the difference in perspective between the model and the observer. One would expect that the complexity of the kinds of behaviours which are being imitated, and the contexts in which they occur, would increase the overall difficulty of reproducing them. One must consider the issue of the *function* of imitation. Why would anyone imitate an arbitrary action, such as opening and closing a hand? If an arbitrary or non-functional action was presented to an animal and it did not imitate the model one would not know whether it could not imitate or whether it was not motivated to do so.

A distinction needs to be drawn between the concepts of "imitation" and "imitative learning". It is possible to faithfully imitate a succession of different actions without actually learning anything: that is, if all the modelled action are already within the imitator's repertoire. It is hard to imagine, except in the context of play, why an animal would imitate familiar arbitrary actions. Most researchers have concentrated on imitative *learning* because the potential functional value is reasonably obvious. Through imitative learning one can acquire novel behaviours or learn how to solve a problem by seeing a model do it first.

Tomasello (1990) suggests that one kind of behaviour in which imitation may be adaptive is gestural communication. Goodall (1986) comments that, "If a new communication signal is to be incorporated into the repertoire of the group as a whole, more is required than that other individuals imitate the pattern" (p. 145). The actor must use the signal in the correct contexts for it to convey an appropriate message to the recipient. Goodall describes one instance where a young chimpanzee, Fifi, produced a novel hand shaking action as an apparent threat gesture and her playmate, Gua, was observed to use the same gesture in a similar way. But, Tomasello *et al.* (1989) in a long term observational study of gestural communication in young chimpanzees found no apparent evidence of imitation.

There have been relatively few studies on imitation of gestures in animals. The majority of studies have concentrated on the imitation of actions used to manipulate objects in order to secure a food reward. In the wild there are two kinds of behaviour in which objects are manipulated in order to secure food: processing of different kinds of foods, such as insects and embedded or partially embedded fruits and roots, and tool use. Visalberghi and Fragaszy (1990) note that:

"Imitation is particularly useful as a means for learning from others when the observer is not proficient, opportunities for practice are limited, costs of errors are high, and learning by individual experience would be a slow process. Imitation would seem to have the greatest potential value to nonhumans, for example in learning ways to find, capture, and process foods" (p. 247).

The kind of situation in which one might expect an animal to imitate is in processing partially or wholly embedded foods (i.e., the nutritious part of the food is surrounded by a tough inedible husk). Jolly (1988) points out that there are reasons for thinking that an animal would need a degree of intelligence to be able to process embedded foods. It involves a degree of problem solving, since the animal must work out how to penetrate or remove the outer husk in order to gain access to the nutritious flesh or kernel inside. Also, one would expect a hierarchical food processing task to be more difficult to imitate than one that involves performing a discrete action pattern. In imitating a hierarchical task one need not only recall what exact actions to use, but also their sequence and logical structure (Byrne in press).

Another context in which imitation has been studied is tool use. Tool use is thought to be particularly cognitively demanding because it involves a mental operation akin to lateral thinking. One performs a kind of mental side step by directing one's attention to an intermediary object, the tool, before pursuing a particular goal.

One must be careful in studying imitation, not to confuse an apparent lack of ability to imitate with a lack of ability or propensity to perform the modelled task. If the species in question is not known to regularly use tools or process embedded foods, it may not be a fair test of imitation to require them to observe and replicate such behaviours. For example, very few monkey species are known to use tools in the wild, so perhaps we should not be surprised if they do not imitate such activities in laboratory tests. One way to overcome this problem is to devise experimental tasks which are based on the behaviour of wild individuals in the given species.

Visalberghi and Fragaszy (1989) observed that "the best evidence for imitation in apes comes from observations of play, not problem-solving tasks" (p. 264). Whiten and Byrne (1988) comment that "if a big knowledge base permits greater cleverness - then we might expect intelligence to be marked by a tendency to gather declarative knowledge" (p.

53). By exploring objects and one's environment through play and imitation one can learn important facts which may prove to be useful at some later time. Whiten and Byrne comment:

"One of the most plausible "arguments by design" for the function of play is that it serves to gather knowledge ... to allow future flexible response to relatively novel circumstances; Fagen (1976) drew the analogy to the aeroplane which is flown under the control of a computer through such exaggerated manoeuvres that it would look to be "playing", while feedback about the effects of these behavioural extremes is used by engineers to build into the control system a model of actions and their effects which permits the consequences of new actions to be predicted" (p. 59).

If play includes the precise actions or behavioural program of another individual the imitator may benefit by being able to build into his or her "control system" actions that he or she may not have discovered through individual exploration.

Let us consider how Kohler's chimpanzee, Sultan, learned to join together two sticks in order to extend his reach to a banana situated outside his cage. For over an hour Sultan struggled with the problem to no avail. The experiment was stopped because it seemed hopeless.

"The keeper is left there to watch him ... Keeper's report: "Sultan first of all squats indifferently on the box which has been left standing a little back from the railings, then he gets up, picks up the two sticks, sits down again on the box and plays carelessly with them. While doing this, it happens that he finds himself holding one rod in either hand in such a way that they lie in a straight line. He pushes the thinner one a little way into the opening of the thicker, jumps and is already on the run towards the railings, to which he has now half turned his back and begins to draw the banana toward him with the double stick. I call the master. Meanwhile one of the animal's rods has fallen out of the other as he has pushed one of them only a little way into the other, whereupon he connects them again" (Kohler 1927, p. 115, cited in Jolly 1985).

Of course, Sultan was not imitating but his behaviour shows one of the possible benefits of playful exploration. If an animal is too focused on finding the solution to a problem or too highly motivated it may actually hinder intelligent exploration and subsequent innovative learning. Exploration of objects which incorporates imitation of a model's behaviour may be a rich and intelligent form of learning in which the potential benefits may not be immediately apparent. Adding new arbitrary action-patterns and programs to one's behavioural repertoire through imitation may be of value by contributing to the degree of behavioural flexibility one has in regards to finding solutions to future novel problems.

The present account of imitative play relates very well to Whiten and Byrne's (1988) discussion of "social intelligence". They dissected the concept of social intelligence and considered factors such as curiosity, problem-solving, innovation, flexibility, social play and imitation. The Social Intelligence Hypothesis suggests that human intelligence may have evolved primarily to deal with social rather than merely technical problems. Whiten and Byrne (1988) comment, "The most basic proposition ... is that, although most research on animal and human intellect has focused on how intelligence deals with the physical world (and the very concept of intelligence has been shaped by this), in reality intelligence is applied also in dealing with other individuals" (p. 2). Imitation is a possible bridge between technical and social intelligence: it can be used to learn social skills (such as gestural communication) and technical skills (such as food-processing and tool-use). Imitation would, therefore, seem an important behaviour to consider in relation to the evolution of human intelligence (Byrne in press c).

It is probably a hopeless task to try and generate a taxonomy of "intelligence" (social or otherwise) across the animal kingdom (see Romanes 1882 for just such an attempt). Animals have evolved to fill different niches and are therefore predisposed to solve different environmental and social problems in different ways. So a straightforward comparison between different species, especially distantly related species, would be inappropriate. Yet, if one is primarily concerned with the evolution of *human* intelligence, the task is far from hopeless. One simply looks for *human-style* learning and problem-solving in other, and especially closely related, animal species. We know that humans often solve problems and learn novel actions by imitating other individuals. It is therefore relevant to ask, can and/or do non-human primates imitate in the same way?

Chapter 9

CAN YOUNG CHIMPANZEES IMITATE ARBITRARY ACTIONS? HAYES & HAYES (1952) REVISITED

This chapter forms the basis of a paper submitted for publication under the same title by, D. M. Custance, A. Whiten and K. A. Bard

Chimpanzees appear to be one of the most imitative non-human species (see chapter 4). However, the majority of evidence for imitation in chimpanzees has come from uncontrolled observations. There are only two properly designed experiments which claim to have found positive evidence of imitation in chimpanzees (Hayes & Hayes 1952; Tomasello *et al.* in press). Tomasello *et al.* (in press) required six chimpanzees to imitate arbitrary actions performed on 16 different objects (see chapter 4). Hayes and Hayes (1952) required one chimpanzee to imitate a series of 70 arbitrary object- and non-object related actions. Since these studies presented arbitrary actions, they are necessarily more concerned with issues related to the cognitive nature of imitation than its functional value. In other words, the experimental results pertain to the question, "*can* chimpanzees imitate?" rather than "*do* chimpanzees imitate?". The present experiment is a modified version of Hayes and Hayes' imitation action series, and thus, it is also primarily concerned with issues related to the cognitive structure rather than the function of imitation.

It was mentioned in chapter 8 that there are two ways of characterising the cognitive processes underlying imitation. The first relates to imitative problem-solving, where it is suggested that in order to imitate one must read the intention or purpose behind a model's actions (e.g., Beck 1972; Cheney & Seyfarth 1990; Tomasello *et al.* 1993). The second approach considers imitation in terms of the cognitive calculations needed to transform visual information into matching motor acts (Bruner 1972; Whiten

& Byrne 1988; Whiten & Ham 1992; Meltzoff 1992; Heyes 1993). When only arbitrary actions are presented in an imitation study (i.e., there is no direct goal or purpose related to the act) it is best to consider the results in terms of visual-motor perspective-taking rather than mental state attribution.

Action imitation is thought to be a cognitively challenging ability because an imitator must compensate for the difference in perspective between his or her perception of a model's actions and his or her imitative response (Bruner 1972; Palameta 1988; Whiten & Ham 1992; Heyes 1993). Heyes (1993) provides the example of curtsying to illustrate this point:

"If I look down when I curtsy, I see something very different from what I see when I look across at somebody else curtsying. If animals can imitate movements like this, without being rewarded for successive approximations to the modelled movement, then it is something of a mystery ... how might an animal ... map visual input from a model onto disparate visual and tactile feedback from their own actions?

Thus, task analysis suggests that imitation is an especially demanding variety of visual-tactile cross-modal performance (Ettlinger 1960; Ettlinger & Wilson 1990; Meltzoff 1990; Rose 1990), of behaviour requiring an individual spontaneously to equate patterns of sensory stimulation in different modalities" (p. 1006).

Heyes and Dawson (1990) claims that rats are capable of imitation. Observer rats were found to be capable of compensating for the difference in perspective between themselves and a model when pushing a bidirectional vertical bar, either from left to right or vice versa (see chapter 6 for greater detail). The rats' behaviour was not imitation in the sense of reproducing the precise physical form of the model's actions (Galef 1988; Whiten and Ham 1992): Heyes and Dawson did not mention if the rats imitated in the sense of, for example, pushing the bar with the snout versus pushing with the paw. Nevertheless, the fact that the rats were able to compensate for the difference in perspective means that they exhibited a very important cognitive component of imitation. Bruner (1972) suggests that the ability to compensate for differences in perspective between oneself and a model is one of the most cognitively demanding aspects of action imitation.

The difference in perspective between a model and imitator is most marked on actions which are either wholly or partially outside the actor's field of view, such as facial expressions or whole body acts. Meltzoff and Moore (1977) claimed that human neonates are capable of imitating novel facial expressions, such as mouth opening and tongue protrusion. Meltzoff *et al.* (1991) went on to argue that such imitations are mediated by an amodal or representational code:

"Although the hypothesis that newborns are more (or less) a bundle of reflexes and releasers doubtlessly will be debated for some time, it may be more accurate to think of the young infant, even the newborn, as a representational being. In this view neonates are capable of registering "supramodal" or "amodal" information about the adult's movement patterns that is used directly as the basis for the infant's own motor plans. Thus conceived, the neonate's encoding of the adult's act is neither exclusively visual nor exclusively motor, but rather is a modality-free description of the event. Such an internal representation constitutes the "model" that directs the infant's actions and against which he can match his motor performance. Thus, infants could compare the proprioceptive information from their own unseen body movements to their representation of the visually perceived model and sharpen their match over successive efforts. This phenomenon of gradual accommodation to the target has been observed ... Similarly, imitative responses would not need to be fired-off in the presence of the model, but might be initiated from the infant's memory of what the adult has done" (p. 406).

The evidence for imitation in human neonates is highly controversial (see Anisfeld 1991 for a review). Despite this, Meltzoff *et al.*'s reasoning in relation to what constitutes evidence that an instance of imitation is based on an amodal or representional code seems to be basically sound.

Although imitation would seem to be a very important ability in terms of gaining an insight into the cognitive capabilities of different groups of subjects, research into the area has been dogged by methodological problems (see chapter 2 and 3). It has proved difficult to devise experimental methodologies which are capable of distinguishing imitation from other mimetic processes, such as stimulus enhancement and contagion. Hayes and Hayes (1952) experimental design is of particular interest because it does control for these processes.

Hayes and Hayes (1952) taught their three-year-old home-raised chimpanzee, Viki, through shaping, molding and reinforcement, to reproduce several actions on the command, "Do this!". "Beginning with the twelfth, however, certain new items were imitated immediately, without preliminary tutoring - provided that she had previously done them in other situations. ... Beginning with the twentieth task, at least ten were copied immediately, even though we were quite certain that she had never done them before under any circumstances" (p. 452). The authors reported that Viki eventually imitated 55 out of 70 demonstrated actions. Stimulus enhancement was controlled for since only arbitrary actions were presented, and not solutions to technical problems. Contagion was controlled for because the greater number of actions reproduced, the more unlikely it becomes that contagion is the underlying mechanism (Meltzoff *et al.* 1992).

However, Hayes and Hayes' work is flawed because they did not provide scientifically adequate detail on either their procedure or results. They did not list the demonstrated actions, and they only described two of Viki's completely novel imitative responses - whirling on one foot and stretching the mouth with the index fingers. Thus the claim that 55 actions were imitated is not supported by published data. The experiment begs replication.

The present experiment is a replication of Hayes and Hayes' original work, except: 1. we ensured that there was a clear distinction in the way the taught and novel actions were presented. Hayes and Hayes had continued after the first few demonstrations of a novel item to mold and shape Viki's responses until they were accurate reproductions of the demonstrated action. We simply presented the novel items to our two chimpanzee subjects a total of six to eight times without providing any direct instruction. (2) Hayes and Hayes proposed no objective measure for determining the accuracy of Viki's responses. In the present experiment, two independent observers were required to code videotaped recordings of the chimpanzees' behaviour, and, (3) unlike Hayes and Hayes, we describe the demonstrated actions and the chimpanzees' respective imitations in detail.

METHOD

Subjects

The subjects were two nursery-reared chimpanzees (*Pan troglodytes*) at Yerkes Regional Primate Research Center of Emory University. Scott (SC) was a male, whose age spanned from four and a half to five years during the study. Katrina (KA) was a female, whose age spanned from four years and five months to four years and eleven months. SC and KA were chosen for the imitation project because they were known to be very cooperative individuals who seemed to enjoy interacting with humans.

SC and KA had been placed in Yerkes' Great Ape Nursery within twenty-four hours of birth because their biological mothers did not have sufficient maternal behaviours to provide adequate care (see Bard 1994 for further details of maternal competence in chimpanzees). Although the chimpanzees were given regular contact with humans, SC and KA were placed in same-age peer groups from six weeks and four weeks of age respectively. While SC and KA were in the great apes nursery they participated in much of the recent developmental research conducted there (e.g., Bard *et al.* 1990; 1991). However, none of this research involved teaching them to imitate specific activities or actions. For further details on SC and KA's upbringing see Custance & Bard, 1994).

Procedure

Prior to more formal testing it was decided that the demonstrator (D. M. Custance) should spend some time getting to know the chimpanzees and establishing friendly relations with them. For two weeks the demonstrator spent some part of every day with the chimpanzees. Due to reasons of safety it was decided that the demonstrator should enter the cage with the chimpanzees. We did not know what effect

Table 9.1: Descriptions of the Taught Actions

ACTION	DESCRIPTION
Shake hand	The hand was shaken loosely from the wrist (Figure 9.1).
Praying hands	The hands were placed together as if praying.
Raise one arm	One arm was raised in the air (Figure 9.2).
Raise two arms	Two arms were raised in the air Figure 9.3).
Wipe hands	The hands were held flat together. The top hand wiped the bottom one and both were flipped over with each wipe.
Swing arm	One arm was swung back and forth several times.
Raise foot	One foot was raised about twelve inches from the ground.
Stamp foot	One foot was stamped on the floor several times.
Slap floor	The floor was slapped several times with one hand.
Wipe floor	The floor was wiped from side to side with the flat on one hand.
Grasp wrist	The right hand grasped the left wrist (Figure 9.4).
Touch chin	The index finger of one hand was placed on the chin (Figure 9.5).
Touch underarm	The left arm was raised and the index finger of the right hand was placed on the left armpit (Figure 9.6).
Pat stomach	The stomach was patted alternately with the flat of each hand several times.
Wipe face	The flat of one hand was wiped down the face several times.

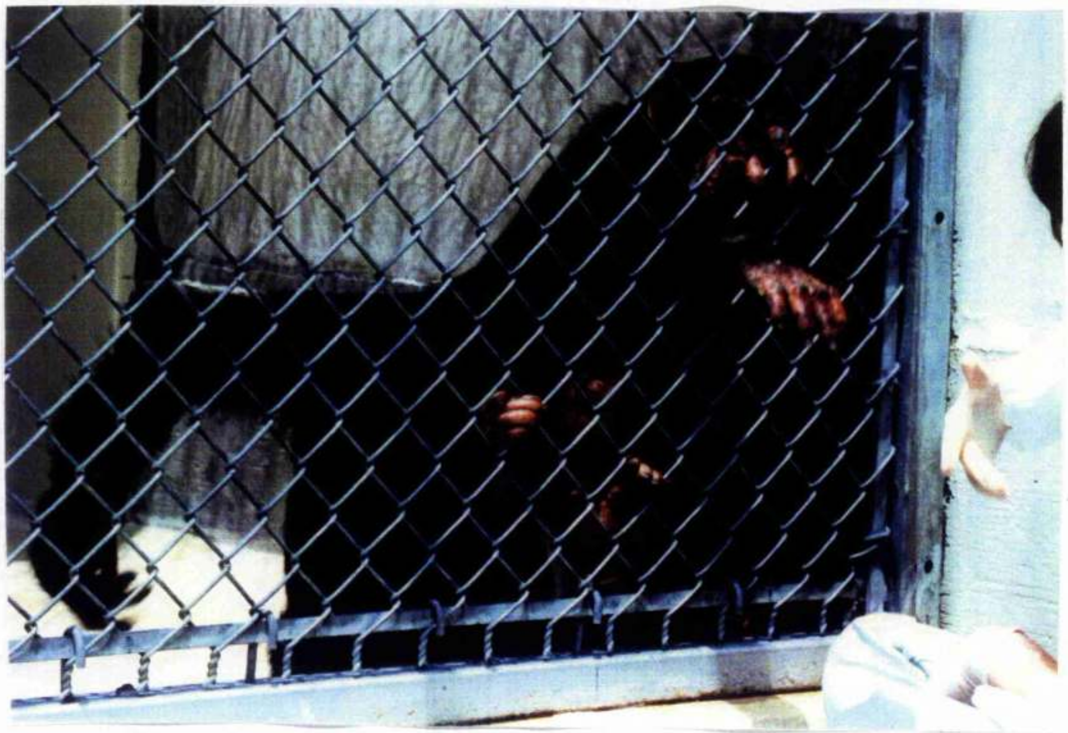


Figure 9.1: "Shake hand" (SC on right, KA on left) - taught action

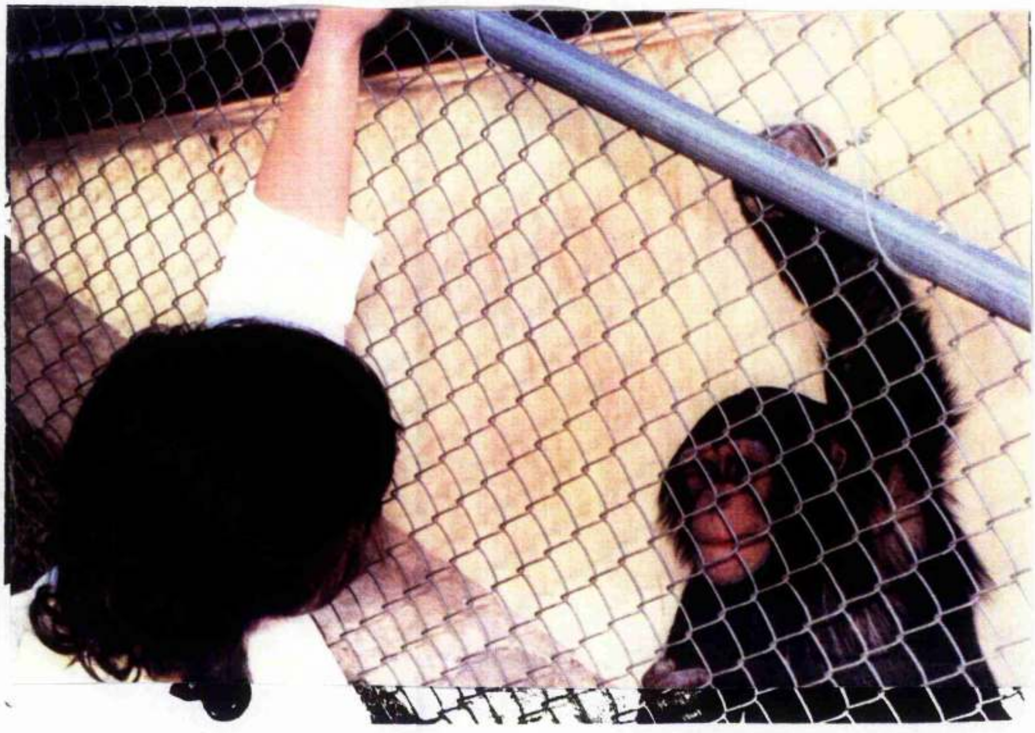


Figure 9.2: "Raise one arm" (SC) - taught action

Figure 9.3: "Raise two arms" (KA on right, SC on left) - taught action

Figure 9.4: "Grasp wrist" (SC) - taught action

Figure 9.5: "Touch chin" (KA) - taught action

Figure 9.6: "Touch under arm" (SC on left, KA on right) - taught action

Table 9.2: Descriptions of the Novel Actions

ACTIONS	DESCRIPTIONS
BLOCK: FACIAL	
Protrude tongue	The tongue was pointed and protruded out of the mouth.
Protrude lips	The lips were puckered and pouted forward.
Lip smacking	The mouth was opened and closed with the lips smacking against each other.
Teeth chattering	The teeth were bared knocked together to make a clicking sound.
Puff out cheeks	The lips were held shut as the cheeks were filled with air.
Close eyes	The eyes were closed for a few seconds and opened again.
BLOCK: SINGLE HAND	
Open hand	One hand was held up with the palm facing away from the body and the digits splayed apart.
Finger wiggling	The hand was held as in open hand while the fingers were sequentially curled and straightened.
Stiff wave	The hand was held as in open hand except the digits were closed. The hand was then rhythmically rotated from side to side from the wrist.
Raised index	The hand was held up with the palm facing away from the body and kept in a fist except for the index finger which was extended upward.

ACTIONS	DESCRIPTIONS
Circle	The hand was raised sideways with the fingers curled over, their tips touching the tip of the thumb.

BLOCK: SYMMETRICAL HANDS

Clapping	The hands were held palms together, with the fingers pointing away from the body and clapped together several times.
Index fingers touch	The hands were held about a foot apart and kept in fists except for extended index fingers which were pointing toward each other. The hands were then moved together until the tips of the index fingers touched.
All digit tips touch	The hands were held about a foot apart, palms facing each other and fingers bent so that their tips faced each other and splayed apart. The hands were brought together until the tips of all the equivalent digits touched.
Interlink fingers	The hands were held with the fingers facing away from the body, and apart with the base of the palms together. The fingers were interweaved together and curled linking the hands.
Roll hands	The hands were held in fists, sideways on to the body, with one in front of the other. They were then alternately circled around each other.

ACTIONS	DESCRIPTIONS
Peekaboo	The hands were held flat, edge to edge, fingers closed and up in front of the face. They were then moved apart to reveal the face and then brought back together again.

BLOCK: ASYMMETRICAL HANDS

Clap back of hand	The right hand was held over the top of the left hand with the fingers closed, the palms flat and the fingers facing away from the body. The right hand then clapped the back of the left hand several times.
Two-fingered clapping	The left hand was held palm up, with the fingers together. The right hand was held in a fist except with the first two fingers extended, which were used to clap the left palm.
Palm point	The left hand was held open, fingers together and pointing upward. The right hand was held a foot away in a fist with the index finger extended and pointing toward the left palm. The right hand was moved over to the left palm until the tip of the index finger touched it.
Palm punch	The left hand was held as in "palm point", while the right hand was held a foot away in a fist. The right fist was then used to punch the left palm.
Grab thumb	The left hand was held in a fist with the palm facing away from the body and the thumb extended. The right formed a fist around the left thumb.

ACTIONS	DESCRIPTIONS
Rabbit hole	The left hand made a "circle" (see single hand action) and the right hand formed a fist with the index finger extended. The right index finger was then placed into the circle and made a circular motion.
BLOCK: TOUCH IN SIGHT	
Shoulder	The left shoulder was grasped by the right hand.
Elbow	The left hand rested on the left shoulder with the elbow held up and pointing away from the body. The right hand grasped the left elbow.
Stomach	The flat of the right hand was placed on the stomach.
Thigh	The flat of the right hand was placed on the middle of the left thigh.
Knee	The right hands grasped the left knee.
Foot	The right hand grasped the left foot.
TOUCH OUT OF SIGHT	(All performed sitting in the haunches and with the right hand).
Back of head	The flat of the hand was placed on back of the head.
Top of head	The flat of the hand was placed on the top of the head.
Nose	The index finger was placed on the tip of the nose.
Ear	The index finger was placed on the ear.
Clap behind	The hands were clapped together once behind the back.
ACTIONS	DESCRIPTIONS
Elbow behind	The left arm was bent with the elbow pointing backward. The right hand was brought around the back and touched the left elbow.

ACTIONS	DESCRIPTIONS
FACE/HEAD RELATED	
Whistle	The lips were protruded and one long whistle was blown.
Mouth pop	The right hand was made into a fist with the index finger extended and the palm facing away from the body. The end of the index finger was then placed against the inside of the left cheek. The lips were closed around finger which was kept straight and jerked, from the wrist, out of the mouth making a pop sound.
Lip wobbling	The lips were protruded. The right hand formed a fist with the index finger extended sideways on to the body. The index finger was placed against the lips and the hand moved up and down causing the lips to smack against one another.
Mouth pull	Both hands were formed in fists with the index fingers extended. The index fingers were hooked inside the corners of the mouth and moved apart pulling the mouth wider.
Look up	The head was tipped upward in a firm clear manner.
Look right	The head was turned to the right in a firm and clear manner.
BLOCK: WHOLE BODY	
Jump	Standing upright, the hands held against the sides of the body, the demonstrator jumped about six inches off the ground.

ACTIONS	DESCRIPTIONS
Turn around	Standing upright, the hands were held against the sides of the body
Sit	Sitting on her haunches, the demonstrator sat back on her posterior and clasped her bent knees with her hands.
Flap arm	Kneeling on one knee, the arms were raised and waved up and down as if imitating a bird.
Hug self	Kneeling on one knee, the arms were crossed over one another in front of the body, grasping the opposite upper arm. The upper body was then twisted back and forth from the waist, causing the body to rock from side to side.
Foot to foot	Standing upright, each foot was alternately lifted from the ground.

interacting through the fence would have on experimental procedure. Therefore, the two week habituation period was also used as a pilot study.

During the two week pilot study the demonstrator presented 8 arbitrary actions to the chimpanzees (make a fist, shake hand, praying hands, slap floor, raise one arm, raise two arms, hold arms out to the side, raise foot). The demonstrator issued the command "Do this" and demonstrated one the actions and noted down each of the chimpanzees' responses. The demonstrated actions were interspersed in the middle of play and tickle interactions through the fence. The chimpanzees were not rewarded for their responses.

There was very little evidence of imitation from the chimpanzees. For the vast majority of demonstrations they gave no response. The only action that SC matched was "shake hand", but SC often shook his hand in an apparent attempt to gain the attention of humans outside his cage. He actually shook his hand in response to many of the different actions including the matching target item.

The chimpanzees responded most to action in which the could touch and coact with the demonstrator. For example, in response to "slap floor", SC reached out under the fence and make repeated grabbing movements at the demonstrator's hand. SC responded to "praying hands" by reaching through the fence and touching the demonstrator's hands, occasionally her reached out with both his hands so that his response very crudely resembled the demonstrated action.

During the pilot study KA spent most of her time generally ignoring the demonstrated action and prefered to try and initiate chase and tickle games instead. The chimpanzees were not given food rewards during the initial pilot testing. KA seemed to be quite highly motivated by food and became much more responsive when food rewards were introduced. It was also found that interspersing demonstrations during play was ineffective, since the chimpanzees did not concentrate on the demonstrated actions and prefered to continue playing. Therefore, it was decided that testing sessions should be treated like work sessions and any play between the demonstrator and chimpanzees should be restricted to when formal testing had ended.

It was decided during the pilot study that working through the fence would not in fact be a hinderance to experimental procedure. On the contrary, the fence acted as a useful barrier; it mediated interaction between the chimpanzees and the demonstrator to a greater extent than if the demonstrator had been inside the cage with the subjects. Also when food rewards were introduced the dispensing of rewards was easier than if the demonstrator had been inside the cage. In addition, occasionally the subjects, especially the young male SC, were very boisterous. By interacting through the fence it was easy to gauge their moods and terminate interactions until the subjects were calm and willing to quietly participate in the testing session.

After the two week pilot study a more formal teaching regime was introduced. This phase of the experiment lasted for approximately three and half months. There were two to three testing session every weekday. During this period 15 different actions were taught to the chimpanzees using classical and operant conditioning techniques, such as molding and shaping with food rewards. The taught actions are listed and described in Table 9.1 and Figures 9.1-9.6 are photographs of the chimpanzees performing some of the taught actions. Two further actions were presented in the early stages of the teaching phase, but later rejected. Despite repeated attempts the chimpanzees never learned to close their fist on command. They would hold one hand out towards the demonstrator, but would not close it into a fist. The demonstrator also taught the chimpanzees to reproduce the action of holding their arms out wide. However, the testing area in front of the chimpanzees' cage was small and it was difficult for the demonstrator to perform this action, so she eventually rejected it.

The chimpanzees' behaviour was shaped using food rewards of peanuts, grapes and raisins. At first the chimpanzees were liberally rewarded for nearly every response. Gradually rewards were withheld for more and more accurate reproductions of demonstrated items. In the last stages of the teaching phase the chimpanzees were rewarded for only every third or fourth correct response (that is correct in terms of matching three or four different taught actions).

Learning during this phase of the experiment followed several stages. Since during the pilot study the chimpanzees seemed motivated to reach out towards and touch the demonstrator, the first few items took advantage of this tendency. For example, raise one and two arms was taught by the demonstrator raising her arms and then placing her hands against the fence. The chimpanzees would reach up to touch the demonstrator's hands, and when they did so they received a reward. Next, the demonstrator placed her hands up to the fence, but just as the chimpanzee was about to touch her she withdrew her hands and rewarded the chimpanzee simply for raising its arms. Gradually the demonstrator was able to raise her hands away from the fence and the chimpanzee would still respond by raising its arms.

Similarly, the chimpanzees were taught "wipe floor" by the demonstrator placing her hand on the floor. There was a six inch gap at the base of the fence which seperated the chimpanzee and the demonstrator. The chimpanzee could reach out under the fence and place its hand on top of the demonstrator's. The demonstrator then slowly wiped her hand back and forth and rewarded the chimpanzee for following the movement of her hand. Gradually the demonstrator drew her hand back out of reach and rewarded the subject if it wiped the area of floor adjacent to her hand.

Since the chimpanzees tended to prefer to reach out toward the demonstrator, actions that were directed towards their own body were slightly more difficult to teach. Again the demonstrator used their desire to touch her to shape their response. "Grasp wrist" was taught by first demonstrating "praying hands". Once the chimpanzee had protruded both hands through the fence the demonstrator gave the command "Do this", demonstrated "grasp wrist", and then touched one of the chimpanzee's wrists with her hand. The chimpanzee would reach across to touch the demonstrator's hand, the demonstrator withdrew her own hand and rewarded the chimpanzee for grasping its own wrist.

Simiarly, "touch chin" was taught by the demonstrator saying "Do this" and then performing the action. Next she would reach through the fence and touch the chimpanzee's chin. Typically, the chimpanzee would reach up toward the demonstrator's hand. The demonstrator would withdraw her hand as the chimpanzee touched its own chin.

The next important step in teaching was to ensure that the chimpanzees were turn-taking. First, the demonstrator made sure the chimpanzees could not touch her, and thus they were forced to perform the taught action separate from the experimenter's body. Second, it was important that the chimpanzees produced the taught actions only after they had received a demonstration. Often the chimpanzees would try to anticipate the demonstrator's actions and they would perform a randon number of taught actions before they had received a specific demonstration. Therefore, every time the chimpanzees performed a taught action independent from a demonstration the demonstrator would clearly say "No" and turn her back on the subject for a few seconds. This technique was very effective and the chimpanzees quickly began to sit still and wait for the next demonstration before they performed an action.

At the end of the teaching phase two measures were used to determine whether to go on to phase 2 in which 48 novel actions were presented to the subjects. The first measure was a test to determine whether the chimpanzees were reliably responding to the taught actions. Over the course of four days the chimpanzees were presented with the 15 taught actions each day and they were required to respond correctly to 80% of the items or above in at least three out of the four days. KA responded at the level of 100% correct on days 1 and 2 and 93.33% (14 out of 15) correct on days 3 and 4. SC responded at the level of 80% (12 out of 15) correct on days 1 and 2, 73.33% (11 out of 15) correct on day 3, and 86.67% (13 out of 15) correct on day 4.

The second less formal test was to see if there was some indication that SC and KA had made the transition from imitating taught actions to novel items. Six probe items were devised: (1) the sole of one foot was wiped from side to side across the floor, (2) one hand was wiped back and forth across the floor, rather than from side to side as in the taught action "wipe floor", (3) one foot was raised and shaken, (4) the head was shaken from side to side, (5) two hands were used to alternately slap the floor, (6) sitting down, both feet were used to alternately stamp the floor. In response to shake foot, SC performed "raise foot" and then protruded his hand through the fence just above his foot and performed "shake hand". He very briefly slapped the floor with both hand simultaneously rather than alternately, as shown. SC also shook his head, but he was apt to shake his head when excited. KA imitated the actions of wiping the floor with her foot and wiping her hand back and forth just as they were demonstrated. It would have been preferable to have extended the teaching phase to a point at which the chimpanzees were regularly imitating novel items, but unfortunately time constraints prohibited further delay. Therefore, we went on to phase 2, and demonstrated a predetermined series of 48 untaught actions (see Table 9.2).

The 48 test items consisted of eight conceptually distinct blocks with six actions within each block. The blocks distinguish different categories of actions, some of which might be expected to be more cognitively challenging than others. (For example, Piaget (1962) suggested that it is more cognitively challenging to imitate actions performed out of sight than actions performed in sight.) The test items were presented in a randomised order to the chimpanzees.

There were two thirty-minute testing sessions a day, at the same times each day, five days a week. Three to four novel actions were demonstrated at regular intervals in the middle of a random series of taught actions. Each novel action was demonstrated three to four times to each subject. After the 48 novel actions had been tested once, their order was randomized again and the series was demonstrated a second time.

All of the testing sessions were recorded on video-tape. The video camera was mounted on a tripod and positioned behind and to one side of the demonstrator. The demonstrator crouched down about two to three feet from the front of the cage and slightly to one side of the chimpanzees. The chimpanzees were very cooperative and the demonstrator was able pat the ground opposite the place she wanted them to sit and they would readily comply. (The chimpanzees were not directly taught to do this, they simply seemed to know what was required of them.) The camera was carefully positioned so that the chimpanzees and as far as possible not the demonstrator were within the frame. There was no camera operator, the demonstrator positioned and focussed the camera before testing began, started recording and then began the test session. Despite the attempts to exclude the demonstrator's actions from the recorded video film, in many of the trials the demonstrator's actions were visible. However, all of the demonstrator's actions tended to be to one side of the chimpanzees and it was possible to cover the demonstrated actions using a cardboard screen so that only the chimpanzees' responses were visible. This was important when the independent observers were required to code the chimpanzees' responses.

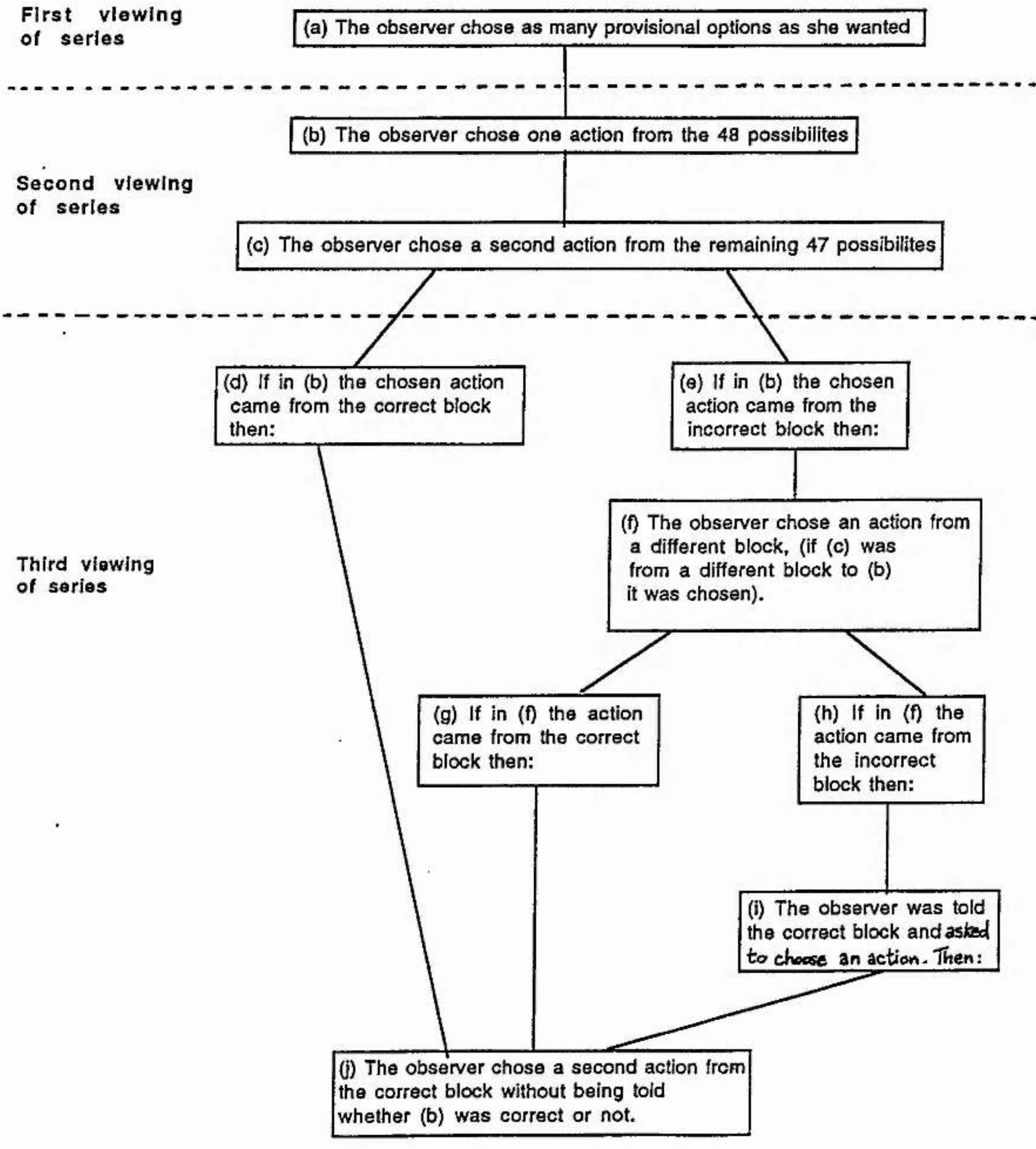
The chimpanzees were not given food rewards for their responses to approximately the first 20 novel items. Unfortunately, the result of this was that about half way through the first series of demonstrations they began to refuse to attempt to imitate novel items. A refusal was reasonably easy to recognise since the subjects stopped interacting with the demonstrator by either turning or walking away from the front of the cage. In order to keep their motivation high, they were consequently rewarded after the third or fourth demonstration if they clearly responded to the novel item. They were given verbal encouragement throughout.

All the testing was conducted in SC and KA's living quarters. They were always together during testing. Both chimpanzees tended to become very upset if they were separated. It was important that they remain calm and highly motivated during the testing sessions. Obviously, distressing an animal in any way is automatically incompatible with extracting their optimal cognitive performance.

Method of Analysis

Two independent observers, who were blind as to the action being demonstrated, coded the chimpanzees' responses from videotape. The observers were first given a list of all the demonstrated actions and familiarized with them by the demonstrator demonstrating each action several times. The observers then watched sections of the videotaped test sessions in which the demonstrator's actions were masked from view. The observers were required to identify which action they thought the chimpanzees

Figure 9.7: Coding System



were imitating based on seeing their responses alone. Each series was presented to the observers in a different random order.

The observers' efforts at classification were assessed in a structured sequence of choices designed to exploit the possibility that identification would vary in its degree of accuracy. The aim was to establish the success rate at whatever level of accuracy it occurred, for comparison against chance success rates using binomial tests of probability. Figure 9.7 is a schematic representation of the coding system and should be studied in conjunction with the following explanation.

The observers watched each of the chimpanzee's responses to each series of demonstrations a total of three times. On the first viewing they noted down, for each set of responses to each demonstrated action, as many provisional options as seemed feasible for which individual action they thought was being imitated out of the 48 possibilities (see a in Fig. 9.7).

On the second viewing, the observers firmed up their provisional choices and nominated which individual action they thought was being imitated (see b in Fig. 9.7). They also indicated what would be their second choice of action if the first turned out to be incorrect (see c in Fig. 9.7).

On the third viewing, the observers were told whether or not their first choice of action came from the correct block. If they had chosen an action from the correct block (see d in Fig. 9.7), they were told that the block was correct, and they were asked to choose a second action from that block (see j in Fig. 9.7). If they had chosen from an incorrect block (see e in Fig 9.7), they were told so, and asked to choose an action from another block (see f in Fig. 9.7). If they then chose from the correct block (see g in Fig 9.7), they were asked to choose a second action from that block (see j in Fig. 9.7). If their second choice of action came from the wrong block (see h in Fig. 9.7), they were then told the correct block and asked to select an action from it (see i in Fig. 9.7). Finally, they were asked to choose a second action from the correct block (see j in Fig. 9.7). At no time were they told whether they had chosen the correct individual action. Throughout the coding, the observers were allowed to watch each of the chimpanzees' three or four responses to each demonstrated action as many times as they liked.

RESULTS

Independent Observers' Scores

The observers' scores are listed in Table 9.3. The actions are listed in the order in which they were demonstrated. According to binomial tests performed on the observers' results, each observer correctly identified on their first choice a significant number of both blocks and actions: the probability was <0.0001 for both observers' coding of KA's series 1 ($N=23$) and 2 ($N=21$) and SC's series 1 ($N=27$) and 2 ($N=21$) (see Table 9.4). Accordingly, it was not necessary to exploit the weaker choices built into the coding scheme described above (Fig. 9.7). This scheme is presented here because of its relevance to future studies of this kind in which first choices alone might not provide such a highly significant number of identifications.

Imitations of Actions Performed In and Out of Sight

In order to test the hypothesis that actions performed in sight are easier to imitate than those performed out of sight (Piaget 1962) an additional analysis was performed. All the hand actions and the actions in the block "Touch in sight" were compared with the actions in the "Facial", "Head/face related", "Whole body" and "Touch out of sight" blocks. ("Whole body" actions are, of course, partially within the view of the actor. These are included in the out of sight category because one can not see all of one's body as one can see, for example, all of one's hand when imitating hand actions. Therefore, "whole body" actions appear to have more in common with actions performed out of rather than in sight.)

Key for Tables 3a to 3d

See Figure 1 for descriptions of the stages denoted by the letters.

*	-	Action chosen from the correct block at (a).
2	-	Action chosen from the correct block at (b) or (e).
3	-	An action from the correct block was not chosen.

*	-	Correct action chosen at (a).
2	-	Correct action chosen at (b).
3	-	Correct action chosen at (e).
4	-	Correct action chosen at (h).
5	-	Correct action chosen at (i).
6	-	Correct action not chosen.

Table 9.3: Observers' Scores for Each Chimpanzees Series 1 and 2 Responses

KA's Series 1 Responses

ACTIONS	OBSERVER 1		OBSERVER 2	
	Block	Action	Block	Action
Touch elbow	*	*	*	*
Grab thumb	2	**3**	*	*
Circle	*	**4**	*	**6**
Touch stomach	*	*	*	**6**
Protrude lips	*	**6**	*	**6**
Mouth pop	*	*	*	**2**
Teeth chattering	*	*	*	*
Clap back of hand	*	*	*	*
Lip wobbling	2	**6**	3	**6**
Lip smacking	*	*	*	*
Touch nose	*	*	2	**2**
2-fingered clapping	2	**2**	2	**2**
Flap arms	*	**6**	*	*
Touch shoulder	*	**6**	*	**6**
Protrude tongue	*	**6**	*	**6**
Look up	2	**2**	*	*
Peekaboo	*	*	3	**4**
Hug self	*	*	*	**6**
Stiff wave	3	**5**	3	**5**
Roll hands	3	**5**	3	**5**
Touch foot	*	**6**	*	**6**

KA's Series 2 Responses

ACTIONS	OBSERVER 1		OBSERVER 2	
	Block	Action	Block	Action
Protrude lips	3	5	*	6
Touch shoulder	*	2	*	2
Touch top of head	*	6	2	6
Lip wobbling	2	2	*	*
Touch back of head	*	*	*	2
Pull mouth	3	6	2	2
Touch foot	*	*	*	*
Peekaboo	*	*	*	*
Touch knee	3	6	3	6
Hug self	*	*	*	*
Clapping	*	*	*	*
Touch nose	*	*	*	*
Mouth pop	*	6	3	4
Touch thigh	*	6	*	6
Close eyes	*	6	*	6
All digit tips touching	*	*	*	*
Look up	2	3	*	*
2-fingered clapping	2	2	2	6
Protrude tongue	*	6	*	6
Touch ear	*	6	*	6
Touch stomach	*	*	*	2
Clap back of hand	*	*	*	*
Puff out cheeks	3	5	3	6
Interlink fingers	*	*	*	*

SC's Series 1 Responses

ACTIONS	OBSERVER 1		OBSERVER 2	
	Block	Action	Block	Action
Touch elbow	*	2	*	2
Close eyes	*	6	*	6
Grab thumb	*	*	*	*
Clap behind	3	6	3	5
Look right	*	6	*	2
Roll hands	*	6	*	*
Circle	2	2	*	6
Touch stomach	*	*	3	6
Foot to foot	*	*	*	*
Protrude lips	2	6	*	2
Touch back of head	2	5	*	6
All digit tips touching	*	*	*	*
Open hand	3	4	*	2
Touch thigh	*	2	*	2
Clap back of hand	2	2	*	*
Touch knee	3	3	3	3
Lip wobbling	2	6	3	4
Lip smacking	*	*	*	*
Touch nose	3	6	2	2
Interlink fingers	*	2	*	*
Finger wiggling	*	2	*	*
Touch shoulder	3	4	3	5
Protrude tongue	2	5	3	6
Touch top of head	*	*	*	2

ACTIONS	OBSERVER 1		OBSERVER 2	
	Block	Action	Block	Action
Puff out cheeks	2	**6**	2	**6**
Hug self	*	*	*	*
Stiff wave	*	*	*	**6**

SC's Series 2 Responses

ACTIONS	OBSERVER 1		OBSERVER 2	
	Block	Action	Block	Action
Protrude lips	*	**6**	*	**2**
Touch shoulder	*	**6**	*	*
Touch top of head	*	**2**	*	**2**
Touch stomach	*	*	*	*
Lip smacking	*	*	*	*
Touch back of head	*	*	*	*
Touch foot	*	**2**	*	**6**
Teeth chattering	*	**2**	*	**6**
Hug self	*	**2**	*	*
Touch nose	*	*	*	*
Mouth pop	3	**6**	*	**2**
Touch thigh	*	**6**	*	**6**
2-fingered clapping	2	**2**	2	**5**
Protruded tongue	2	**6**	3	**6**
Flap arms	*	**6**	*	**2**
Touch ear	2	**5**	*	**2**
Open hand	2	**2**	*	*
Jump	*	*	*	*
Clap back of hand	*	*	*	*
Puff out cheeks	*	**2**	*	**6**
Lip wobbling	2	2	2	3

Table 9.4: Observers' Binomial Scores for Each Chimpanzee and Each Series of Actions.

KATRINA	SERIES	N	Ob 1	O 2
No. of blocks	one	21	15*	15*
identified.	two	23	17*	18*
No. of actions	one	21	9*	7*
identified	two	23	10*	9*

SCOTT	SERIES	N	O 1	O 2
No. of blocks	one	27	15*	19*
identified	two	21	15*	17*
No. of actions	one	27	8*	9*
identified	two	21	6*	9*

* - $p < 0.0001$

Table 5: Proportional Scores for the Blocks of Actions

Block	Subject	No. of Responses	Mean
Facial	KA	6	5.00
	SC	6	5.91
Head/face related	KA	4	10.37
	SC	3	4.54
Touch out of sight	KA	4	6.94
	SC	5	8.52
Whole body	KA	2	9.50
	SC	4	10.71
Single hand	KA	2	1.00
	SC	4	9.40
Symmetrical hands	KA	5	9.60
	SC	3	10.29
Asymmetrical hands	KA	3	10.20
	SC	3	10.25
Touch in sight	KA	6	7.44
	SC	6	8.23

The observers' coding was allotted scores which were proportionate to their relative levels of probability. The probability of choosing the correct block on the first choice was one out of eight or 0.125, while the probability of choosing the correct individual action was six times smaller, at one out of forty-eight or 0.0208. Therefore, the identification of the correct block on the first choice was given the score of 1, the correct first choice of action was scored as 6, the correct second choice of block was scored as 0.87, and the correct second choice of action was scored as 5.87.

A summary of the results for each chimpanzee in each block using this proportionate method of scoring is presented in Table 9.4. Mann Whitney $\underline{U}$ tests showed that there was no significant difference between the scores for the actions performed in sight compared to those performed out of sight with $\underline{p} > 0.05$ for both SC ($\underline{U}=1$; $\underline{N}=4,4$) and KA ($\underline{U}=8$; $\underline{N}=4,4$). The mean score for actions in-sight was 8.3; for actions out-of-sight the mean score was 7.69. Therefore, the hypothesis that actions performed in sight are less difficult to imitate than actions performed out of sight is not supported by the results of this experiment.

When the results from the two series were combined, KA had responded to 32 out of the 48 demonstrated actions and 18 of these were correctly identified on the first choice by at least one observer. SC's responded to 35 out of the 48 demonstrated items and 17 of these were correctly identified on the first choice by at least one observer.

Mechanisms Underlying Similarity: Detailed Descriptive Analysis

Below, all of the novel responses which were correctly identified by at least one of the observers on the first choice are described. The descriptions are divided into three categories: (1) contagious or familiar responses (2) novel modifications of *taught* actions, and (3) completely novel responses (i.e., they do not significantly resemble any of the taught actions.) The descriptions are prefixed with information about which subject responded and in which series of demonstrations. Hence, "KA 1" refers to Katrina's first series, while "SC 2" refers to Scott's second series, and so on. Novel demonstrations appear in bold print and taught actions are denoted by quotation marks.

Contagious or Familiar Actions

Teeth-chattering (KA 1 and 2): KA accurately imitated **teeth-chattering**. On two occasions during the teaching phase KA had spontaneously chattered her teeth together.

Open hand (SC 1): SC reached one hand through the fence toward the demonstrator.

All digit tips touching (KA 2): "Praying hands".

Touch stomach (KA 1 and 2): "Pat stomach".

Touch foot (KA 2): "Pat stomach", "touch underarm" and "stamp foot".

Look up (KA 1 and 2): Just before the demonstration KA spontaneously nodded her head which was an action she was apt to do in anticipation of food. When **look up** was demonstrated, she nodded her head in a very exaggerated and vigorous manner.

Novel Modifications of Taught Actions

Finger wiggling (SC 1): SC protruded his fingers through the fence and moved them simultaneously up and down. This seemed to be a modification of "shake hand".

Stiff wave (SC 1): SC protruded his left hand through the fence and held it still while he rocked his upper body from side to side. This appeared to be a modification of "shake hand".

Clapping (KA 2; SC 2): Both the chimpanzees started to respond with "wipe hands" and modified this until they were very clearly **clapping**. They held their hands in a different orientation to the demonstrator. The demonstrator held her hands with the thumbs uppermost, while the chimpanzees held their hands with the palm of the lower hand facing upwards and the back of the top hand uppermost.

All digits touching (SC 1 and 2): SC touched the tips of all his digits except his thumb while holding his palms far apart. SC's response could have been a modification of "praying hands".

Interlink fingers (KA 1; SC 2): Both chimpanzees appeared to perform a modification of "praying hands". They wrapped their fingers, nestled together, around one of the bars of their cage.

Roll hands (SC 1): SC held one hand in front of the other and loosely shook them, which appeared to be a modification of "shake hand".

Clap back of hand (KA 1 and 2; SC 1 and 2): Both chimpanzees appeared to modify "grasp wrist" by patting the back of one of their wrists or hand with the other hand.

Grab thumb (KA 1; SC 2): Both chimpanzees appeared to modify "grasp wrist". KA grasped half way over the left side of right hand with her left hand. SC delicately placed the fingertips of left hand on his right forearm.

Touch elbow (KA 1): KA performed "touch underarm" and then groped her left hand up the underside of her right arm toward her elbow.

Touch shoulder (SC 2): SC grasped his right shoulder with his left hand. This could have been a modification of "touch under arm" in which SC simply performed the taught action without raising his arm.

Touch stomach (SC 1 and 2): SC placed one or both hands on his stomach, which seemed to be a modification of "pat stomach".

Touch top of head (SC 1 and 2): First, SC performed "wipe face". Then he placed one hand on his forehead and slowly wiped it once from the crown of his head down over his forehead. In the second series he responded to two demonstrations by very briefly placing one hand on the top of his head.

Mouth pop (SC 2): SC performed "touch chin", he slowly opened and closed his mouth and as he did so he cupped his chin with his right hand and jerked it to the right as he jerked his head to the left. (The observers did not recognize this as mouth pop, nevertheless it seems a significant response.)

Lip wobbling (KA 2; SC 2): Both chimpanzees appeared to perform modifications of "wipe face". KA opened and closed her mouth while she wiped downward over the sides of her face and head with one hand several times. SC wiped up and down over his mouth area with the fingertips and thumb of his left hand.

Hug self (KA 1 & 2; SC 1 & 2): Both chimpanzees responded with what seemed to be modifications of "touch underarm". Either sitting or standing they swayed from side to side with one arm raised and the other hugging across the front of the body.

Flap arms (KA 1; SC 2): KA performed "raise two arms" and then rhythmically bobbed her body up and down while jiggling and patting her hands against the fence. SC's response was similar except he kept his hands relatively still and he bobbed his head and body in a more exaggerated manner. (SC's response could not be coded by the independent observers because the demonstrator partially obscured his actions from view of the camera.)

Novel Responses

Lip smacking (KA 1; SC 2): KA rapidly smacked her lips together. SC slowly and gently smacked his lips together.

Peek-a-boo (KA 1 & 2): KA patted her face, either sides of her face, and the crown of her head simultaneously with both hands.

Touch back of head (KA 1; SC 2): KA reached over the top of her head to place her left hand on the back of her head. She then swivelled her arm out to the side and placed both hands on the back of head. SC placed his left hand on the back of his head with his elbow out to one side as shown.

Touch nose (KA 1 & 2; SC 2): KA first performed "touch chin". She then brought her hand straight to the middle of her face and touched her nose and the area just above it with the tip of her middle finger. SC rubbed generally at the middle of his face with one hand and then clearly touched his nose with the tip of his thumb.

Clap behind (SC 1): SC crossed his right arm over his left across the front of his body, and patted or grasped at his sides several times. (The observers did not identify SC's action as clap behind on their first choice, but it still seemed to be a novel and significant response.)

Mouth pop (KA 1 & 2): In both series KA responded to two of the demonstrations by placing the tip of her thumb to first one and the other inner eye socket. On the third demonstration she placed the tip of her thumb in her mouth and jerked it out, downwards and to one side, making a slight smacking sound with her lips as she did so.

Look right (SC 1): SC leaned his upper body to the left, mirroring the demonstration. He kept his eyes fixed on the demonstrator's face so that his response did not seem to be a contagious reaction of looking in the same direction as cued.

Jump (SC 2): SC raised himself rapidly from sitting, to standing, to sitting again.

Amended Binomials

Since SC and KA both performed a number of actions which could be thought of as either contagious responses or familiar behaviors, a more conservative analysis was performed. These actions were excluded, and only the modifications of taught actions and novel responses were counted. Binomial tests of probability performed on the amended scores showed that each observer correctly identified a significant number of modified taught actions and novel responses at the level of $\underline{p} < 0.0001$ for each of the chimpanzees' two series of demonstrations (see Table 9.5). If we take the novel modifications of taught actions and the completely novel responses to be cases of "true" imitation, it follows that: KA made 13 such responses which means she imitated 27.1% of the 48 demonstrated acts, and SC made 20 such responses which means he imitated 41.67% of the demonstrated items.

Table 9.6: Amended Binomial Scores for Actions.

NAME	SERIES	N	Ob 1	Ob 2
KA	one	23	7*	5*
KA	two	21	7*	8*
SC	one	27	7*	8*
SC	two	21	6*	8*

* - $p < 0.0001$

DISCUSSION

These results support Tomasello *et al.*'s (in press) and Hayes and Hayes' (1952) claim that chimpanzees can imitate arbitrary (i.e., non-functional) actions. It is difficult to directly compare the present results with the behaviour of the chimpanzees in Tomasello *et al.*'s experiment, because all of the actions in the latter experiment were directed toward objects and the exact motor patterns that were used were not described. SC and KA did appear to have imitated at least as many novel actions as Viki originally did. Hayes and Hayes state that Viki imitated "at least 10 completely novel acts". The independent observers in the current study recognised 13 of KA's and 20 of SC's novel responses. However, it is impossible to judge just how accurate SC and KA's imitations were in comparison to Viki's, because Hayes and Hayes' description of Viki's behaviour was so scant.

It is easier to make direct comparisons between the results of the present study and Moore's (1992) experiment on arbitrary non-object related imitation in an African Grey Parrot. Moore not only presented similar kinds of actions to the ones used here, but he also described the responses of his subject in detail. Moore's parrot, Okichoro, imitated a total of ten actions (waving, tongue protrusion, arm flailing, knocking, looking down, reaching for and apparently dropping a non-existent object, head shaking, head nodding, looking up and turning round); he failed to imitate winking and opening and closing a hand. The main difference between the parrot's and chimpanzees' imitations was in relation to the time it took them to respond. Whereas the chimpanzees' imitations were almost immediate, there was often an "incubation period" of several months before the parrot began imitating novel actions. Moore argued that the differences in primate and parrot imitation "reflect convergence, not homology" (p.257). Nevertheless, it would seem that the parrot was capable of more complex cognitive operations than has been hitherto assumed.

It should be noted that very few, if any, of SC and KA's responses could be considered "perfect" imitations. Even some of their clearest imitations were flawed in some way. For example, SC's **all digits touching** was very similar to the model but he only touched his finger tips and made no attempt to hold the tips of his thumb together. KA imitated **teeth-chattering** perfectly but she had previously independently discovered how to click her front teeth together. Although both chimpanzees clearly **clapped** their hands, they held them in a different orientation to the demonstrated version. KA's imitation of **lip smacking** was perfect, while SC smacked his lips much more slowly and gently than demonstrated. SC imitated **touch back of head** almost perfectly, except that he used his left rather than his right hand; while KA reached over the top of her head to place one and then both hands on the back of her head. KA did clearly **touch nose**, but she used her middle finger rather than her index finger. The actions listed here were some of the most accurate imitations, the other responses were on the whole less similar to the demonstrated action.

There are possible explanations for the less than perfect responses by the chimpanzees. First, it is possible that the fact that they were imitating another species may have disrupted the transformation of visual information to motor acts. In other words, chimpanzees may imitate conspecifics more accurately than humans. Second, it is also possible that they could have imitated more accurately, but they did not realise that the command "Do this!" meant they were supposed to imitate the demonstrated action as perfectly as possible. The latter possibility still suggests that the translation of visual input to motor output is not automatic or straightforward and that the chimpanzees had a degree of control or latitude in the way they responded. In regards to the former possibility, it seems feasible that the chimpanzees may have experienced some difficulties in imitating a different species. But it is important to note that even when humans imitate one another the initial response is not always perfect. J. Brown (pers. comm.) found that three to five year old children do not always perfectly imitate. They experienced problems in locating parts of the body which were out of sight, such as touching an ear or touching the tip of their nose. Even adult humans do not always perfectly imitate. One adult who was informally presented with the action **mouth pop** on several different occasions consistently responded by incorrectly orientating her hand so that the palm faced inwards rather than outwards.

One potentially significant feature of the chimpanzees' behaviour was that many of their responses seemed to be modifications of taught actions. Piaget (1962) suggested that imitation involves a gradual accommodation and assimilation of new actions which build upon previously acquired skills. It has been suggested that if one presents a completely novel action to a subject that does not relate to any action she or he has imitated before, the subject will be unlikely to respond (Piaget 1962; Kaye 1982). To gain an insight into why imitation might develop this way, consider a thought experiment in which one is required to program a computerised robot to imitate. One could program the robot to respond to certain specific visual cues with specific pre-programmed matching actions. Such a program would be relatively easy to design but the resulting behaviour would be equivalent to contagion not true imitation. It would be much more difficult to design a flexible learning program that could match any novel or unprogrammed action. Instead of a rather linear input - output design, the program would need to be something like a neural net which would be capable of breaking down visual information into its constituent parts and translating these into equivalent motor actions. One solution to this complex programming challenge could be to take previously learned or programmed imitative behavioural units and instruct the system to combine or modify these so that they at least approximate the modelled act. Hence, if the robot has learned to imitate touching its stomach and patting its leg, it might prove easier to subsequently imitate the novel action of patting its stomach. Thus, the robot could gradually build up a large database of different behavioural units, so that eventually it would be able to reconstitute and combine them in such a way that it could accurately imitate practically any novel modelled act.

Many of the chimpanzees' responses seemed to follow the pattern of modifying and combining familiar imitative actions. When SC and KA imitated **clap back of hand** they appeared to perform "grasp wrist" with the novel element of patting rather than just grasping. This novel and appropriate response may have been a combination of "grasp wrist" with elements of "slap floor" and "pat stomach". SC also clearly combined two taught actions when he responded to **shake foot**, (which was a probe item at the end to the teaching phase), by raising his foot and shaking his hand just above it. SC's accurate imitation of touch shoulder could have been a modification of "touch under arm" in which he simply performed the taught action without raising his arm. In the results section, a total of 16 actions are listed in which the chimpanzees' responses appeared to be modifications of taught actions.

A small number of imitations performed by the chimpanzees were very different to the taught actions. It is difficult to see how the chimpanzees were able to achieve some of these imitations unless they were being guided by some kind of intermodal visual - proprioceptive code. For example, **lip-smacking** is unlikely to be a contagious response because, unlike with some species of monkey, it is not a species-typical behaviour in chimpanzees. None of the taught items involved imitating facial expressions. KA had previously performed the similar action of **teeth-chattering**, but that does not explain how she achieved the fine and detailed modifications needed for **lip-smacking**. SC had not been observed, previous to his **lip-smacking** response, performing any similar rhythmical action with his mouth. In regards to **touch nose**, the chimpanzees had been taught "touch chin", but that does not explain how they were able to accurately pin-point their nose. The two handed simultaneous patting performed by KA in response to **peek-a-boo** was novel. She had been taught "wipe face" and "pat stomach", but she had never previously patted any part of her body with two hands at the same time. Both chimpanzees had learned to imitate "touch chin" and "wipe face" but both these actions were very different from **touch back of head** and hence they cannot explain how the chimpanzees were able to locate this out of sight body part. SC's responses to **clap behind, look right** and **jump** bare no resemblance to any of the taught actions. KA's responses to **mouth pop** were particularly novel and significant. Piaget (1962) had mentioned that children appear to often confuse eye and mouth movements. Perhaps KA's initial response of placing her thumb up to her eye was an example of the same kind of confusion. Certainly none of the taught actions involved specifically manipulating the eyes or mouth.

One might be tempted to explain the chimpanzees' responses in terms of shaping, since the demonstrator provided food rewards. However, it seems unlikely that these factors could have played any more than a general motivating role. The food reward did not automatically follow specific novel responses. It always followed the final demonstration of a novel item if the chimpanzee had at least responded to one out of the three or four demonstrations. Sometimes the final demonstration was followed by a refusal or an inappropriate response, but the chimpanzee was still rewarded if it had responded to one of the previous demonstrations. The chimpanzees also often only responded to one or two of the demonstrations. It is difficult to see how, with so few demonstrations and responses on each item, the demonstrator could have significantly shaped the chimpanzees' behaviour.

The results of the present experiment do not support the prediction, based on Piaget's (1962) theory, that actions performed out of sight would be more difficult to imitate than action performed in sight. No significant difference was found in how well the chimpanzees imitated actions performed in and out of sight. It is possible that no significant effect was found because the chimpanzees may have already possessed the cognitive ability which enables them to mentally represent out of sight body parts. Chimpanzees as young as 30 months of age are able to use mirrors to locate a mark placed on their eyebrow (Lin, Bard & Anderson 1992). However, with such a small number of comparison groups in the present study, (N = 4, 4), we would be reluctant to lay any great claims on the significance of this negative result.

The imitative behaviour exhibited by the subjects in the present experiment suggest that chimpanzees are capable of complex and possibly rather flexible intermodal visual-motor co-ordination and control. Yet, one is inevitably left wondering what is the functional significance of these cognitive abilities. It has been suggested that imitation would be an adaptive ability in relation to gestural communication (e.g., Goodall 1986), food processing (e.g., Visalberghi & Fragaszy 1990) and tool-use (e.g., Cheney & Seyfarth 1991). However, no study with chimpanzees had found positive evidence of imitation in a technical problem-solving task (Tomasello *et al.* 1987; Nagell *et al.* in press).

Tomasello *et al.* (in press) argue that mother-reared chimpanzees do not, in fact, imitate. They suggest that only enculturated chimpanzees, i.e., those individuals raised in a human-like manner who have had their attentional behaviour socialized in a uniquely human way, learn to imitate. SC and KA were raised in a peer group and received standard nursery care. Obviously, the teaching regime they underwent influenced the degree to which they exhibited imitative behaviour, but this was very different form being raised in a human-like way. A more clear investigation and description of the precise processes necessary for the development of imitation is needed. One issue which is yet to be resolved is whether feral chimpanzee enculturation (i.e., being raised in their natural habitat by their biological mother) can provide the conditions necessary for the development of imitation in chimpanzees (Bard 1994; Whiten 1993). This is an important issue for future research, since without knowing why chimpanzees have evolved at least the cognitive *potential* to imitate, the discovery that they do possess such an ability will remain a rather strange, albeit interesting, anomaly.

The experiment described in Chapter 10 addresses the question of whether non-human primates do imitate functional or goal-related activities.

Chapter 10

CAN CHILDREN, CHIMPANZEES OR CAPUCHIN MONKEYS IMITATE THE ACTIONS USED TO OPEN A PERSPEX FORAGING OBJECT?

It would now be impossible to reasonably suggest that there is no convincing evidence of action imitation in animals. Finally, after 100 years of research, properly controlled studies have provided clear evidence of an imitative ability in three non-human species: chimpanzees, orangutans and African Grey Parrots. A modified version of Hayes and Hayes' (1952) experiment, (see Chapter 9), found that two chimpanzees were capable of imitating arbitrary non-object-related actions. Tomasello *et al.* (in press) experimentally demonstrated that enculturated chimpanzees can imitate arbitrary actions performed on objects. Moore (1992) found that an African Grey Parrot was able to imitate a number of arbitrary non-object-related actions. Russon and Galdikas (1992) observed many instances of spontaneous imitation in a systematic observational study of imitation in ex-captive orangutans (see Observation Database, Chapter 5).

Budgerigars (Dawson and Foss 1965; Galef et al. 1986) and pigeons (Palameta & Lefebvre 1988; Palameta 1989) have exhibited a rather fragile ability to imitate actions used to gain access to artificial "embedded" food (i.e., food which is surrounded by an inedible outer covering). However, the behaviours that the birds reproduced were species-typical pecking and foot-scratching movements; hence these results might be explained in terms of a combination of stimulus enhancement and contagion, rather than imitation. Heyes and Dawson's (1990) experimental demonstration that rats can compensate for the difference in perspective between themselves and a model when pushing a bidirectional vertical bar is more impressive than the budgerigar and pigeon data. Bruner (1972) suggested that the ability to compensate for differences in perspective between oneself and a model is one of the most cognitively demanding aspects of action imitation (see chapters 7 and 9).

The strongest experimental evidence of non-human imitation has come from studies in which the subjects were required to imitate arbitrary or non-functional behaviours (i.e., Tomasello *et al.* in press; Moore 1992; Chapter 9 of this document). These studies show that chimpanzees and African Grey Parrots possess the ability to imitate actions, but they shed little light on why these animals might possess such an ability. Moore notes that, "the parrot's imitation appears to have nothing to do with skill learning or tool use; it may normally be related to social display" (p. 257). Tomasello *et al.* (in press) argue that neither wild nor captive mother-reared chimpanzees possess the ability to imitate. Instead, the authors propose that only chimpanzees raised by *humans* learn to imitate, by having their attention socialized in a uniquely human-like manner. However, even if one accepts Tomasello *et al.*'s line of argument, presumably chimpanzees still possess the cognitive *potential* for imitation, and one is left wondering why they have evolved this cognitive ability.

Visalberghi and Fragaszy (1990) suggest that the ability to imitate might be most adaptive for non-human primates when they are learning how to process novel food. Most food-processing in non-human primates involves direct manual manipulation. Sometimes the food is embedded or partially embedded and the inedible portion needs to be stripped away. Most primates use just their hands and mouth to process food, although chimpanzees and capuchin monkeys often also use tools. Imitation would seem to be a potentially adaptive ability when learning complex behaviours such as tool-use and embedded food processing.

Some researchers have suggested certain observations of food processing and tool-use do constitute evidence of functional imitation in feral non-human primates. However, most of these behaviours can be explained in terms of processes other than imitation, such as stimulus enhancement and contagion. Only three observational studies of wild primates strongly suggest imitative learning. Goodall (1973) observed young chimpanzees apparently imitating in play aspects of different kinds of tool-use (see database in chapter 4 for details). Hauser (1988) observed the rapid spread of acacia pod dipping in vervet monkeys which was very suggestive of imitation. Byrne and Byrne (in press) conducted an observational study in which wild mountain gorilla infants appeared to learn the techniques for processing thorny, stinging and embedded foods by imitating adults.

If non-human primates possess the ability to imitate goal-directed activities, then researchers should be able to experimentally demonstrate this fact. However, the few experiments which have presented non-human primates with functional or goal-related tasks were either methodologically flawed, or they found no evidence of imitation. For example, Tomasello *et al.* (1987) found that young chimpanzees emulated rather than imitated the tool-using behaviour of a model (see Chapters 2 and 5). Nagell *et al.* (in press) found no convincing evidence, either for or against, an imitative ability in chimpanzees in relation to a raking task (see Chapter 5). There are a number of experimental reports which claim to have provided positive evidence of functional action imitation in monkeys (e.g., Hobhouse 1901; Kinnaman 1902; Haggerty 1909; Warden & Jackson 1935), however, all of these results can be explained in term of learning processes other than imitation (see Chapter 6). Studies on action imitation in monkeys which have controlled for other social learning processes, found no evidence of imitation (e.g., Visalberghi 1987; Westergaard & Fragaszy 1987; Fragaszy & Visalberghi 1989, 1990; Visalberghi & Trinca 1988; also see Visalberghi & Fragaszy 1990 for a review).

In fact, there have been very few studies on imitation in animals which have adequately controlled for other less cognitively complex learning processes (see Galef 1988 for a review). In view of this fact, perhaps we should not be particularly surprised at the apparent sparsity of convincing evidence. The lack of evidence may be indicative of a failing in scientific method, rather than a lack of imitative ability in non-human species (Heyes 1993).

One of the most promising experimental approaches to imitation is the multi-act method, which was first used by Dawson and Foss (1965), and has been strongly recommended by Galef (1988). Dawson and Foss presented three groups of budgerigars with the same set of apparatus: a dish of bird seed covered with a paper lid. Each group saw a model use a different technique to remove the paper lid. Model A nudged the lid off with its beak, model B lifted it off with its beak, and model C knocked it off with its foot. The critical test of imitation was whether the three groups of observers used different methods to remove the lid, based on the different demonstrated actions they had observed. Dawson and Foss found only very fragile evidence of imitation in their budgerigar subjects. Nevertheless, the multi-act approach is an important methodological breakthrough, because it controls for stimulus enhancement by requiring different groups of subjects to manipulate an identical set of apparatus in different ways. The important aspect of the multi-act method is not that the subjects need simply solve the task relatively quickly after observing a model, but rather they must learn to use the same technique as the model.

The aim of the present experiment was to test for functional or goal-related imitation, in a number of primate species, using a multi-act approach. Three kinds of primates were tested: human children, chimpanzees (*Pan troglodytes*), and tufted capuchin monkeys (*Cebus apella*). The experimental apparatus was a perspex box or "fruit" which was locked using two kinds of mechanisms. A demonstrator opened each of the locks using two alternative methods. The subjects were divided into two groups and each was shown alternative methods for opening each of the locks.

The "foraging box" or "perspex fruit" was specifically designed to simulate the kind of complex manipulative food-processing that primates engage in when attempting to eat embedded food. Although humans, chimpanzees, and capuchin monkeys have been observed regularly using tools, the same cannot be said of most other primate species. Hence, in the present experiment, tasks which involved tool-use were deliberately avoided, since it was hoped that eventually this task (or one similar to it) would be presented to many different species of non-human primates, so that a comparison of their relative imitate abilities could be made. Therefore, this experiment is intended to be the first step in a long-term, multi-species, comparative program of research, on functional action imitation in human and non-human primates.

METHOD

Subjects

The subjects were eight chimpanzees (*Pan troglodytes*), six capuchin monkeys (*Cebus apella*), eight 2-year-old children, eight 3-year-old children and eight 4-year-old children.

The approximate mean age of the chimpanzees was 52.89 months (range = 36 months). There were six females, Uska (US), Noelia (NO), Cheyene (CH), Linda (LI), Lara (LA), and Katrina (KA) and two males, Uti (UT) and Scott (SC). US, NO, CH, LI, LA, and UT all came from Madrid Zoo, while SC and KA came from the Yerkes Regional Primate Research Center of Emory University. All of the Madrid chimpanzees, except LI, had been confiscated by the Spanish authorities at an early age, when they were illegally imported into Spain. LI had been rescued at approximately five years of age from a beach photographer (she was missing all her front teeth). LI was tested soon after she arrived at the zoo. SC and KA had been born in captivity. They were placed in the Yerkes' Great Ape Nursery within 24 hours of birth because their biological mothers did not exhibit sufficient maternal behaviours to rear them. They took part in the present experiment prior to participating in the imitation experiment outlined in Chapter 9.

The capuchin subjects were from the Primate Laboratory of the University of Georgia. They had a mean age of 66.83 months (range = 53 months). There was one female, Beamer (BE), and five males, Jobie (JO), Willy (WI), Xavier (XA), Chris (CH), and Xenon (XE). All the monkeys, except for JO, had been mother-reared in a large captive group. JO had been removed from his mother soon after birth because she was ill and he was consequently hand-reared. All the subjects were pair-housed in a room adjacent to two larger capuchin colonies.

All of the 2-year-old human subjects were recruited from the St. Andrews Cosmos Playgroup. There were four males and four females with a mean age of 28.25

Table 10.1: Group Configurations in Foraging Box Experiment

CHIMPANZEES

Name	Gender	Shown on pin	Shown on handle	Shown on Bolts	Age in months
SC	male	Turn	Turn	Poke	50
NO	female	Turn	Turn	Poke	72 approx.
CH	female	Turn	Turn	Poke	60 approx.
LI	female	Turn	Turn	Twist	60 approx.
UT	male	Spin	Pull	Twist	60 approx.
US	female	Spin	Pull	Twist	96 approx.
KA	female	Spin	Pull	Twist	49
LA	female	Spin	Pull	-	36 approx.

CAPUCHINS

Name	Gender	Shown on pin	Shown on handle	Shown bolts	Age in months
XA	male	Turn	Turn	Poke	92
WI	male	Turn	Turn	Twist	89
BE	female	Turn	Turn	Poke	52
JO	male	Spin	Pull	Twist	65
XE	male	Spin	Pull	Twist	64
CH	male	Spin	Pull	Poke	39

2 YEAR OLDS

Name	Gender	Shown on pin	Shown on handle	Shown on bolts	Age in months
2a	male	Turn	Turn	Poke	31
2b	male	Turn	Turn	Poke	30
2c	female	Turn	Turn	Poke	29
2d	female	Turn	Turn	Poke	26
2e	male	Spin	Pull	Twist	26
2f	male	Spin	Pull	Twist	29
2g	female	Spin	Pull	Twist	25
2h	female	Spin	Pull	Twist	30

3 YEAR OLDS

Name	Gender	Shown on pin	Shown on handle	Shown bolts	Age in months
3a	male	Turn	Turn	Poke	42
3b	male	Turn	Turn	Poke	38
3c	female	Turn	Turn	Poke	42
3d	female	Turn	Turn	Poke	43
3e	male	Spin	Pull	Twist	40
3f	male	Spin	Pull	Twist	41
3g	female	Spin	Pull	Twist	37
3h	female	Spin	Pull	Twist	41

4 YEAR OLDS

Name	Gender	Shown on pin	Shown on handle	Shown bolts	Age in months
4a	male	Turn	Turn	Twist	52
4b	male	Turn	Turn	Poke	53
4c	female	Turn	Turn	Poke	54
4d	female	Turn	Turn	Poke	55
4e	male	Spin	Pull	Poke	55
4f	male	Spin	Pull	Twist	53
4g	female	Spin	Pull	Twist	54
4h	female	Spin	Pull	Twist	52

months (range = 6 months). All of the 3-year-old human subjects came from the St. Andrews Puffin Playgroup. There were four males and four females with a mean age of 40.5 months (range = 5 months). Four of the four-year-old subjects came from the Puffin Playgroup and four came from the St. Andrews Primary School. There were four males and four females with a mean age of 53.5 months (range = 3 months). For details relating to age and gender on all the subjects see Table 10.1.

Apparatus and Procedure

The main apparatus consisted of a transparent perspex "foraging box" or "fruit" with a hinged lid and two types of locking devices. The locks were: 1. Bolts-lock: a pair of plastic rods inserted in a set of bolt rings, and 2. Barrel-lock: a brass handle locked in place with a small T-shaped pin. The box was mounted on a wooden base. Behind the foraging box a wooden block was attached to the base which acted as a support for the lid preventing the hinges from being damaged by them being bent too far back. Two versions of the foraging box were used. A large version (21cm X 17cm X 14cm) was presented to the chimpanzees and the children. A similar but smaller version was presented to the capuchins so that it more closely corresponded to their hand size (see Fig. 10.1).

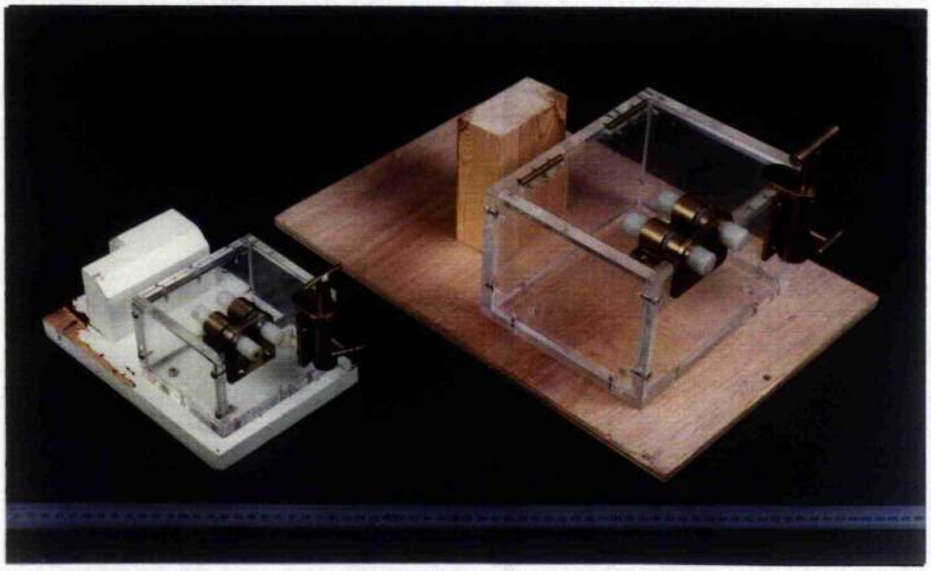


Figure 10.1: Comparative sizes of the two foraging boxes

The locking devices were designed so that each could be dismantled using two distinctly different action-patterns.

The Bolts-lock

The bolts consisted of two sets of brass bolt rings and two smooth plastic rods or bolts. Two of the rings were screwed onto the lid of the box and two adjacent rings were screwed on the outer front wall. The plastic rods were pushed through each set of rings so that the lid could only be opened if the rods were first removed. A demonstrator removed the bolts using two different techniques.

Poke Technique

The rods were poked, one after the other, out of the bolt-rings from the front of the box using the tip of the right index finger (see Fig. 10.2). The rods were collected in the left hand as they were pushed out over the lid. The box was opened by pulling up on the bolt rings attached to the lid.

Twist Technique

The protruding end of one of the rods was grasped in the right hand and twisted in a clockwise direction while being simultaneously pulled until it came out. The second rod was pulled and twisted out in a similar manner (see Fig. 10.3). The plastic rods were not threaded, so the twisting action was not strictly necessary - they could have been simply pulled out. The twisting action was incorporated to make sure that the two demonstrated methods were very distinct from one another.

The Barrel-lock

The barrel-lock consisted of three parts. There was a cylindrical brass tube with

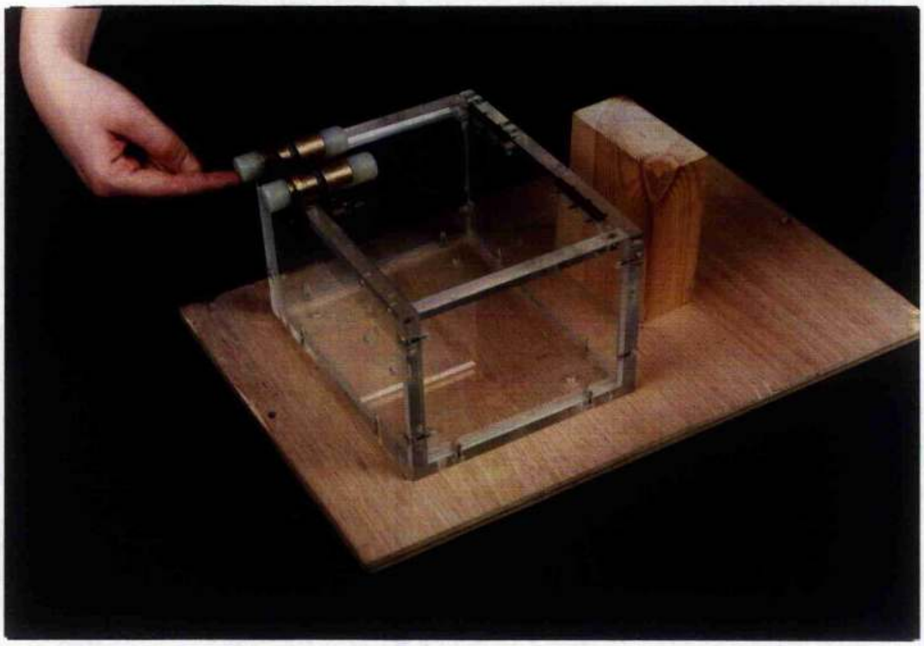


Figure 10.2: *Poking* the bolts

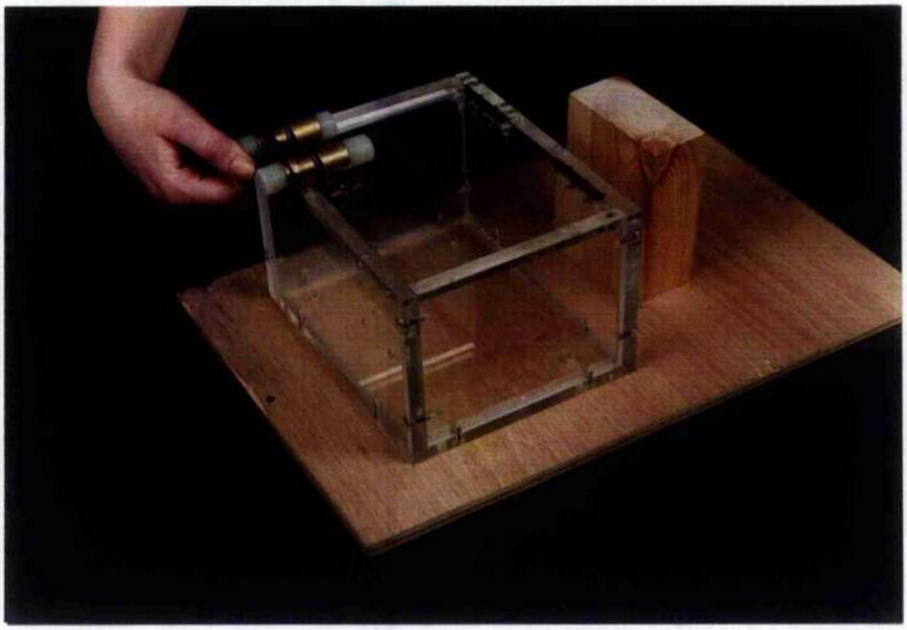


Figure 10.3: *Twisting* the bolts

a hole drilled through the front that was mounted on the front wall of the box. A brass handle with a cylindrical barrel and a wide lip that projected 3 or 4cm from the top of the barrel with a T-bar on top was slotted into the tube. A hole was bored into the barrel of the handle so that when the lip of the handle was positioned over the lid of the box the holes in the brass tube and the barrel of the handle were exactly aligned. A small brass T-shaped pin was inserted through the aligned holes, so that one could only move the handle if the pin was first removed.

As with the bolts-lock, the handle was demonstrated using one of two different techniques.

Turn Technique

The pin was turned four times, holding it between the right thumb and the side of the right index finger, before it was pulled out (see Fig. 10.4). The pin was not threaded and therefore turning it was an arbitrary action deliberately built into the design of the experiment. It was reasoned that, as turning the pin was not necessary, if an observer consistently turned the pin it would most probably be because he or she had seen the demonstrator turn it. (The same argument can be used for twisting the rods.) To pull the pin out, either side of the stem was gripped between the sides of the terminal phalanges of the right index and second fingers with the palm facing upward (see Fig. 10.5). After the pin had been pulled out, the handle was turned through 90 to 180 degrees in a clockwise direction out of the way of the lid (see Fig. 10.6). The box was opened by pulling up on the bolt rings attached to the lid (see Fig. 10.7).

Pull Technique

The pin was spun four times in a clockwise direction using the side of the terminal phalange of the extended right index finger (see Fig. 10.8). The handle was grasped by the T-bar (with a right hand power grip) and pulled straight out of the barrel holder (see Fig. 10.9). The lid was pulled opened by the bolt rings.

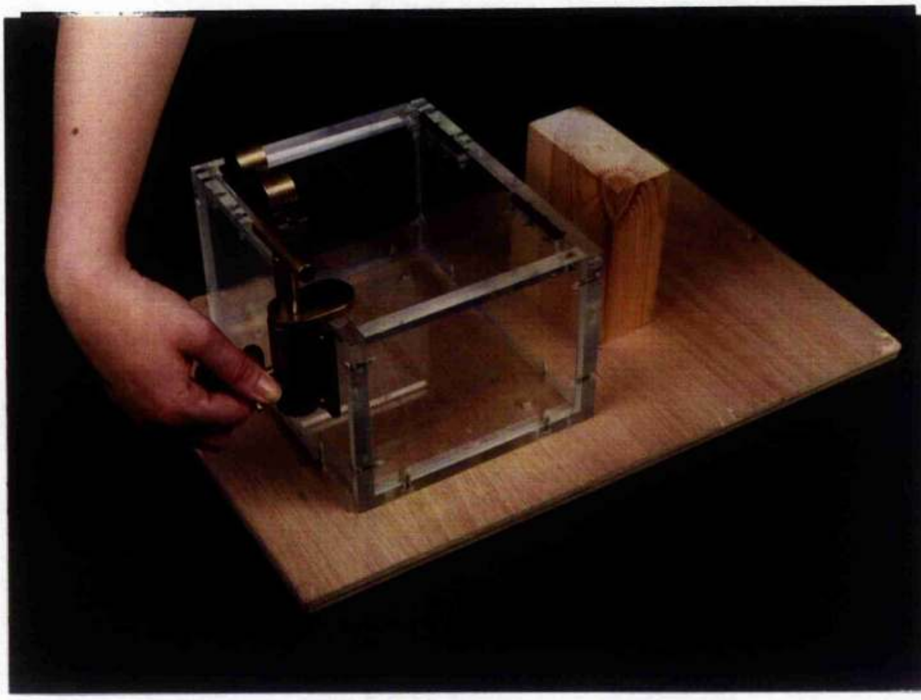


Figure 10.4: *Turning* the pin

Figure 10.5: Pulling the pin out

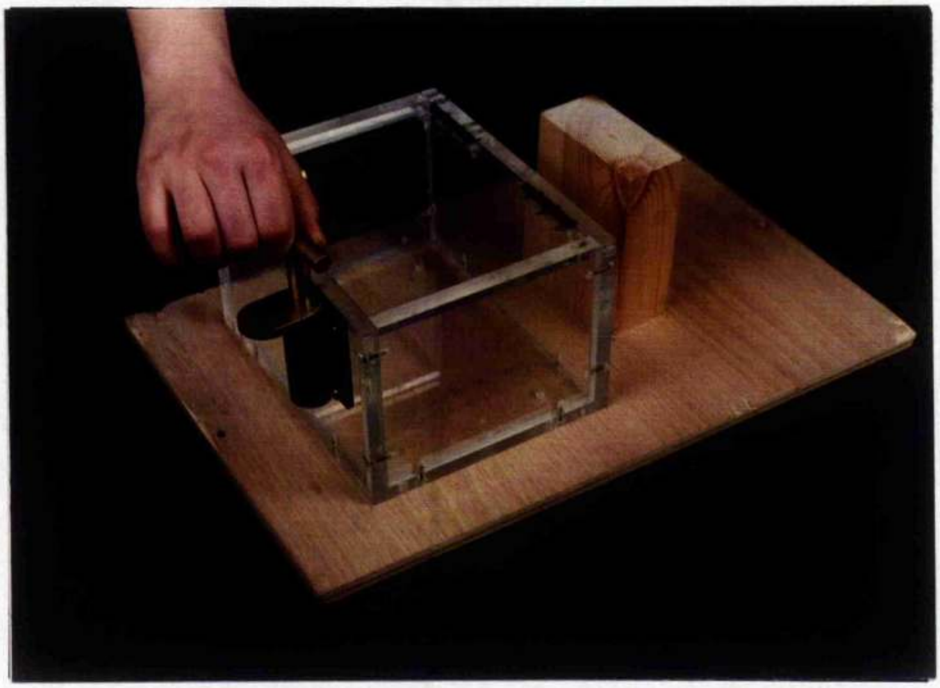


Figure 10.6: *Turning* the handle

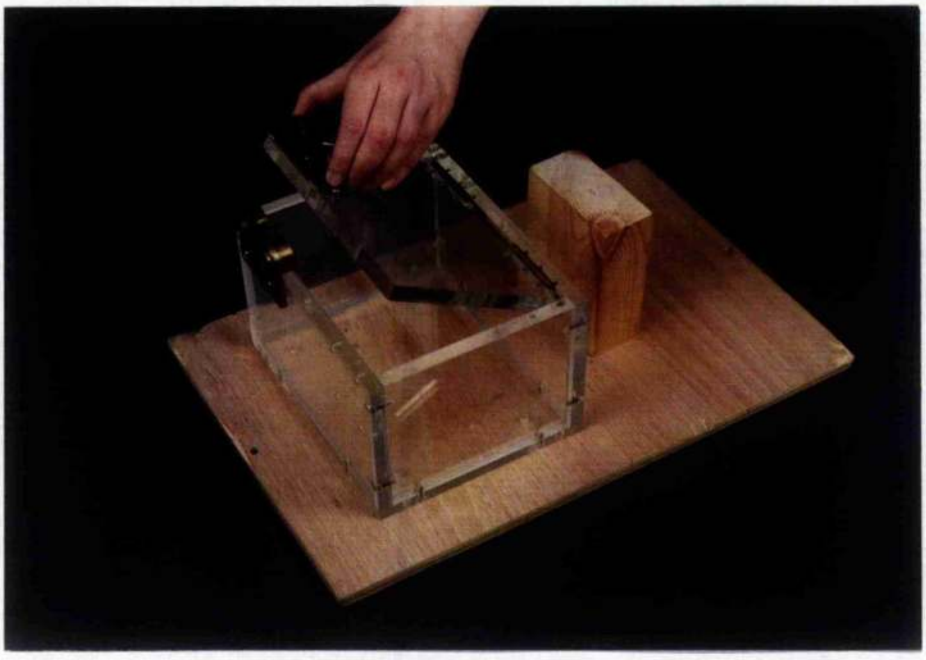


Figure 10.7: Pulling open the lid of the box

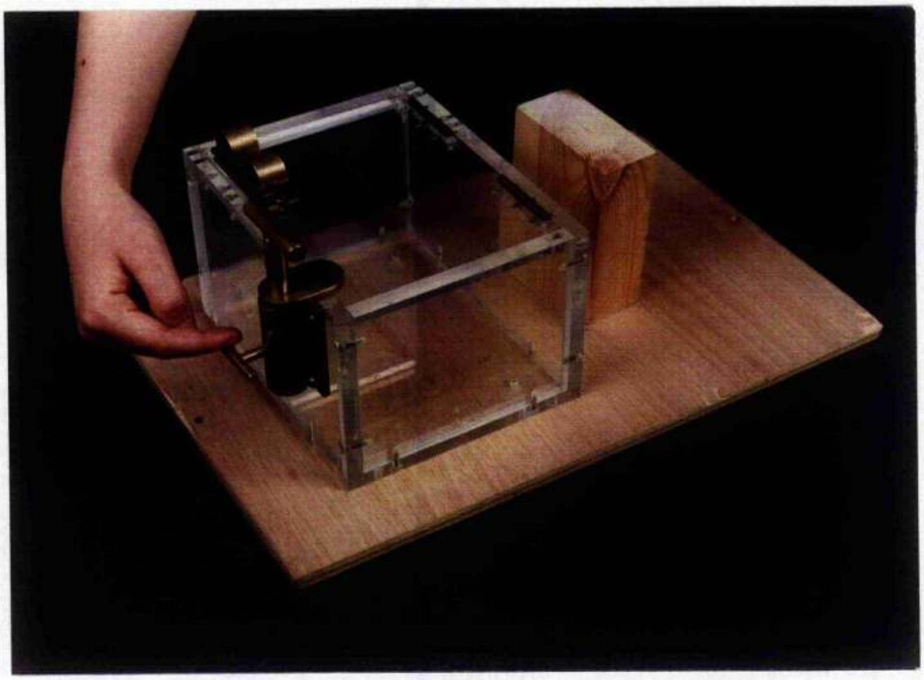


Figure 10.8: *Spinning* the pin

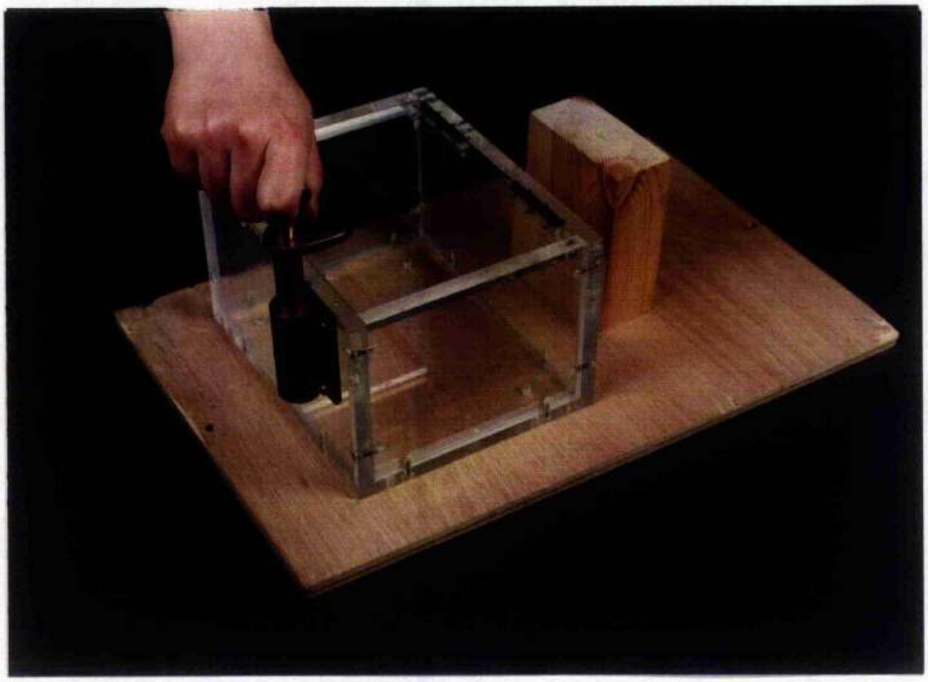


Figure 10.9: *Pulling* the handle

The barrel-lock and bolts were demonstrated separately. When the barrel-lock was presented, all of the bolts-lock was removed except for the brass rings on the lid. When the bolts-lock was presented, all the barrel-lock was removed. We could have demonstrated the latches together; after all, the order in which each of the latches were demonstrated was a factor that the subjects could have imitated. After much deliberation, we decided to present the latches separately, because as a first step we simply wanted to explore the basic issue of whether non-human primates can imitate actions used in a functional task. The issue of whether they can recall and imitate complex sequences of actions is an important issue for future research that builds on this initial step.

The subjects in each of the five samples (i.e., the capuchins, chimpanzees, 2-year-olds, 3-year-olds and 4-year- olds) were divided into two groups. Each group was shown an alternative method from the other in relation of opening the box. (It is important to note at this stage that the term "sample" in the present document is being used to refer to the different types of subjects that took part in the experiment. Hence, there was a total of five samples: 1. capuchins, 2. chimpanzees, 3. 2-year-old children, 4. 3-year-old children, 5. 4-year-old children. The term "group" is being used to refer to the division between the subjects based on which alternative method they were shown.) On the barrel-lock, the subjects in Group A were shown turning the pin and turning the handle, while Group B was shown spinning the pin and pulling the handle. On the bolts-lock, Group A was shown poking, while Group B was shown twisting.

The groups and samples were balanced, as far as was possible, for gender and location (e.g., the effect of location was balanced for the chimpanzees by ensuring that the two Yerkes chimpanzees were shown alternative methods). Each subject received two test sessions with four, two minute trials in each session. In the first session the barrel lock was demonstrated, and in the second session the bolts were presented. Before each of the trials the subjects received one demonstration from a human demonstrator of how to open the box.

Due to unavoidable differences in the testing conditions, the procedure differed slightly between the Madrid chimpanzees, the Yerkes chimpanzees, the capuchins and the children.

Chimpanzees: Madrid Procedure

The experiment was conducted in the inside area of the chimpanzees' living quarters. All the chimpanzees were moved into section C of the cage (see Figure 10.10 for an overhead plan of the cage). Two sets of sheets were hung from the roof of the cage so that they covered the windows of the inside area. The sheets were strategically positioned so that the chimpanzees could not reach and pull them down. The sheets prevented individuals in the outside area from seeing the testing that took place inside.

The inner area was divided into two sections by a five-foot-high brick wall and a mesh fence that reached from the top of the wall to the ceiling. A four-foot-high platform was placed two feet from the brick and mesh partition in section A of the cage. The inside area was adequately lit with fluorescent lights.

One subject was collected from section C and carried or led to section B. The experimenters made sure the subject was settled before testing commenced. At least one experimenter stayed with the chimpanzee at all times.

Out of sight of the subject, a food reward was locked inside the foraging box. The food consisted of favoured treats such as strawberries, grapes, plums and mango. None of the subjects in the experiment was food deprived. Once the food was locked inside the foraging box, it was placed on the raised wooden platform in section A. The latches faced towards the adjacent area which contained the chimpanzee subject and the human companion. The subject sat upon the wall directly opposite the box and watched through the mesh fence. In order that the demonstrator should not impede the chimpanzee's view, she stood to one side and slightly behind the platform and reached over to the front of the box to manipulate the latches. (Figure 10.11 is a photograph of the foraging box being presented to one of the chimpanzees in Madrid Zoo.) A third person operated a video camera and filmed the experimental trials.

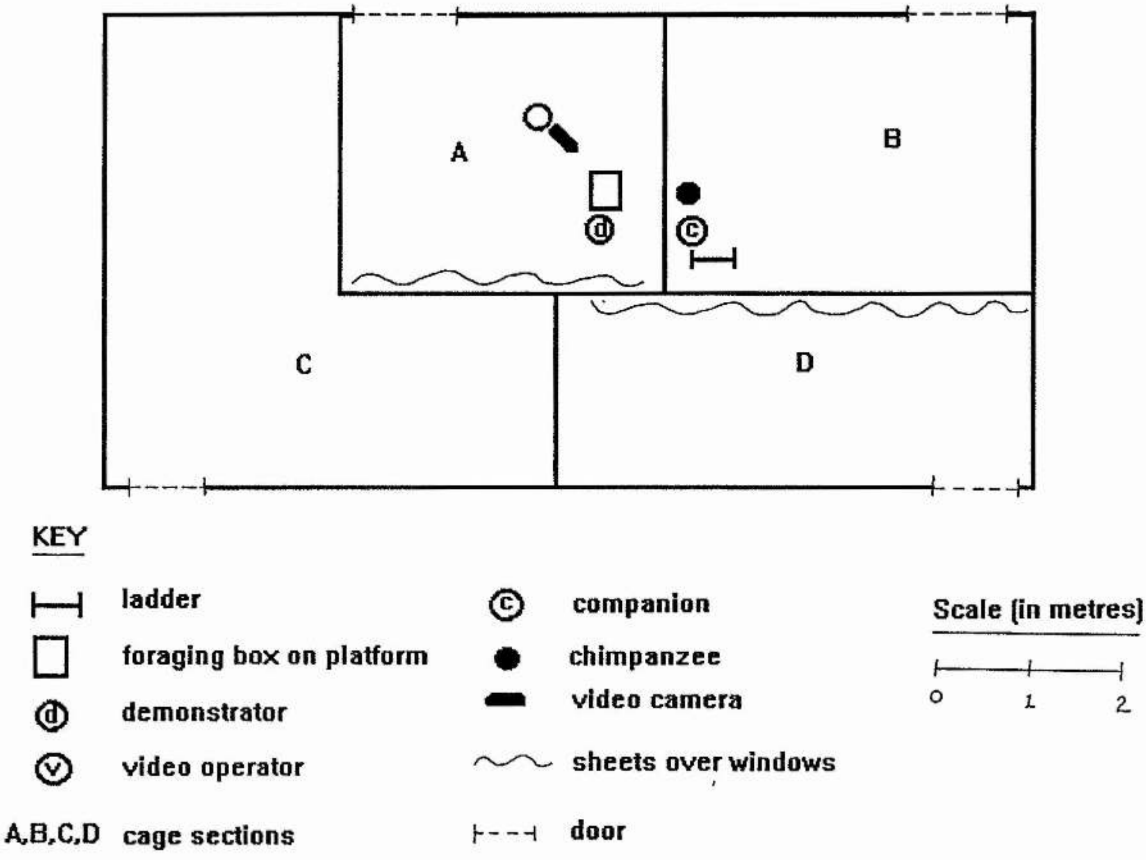


Figure 10.10: Overhead view of the testing conditions at Madrid Zoo

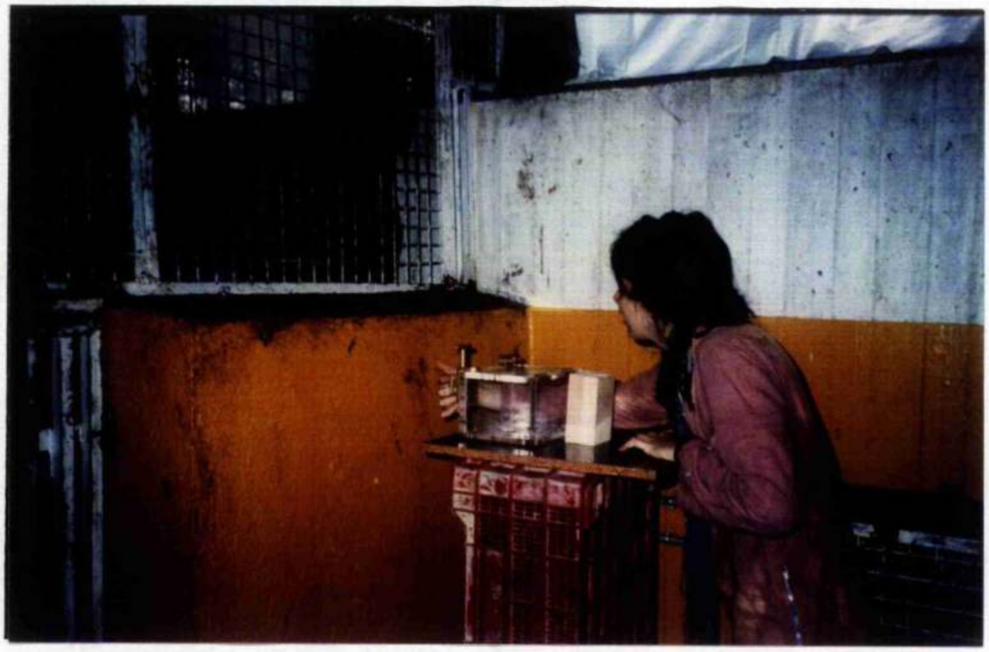


Figure 10.11: Demonstration in Madrid Zoo

When the demonstrator had opened the foraging box once, it was carried into a side passage and the box was reassembled out of sight of the subject. It was then carried into the cage with the subject, and placed in the middle of the floor in the same orientation as it had been placed on the demonstrating platform. The mean time from the end of the demonstration to when the foraging box was placed in the cage with the subject was 29.71 seconds. In each trial the subject was allowed a maximum of two minutes to manipulate the foraging box.

When the two-minute trial was over the box was taken back into the side passage, and if necessary, more food was placed inside. The latch was re-locked and the next trial began. Each subject received four trials per experimental session. All of the trials were recorded on video tape.

Chimpanzees: Yerkes Procedure

Two outside play-yards were used for testing (see Figure 10.12 for an overhead view of the testing area). The subjects were placed in separate play-yards and each was

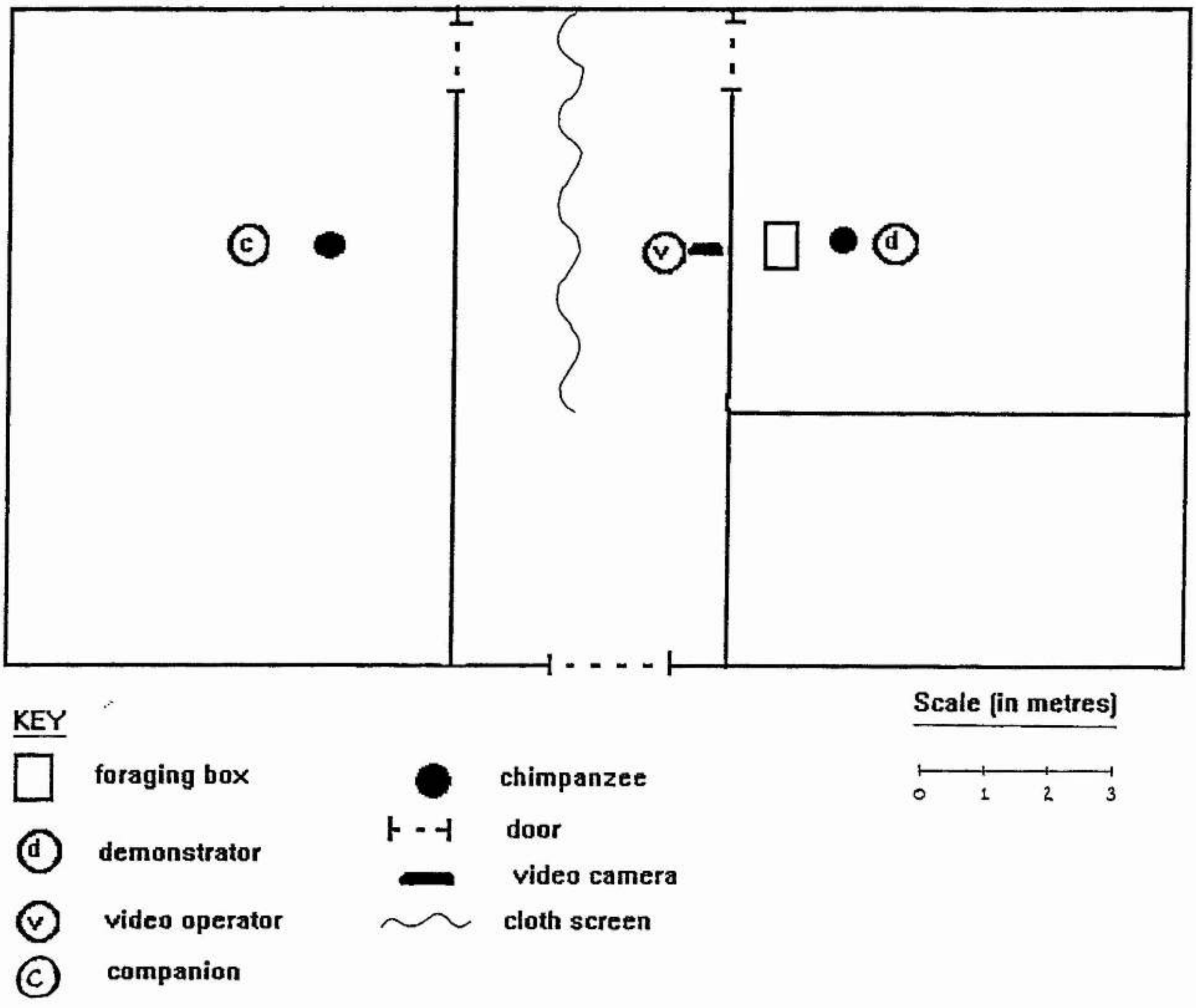


Figure 10. : Overhead view of the testing conditions at Yerkes

Figure 10.13: KA *turning* the pin

Figure 10.14: KA *pulling* the handle out

Figure 10.15: KA *twisting* one of the bolts

Figure 10.14: KA opening the box

accompanied by a human companion. A sheet was hung from the mesh roof of the walk-way which separated the play-yards so that the chimpanzees were visually separated. A video camera was positioned outside the yard of whichever chimpanzee was being tested. The foraging box was placed on the floor inside the yard with its latches facing away from the video camera.

One person operated the video camera outside the yard, while a second remained inside with the chimpanzee. It was not possible to transfer the foraging box back and forth between the outside and the inside of the cage as in Madrid, since there was one less experimenter and the chimpanzees were more likely to escape. Hence, the box remained in the play yard and the chimpanzee sat in the experimenter's lap while she demonstrated the latches. When the box was reassembled, the camera operator passed the food reward to the demonstrator. The subjects were prevented from seeing the box being reassembled by the experimenter holding her hand over their eyes, which seemed to be treated as a game by the chimpanzees and was easily tolerated. Figures 10.13 to 10.16 shows KA in various stages of opening the barrel- and bolts-locks.

Capuchins: Procedure

Testing took place in a well-lit room separate from the monkeys' home cages. Each subject was carried in a metal transport box from their home cage into the testing room and transferred to the test cage. The test cage was originally designed for a study on capuchin decision-making, but it adequately served the purposes of the present experiment. It was made up of three sections with interconnecting sliding perspex doors (see Figure 10.17). The monkeys watched from the middle section as the box was placed on a platform and demonstrated opposite them. After the demonstrations the foraging box was placed in the far right hand section of the cage. The door to the right section was lowered so the subject could enter and then it was closed behind him or her. The monkeys' manipulations were recorded on video tape.

In order to provide an objective test of whether the capuchin subject was

Figure 10.17: Test cage for the capuchin subjects

sufficiently calm in the testing situation to present the foraging box, a small pre-test task was devised. The experimenter held up both of her hands with the palms open and facing towards the monkey. One of her hands contained food and the other was empty. The hands were then hidden behind the experimenter's back for 5 seconds. They were then presented to the monkey closed into fists and the subject had to remember where the food was hidden and reach out and touch that hand in order to receive the reward. The foraging box trials only commenced if the subject chose the correct hand in at least five out of six pre-test trials, within two blocks of six trials.

Even with the pre-test, the monkeys would still sometimes show no motivation to manipulate the box. (Capuchins appear to be quite nervous creatures and they become easily distracted.) Therefore, a "no trial" rule was devised so that if the subject did not manipulate the box for ten or more consecutive seconds during the two minute-trial it was counted as a "no trial". After two consecutive "no trials" testing was abandoned for the day with that particular subject.

One pair-housed monkey, Quasar, never passed the pre-test memory task. He showed no motivation in the test situation and would usually sit or lie down at the back of the cage. A second pair-housed subject, Jill, regularly passed the pre-test but she showed no motivation with the foraging box. Despite having received over 40 presentations, she never passed the ten second consecutive manipulation criterion. Therefore, both Jill and Quasar were dropped as subjects. A further 8 colony monkeys, who were captured three to four times a week over a three month period, also failed to become sufficiently habituated to the test situation. Therefore, a total of 16 monkeys were presented with the box, but only 6 proved to be suitable subjects.

The procedure was almost identical to that used for the Madrid chimpanzees. The monkeys were divided into two groups and shown alternative methods for opening the box. There was a maximum of four, two-minute trials per test session. One main difference was that instead of just one demonstration before the subject's two-minute trial the capuchins received three demonstrations. The reason for the extra demonstrations was that, unlike the chimpanzees, the monkeys were more easily distracted. It was important to ensure, as far as possible, they had seen all the relevant aspects of opening the latches before they were given direct access to the foraging box. The capuchins also received a total of 8 rather than 4 trials on each latch. There was only one experimenter who demonstrated the box and operated the video camera (which was set on a tripod). Finally, it was necessary to modify the box in order to ensure that the detachable parts could be retrieved at the end of each trial. Therefore, the handle, pin and bolts were attached to the box with string.

Children: Procedure

Each of the eight children from the different age categories were divided into two equally sized experimental groups which were counterbalanced for gender. Each experimental group was shown alternative methods for opening the box. The details of age, gender, and methods shown for each subject is displayed in Table 10.1.

The apparatus was exactly the same as was used for the chimpanzee subjects (Figure 10.1). The procedure was basically the same as that used with the Madrid chimpanzees, except for the following details. The 2-year-old children were tested at home because there was no suitable testing area at the play or toddler group venues. The three and four year olds were tested in a room separate from the main play or activity area at their school or play-group. The foraging box was placed upon the floor for both demonstration and presentation to the children. There was only one experimenter who demonstrated the box and operated the video camera (which was set on a tripod). In order to make the procedure analogous to the ape and monkey testing, the experimenter gave no explicit verbal instructions (such as, "Watch me" or "Look"), to the children prior to or during the demonstration of the foraging box. The 2-year-old subjects' mothers, who were present during testing, were also instructed not to verbally instruct or direct the attention of their children. The box was reassembled behind a cloth screen or by stepping briefly outside the room.

Method Of Analysis

The video-taped trials were analyzed using two methods. First, a microanalysis of the actions used in each trial was conducted. All the trials were analysed with the aid of a SVHS frame-by-frame video system. A comprehensive list of all the different actions performed by all the subjects in each of the trials was compiled. The experimenter then analysed each of the trials and noted the sequence and number of different actions performed. The time it took each subject to first dismantle each of the two locks and open the box was also recorded.

The microanalysis in the present experiment concentrated on *single* actions, and hence, it was not able to capture the overall impression gained from observing a continuous sequence of behaviour. It would have been difficult (not to mention, inappropriate) for the microanalysis to take into account more subjective evaluations, such as how confident and clear a subject's actions appeared to be. Independent observers, however, can take these factors into account. As long as the observers are blind to the method shown and they significantly agree with each other in respect to their evaluations of the subjects' behaviour, then such data is potentially very valuable. Therefore, the second method used to analyze the video-taped trials was to require two blind independent observers to judge on each trial which of the two alternative methods was being imitated.

The independent observers viewed video-taped segments from all of the barrel-lock and bolts-lock trials. Each barrel-lock video segment was 30 seconds long, and each bolts-lock segment was 40 seconds long. Since very often many of the behaviours performed in any given trial were not directed toward the box or the latches, it was decided to limit and standardize which part of each trial the independent observers scored. On viewing all the trials, it was found that the greatest concentration of relevant actions (i.e., actions directed toward the latches) on the barrel-lock, occurred in the 20 seconds of manipulation prior to when the handle was turned or pulled out and 10 seconds after that point. If in any of the barrel-lock trials the experimental subject did not remove the pin, or did remove it but then did not go on to pull or turn the handle, the independent observers simply coded the first 30 seconds of manipulation in that particular trial. On the bolts-lock, most of the relevant actions were performed in the first 40 seconds of manipulation.

On viewing each video segment, the observers scored which of the alternative demonstrated methods they thought the subjects were imitating. They then gave each segment of video a score of 0 to 3, according to how certain they were that the subject was imitating one method rather than the other.

0 = the observer could not decide between the two methods, either because no clear actions were performed on the box or because the actions used were an equal mixture of both of the demonstrated techniques.

1 = the coder was only partially confident of the method being imitated.

2 = the coder was reasonably confident of the technique being imitated.

3 = the coder was very confident that the subject was imitating one method rather than the other.

The observers scored the acts on the pin, handle and bolts separately. On the pin they decided between "spin" and "turn", on the handle they scored between "pull" and "turn" and on the bolts they scored either "twist" or "poke". The video segments were presented in a randomized order.

Interobserver reliability was tested using BINOMIAL tests of probability. First, the number of times the observers agreed which alternative method was being imitated in each sample for the pin, handle and bolts was calculated (see Table 10.2). Since there were two choices of actions on each of the main manipulandum, the probability of agreement was at the level of 0.5. The level of agreement between the independent observer on all the samples for each of the manipulandum was highly significant at the level of $P < 0.001$.

Table 10.2: Interobserver Reliability

Sample	Manipulandum	Agreement	Probability
Capuchins	pin	55/64	P<0.001
	handle	58/64	P<0.001
	bolts	59/64	P<0.001
Chimpanzees	pin	28/32	P<0.001
	handle	27/32	P<0.001
	bolts	27/32	P<0.001
2-year-olds	pin	28/32	P<0.001
	handle	28/32	P<0.001
	bolts	30/32	P<0.001
3-year-olds	pin	28/32	P<0.001
	handle	30/32	P<0.001
	bolts	32/32	P<0.001
4-year-olds	pin	28/32	P<0.001
	handle	31/32	P<0.001
	bolts	32/32	P<0.001

Statistical Tests

Statistical Analysis of the Microanalysis Data

In this experiment the most important measure, in respect to imitation, is whether there is a significant difference in the number of target actions performed between the two groups in each of the samples. MANN-WHITNEY-U SMALL SAMPLE tests (Siegel 1956; Robson 1983) were used to compare between Group A and Group B. Each of the six target actions (spinning and turning on the pin, pulling and turning on the handle, and poking and twisting on the bolts) were analysed separately. Therefore, in respect to each target action a total of five Mann-Whitney-U tests were conducted (i.e., one test per sample). Since the sample sizes in the present experiment were so small, the Mann-Whitney-U was the obvious choice of statistical test for comparing between groups within samples.

KRISKAL WALLIS ANOVAs were used to test between samples, to judge whether any of the samples were imitating more than the others. To achieve this, the data in relation to each pair of alternate target actions was combined to produce a single score which expressed *the percentage of actions which were opposite to the method shown*. For example, subject 4h was shown "pull" on the handle but she performed 90 turns and only three pulls. This means that 96.77 percent of the total of turns and pulls performed by 4h were different to the method shown. A KRUSKAL WALLIS ANOVA was then performed on these percentage scores between all of the samples.

It was predicted that one way the subjects might respond would be to initially imitate the demonstrated act and then, only later, in the course of subsequent explorations, would they be likely (if at all) to independently discover the alternative demonstrated target act. To test this prediction, it was noted how many subjects performed the action they saw demonstrated before the alternative method. BINOMIAL tests of probability were then performed on this data to establish whether the number of subjects within each sample who exhibited the predicted direction of response was above the level of chance ($p < 0.05$).

In reporting the results of the statistical tests the actual table P-value is stated. The reason for this is that with small samples it is more difficult to establish whether an effect is truly present; the probability scores can at least indicate whether there seems to be a strong trend in the predicted direction versus there being no indication of an effect. All the tests were one-tailed, (i.e., the level of significance was $p < 0.05$). This was because there were clear predictions related to the expected direction of the effect. For example, in relation to the handle it was predicted that Group A (shown turning) would "turn" the handle more that Group B (shown pulling), and Group B would "pull" the handle more than A.

Analysis of the Independent Observer Scores

It was hypothesised that, if the subjects in a sample were clearly imitating at least one of the demonstrated actions, then the independent observers' scores for Groups

A and B would significantly differ from one another. To statistically test this hypothesis, the observers' scores were converted into a single continuous scale. For example, in relation to the bolts, at one end of the scale "twist 3" was scored as 1 and at the other end "poke 3" was scored as 7; the other scores were ranged between these two extremes (see the scales at the base of Figure 10.33). The means of the two independent observers' converted scores on each of the subjects' trials were calculated and tabulated. MANN-WHITNEY-U tests were used to judge whether there was a significant difference between Groups A and B within each sample on the pin, handle and bolts.

RESULTS

The Barrel-lock

Actions Performed on the Pin: Microanalysis

The actions performed on the pin can be divided into four different categories: "spins", "turns", "pulls" and "other". Below, the individual actions within each category are listed and defined.

NB: The thumb is referred to as the first digit, the index finger is referred to as the second digit and so on to the little finger which is called the fifth digit (after Napier 1980).

1. *Spins*

Spins were classified as actions in which the pin was *pushed* around by part of the hand without it being gripped.

a. **Index finger spin**: the pin was spun with an extended second digit. This was the method used by the demonstrator.

b. **Third digit spin**: the pin was spun with an extended third digit.

c. **Thumb spin**: the pin was spun with an extended first digit.

d. **Open hand spin**: the pin was spun with the fingers of an open hand.

2. *Turns*

A turn was defined as any action in which the pin was gripped in the hand(s) and then either the fingers, wrist or arm was rotated thereby rotating the pin. Below, the different grips that were used to turn the pin are listed. The categorisation of the grips used in the present analysis is based on Napier (1980).

a. **Pad-to-pad precision grip**: the pin was gripped between the pads of the thumb and index finger (see Fig 10.18e).

b. **Semi-precision grip**: the pin was gripped between the pad of the thumb and the side of the index finger (see Figure 10.18a). This was the grip the demonstrator used to turn the pin.

c. **Chuck grip**: The pin was gripped between the pads of the thumb and two or more fingers (see Fig. 10.18b).

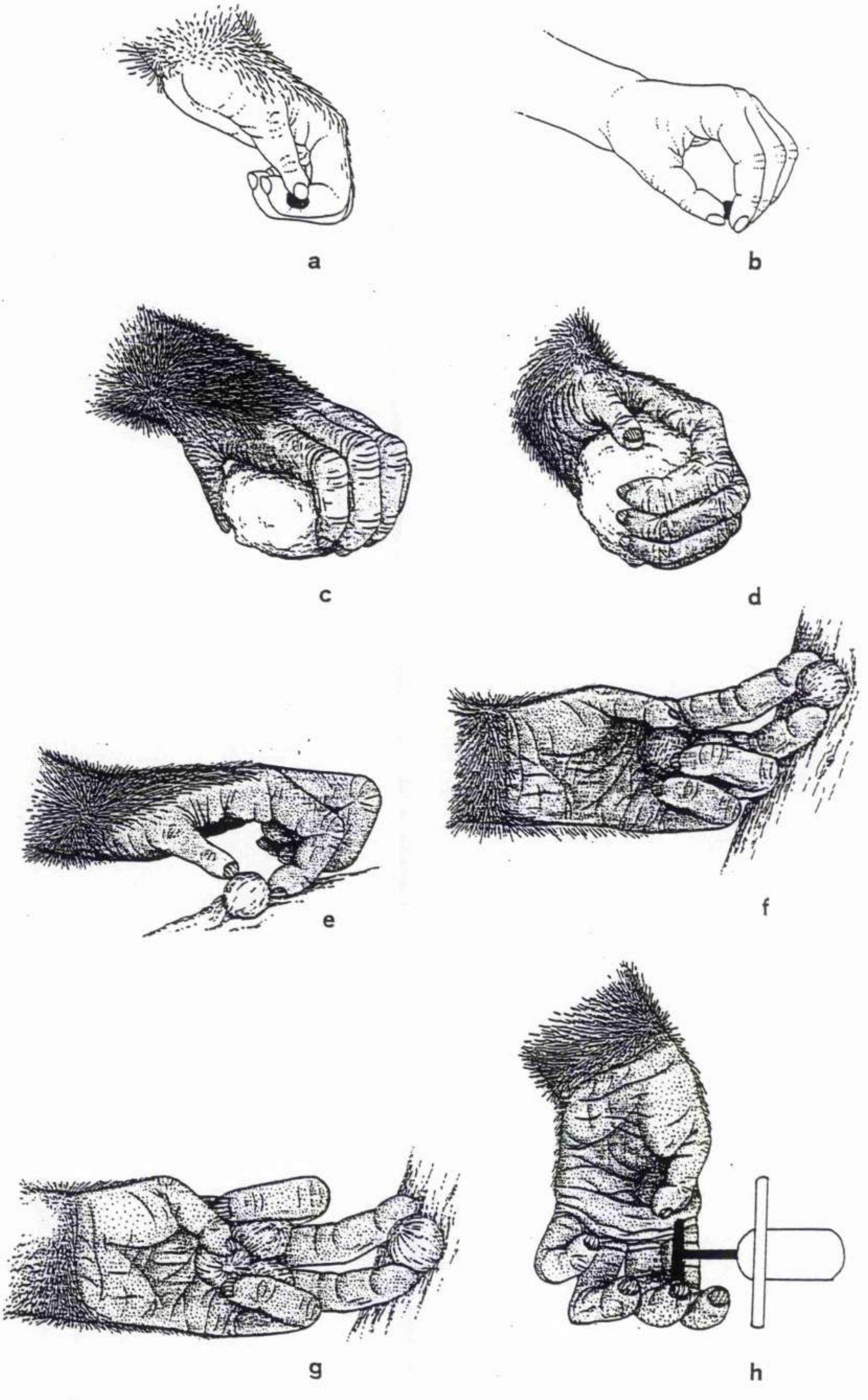
d. **Power grip**: The pin was gripped against the palm with the fingers curled over the top of it. The subject usually gripped the pin sideways on. Napier (1980) states that the power grip "is executed between the surface of the fingers and the palm with the thumb acting as a buttressing and reinforcing agent" (p.77).

e. **Two handed grip**: each arm of the pin was gripped in both hands using either precision, semi-precision, or chuck grips.

3. *Pulls*

A pull was defined as any action in which the pin was gripped and pulled out. All of the grips described above for "turning" were also used to pull the pin. Two other pulls were also performed.

a. **Hooked scissor grip**: The stem of the pin was gripped either between the second



a - semi-precision grip (chimpanzee); b - chuck grip (human); c - forward power grip (chimpanzee); d - sideways power grip (chimpanzee); pad-to-pad precision grip (chimpanzee); f - scissor grip between index and second fingers (chimpanzee); g - scissor grip between second and third finger (chimpanzee); h - overhead view of hook grip on pin (chimpanzee). Illustrations a and b from Christel (1993 , illustrations c to h from Boesch & Boesch (1993).

Figure 10.13: Illustrations of the Different Kinds of Grips used on the Pin and Handle

and third digit or the third and fourth digit with the ends of the fingers bent over cross-bar of the pin and the palm facing up. This was the method used by the demonstrator to pull the pin out (see Figure 10.18f&g). This grip is a combination of two separate grips described by Napier (1980): 1) the **hook grip**, in which a subject fingers are flexed and bent at the ends and an object is held without the support of the thumb (we often hold bag-handles in this manner), and 2) the **scissor grip** in which an object is held between the terminal phalanges of the second and third digit (people often hold cigarettes this way).

b. **Bite pull**: some of the capuchins used their teeth to pull the pin out.

Other

a. **Flicking**: The pin was rotated by hitting down or up on it with the fingers of an open hand.

b. **Two handed flicking**: open hand was flicked down on one arm of the pin as the other hand was flicked up at the other arm.

c. **Rubbing**: the palm of the hand was used to roughly rub the pin (one capuchin (CH) and one chimpanzee (LA) performed this action).

d. **Hook rotation**: the pin was partially gripped (sideways on) in the fingers with the palm facing upwards without the aid of the thumb (see Figure 10.18h). The hand was then moved back horizontally so that the pin was rotated by the fingers. Although the pin was gripped, the hand was not rotated, therefore the **hook rotation** does not constitute a turn. This action seemed to be a cross between spinning and turning and hence it has been treated as if it were a separate action in the present analysis. Only three subjects performed hook rotations: the chimpanzee, LI, hook rotated the pin 21 times, the 3-year-old subject, 4d, hook rotated it once and the capuchin, WI, rotated it twice in this manner.

e. **Jiggle**: the pin was gripped and the hand made a side to side rotational movement without actually fully rotating or turning the pin.

f. **Grasps**: the pin was simply gripped in the hand and released. All of the grips described in regards to turning and pulling the pin were also used to grasp it.

In respect to the present analysis, the most relevant categories of actions performed on the pin were the demonstrated acts: *turns*, *spins* and *pulls*. Only three subjects, 2e, 2h and 4g, used the same **hooked scissor grip** as the demonstrator to *pull* out the pin. Therefore, there was very little evidence of the subjects imitating the precise grip used in pulling out the pin.

Table 10.3, presents the median number of *turns* and *spins* on the pin. It can be seen that, on the whole, very few *spins* were performed by either of the two groups in any of the samples. Thus, it is not surprising that when Mann-Whitney-U tests were used to compare the amount of spinning performed by Groups A and B, no significant difference was found within any of the five samples (capuchins $U_{(3,3)}=1.5$; $P=0.15$; chimpanzees $U_{(4,4)}=6$; $P=0.343$; 2-year-olds $U_{(4,4)}=5.5$ $P=0.293$; 3-year-olds $U_{(4,4)}=6$, $P=0.343$; 4-year-olds $U_{(4,4)}=7$, $P=0.443$).

Table 10.3 shows that some degree of *turning* was exhibited within all of the samples. However, a further five Mann-Whitney-U tests showed that there was no significant difference in the amount of turning performed by Groups A and B within each sample (capuchins $U_{(3,3)}=1.5$, $P=0.15$; chimpanzees $U_{(4,4)}=5$, $P=0.243$; 2-year-olds $U_{(4,4)}=6.5$, $P=0.393$; 3-year-olds $U_{(4,4)}=7$, $P=0.443$; 4-year-olds $U_{(4,4)}=3$, $P=0.1$).

Figure 10.19 is a graph of the median scores for *turning* the pin in Groups A and B within each sample. It clearly illustrates the fact that there was no consistent pattern in terms of the direction of response, in respect to the amount of pin-turning exhibited between the two groups. However, there does appear to be a difference between the samples. A Kruskal Wallis Anova indicated that there was a highly significant difference in the number of turns performed between the five samples ($KW_{(6,8,8,8,8)}=23.443$, $P<0.0001$). A Dunnes' post hoc test showed that the 3-year-old subjects turned the pin significantly more than the chimpanzees (Mean $\text{difference}_{(8,8)}= -16.175$, $P<0.05$) and the capuchin monkeys (Mean $\text{difference}_{(8,6)}=$

Table 10.3: Median Scores of "Turns" abd "Spins" on the Pin

	Turns		Spins	
Groups	A	B	A	B
Capuchins	6	0	0	0
Chimpanzees	5	6.5	0	0
2 year olds	12.5	22	0	0.5
3 years olds	51	26	0	0.5
4 year olds	33	57.5	0.5	0.5

A = Shown TURN

B = Shown SPIN

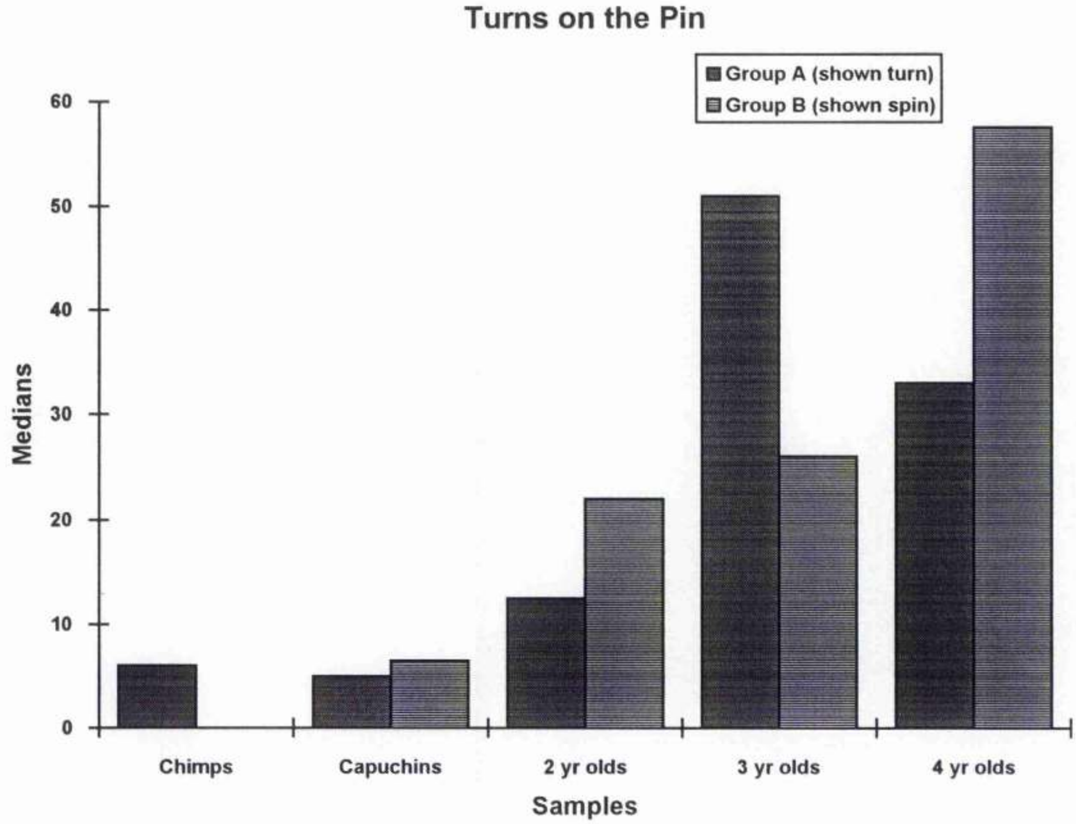


Figure 10.19: The median number of turns on the pin by group A (shown turn) and B (shown spin) within each sample

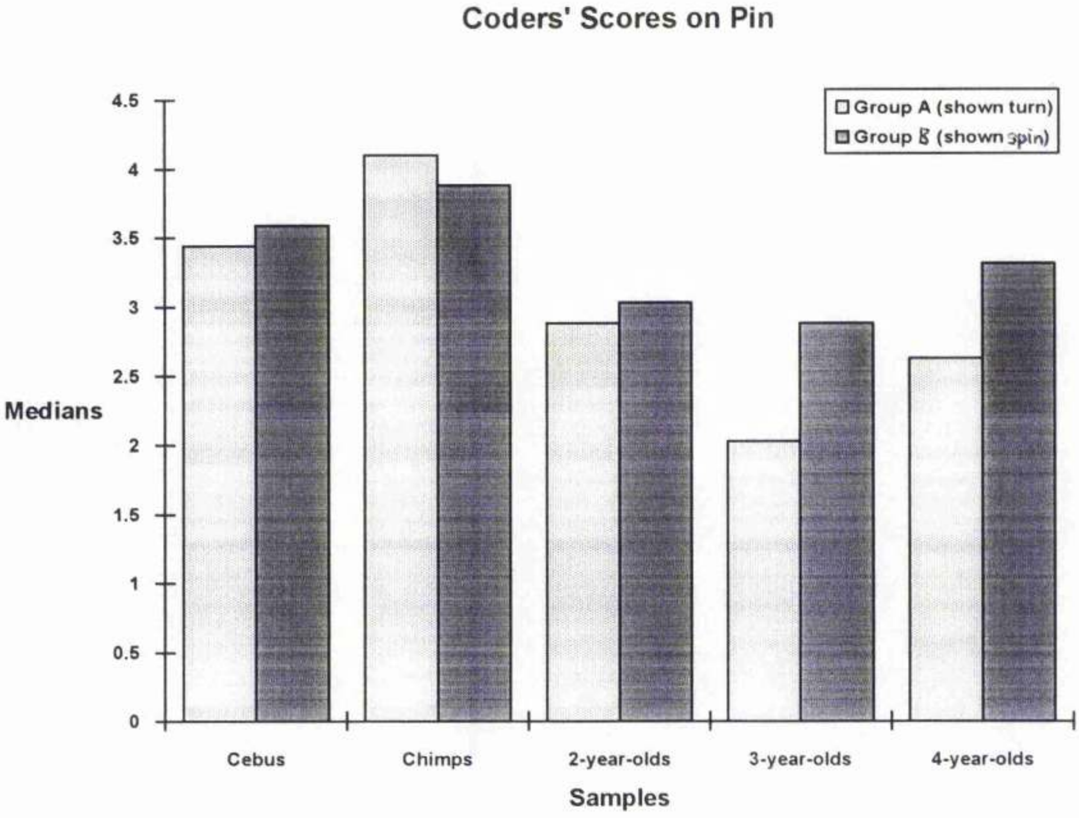


Figure 10.20: The median converted coders' scores on the pin for groups A (shown turn) and B (shown spin) within each of the samples
There was no significant difference between any of the samples' groups A and B.

Conversion Table for Pin

1	2	3	4	5	6	7	Conversion scores
3	2	1	0	1	2	3	Coders' scores
Turn						Spin	

-20.938, $P<0.01$) and, similarly, the 4-year-old subjects turned the pin significantly more than the chimpanzees (Mean difference$_{(8,8)}$ = -18.313, $P<0.01$) and the capuchins (Mean difference$_{(8,6)}$ = -22.375, $P<0.01$). None of the other samples were significantly different from one another.

Actions Performed on the Pin: Independent Observers' Scores

The independent observers' scores reflected the same trends as found in the microanalysis. Figure 10.20 shows that there was no significant difference between the independent observers' converted mean scores for Group A (shown turn) and Group B (shown spin) within each of the samples (Mann-Whitney U tests, capuchins $U_{(3,3)}=1$, $P=0.1$; chimpanzees $U_{(4,4)}=4$, $P=0.171$; 2-year-olds $U_{(4,4)}=7.5$, $P=443$), $P=0.443$; 3-year-olds $U_{(4,4)}=5$, $P=0.243$; 4-year-olds $U_{(4,4)}=5$, $P=0.243$). Therefore, the observers did not detect a difference in any of the samples' Groups A and B, in respect to the nature of the manipulations performed on the pin.

Actions Performed on the Handle: Microanalysis

The actions performed on the handle were divided into three general categories: "turn", "pull", and "other".

Turns

An action was counted as a turn when the pin had been removed and the lip of the handle was turned away from being centrally over the lid. All of the following grips were used to "turn" the handle:

a. **Pad-to-pad precision turn**: (see above for pin).

b. **Semi-precision turn**: (see above for pin).

c. **Chuck turn**: (see above for pin).

d. **Forward power turn**: the hand was gripped over the top of the T-bar of the handle in a fist (see Fig.18c).

e. **Sideways power turn**: the T-bar was gripped against the palm and the thumb with the side of the index finger uppermost (see Fig 10.18d).

f. **Lip turn**: the lip of the handle was gripped and turned using either a precision, semi-precision or chuck grip.

g. **Two handed turn**: the T-bar was turned with two hands, using either the **pad-to-pad precision grip**, the **semi-precision grip**, the **chuck grip** or the **power grip**.

Pulls

An action was counted as a pull when the pin had been removed and the handle was lifted up at least approximately two-centimetres out of its holder. All of the grips described above in relation to turns were also used to pull the handle.

a. **Pad-to-pad pull**; b. **semi-precision grip pull**; c. **chuck pull**; d. **forward power grip pull**; e. **sideways power pull**; f. **lip pull**; g. **two handed pull**. There was also one other pull.

h. **Bite pull**: Some of the capuchins used their teeth to pull the handle out.

Others

a. **Open hand spin**: (see above for pin)

b. **Rubbing**: (see above for pin).

c. **Grasps**: An action was counted as a "grasp" when the handle was gripped in the subject's hand(s) and then released without it having being turned or pulled up. The majority of grasps occurred before the pin had been removed. All of the grips described for turns were also used to grasp the handle.

d. **Biting**: Some of the capuchin and chimpanzee subjects mouthed or bit the handle.

e. **Pull-turn**: was when the handle turned in the subject's hand as he or she was pulling it up. Since this act was a combination of pulling and turning it was counted as neither.

In respect to the present analysis, the most relevant categories of action performed on the handle were *turn* and *pull*, as these were the two demonstrated acts. In regards to *turning* the handle, Figure 10.21 shows that the data in all the samples is in the predicted direction for imitation, with Group A (shown turn) turning the handle more than Group B (shown pull). However, only the 2- and 3- year-olds in Group A (shown turn) turned the handle significantly more than Group B (shown pull), (Mann-Whitney-$U_{(4,4)}=0$, $P=0.014$ and $U_{(4,4)}=1$, $P=0.029$, respectively). No significant difference was found in the amount of turning on the handle between Groups A and B within any of the other samples (capuchins $U_{(3,3)}=2$, $P=0.2$; chimpanzees $U_{(4,4)}=5$, $P=0.243$; 4-year-olds $U_{(4,4)}=4$, $P=0.171$). Therefore, the microanalysis suggests that only the 2- and 3-year-old subjects clearly imitated turning the handle.

Figure 10.22 clearly illustrates that there was no significant difference in the amount of *pulling* performed by the chimpanzees and capuchins in Groups A and B (chimpanzees $U_{(4,4)}=6.5$, $P>0.3$; capuchins $U_{(3,3)}=4.5$, $P>0.5$). Figure 10.22 does suggests that there is stronger evidence for imitation of pulling in the three human samples. However, only the 4-year-olds' Group B (shown pulling) pulled the handle significantly more than Group A (shown turning), ($U_{(4,4)}=0$, $P=0.014$). No significant difference was found in the number of pulls performed by Groups A and B in relation to the other two samples of children (2-year-olds $U_{(4,4)}=4$, $P=0.171$; 3-year-olds $U_{(4,4)}=6$, $P=0.343$). Therefore, the microanalysis data suggests that there is only clear evidence of imitation on pulling the handle in the 4-year-old subjects.

Binomial tests of probability were used to test whether the subjects in each sample showed the tendency to exhibit the action they had seen demonstrated before the alternative action, above the level of chance ($P<0.05$). None of the tests for each sample were found to be significant: four out of the six capuchins ($P=.344$), two out of the eight chimpanzees ($P=0.145$), six out of the eight 2-year-olds ($P=0.145$), five out of the eight 3-year-olds ($P=.363$) and six out of the eight 4-year-olds ($P=0.145$) performed the demonstrated action first. Therefore, there was not a significant tendency in any of the samples of subjects for them to first imitate the method they had

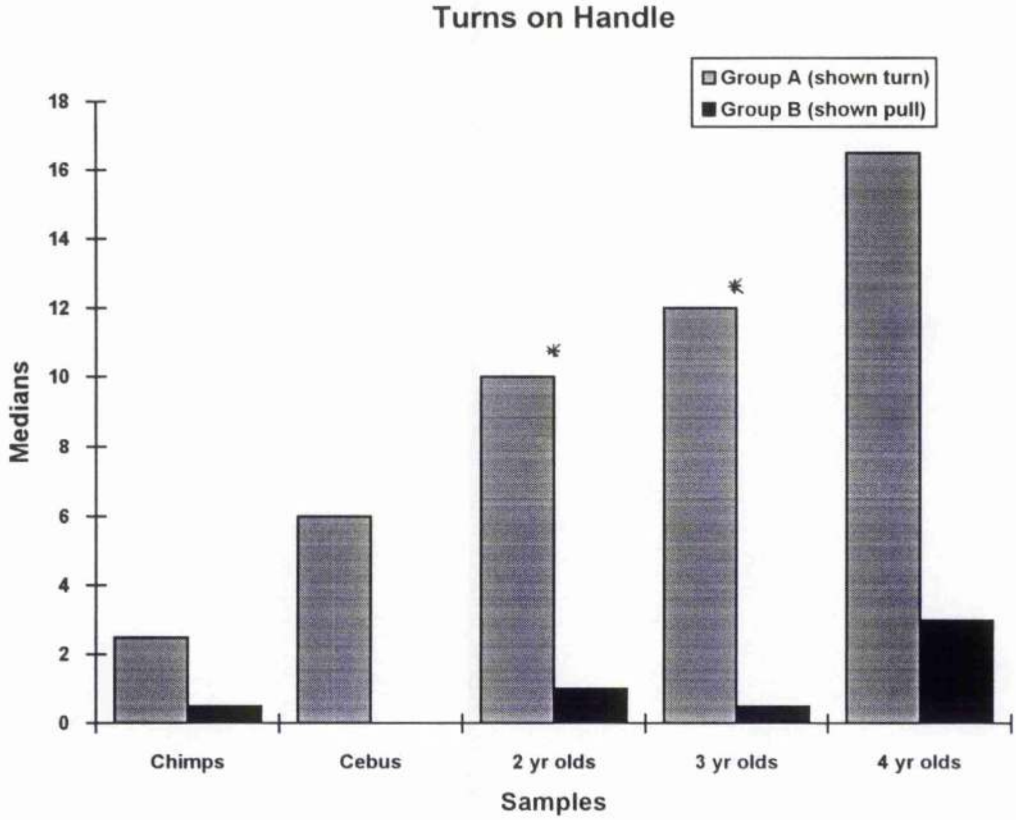


Figure 10.21: The median number of turns on the handle by groups A (shown turn) and B (shown pull) within each sample

* There was a significant difference between groups A and B ($P<0.05$), [2-year-olds: $U(4,4)=0$, $P=0.014$; 3-year-olds: $U(4,4)=1$, $P=0.029$]

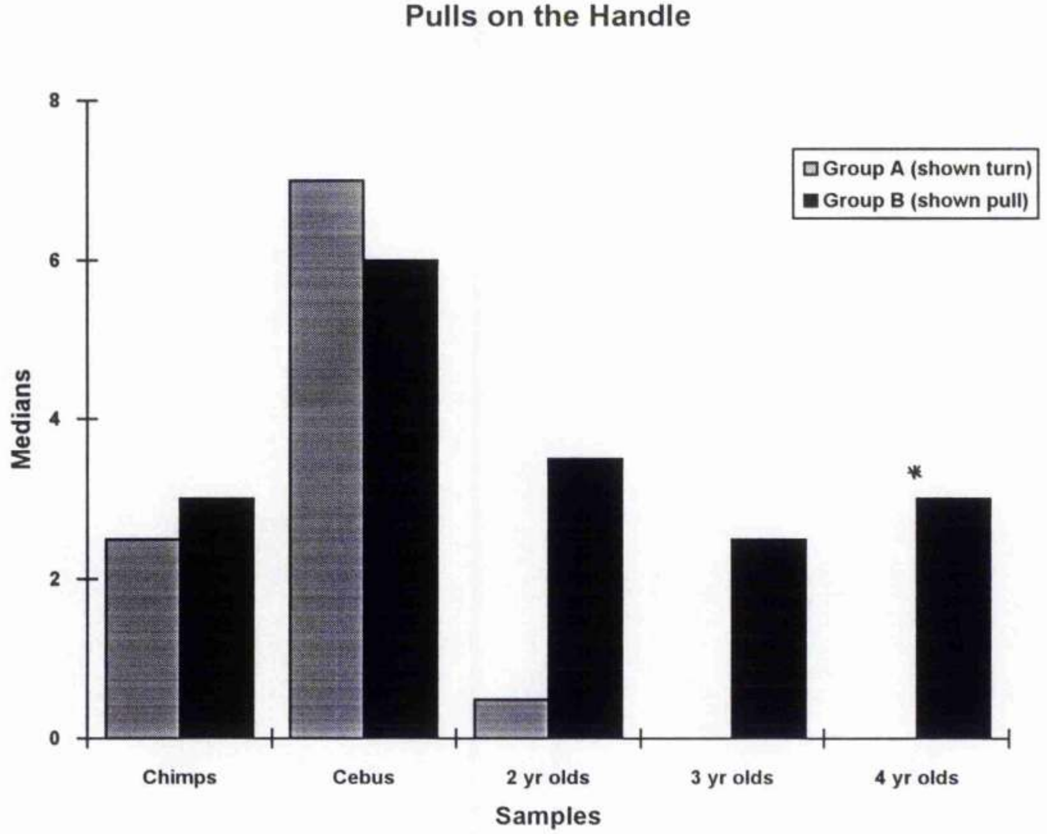


Figure 10.22: The median number of pulls on the handle by groups A (shown turn) and B (shown pull) within each of the samples
* There was a significant difference between groups A and B ($P<0.05$), [4-year-olds: $U(4,4)=0$, $P=0.014$]

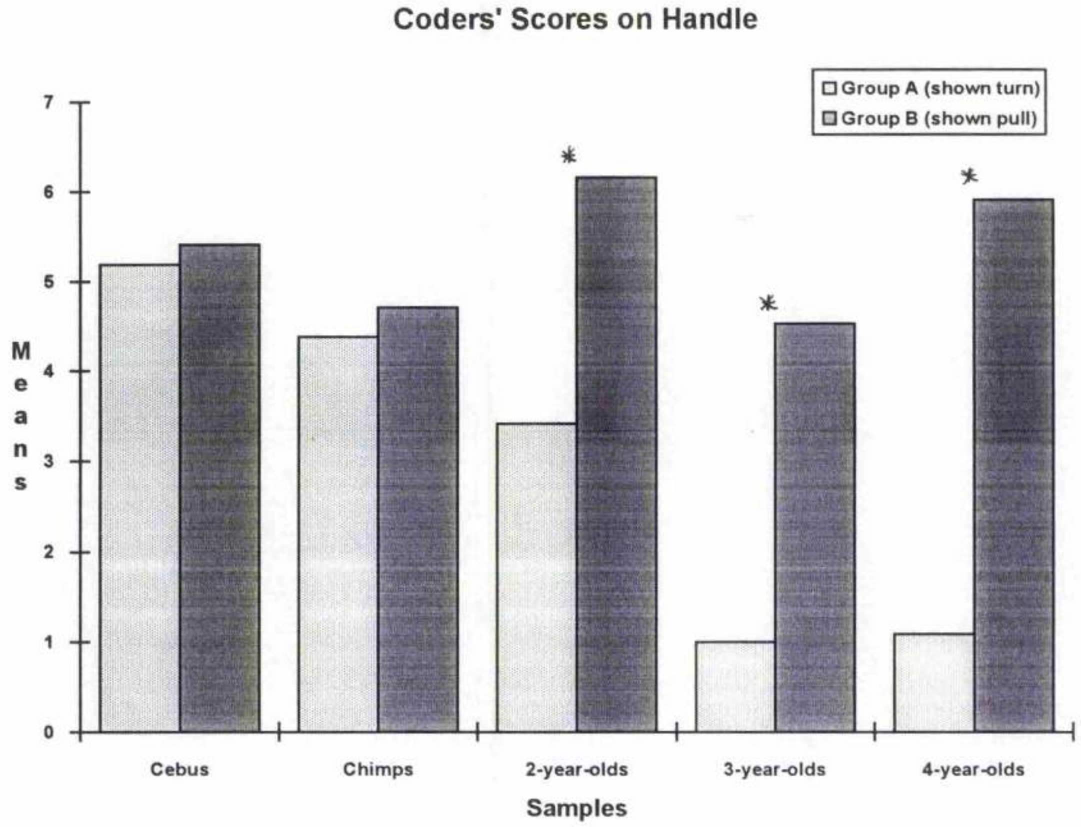


Figure 10.23: The mean converted coders' scores on the handle for groups A (shown turn) and B (shown pull) within each of the samples
* There was a significant difference between groups A and B ($P<0.05$), [2-year-olds: $U(4,4)=1.5$, $P=0.043$; 3-year-olds: $U(4,4)=0$, $P=0.014$; 4-year-olds: $U(4,4)=0$, $P=0.014$]

<u>Conversion Table for Handle</u>

1	2	3	4	5	6	7	Conversion scores
3	2	1	0	1	2	3	Coders' scores
Turn						Pull	

seen demonstrated on the handle, and then only later independently discover the alternative target action.

Actions Performed on the Handle: Independent Observers' Scores

The independent observers' scores generally reflected the same trends as found in the microanalysis. Figure 10.23 shows that there was no significant difference between the independent observers' mean converted scores for the chimpanzees in Groups A and B (Mann-Whitney U test, $U_{(4,4)}=8$, $P=0.557$), nor in the capuchin groups ($U_{(3,3)}=4$, $P=0.5$). There was a significant difference between the scores given to Groups A and B for the 2-year-old ($U_{(4,4)}=1.5$, $P=0.043$), 3-year-old ($U_{(4,4)}=0$, $P=0.014$) and 4-year-old ($U(4,4)=0$, $P=0.014$) subjects. Therefore, the independent observers' scores indicate that the three samples of children imitated the actions performed on the handle, while the non-human primates did not. This trend is evident in Figures 10.21 and 10.22.

If imitating the exact demonstrated method was a particularly efficient way of learning how to open the foraging box, one would expect the children to solve the barrel-lock more quickly than the chimpanzees and capuchins. However, Table 10.4 shows that the apes have the lowest median time among all the samples for first solving the barrel-lock. Furthermore, a Kruskal Wallis Anova found that the variance between the samples was not significant ($KW_{(6,8,8,8)}=5.711$, $P=0.2218$). Therefore, there seemed to be no great advantage accrued from imitating the method used by the demonstrator.

Table 10.4: Median times to first solve barrel-lock in each sample (first four trials).

Sample	Mean times (in seconds)
Capuchins	476.5
Chimpanzees	46.5
2-year-olds	70
3-year-olds	123.5
4-year-olds	91

Table 10.5 is a summary of the result on the handle in which it can be seen that the only evidence for imitation came from the child subjects.

Table 10.5: Summary of results on the handle

	Cap	Chps	2s	3s	4s
No. of Turns	-	-	*	*	-
No. of Pulls	-	-	-	-	*
Binomial	-	-	-	-	-
Coders' scores	-	-	*	*	*

* - significance at $P<0.05$

The Bolts-lock

Microanalysis

The actions used to manipulate the bolts were divided into five categories: "Poke", "twist", "push", "pull" and "other".

Pokes

An action was counted as a poke when the end of the bolt either nearest to or furthest away from the subject was forced through the bolt rings using the tip of one digit.

a. **Straight index poke**: the end of the bolt was poked with the tip of an extended second digit (method demonstrated to Scott and Katrina).

b. **Hooked index poke**: the end of the bolt was poked with the tip of a hooked second digit (method demonstrated to Madrid chimpanzees and children and capuchins, see Fig. 10.2).

c. **Straight third digit poke**: as straight index poke, but the tip of the third digit was used to poke the bolt.

d. **Hooked third digit poke**: as hooked index poke, but with the third digit.

e. **Thumb poke**: the end of the bolt nearest to the subject was poked with the tip of the thumb (method preferred by the children).

f. **Two handed**: the tips of two thumbs or two second digits were used to poke both bolts simultaneously.

Twists

An action was counted as a twist if one of the bolts was gripped in the hand or teeth, rotated in one direction and released.

a. **Semi-precision twist**: the end of a bolt was gripped in a semi-precision grip and twisted. This was the demonstrated action.

b. **Chuck twist**: the bolt was twisted using a chuck grip.

c. **Power twist**: the bolt was taken in a power grip and twist by mainly moving the arm rather than by rotating the wrist.

d. **Bite twist**: one of the capuchins (JO) bit the end of a bolt and twisted it with his teeth.

c. **Two handed**: both bolts were gripped by both hands and twisted simultaneously (only exhibited by the children).

Pushes

Some of the subjects pushed either end of the bolts with the pad(s) of one or more of their digits. Although pushes look like pokes they are not equivalent actions. For instance, a subject could not strictly remove a bolt by just pushing it, he or she would have to change the orientation of his or her hand to poke the bolt all the way through the bolt-rings. Therefore, only actions that involved placing the tip of the finger against the end of a bolt were counted as pokes, and actions which involved placing the pad of a digit or any other part of the hand against the end of a bolt were counted as pushes.

a. **Index finger push**: the end of the bolt was pushed with the pad of an index finger.

b. **Third digit push**: the end of a bolt was pushed with the pad of the third digit.

c. **Thumb push**: the pad of the thumb (or first digit) was used to pushed the end of a bolt.

d. **Multi-finger push**: the pads of more than one finger was used to push at the end of a bolt.

e. **Knuckle push**: the point of the first joint of the index finger was used to pushed at the end of a bolt.

f. **Palm push**: the palm of a hand was used to push the end of one or both bolts.

g. **Teeth push**: the end of a bolt was pushed in using the teeth.

Pulls

An action was counted as a pull when the bolt was grasped in the hand or teeth and pulled out of the bolt-rings without twisting it.

a. **Hand pull**: the end of a bolt was gripped in the hand and pulled.

b. **Teeth pull**: end of a bolt was gripped in the teeth and pulled.

Other

a. **Grasp**: the end of a bolt was grasped by the hand and released.

b. **Bite**: the bolts were mouthed or chewed while they were still in the bolt-rings. Only the chimpanzees and capuchins bit the bolts.

NB: On each action it was noted which end of the bolt was manipulated (the end of the bolt protruding over the lid of the box was defined as the "back" of the bolt, and the end that protruded from the front of the box was defined as the "front" of the bolt.

In respect to the present analysis, the two most relevant action categories were "poke" and "twist", as these were the two demonstrated methods. Figure 10.24 is a histogram of the median number of *pokes* performed by each group in the five samples. It can be seen that all the samples' median scores are in the direction predicted for imitation. In other words, the subjects who saw poking (Group A) poked more than the subject who saw twisting (Group B). However, only the 3-year-olds in Group A (shown poke) poked the bolts *significantly* more than Group B (shown twist) (Mann-Whitney-$U_{(4,4)}=0$, $P=0.014$). There was no significant difference found in the number of pokes performed by Groups A and B in the capuchins $U(3,3)=7$, $P>0.6$); chimpanzees $U_{(3,4)}=2$, $P=0.114$; 2-year-olds $U_{(4,4)}=3.5$, $P=0.136$; 4-year-olds $U_{(4,4)}=6$, $P>0.343$. Therefore, only the 3-year-olds' Group A poked the bolts significantly more than Group B.

As mentioned in the procedure section, one chimpanzee, CH, was given a further four trials in which she observed poking on the bolts. In these extra trials CH poked the bolts a further 17 times. In order to incorporate the data from CH's extra

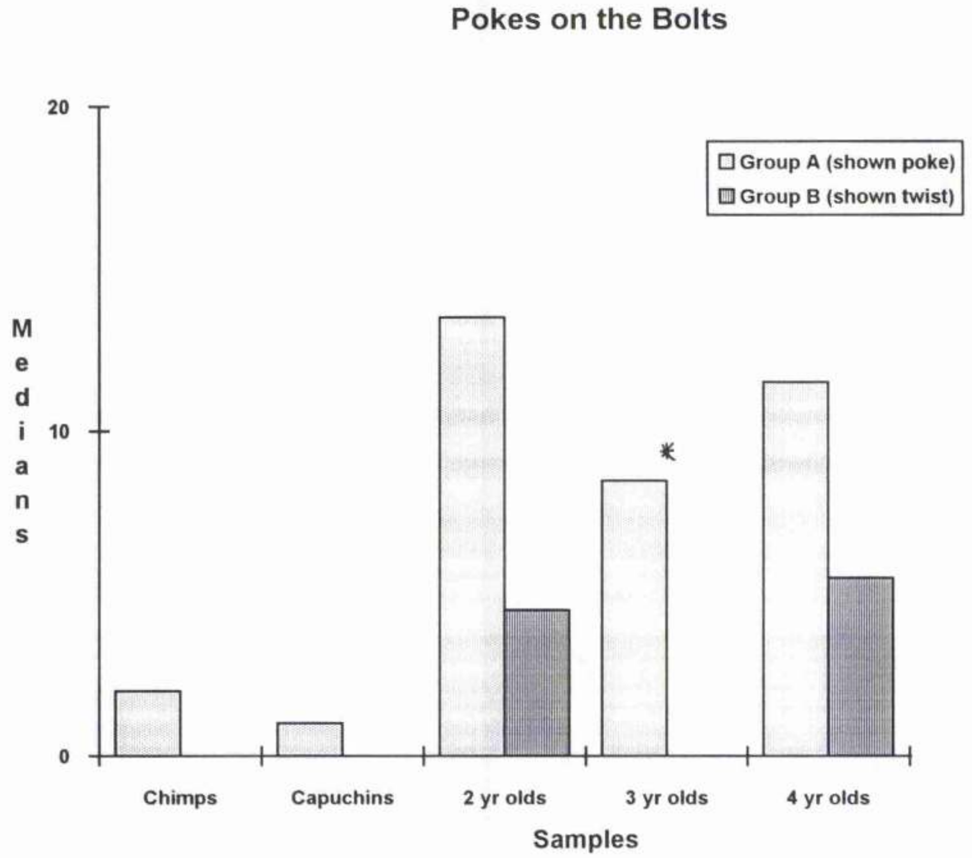


Figure 10.24: The median number of pokes on the bolts by groups A (shown poke) and B (shown twist) within each sample

* There was a significant difference between groups A and B ($P<0.05$), [3-year-olds: $U(4,4)=0$, $P=0.014$]

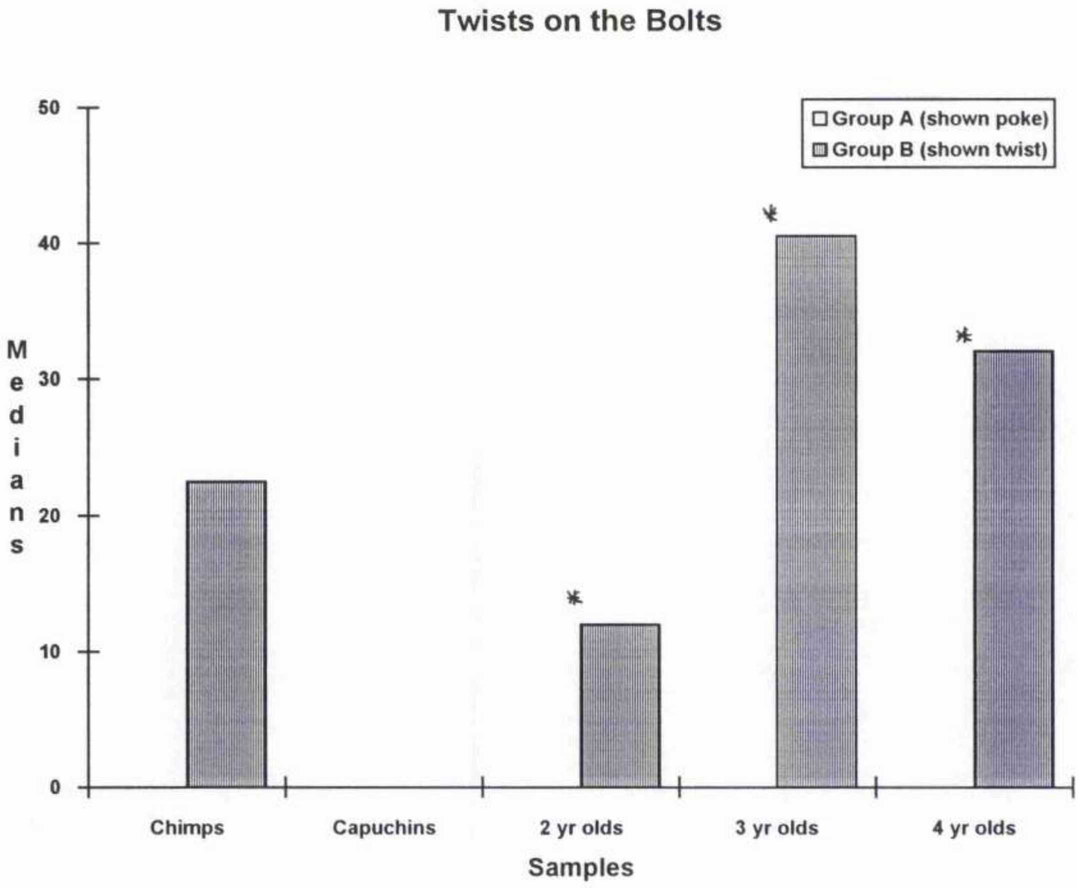


Figure 10. 25: The median number of twists on the bolts by groups A (shown poke) and B (shown twist) within each sample

* There was a significant difference between groups A and B ($P<0.05$), [2-year-olds: $U(4,4)=0$, $P=0.014$; 3-year-olds: $U(4,4)=0$, $P=0.014$; 4-year-olds: $U(4,4)=0$,)=0.014]

trials into the analysis, the mean number of target actions per trial were analysed in relation to poking for the chimpanzees. Although there was not a significant difference in the mean amount of poking per trial by the chimpanzees' Groups A and B: $U_{(3,4)}=1$, $P=0.057$, the P-value suggests that there was at least a strong trend in the direction of imitation.

Figure 10.25 is a histogram of the median values per group within each sample for the number of *twists* performed on the bolts. In all the child samples the median scores for twisting are higher in Group B (shown twisting) than Group A (shown poking), (Mann-Whitney-$U_{(4,4)}=O$, $P=0.014$), 3-year-olds' ($U_{(4,4)}=0$, $P=0.014$) and 4-year-olds'($U_{(4,4)}=0$, $P=0.014$). Although, the chimpanzees in Group B (shown twist) did not twist the bolts significantly more than Group A (shown poke), the P-value indicates that there was a strong trend in the predicted direction for imitation ($U_{(3,4)}=1$, $P=0.057$). There was no significant difference between the capuchins' Groups A and B in terms of the amount of twisting performed ($U_{(3,3)}=3$, $P=0.35$).

Figures 10.26 to 10.30 present, not only the median number of *pokes* and *twists* in each sample, but also the median number of pushes, pulls on the front of the bolts, and pulls on the back of the bolts. There are good reasons for combining certain of these extra categories with the two target actions (i.e., poke and twist). The direction of the movement of the bolt in "pulls on the front" was the same as in twisting, while in "pulls on the back" the direction in which the bolt moved was the same as in poking. Therefore, one might predict that the subjects who had seen twisting would pull on the front of the bolt more than the subjects who had seen poking; while the subjects who had seen poking would pull on the back of the bolt more than the subjects who had seen twisting. Also, pushing seems a more similar action pattern to poking than twisting. One might, therefore, predict that subjects who saw poking would push the bolts more than subjects who saw twisting.

Figures 10.26 to 10.30 show that in all the samples, except the 4-year-olds, the subjects in Group A (shown poking) tended to push the bolts more than the subjects in Group B (shown twisting). Also, in all the samples, except the chimpanzees, the

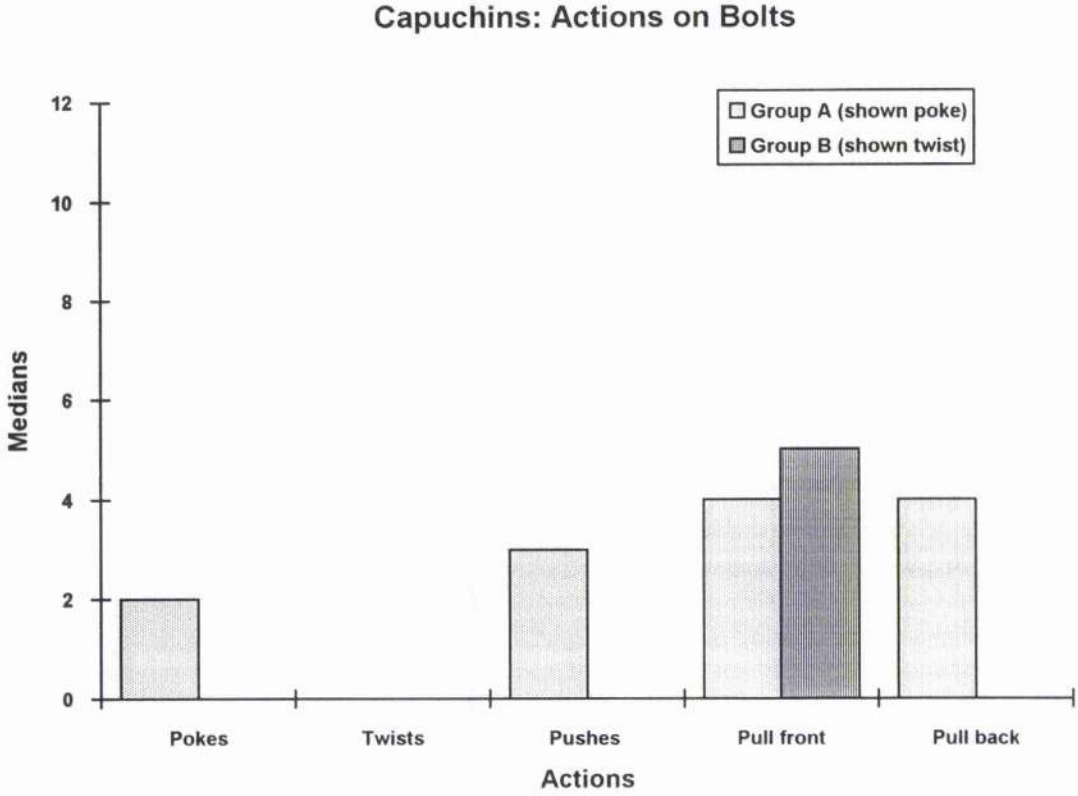


Figure 10.26: The median number of different actions performed on the bolts by the capuchins

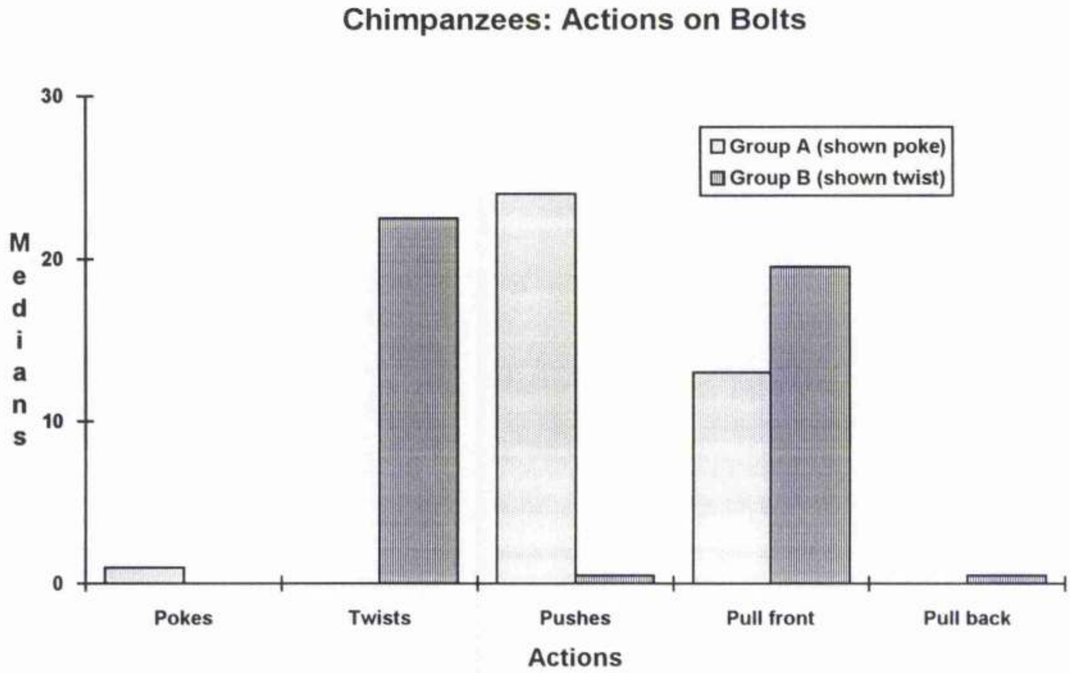


Figure 10.27: The median number of different actions performed on the bolts by the chimpanzees

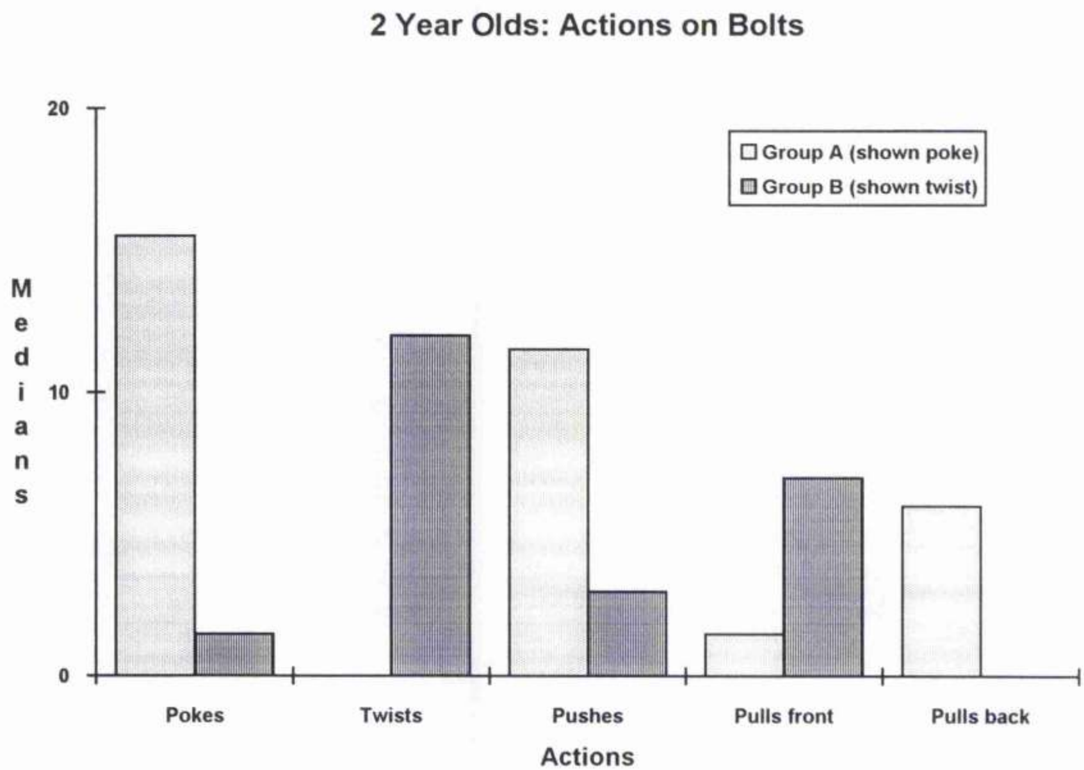


Figure 10.28: The median number of different actions performed on the bolts by the 2-year-olds

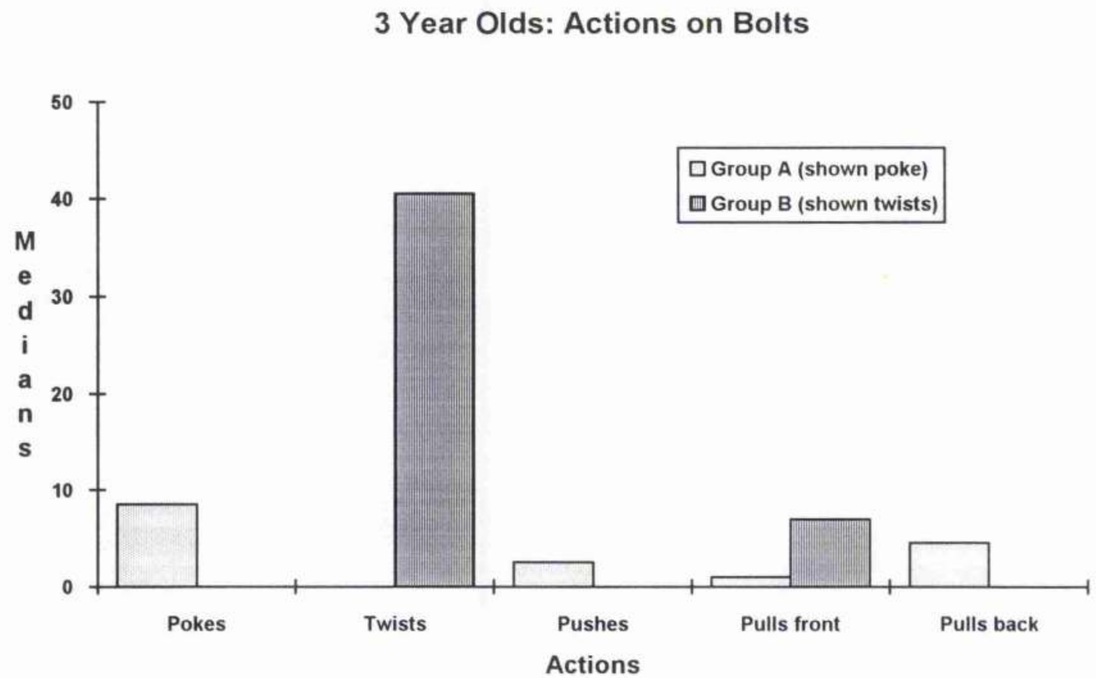


Figure 10.29: The median number of different actions performed on the bolts by the 3-year-olds

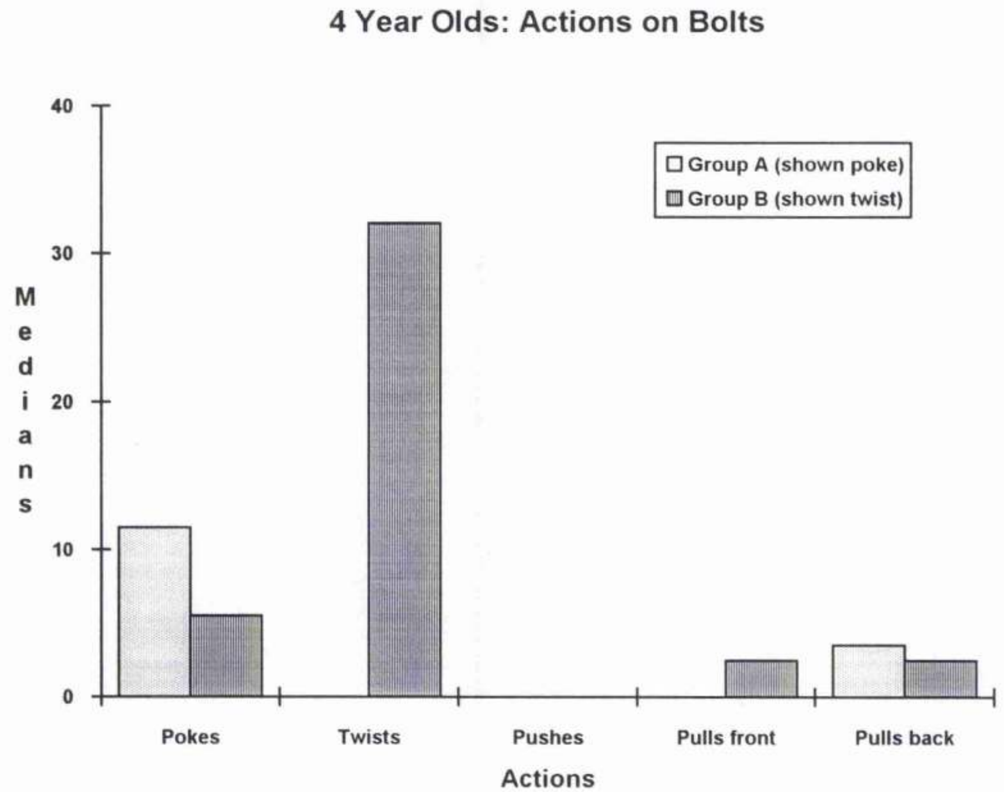


Figure 10.30: The median number of different actions performed on the bolts by the 4-year-olds

median scores for pulling on the back of the bolts were higher in Group A (shown poke) than in Group B (shown twist). In all of the samples, the median scores for pulling on the front of the bolts were higher in Group B (shown twist) than in Group A (shown poke). Therefore, there seems some justification for combining categories of actions which are similar to one another.

Figure 10.31 shows that only the 2-year-olds (Mann-Whitney U test, $U_{(4,4)}=1$, $P=0.029$) and the 3-year-olds ($U_{(4,4)}=0$, $P=0.014$) in Group A (shown poke) performed significantly more *poke-like* actions on the bolts than Group B (shown twist). There was not a significant difference between the two groups in the other samples (capuchins: $U_{(3,3)}=3$, $P=0.35$; chimpanzees: $U_{(3,4)}=3$, $P=0.1$; 4-year-olds: $U_{(4,4)}=4.5$, $P=0.202$). Therefore, it appeared that only in the 2- and 3- year-old samples did the subjects who saw poke perform more poke-like actions than the subjects who saw twist.

Figure 10.32 shows that the chimpanzees (Mann-Whitney U test, $U_{(3,4)}=0$, $P=0.028$), 2-year-olds ($U_{(4,4)}=1$, $P=0.029$), 3-year-olds ($U_{(4,4)}=0$, $P=0.014$), and 4-year-olds ($U_{(4,4)}=0$, $P=0.014$) in Group B (shown twist) performed significantly more *twist-like* actions that Group A (shown poke). There was no significance difference between the two capuchin groups ($U_{(3,3)}=4$, $P=0.5$). Therefore, it appeared that in all the samples, except for the capuchins, the subjects who saw twist performed significantly more twist-like actions than the subjects who saw poke.

Binomial tests of probability were used to test whether the subjects in each sample showed the tendency to exhibit the action they had seen demonstrated before the alternative target action, above the level of chance ($P<0.05$). All the samples, except the capuchins, performed the demonstrated target action before they exhibited the alternative action, (if they did at all). Only four out of the six capuchins exhibited the demonstrated action first ($P=0.334$), while all seven of the chimpanzees ($P=0.008$), seven out of the eight 2-year-olds ($P=0.035$), all eight of the 3-year-olds ($P=0.004$), and seven out of the eight 4-year-olds ($P=0.008$) exhibited the demonstrated act prior to the alternative target action. Therefore, all the sample of subjects, except the

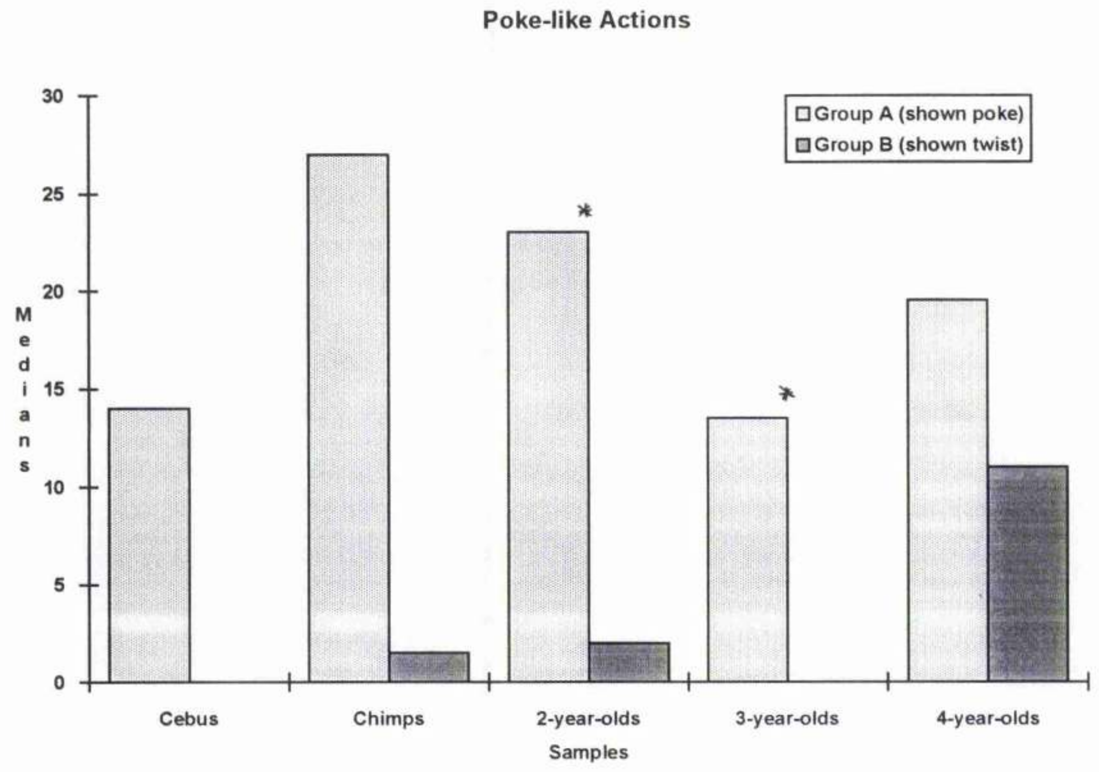


Figure 10.31:The median number of poke-like actions on the bolts by groups A (shown poke) and B (shown twist) within each sample
* There was a significant difference between groups A and B ($P<0.05$), [2-year-olds: $U(4,4)=1$, $P=0.029$; 3-year-olds: $U(4,4)=0$, $P=0.014$]

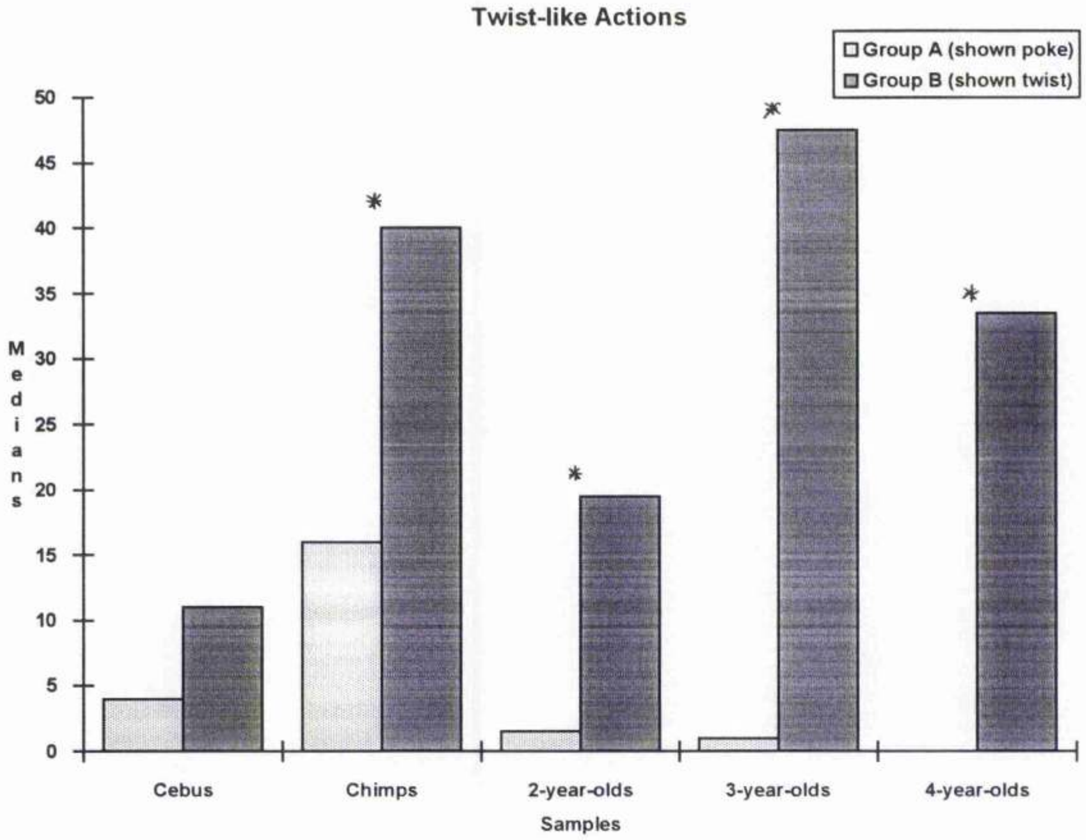


Figure 10.32:The median number of twist-like actions on the bolts by groups A (shown poke) and B (shown twist) within each sample

* There was a significant difference between groups A and B ($P<0.05$), [chimpanzees: $U(3,4)=0$, $P=0.028$; 2-year-olds: $U(4,4)=1$, $P=0.029$; 3-year-olds: $U(4,4)=0$, $P=0.014$; 4-year-olds: $U(4,4)=0$, $P=0.014$]

capuchins, tended to attempt to perform the act they had seen demonstrated before they discovered, through individual exploration, the alternative method.

Independent Observers' Scores

The independent observers' scores reflected the results found in the microanalysis. The means of the observers' converted scores, which are presented in Figure 10.33, showed that there was a significant difference in the observers' mean converted scores for Groups A and B in the chimpanzees (Mann-Whitney-U test, $U_{(3,4)}=0$, $P=0.029$), 2-year-olds ($U_{(4,4)}=1.5$, $P=0.043$), 3-year-olds ($U_{(4,4)}=0$, $P=0.014$) and 4-year-olds ($U_{(4,4)}=0$, $P=0.014$). There was not a significant difference between the capuchins ($U_{(3,3)}=3$, $P=0.35$). Therefore, at least one of the two groups in all the samples, except the capuchins, must have clearly imitated the demonstrated action in order for the blind independent observers to be able to distinguish between them.

Table 10.6 shows the median times for each sample to first solve the bolts-lock. It can be seen that the capuchins were much slower than the other samples in first solving the bolts-lock. There was a significant variation between the samples (Krusal-Wallis Anova, $KW(6,7,8,8,8)=16.757$, $P=0.0022$). A Dunne's post hoc test showed that the difference lay between the capuchins versus the 3-year-old children (mean difference=19.313, $P<0.01$) and the 4-year-olds (mean difference=20.5, $P<0.01$). No significant difference was found between any of the other samples. Therefore, the four samples who appeared to have imitated the demonstrator were more efficient in solving the bolt-lock than the capuchins for whom no clear evidence of imitation was found.

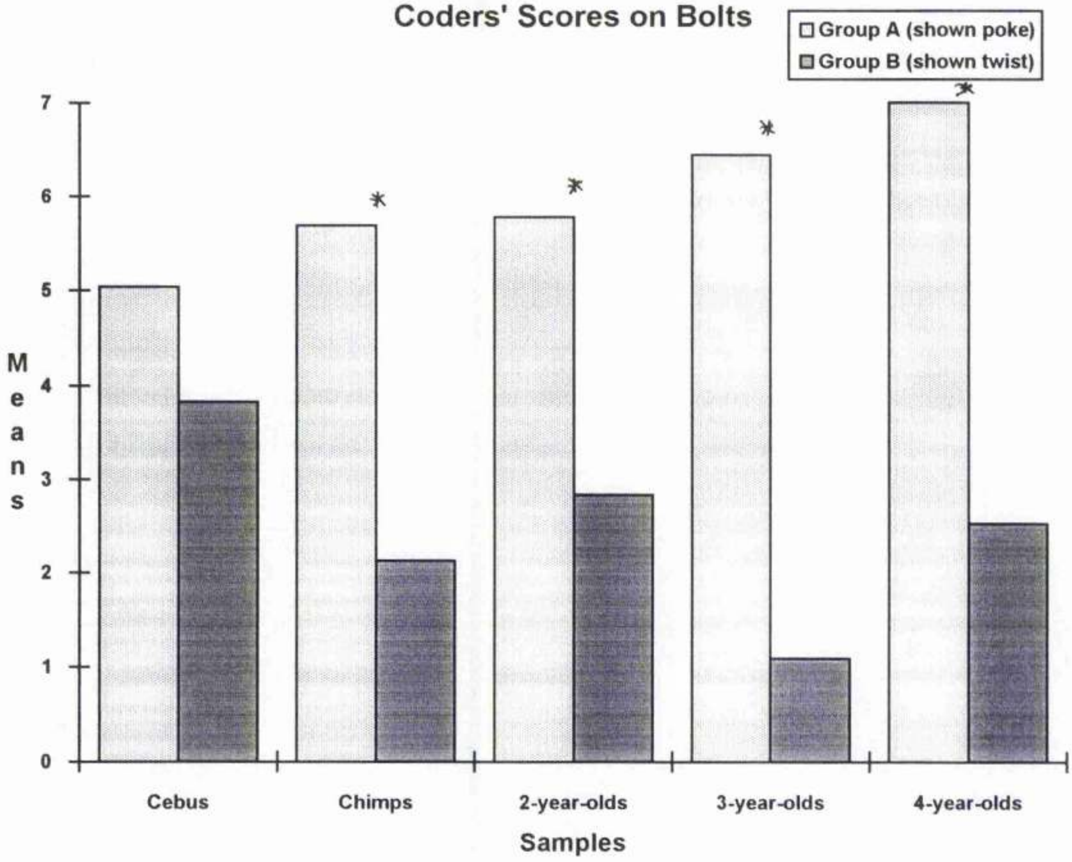


Figure 10.33: The mean converted coders' scores on the bolts for groups A (shown poke) and B (shown twist) within each of the samples.
* There was a significant difference between groups A and B (P<0.05), [chimpanzees: U(3,4)=0, P=0.029; 2-year-olds: U(4,4)=1.5, P=0.043; 3-year-olds: U(4,4)=0, P=0.014; 4-year-olds: U(4,4)=0, P=0.014]

Conversion Table for Bolts

1	2	3	4	5	6	7	Conversion scores
3 Twist	2	1	0	1	2	3 Poke	Coders' scores

Table 10.6: Median times to first solve the bolts-lock (first four trials).

Sample	Median times (in seconds)
Capuchins	390
Chimpanzees	38
2-year-olds	77
3-year-olds	17
4-year-olds	22.5

Table 10.7 is a summary of results on the bolts-lock. It can be seen that there was evidence of imitation in the chimpanzees and children, but not the capuchins.

Table 10.7: Summary of result on the bolts-lock

	Cap	Chp	2	3	4
No. of pokes	-	-	-	*	-
No. of twists	-	-	*	*	*
No. of poke-like	-	-	*	*	-
No. of twist-like	-	*	*	*	*
Binomial	_	*	*	*	*
Coders' scores	_	*	*	*	*

* - significant at $P < 0.05$

Table 10.8 is a summary of the results from the pin, barrel-lock and bolts-lock. It can been seen that there is strong evidence of imitation in the children, marginal in the chimpanzees and none from the capuchins.

Table 10.8: Summary of the results from the pin, barrel-lock and bolts-lock

PIN	Cap	Chp	2	3	4
turns	-	-	-	-	-
spins	-	-	-	-	-
coders	-	-	-	-	-

BARREL	Cap	Chp	2	3	4
turns	-	-	*	*	-
pulls	-	-	-	-	*
binomial	-	-	-	-	-
coders	-	-	*	*	*
Time (secs.)	476.5	46.5	70	123.5	91

BOLTS	Caps	Chps	2	3	4
pokes	-	-	-	*	-
twists	-	-	*	*	*
poke-like	-	-	*	*	-
twist-like	-	*	*	*	*
binomial	-	*	*	*	*
coders	-	*	*	*	*
Time (in secs.)	390	38	77	17	22.5

DISCUSSION

The present study provides the first evidence of functional exact action imitation in non-human primates. The two groups of chimpanzees differentially imitated the alternative demonstrated methods for removing the bolts. The children also imitated the actions used to manipulate the bolts. There was not a significant difference in the methods used by the two groups of capuchin subjects, although the general trend was in the predicted direction for imitation. None of the samples imitated the exact method used to rotate the pin, although the children turned the pin more than the chimpanzees and capuchins. There was very little evidence that the chimpanzees or capuchin monkeys imitated the actions used to manipulate the handle. In contrast, the children did appear to imitate the demonstrated method on the handle. Let us now consider these results in more detail.

It would appear that all the subjects tended to *turn* rather than *spin* the pin, even if they had observed the demonstrator spinning it. Some of the human subjects turned the pin much more than was actually demonstrated. The demonstrator turned the pin four times per trial, so across the four trials the subjects observed a total of 16 turns. However, subject 3a performed 185 turns, 3c performed 195, 4e turned the pin 70 times and 4f turned it 88 times! Why were the children turning the pin to such a great extent? A possible explanation for the large number of turns is that the children may have assumed that turning the pin was a functionally significant action (i.e., they may have thought it was similar to a key). Indeed, a number of the children upon removing the pin, re-inserted it and continued turning. This pattern was exhibited only once by one of the non-human subjects (the chimpanzee, SC).

Since the pin was not threaded, it was not necessary for the subjects to rotate it prior to pulling it out. A number of the human subjects seemed to adopt the general imitative program "rotate the pin", but they did not exhibit exact action imitation in terms of differentiating between "spinning" versus "turning". The relatively small number of pin rotations performed by the nonhuman subjects (except for LI who **hook rotated** the pin a total of 18 times in trial two) does not present a strong case for program-level imitation. Although, some of the monkeys and all of the apes did rotate the pin a few times, it was likely that the subjects would have rotated it to a small extent when individually exploring its properties. The same cannot be said for the majority of the children, since many of them rotated the pin far more than one would expect if they were merely engaged in individual trial and error.

The only significant differences between Groups A and B, on the manipulations of the handle, came from the children. They appeared to be imitating the action shown, but they also to a certain extent discovered the alternative target act. The chimpanzees tended to pull the handle out regardless of the method they had observed. Only one chimpanzee subject, LI, appeared to turn the handle in a deliberate and consistent manner. Prior to opening the foraging box LI only turned the handle four times, however, in exploration after having opened the box she turned the handle a total of 22 times. (NB: Only actions performed prior to the solution were included in the analysis.) The capuchins tended to both pull and turn on the handle regardless of the method shown.

In regards to the barrel-lock, the children appeared to imitate the method they saw demonstrated, while the non-human subjects did not. The speed with which some of the chimpanzees first solve the barrel-lock (e.g., SC took 11 seconds, NO opened it in 7 seconds, and UT solved it in 10 seconds) suggests that they had learned *something* from watching the demonstration, even if they did not always use the exact demonstrated method. It is possible that these subjects were emulating, (i.e., they had learned about the affordances of the object through observing the demonstration, and then they worked out for themselves how to achieve the same result). Since the chimpanzees solved the barrel-lock at least as quickly as the children, there did not seem to be a great advantage in imitating the precise demonstrated method. The capuchins were, on the whole, less successful than the chimpanzees and children in opening the barrel-lock. They tended to engage in more non-relevant actions, such as pushing the box around the cage and tipping it over. They were also more easily distracted and often abandoned their manipulations of the box during a trial to explore some other part of the test cage, or to listen to sounds outside the testing room.

The bolts-lock produced clearer evidence of imitation than the barrel-lock. All the samples, except the capuchins, imitated the demonstrated method. Although the capuchin data was not significant the general trend was in the predicted direction for imitation.

One might be tempted to account for the present results in terms of processes other than imitation. The multi-act approach controls for *stimulus enhancement* by presenting identical apparatus to separate experimental groups. It does not seem likely that *contagion* was the process involved, as there is no reason to assume that poking and twisting are actions subject to contagious suggestion in humans or chimpanzees. It might be suggested that the subjects were reproducing the *movement of the objects* rather than the model's action pattern (Hogan 1988 called this process valence transformation). Although it is possible to apply this argument to the barrel-lock, valence transformation cannot explain the bolts-lock results. On poking, the movement of the bolts through the bolt-rings could be achieved just as well by pulling them out from the back rather than poking, however, very clear poking was observed within all the samples. On twisting, the rotational movement of the bolts themselves could not be seen by the observers: the model's hand covered the end of the bolt, and only the subsequent twisting movement of the hand, wrist, and arm was evident. Therefore, in imitating the twisting method, the observers could only be ostensibly reproducing the model's *actions* rather than the rotational movement of the bolts. Therefore, the bolts-lock results seem best explained in terms of imitation.

It has been hypothesised that there is a monkey-ape difference in the ability to imitate (Visalbergi & Fragaszy 1990; Whiten & Ham 1992). The present results might appear to lend support to the claim that apes can imitate, while monkeys can not. However, the negative result from the capuchin subjects in the present study may simply be due to a large variance in response and a small number of subjects. It might also be the case that although chimpanzees readily imitate humans, capuchins do not. Stronger evidence of imitation may have been found if a conspecific model had been used rather than a human. Also, the conditions under which the foraging box were presented did not in any way approximate those found in the natural social environment. It would be of great interest in future studies to present a similar task within the context of a natural social group, with a familiar conspecific acting as the model.

Certainly, it is difficult to judge how the result of the present experiment apply to the imitative ability of feral capuchin monkeys and chimpanzees. These subjects had not be raised in a manner similar to their wild counterparts. As mentioned earlier, Tomasello *et al.* (in press) argue that wild chimpanzees do not imitate, and only enculturated individuals develop an imitative ability. However, in the present study, all but one of the chimpanzees, (LI), had been raised with other chimpanzees, and could not be said to be any more enculturated than Tomasello *et al.*'s non-enculturated subjects. LI was a rescued beach photographer's chimpanzee, and hence she was probably predominantly raised by humans. LI did seem to be one of the more imitative subjects as she imitated not only the method used on the bolts but also rotated the pin several times and was the only chimpanzee to clearly turn the handle. Therefore, it would seem that non-enculturated chimpanzees can imitate but the tendency becomes more marked in enculturated subjects.

Tomasello *et al.* (1993) argued that "True imitative learning ... involves the infant's reproducing the adult's actual behavioral strategy in their appropriate functional contexts, which implies an understanding of the intentional state underlying the behaviour" (p. 497). Thus, the chimpanzees in the present experiment were truly imitating (by Tomasello et al.'s definition), because they reproduced the demonstrator's actual behavioural strategy in the appropriate functional context of opening the bolts-lock. However, it is difficult to tell whether this really implies that the chimpanzees or children really understood the intentional state underlying the demonstrator's actions. There was no function or purpose behind rotating the pin or twisting the bolts, but the subjects still imitated these aspects of the demonstrator's behaviour. Even when some of the subjects (both human and chimpanzee) discovered that they could simply pull the pin or bolts straight out, in subsequent trials they nearly all continued imitating the non-functional rotating or twisting strategies. Therefore, exact action imitation related to problem-solving does not necessarily imply an understanding of the intentional state underlying the modelled behaviour (*cf.* Heyes 1993).

Visalberghi and Fragaszy (1990) argue that, "Imitation is particularly useful as a means of learning form others when the observer is not proficient, when opportunities for practice are limited, when cost of error are high, and when learning by trial and error would be a slow process" (p.249). Even if imitation does not necessarily imply the ability to read the intention or purpose behind another's actions, it still seems likely that the complex cognitive operation of transforming visual information to motor acts is involved (see chapter 8 and 9). The fact that chimpanzees and children seem to be able to employ this ability in relation to problem-solving, means that they are capable of a potentially highly adaptive form of social learning.

Chapter 11

FINAL DISCUSSION

At last, after 100 years of research, comparative psychologists are able to state with some confidence that at least some species of nonhuman animals can imitate actions. However, there are still many questions left unanswered. In this final discussion, I shall consider some of the issues which need to be addressed in future research on imitation and social learning.

First, very little is known about the precise conditions needed for the development of an imitative ability. Bruner (1971) outlined a process called "scaffolding", in which human adults structure and direct developing skills in their infants. The infant is provided with novel activities for imitation which increase in difficulty incrementally, but remain relevant to the child since they are related to activities already within their repertoire (see also Kaye 1982). Hence, adult humans' proclivity for encouraging and nurturing imitative capacities may be as important as the cognitive and imitative abilities of the infants themselves (Custance & Bard 1994). Tomasello *et al.* (1993) argue that chimpanzees only develop imitative abilities when they are exposed to *human* enculturation in the sense of scaffolding. They suggest the most important factor for the promotion of imitative capacities in ape and human infants is socialization of attention.

I suggest that human enculturation may not play such a critical role in the development of imitation. There is some evidence of imitative abilities in mother-raised chimpanzees. Goodall (1973) describes some incidents of behaviour in wild chimpanzees that seem best interpreted in terms of imitation (see reports 5-9 in the observational database, Chapter 4). De Waal also describes the antics of mother-reared juvenile chimpanzees in a zoo in which they imitated the limping and hunched gait of two injured members of their group. It is possible that apes can imitate to a certain extent even without human enculturation. What enculturation may do is to enhance and promote an ability which is already existent in human and ape infants, so that they are more likely to imitate novel activities. Without adult human scaffolding the infant still possesses an imitative ability, but it is a much less predictable and pronounced reponse.

As human infants are encouraged to imitate all kinds of novel activities, especially in relation to problem-solving, it is easy to see the direct advantage they gain by their imitative ability. Great apes may benefit from their imitative ability in a more indirect manner. Imitation in chimpanzees and orangutan seems to have been most often observed in relation to *play* rather than problem-solving. By imitating actions in play the subject may add new skill to its general behavioural repertoire. If, at some future time, the subject is faced with a problem in which it has previously playfully imitated certain elements, the ape may be in a better position to discover a solution. In the same way Birch (1948) found that chimpanzees benefited when they were able to play with sticks prior to being faced with a raking task. Therefore, great apes may not often directly imitate the problem-solving activities of others, but rather they indirectly benefit from imitative play.

One issue which has not been directly tackled by any research to date is whether animals are capable of *reflective* imitation. Simply showing that a subject has imitated the actions used in a functionally relevant task does not automatically prove that his or her behaviour was "purposeful", "goal-directed" (*cf.* Galef 1988) or that he or she has read the intentions behind the model's actions (*cf.* Tomasello *et al.* 1993). Since chimpanzees (Tomasello *et al.* in press), orangutans (Russon & Galdikas 1993) and humans will imitate arbitrary actions just as readily as functional activities, researchers need to devise a means by which they can show that the subject recognises the potential functional relevance of imitating a model's acts. Heyes (1993) suggests that "it would be necessary to manipulate the value of the outcome for the observer ... If the imitative behaviour is goal-directed, one would expect it to occur only when the outcome for the demonstrator is one to which the observer assigns a positive outcome" (p. 1007).

It is also important that researchers devise tests that can assess the imitative abilities of wild subjects. Tomasello *et al.* (1993) have suggested that imitation in captive chimpanzees is an artifact of interaction with humans rather than an inherent ability. The best way to solve this issue is to test wild chimpanzees. It has proved very difficult to devise tests of imitation in the laboratory conditions; one might think it nigh on impossible to test for imitation in the wild. However, multi-act tasks may hold the key to this dilemma. A field experiment could be devised in which two groups of primates are presented with the identical sets of apparatus. One member in each group could be trained to act as model. The models could be taught different methods for manipulating the test apparatus. If the two groups developed different methods for manipulating the test object based on the different methods they have observed, it can be concluded that they are imitating the model.

It is important that many more species are tested, using methodologically sound tasks, to see if they possess an imitative ability. There have been very few studies on imitation in animals which have adequately controlled for other less cognitively complex learning processes. The lack of evidence in relation to action imitation in animals may be indicative of a failing in scientific method, rather than a lack of imitative ability in non-human species. Heyes (1993) states that, "Until more is known about the phylogenetic distribution of the capacity for imitation, hypotheses regarding its adaptive function (e.g., Lefebvre & Palameta 1988), must remain largely speculative" (p. 1001).

It may also prove beneficial to investigate imitation and social learning in non-human species in a broader sense than the more traditional strict comparison with human cognitive processing. It is assumed that social learning is an efficient way of acquiring new skills, but very little research has directly tackled this hypothesis. Box (1992) suggests an approach in which "Propensities that influence social mediation in the acquisition of skill and information are viewed as a cluster of attributes that co-vary in different ways. Studies that co-vary degrees of sociability, life history characteristics and dietary options, for example, argue for cost-benefit analyses that address empirical predictions in different groups" (IPS conference abstract). It may be the case that most species simply would not greatly benefit from an imitative ability, and other forms of learning, such as stimulus enhancement and contagion, play a much more central role. Other forms of social learning, quite apart from imitation, are not well understood and are worthy subjects of study.

With the recent methodological breakthroughs, the field of social learning and imitation offers great research opportunities. Comparative psychologists need to 1. test many more species, 2. devise viable tests for wild subjects, 3. broaden the scope of investigation and study social learning processes other than imitation, 4. look in greater depth at the developmental factors necessary for the emergence of an imitative tendency. Future research on this topic promises to very exciting indeed.

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