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UNIVERSITY OF ST.ANDREWS

Department of Psychology

**DO MONKEYS SEE MONKEYS DO?:
A REVIEW AND ANALYSIS OF IMITATION IN NON-HUMAN PRIMATES**

Submitted for the degree of MSc.

Rebecca Ham, 1990



TH A1175

DECLARATION

I, Rebecca Ham, 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.

21.2.90

I was admitted to the Faculty of Science of the University of St. Andrews under Ordinance General No. 12 on 1st October 1988 as a candidate for the degree of M.Sc.

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I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate to the degree of M.Sc.

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(Supervisor)

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ABSTRACT: For over a century scientists and philosophers have been interested in demonstrating whether non-human animals are capable of learning by imitation. The evidence thus far remains inconclusive. The most convincing evidence exists for primates, although this is currently the subject of major controversy. Problems arise in the study of imitation for both conceptual and methodological reasons. A new experiment was designed to provide a more accurate examination of the imitative ability of primates. The subjects were 20 stump-tailed macaques (*Macaca arctoides*) in a captive colony at the University of St. Andrews. Subjects were between the ages of one and eleven years old. Naive monkeys were exposed to a trained demonstrator performing one of two motor patterns. In the first experiment half of the colony (Group A) were exposed individually to a demonstrator pulling a T-bar in order to receive a peanut delivered to a hole in the T-bar. The other half of the colony (Group B) were individually exposed to a demonstrator twisting a T-bar in order to receive a reward. To reduce isolation induced stress, each half of the colony was exposed as a group to their corresponding demonstrators for Experiment II. The observer was required to attend to at least 30 seconds of relevant demonstration before being allowed to attempt to manipulate the apparatus itself. No significant difference was found between the pull/total ratios for Group A and Group B for DURATION, EXTENT, NUMBER or EFFORT for all trials or for trials one to seven, although a significant difference was found in Experiment I for trials four to seven. There was however a trend in the predicted direction, i.e. the observers showed a greater tendency to perform the motor act demonstrated. A significant difference was found between Group A and Group B for the combining of trials 5 to 7 in Experiment I. No significant difference was found between Experiment I and Experiment II. It was concluded that imitative learning was not demonstrated in these experiments. Reasons for the absence of imitation are discussed.

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CHAPTER 1 IMITATION: A REVIEW

1.1 INTRODUCTION

Imitation, broadly defined as "learning to do an act from seeing it done" has been of interest to scientists for well over a century (Thorndike 1911). Much of the interest in studying imitation stems from a desire to explore the continuity of the human and animal mind (Galef 1988). Success in demonstrating imitation in non-human primates would help to elucidate the evolutionary development of the higher mental faculties of man (Romanes 1900). Failure to find imitative ability in non-human animals, by contrast, would support the uniqueness of man and help define that which sets him apart from the rest of the animal kingdom.

Despite the history of detailed investigation into the imitative phenomenon, convincing evidence for imitation is scarce. I conclude below that impressive evidence of true imitation exists only for the chimpanzee. Even this evidence is not conclusive and has recently been challenged (Tomasello et al. 1987, Tomasello 1989).

Whether vocal imitation in birds is an example of true imitation is not clear. This in itself is a subject of major debate. It is not certain whether imitation of sounds involves the same processes as does imitation of motor patterns, therefore vocal imitation in birds will not be discussed in this thesis. Hereafter in this thesis the term imitation will be used with reference only to visual imitation.

The apparent result of imitation is an increased similarity between the behaviours of two or more animals. Problems that arise in the study of imitation are primarily due to the conceptual and methodological confusion of imitation with other behavioural conformity processes. Thus the purpose of this thesis is twofold; (1) to succeed in isolating imitation by definition from other behavioural conformity processes, and (2) to test for imitative ability in non-human primates by executing an experiment designed to isolate imitation from other behavioural conformity processes.

1.2 THE EVOLUTION OF IMITATION

It is first necessary to assess why and when we would expect imitation to occur in the animal kingdom. Imitation is obviously an effective way of gaining information and acquiring new behaviours. However, if other methods of learning prove to be equally or more effective, then it seems unnecessary for such a behaviour to have evolved. Humphrey (1976) states "it is not her (nature's) habit to tolerate needless extravaganza in the animals on her production lines: superfluous capacity is trimmed back, new capacity is added only as and when it is needed."

According to Nishida (1987) there are three methods by which an animal can acquire information about its environment. Information can be transmitted genetically, learned individually, or learned socially. Genetically transmitted information can be a useful way of gaining knowledge of simple behaviours in a predictable unchanging environment. However, it does not give the opportunity for exploiting new and different food resources, or for quickly adapting to changes in the environment.

Both individual learning and social learning give the animal this opportunity. Individual learning (in which an organism learns entirely by its own efforts, and without influence of others) allows an animal to interact directly with its environment to learn by trial and error the most adaptive strategies. However this method may be costly in terms of time, energy, predation risks, and the dangers involved with trial-and error learning.

Social learning (learning through the influence of others) is usually more rapid than trial-and error learning, and involves less risks of making costly mistakes. Less energy is involved in learning and thus can be directed to other fitness-enhancing behaviours. Weigle and Hanson (1980) found that the metabolic costs of feeding on novel food items for Red Squirrels after watching an experienced model feeding were about half of those who did not have this opportunity.

There are also costs involved with acquiring information from others. Social learning may involve greater cognitive capacity. There seems to be a correlation between intelligence and brain size. Brain matter is costly to manufacture and maintain (Milton 1988). Secondly, social learning may demand specific life history strategies, like prolonged juvenile dependency, and specific social organizations which may not be adaptive in the particular environment in which the animal lives.

It is also important to note that learning from others is only adaptive when the behaviour that is being copied is adaptive. It would not be beneficial, for example, to imitate a strategy for processing a type of food that is complicated or wasteful, when a more efficient strategy may be acquired through individual trial-and error. Boyd and Richerson (1988) illustrate this point by considering a hypothetical population with two types of individuals; LEARNERS and IMITATORS. LEARNERS acquire adaptive behaviours through individual learning. IMITATORS acquire their

behaviour solely by copying other individuals. Assuming the number of IMITATORS within a population is low and assuming imitation is less costly than individual learning, then imitation will be more adaptive. However, as Dawkins(1976) suggests "the best strategy for an individual depends on what the majority of the population are doing." As the number of IMITATORS increases through the population the chance of imitating an individual who has acquired its behaviours through individual learning decreases, and the chance that an IMITATOR is being copied increases. In a variable environment the behaviour being copied may no longer be the most adaptive. It may then prove to be more advantageous for an animal to acquire its behaviours by individual trial-and-error (Boyd and Richerson 1988)

Additionally, it may not be in the interest of an animal who has learned an adaptive behaviour through a costly trial-and-error process to have a non-related animal parasitize of its expertise. It then may be in the experienced animal's interest not to demonstrate the correct behaviour in the presence of a naive individual. Recent evidence suggests that deception may occur in non-human primates (see Whiten and Byrne 1989), and therefore this may be another situation in which the IMITATOR may not be copying the most immediately adaptive strategy and would be better learning through individual trial-and-error processes.

Table 1.1 summarizes these costs and benefits of social learning relative to individual learning.

Table 1.1 Costs and benefits of social learning relative to individual trial-and error learning.

BENEFITS	I	COSTS
	I	
-more rapid than trial-&-error learning	I	-larger brain size
-less risks of making costly mistakes	I	-life history limitations
-less energy involved in learning	I	-possibility of not imitating the most adaptive behaviour

In summary it would be predicted that imitation and social learning would be more common when;

(1) Learning by trial-and-error would be slow

(2) Opportunities for practice are limited due to the costly results of making mistakes.

(3) Opportunities to exploit another's expertise are high

(4) The chance that the imitator's model is experiencing the same environmental conditions is high

Boyd and Richerson (1988) have devised a mathematical model to predict the occurrence of social learning relative to individual learning within a population. A difficulty arises in that the model predicts social learning to be more common than either experimental studies or field observations report. It is possible therefore, that either (i) the model does not acknowledge all costs involved with the process of social learning, or that (ii) the degree of imitation in non-human animals is underestimated. A greater understanding of the circumstances in which Natural Selection would favour imitation has significance in assessing the importance of imitation to non-human animals. It is "crucial to our understanding of how humans fit into the general framework of evolutionary biology" (Boyd and Richerson 1988) by giving further evidence to how we are similar or perhaps different from other animals.

1.3 CONCEPTS AND DEFINITIONS

The use of the word imitation has varied considerably throughout history. The definition of imitation seems to "reflect the methodological traditions in which the researcher works" (Masur 1988). "Imitation" is used widely throughout psychology, biology, philosophy and art. As the need for communication between disciplines increases, so does the urgency and importance of providing clear definitions.

The result of imitation is an increase in the similarity of the behaviours between two or more animals. I will call this phenomenon **behavioural homogeneity**. However, there are many other mechanisms by which an increase in behavioural similarity may occur. Often behaviours are assumed to be acquired by the process of imitation when alternative mechanisms are in fact responsible.

Many definitions in the past have divided imitation into evolutionary stages, or developmental levels. For example, Morgan (1900) describes four evolutionary stages; mimicry, instinctive imitation, intelligent imitation, and reflective imitation. Guillaume (1926) describes four developmental stages; imitative suggestion, trial-and-error imitation, symbolic imitation, and pure imitation. Baldwin (1902) describes four developmental levels; organic imitation, conscious imitation, simple imitation and persistent imitation (internal and external). Piaget (1962) describes six developmental levels, and Mitchell (1989) describes five stages of evolution. Table 1.2 groups these levels of imitation into categories to indicate the similarities in the definitions of the terms.

There is no evidence that these behaviours involve the same processes and no evidence that the behaviours develop successively from one another. As Thorndike (1911) suggested; these processes may be different in kind and not in degree. It is possible that "there is no single imitative capacity that appears in various guises in animals possessing nervous systems of varying complexity" (Galef in press). What this implies is that imitation is not necessarily related to other lower order forms of learning and therefore does not necessarily appear in increasing complexity with animals of increasing intelligence.

Lower level explanations may more accurately describe an observed increase in similarity between the behaviours of animals. Unfortunately, attempts to isolate these behaviours have resulted in an accumulation of many new terms and definitions of which Galef (1988) lists twenty three. This has resulted in an even greater confusion and chaos in the literature. The following, therefore, is an attempt to reorganize and clarify this literature.

The first set of terms I distinguish, describe processes responsible for increased behavioural similarity that do not involve the social influences of others. The second set of definitions involves all instances in which social interaction increases the homogeneity of the behaviours.

A. NON-SOCIAL MECHANISMS

MIMICRY: where natural selection has caused an organism to resemble and thus exploit the behavioural strategy of a second organism. For example, the female firefly *Photuris* replicates the female courtship signals of another firefly species thus capturing the male for food (Lloyd 1965 cited in Mitchell 1988).

Morgan (1900) calls this **first stage imitation**, and Mitchell (1988) calls this **level one imitation**. Mimicry does not involve learning. There is no need for the copier to see the model although the copy is dependent on the *existence* of the model. An increase similarity between the model and the copy develops over generations.

CONVERGENCE: where natural selection has caused an organism to come to resemble another organism in its behaviour because of similar environmental conditions and thus selective pressures. Flying in birds and in bats is an example of behavioural convergence. The behaviours develop under similar environmental pressures over evolutionary time and are not dependent on the existence of the other.

TRIAL-AND-ERROR: where one organism comes to resemble a second organism in its behaviour through trial-and-error learning in similar environmental conditions. When the immediate selective pressures are similar for two or more animals, the probability that they will reach the same solution to a problem will be high. This is different from **convergence** because it involves learning and takes place within an animal's lifetime. **Convergence** does not involve learning, and emerges over generations.

Many behaviours that are unique to a population are described as "traditional" or "cultural" thus implicitly proposing that social learning is responsible for acquisition. However, often the behavioural history and the experiences of these

animals are not known, thus making it impossible to draw conclusions about the process of behavioural acquisition. It is possible that these behaviours are in fact acquired through the individual process of trial-and-error learning in similar environmental conditions. Therefore Galef (1988) suggests the term LOCAL-SPECIFIC BEHAVIOUR to be used to describe behaviours specific to a population where the underlying method of acquisition is unknown. Examples of LOCAL-SPECIFIC behaviours are given in section 1.4

B. SOCIAL MECHANISMS

Galef (1988) suggests two generic terms to be used to describe all behaviours whose expression are influenced socially. SOCIAL LEARNING, is used to refer to all those behaviours that were acquired through the social influences of others and SOCIAL ENHANCEMENT was used to refer to all those behaviours that came to be merely expressed through the social influences of others (i.e. they already existed in the behavioural repertoire of the animal). It does not seem to be a very useful distinction in practice because learning experiences and thus the behavioural repertoire of an animal are often unknown. Therefore, I propose to use the generic SOCIAL ENHANCEMENT to refer to all those behaviours where the social influence of one animal performing a behaviour increases the probability that the same behaviour will come to be expressed in another animal.

The following is a set of terms, often mistaken for imitation describing social mechanisms by which increased behavioural homogeneity may occur.

CONTAGION: where one animal comes to resemble another animal in its behaviour because of the "unconditioned release of an instinctive behaviour in one animal by the performance of the same behaviour in another animal" (Thorpe 1963). This definition implies that the **contagion** is restricted to a predetermined finite set of innately-released behaviours. It can be predicted that this would occur when synchrony of behaviours was clearly adaptive, and that these behaviours would be species specific and stereotyped (Provine 1989). These behaviours would include such behaviours as "schooling" in fish. The adaptive significance of contagious behaviours in humans is less clear. Provine (1989) suggests that yawning is contagious in humans and apparently evolved as a mechanism for coordinating the behavioural and perhaps physiological state of the group.

SOCIAL FACILITATION: Social facilitation has been used and defined in so many ways that it seems that its meaning is now confusing and unclear.

Social facilitation has been used to refer to what we have defined above as **contagious behaviour** (Thorpe 1963, Clayton 1978, Palemata and Lefebvre 1985, Suboski 1984). It has also been used as a generic to refer to all social influences on acquisition of a behaviour.

Visalberghi and Frigaszy (1989) suggest using **social facilitation** to refer to an increase in the homogeneity of the motivation level between two or more animals. Because of increased similarity in motivational level, there would be an increase in the probability that similar behaviours would be performed. Behaviours such as eating, drinking, or antipredator behaviours such as the "flying away response" in birds would be examples of this. However, there is no evidence that these behaviours involve different processes than those involved in **contagious behaviours**.

Clayton (1978) suggests that **social facilitation** can cause an increase in behavioural similarity because of an overall increase in the number and rate of behaviours being performed. An increase in the number and rate of behaviours will increase the probability that the same behaviour will be performed through trial-and-error learning given similar environmental conditions. It has been suggested that an overall increase in the number of responses could occur because of (1) an "energizing" effect or increase in arousal level through the mere presence of a conspecific (Zajonc 1965), or (2) a reduction in isolation induced fear (Tolman 1965).

If the first mechanism is responsible for **social facilitation**, this does not seem to differ significantly from mere "arousal". There is little evidence that the mere presence, as opposed to the behaviour of another conspecific, increases arousal level. Zentall and Levine (1972) noted that rats that observed an empty cage, actually learned to bar press for water faster than rats that observed a cage containing another rat, suggesting that the mere presence of another conspecific may actually have an inhibitory effect on learning. This may be because of the effects of **social facilitation** combined with **stimulus enhancement** to inappropriate areas of the cage by the untrained rat.

There is also little support that an overall increase in the number of responses occurs because of a reduction in isolation induced fear. Frigaszy and Visalberghi (1988) observed that monkeys actually increased exploratory behaviour when they were alone as compared to when they were in the presence of another individual.

It seems that the effects of social facilitation described in any of the above ways would depend on the context of the learning situation. For example, isolation may induce stress for a younger or dependent individual but may allow access or and exploration for a lower ranking animal in the absence of a more dominant individual.

STIMULUS ENHANCEMENT: Observation of one animal by another may increase behavioural homogeneity due to the "enhancement of a particular limited aspect of the total stimulus situation to which the response is being made" (Spence 1937). The classical experiment performed to illustrate this phenomenon was that of Sherry and Galef (1984) on milk-bottle opening in blue tits. Fisher and Hinde (1949) first drew attention to the spread of the tradition in blue tits of pecking through the foil cap of milk-bottles to receive the reward of fresh cream. The behaviour was assumed to have spread between animals by imitative learning. They demonstrated that blue tits would learn to peck through a foil cap much quicker having had the opportunity to observe a skilled demonstrator perform the task. However, Sherry and Galef (1984) performed an elegant experiment to demonstrate that blue tits would learn just as quickly to peck through a foil cap from merely observing a conspecific drinking the cream reward. They did not have to observe the actions of the demonstrator solving the task, but simply the area of the reward. The location of the milk bottle cap was *enhanced*, but the action of pecking through the foil was merely learned by trial and error, and not imitation.

What has never been specified is that **stimulus enhancement** should occur positively with respect to those stimulus where positive reinforcement has occurred or negatively to where negative reinforcement has occurred (Byrne pers comm). The attraction or repulsion should occur dependent on the consequences of the observed animal's behaviour.

Palemata and Lefebvre (1985) have shown that pigeons that observe a conspecific pecking through a paper covering to receive a food reward learn faster to perform this behaviour than those pigeons that observe only pecking through the paper with no reward. It is possible that one demonstration is acting as a stronger stimulus enhancer than the other (Galef 1988).

Stimulus enhancement may occur through (1) decreased fear, or (2) increased attention, towards a particular part of the stimulus environment. Decreased fear or unwillingness to interact with a particular part of the stimulus environment would increase the chances of interaction with the stimulus and thus increase the chance of a similar behaviour being performed through individual learning.

SOCIAL TRIAL-AND-ERROR: where the application of external reinforcement leads organisms to match their own behaviour to those of another conspecific. This has also been called "matched-dependent behaviour" by Miller and Dollard (1941). The behaviour of the demonstrator acts as a discriminative stimulus for the observer, to which it can match its behaviour for external reinforcement. The behaviour is dependent on the presence of the demonstrator, and is not dependent on the stimulus. The increase in similarity of the imitation is determined through external reinforcement, and not through internal reinforcement, i.e. not through the ability of the imitator to recognize the similarities and differences between its behaviour and that of the model.

This involves the same mechanism as non-social trial-and-error learning except in this case the imitation is dependent on the behaviour of the demonstrator.

CLASSICAL CONDITIONING: The behaviour of one animal comes to resemble the behaviour of another animal due to the observer experiencing a stimulus in temporal continuity with the response of the demonstrator. For example, monkey-B observes the fear response of monkey-A. Monkey-B then observes a snake, which elicits fear response in monkey-B. The unconditioned stimulus (UCS) is the snake, and the conditioned stimulus (CS) becomes the fear response in another monkey. Through classical conditioning, monkey-B learns to produce the fear response to the fear response in monkey-A.

Cook, Mineka, Wolkenstein, and Laitsch (1985) use the term "observational conditioning" to refer to the classical conditioning of emotional responses. Berger(1962) uses "pseudovicarious instigation" to refer to this same phenomenon.

Table 1.2 is a summary of all social mechanisms of increased behavioural homogeneity within a population.

TABLE 1.2. REVIEW OF SOCIAL MECHANISMS BY WHICH BEHAVIOURAL HOMOGENEITY BETWEEN TWO OR MORE ANIMALS IS INCREASED.

PREFERRED TERMINOLOGY	PREVIOUS TERMINOLOGY
SOCIAL ENHANCEMENT (Galef 1988)	IMITATION (Morgan 1896, 1900) OBSERVATIONAL LEARNING (Hall 1963) COACTION (Zajonc 1965) SOCIAL LEARNING (Box 1984)
CONTAGIOUS BEHAVIOUR (Thorpe 1963)	INSTINCTIVE IMITATION (Morgan 1896, 1900) (Washburn 1908) PERSISTENT IMITATION (Baldwin 1903) IMITATION (Humphry 1921) IMITATIVE SUGGESTION (Guillaume 1926) MIMESIS (Armstrong 1951, Verplank 1957) ALLELOMIMESIS (Scott 1958) 1st LEVEL IMITATION (Piaget 1962) SOCIAL FACILITATION (Thorpe 1963) 2nd LEVEL IMITATION (Mitchell 1988)
TRIAL-AND-ERROR	INTELLIGENT IMITATION (Morgan 1896, 1900) TRIAL-&-ERROR IMITATION (Guillaume 1926) MATCHED-DEPENDENT (Miller and Dollard 1941) 4th & 5th LEVEL IMITATION (Piaget 1962) TRIAL-&-ERROR IMITATION (Guillaume 1926) 3rd LEVEL IMITATION (Mitchell 1988)
SOCIAL FACILITATION	CONTAGIOUS BEHAVIOUR (Thorpe 1963) AROUSAL (Zajonc 1965)
STIMULUS ENHANCEMENT (Spence 1937)	LOCAL ENHANCEMENT (Thorpe 1963)
CLASSICAL CONDITIONING	VICARIOUS INSTIGATION (Berger 1962) PSEDOVICARIOUS INSTIGATION (Berger 1962) OBSERVATIONAL CONDITIONING (Mineka et al 1984)
IMITATION	REFLECTIVE IMITATION (Morgan 1900) 6th LEVEL IMITATION (Piaget 1962) SYMBOLIC IMITATION (Guillaume 1971) 4th & 5th LEVEL IMITATION (Mitchell 1988)

C. IMITATION DEFINED

There has been a large body of literature dedicated to the defining of imitation. This emphasizes the intangible nature of the term. Even when one succeeds in isolating imitation from other behavioural conformity processes, the meaning of imitation itself is often unclear. It is often defined merely by a process of elimination, i.e. by what it is *not*. The following theoretical criteria are suggested as necessary in defining of imitation for what it *is*. Then a discussion on how these criteria can be reinforced is presented.

CONTINGENCY

It is necessary for the imitation to be contingent upon the model. Observation of the model by the imitator is important for true imitation to occur (Mitchell 1989). This criterion excludes all those non-social mechanisms of behavioural conformity listed earlier especially mimicry and convergence.

NO EXTERNAL REINFORCEMENT

The increased co-ordination between the model and the copy must be due to the ability of the imitator to recognize the similarities and differences between itself and the model. The imitation comes to resemble the model through comparisons between "self" and "other" i.e. through a complex sensorimotor matching process (Provine 1989). The result is achieved through successive approximations toward correspondence between the actions of itself and the actions of the model.

If the behaviour is rewarded externally, then this is merely an illustration of social trial-and-error learning. For imitation it is not necessary that the behaviour be novel, only previously unrewarded. However, it is important to note mention that often a behaviour is made up of many components and at some point these components have been individually rewarded or rewarded in a different context. What is important is that these behaviours have not been rewarded in *this particular context*.

REPLICATION OF A MOTOR PATTERN

Imitation involves a topographical duplication of a motor pattern (Whiten 1989). Understanding the rules guiding another's behaviour (Visalberghi and Fragaszy 1989) and adding one's own variation to reach the same end (Mitchell 1989), may indeed be examples of higher intelligence, but this is not what is generally meant by imitation. Tomasello (1989) recognizes this criterion and suggests the term EMULATION be when an animal attempts to reproduce another's result, and IMPERSONATION to be when an animal attempts to reproduce another animal's behaviour. Tomasello's labelling of these phenomenon is purely semantics. What is important here is for the difference between the two to be recognized.

Meltzoff(1988) reinforces this criterion by stating that "the local enhancement objection does not apply to the imitation of pure body-actions...Local enhancement is classically involved in cases of object manipulation, but it has not been applied to cases in which body movement is copied in the absence of any external object at all."

METHODOLOGICAL PROBLEMS IN DEFINING IMITATION

Unfortunately, given the above criteria, there are still many problems encountered when trying to either demonstrate imitation experimentally, or to deduce imitation from an observation. The following is a discussion of these problems, together with suggestions of ways to circumvent them. This is done by employing mechanisms which increase the probability that a particular behaviour be acquired through the process of imitation.

Problem I: The necessary degree of similarity.

Deciding the necessary degree of similarity between the copy and model can be very subjective. There is little agreement as to the required similarity between the copy(C) and the model(M) in order for C to be considered an imitation of M. Masur (1988) states the reproduction must either be an exact copy of the model, or a close approximation. Passingham (1980) states that "we need not require that the copy be exact; a child's attempt at copying the sounds of speech may be idiosyncratic , but are nonetheless examples of imitation."

There are three main factors that are responsible for determining the degree of similarity between the copy and the model.

A. First are the qualities inherent in the demonstration itself, such as; complexity of the task, speed at which the task is performed.

B. Secondly are the factors involved in the translation of the information from the model to the observer, such as; clarity of the demonstration, distance or speed at which it is performed.

C. Third, are the qualities inherent in the copier itself. These may be divided into three sub categories; (c1) the psychological advancement of the copier. This is the variable which we want to measure, i.e. whether the animal is capable of imitating, (c2) the motor coordination of the copier, i.e. how well the copier can translate mental representations into motor sequences, (c3) physical limitations, eg. a child is unable to accurately imitate the swinging of an elephant's trunk because the child does not possess a trunk.

Within these limits one would expect to see an increasingly closer approximation of the copier to the model with successive trials

Figure 1.1 is a schematic representation of the relationship between these variables.

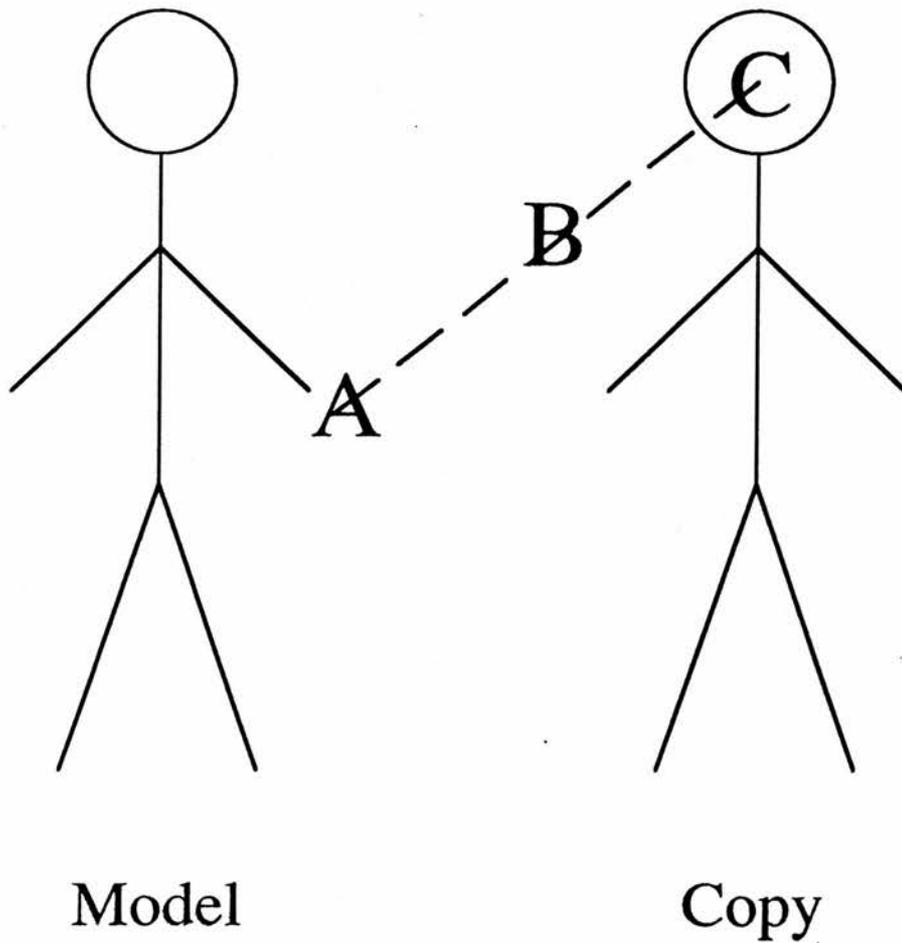


Figure 1.1 Similarity of C to M. Diagram of those factors affecting the degree of similarity of a copy to a model, where A=qualities of the model, B=qualities of the transference of information, C=qualities of the copier

To circumvent the problem of how similar a copy should be to its model, Visalberghi and Fragaszy (1989) suggest that similarity between C and M must be defined a priori. Perhaps the criteria above can be used as a useful framework for making this decision.

Alternatively certain methodology may be employed to prevent such a decision from having to be made at all.

A comparative situation can be set up so that two distinct behaviours are demonstrated by models to two groups of observers. If the ratio of the two behaviours subsequently differs significantly between the two groups of observers, then imitation can be assumed. Meltzoff (1988) used this methodology with human infants. Dawson and Foss (1965) and Galef (1986) performed a similar experiment with budgerigars (Melopsittacus undulatus) being exposed to three different motor patterns to remove a lid from a food dish.

This method has never been used to demonstrate imitation in non-human primates. It is used for the first time on Macaca arctoides in an experiment outlined in chapter two.

Problem II: Delay or Immediacy

There does not seem to be agreement as to whether the imitation should follow the demonstration immediately, or with a period of delay. Uzgiris (1975) sets the criterion of only counting as imitation those replications that occurred within two seconds of the modelled act. Hayes and Hayes (1950), however suggest from observing their home raised chimpanzee that "responses which are delayed, or altered in detail, may be taken as examples not only of imitation but of imitation combined with additional "higher mental processes".

Experiments that aim at producing a delayed imitation rather than immediate imitation, decrease the likelihood that a behaviour could be the result of a matched-dependent process, or contagious behaviour. It would seem that delayed imitation would be of greater significance and be a more adaptive form of learning than being restricted to imitate only in the presence of the demonstrator (Masur 1988).

The upper limits of the delay are set by the criteria that the copy must be contingent upon the model and the lower limits are set on attempting to rule out contagious and social trial-and-error learning. Unfortunately the delay itself may be confounding other abilities such as memory instead of the testing for the ability to imitate.

Delay in animals can be achieved experimentally . Meltzoff(1988) suggests the method of using a pacifier to delay imitative responses in young infants.

Problem III: Novelty

As mentioned earlier, it is not necessary for an imitation to be of a novel behaviour but only a previously unrewarded behaviour. However, requiring imitation of a novel task is often used as a means of ensuring for contingency of the copy upon the model. It is also important in that the ability to imitate novel behaviours has a greater significance for acquiring culturally significant behaviours. Admittedly there is great difficulty being certain about the novelty of a behaviour. Novelty may refer to a novel sequencing of a set of behaviours that are already in the animal's repertoire, or to a novel use of a set of old behaviours (Fragaszy and Visalberghi 1989).

Problem IV: simplicity/complexity

The more difficult a task is, the less likely it is that the solution can be obtained by simple trial-and-error processes. The complexity of a motor pattern sequence decreases the probability that it could have been acquired by mechanisms other than imitation. This is what gives the most credence to the anecdotal evidence for chimpanzee imitation discussed below.

However, although the task must be sufficiently novel and complex, it must be considered that the task must not be too novel or too complex so as to prevent its replication all together (Watson 1908).

SUMMARY

Therefore in designing an experiment in which imitation could be empirically demonstrated the experimenter should attempt to ensure that; (a) the imitation is contingent upon the model, (b) no external reinforcement would be received for any response, and (c) so that replication of the motor pattern used and not just the result of the behaviour is required.

Contingency would decrease the probability that the observer would solve the task through trial-and-error learning, and can be achieved experimentally by increasing the complexity of the task and requiring the imitation of a novel task. The absence of any external reinforcement would decrease the likelihood that the task be learnt by classical conditioning and imitation. Requiring the replication of the demonstrated motor pattern instead of just the solving of the task decreases the likelihood that the task would be learnt by social facilitation or stimulus enhancement. Other behavioural conformity processes such as contagion can be controlled for by requiring a period of delay before allowing the observer to attempt

to solve the task. The methodological problem of deciding the necessary degree of similarity should either be defined a priori using the criteria suggested on page 19, or experimental methods such as those used by Dawson and Foss (1965) Galef et al (1986) and Meltzoff(1977) could be employed.

However, it is also necessary to be able to assess the validity of anecdotal, experimental or field reports of imitation in the literature. The same criteria of contingency, no external reinforcement and replication of a motor pattern can be used. As mentioned above, novel and more complex tasks and having a period of delay between the observation period and the imitation decrease the probability that the behaviour could have been acquired through other behavioural conformity processes and provides more convincing evidence of imitation. When the critical reader is assessing previous studies that claim to have demonstrated imitation, it is necessary to have access to knowledge of the behavioural repertoire of the animal and an understanding of how the behaviour was acquired.

For example, one of the most convincing reports of imitation in chimpanzees is from the Hayes' chimpanzee Vicki (1951). She would imitate on the command "*Do this !*". If the experimenter clapped her hands, so would Vicki and if the experimenter pulled a funny face, so would Vicki. This appears to be very convincing evidence indeed. However if Vicki was trained to "*Do this*" by rewarding her for these particular actions, then this would be merely a case of classical learning and not imitation. The information of her training is not provided. Thus it is important when examining evidence from previous experiments that have claimed to demonstrate imitation, to have a detailed description of the events leading up to the final behaviour.

And finally Galef(1988) suggests that if a behaviour is indeed learnt by imitation, then it would be expected to disseminate *exponentially* through a population. If the behaviour disseminates too slowly it is possible that it is being acquired through trial and error learning.

The following section provides the evidence for imitation in non-human primates. As Galef (1988) suggest what is necessary is "a healthy scepticism and attention to detail" to assess the validity of these claims.

1.4 EVIDENCE FOR IMITATION IN NON-HUMAN PRIMATES

With so long and so detailed a history of investigation into a phenomenon, it seems strange that it is still not clear whether non-human primates can imitate. Thorpe (1963) states that "it becomes doubtful whether we can find any certain examples of such a behaviour anywhere in the animal kingdom below the primates". It is not certain whether imitation as a direct topographical duplication of a motor pattern occurs frequently in any species other than non-humans.

Homo sapiens is of the order *Primates*, and shares a common ancestry with other apes and monkeys. Being of the same order, humans share many of the same behavioural and physical characteristics as other primates. Perhaps this is the basis for the common assumption that monkeys and apes are proficient imitators. Kohler (1925) states that "in this case a widespread opinion is absolutely wrong". Visalberghi and Fragaszy (1989) illustrate how embedded this idea is in our thinking by showing that terms meaning "to imitate" in different languages often include a root word meaning *monkey* or *ape*. Table 1.3 lists a few of these.

Table 1.3. Expressions meaning "to imitate" in different languages (Visalberghi and Fragaszy in press).

LANGUAGE	TO IMITATE	MONKEY
Italian	Scimmiottare	Scimmia
French	Singer	Singe
Portuguese	Macaquear	Macaco
German	Nachaeffen	Affe
Spanish	mono de imitacion	Mono
Polish	Malpa	Malpowac
Finnish	Apinoida	Apina
English	to ape to monkey monkey see, monkey do	

Positive evidence for imitation in monkeys is often confused with other behavioural conformity processes, as detailed in the following pages.

Negative evidence for imitation may often go unreported. Observations from the field when a behaviour fails to spread through a group, are often ignored because the behaviours are assumed to be adaptively insignificant. Negative laboratory results are often blamed on poor experimental design. These results are nevertheless important in assessing the imitative abilities of monkeys. Negative results "allow us to determine the outer bounds of a species' abilities. We will never know the boundaries if we report only their success" (Visalberghi and Frigaszy in press).

In the following pages I have formulated lists of claims of imitation (or lack of imitation) from the literature. These lists may appear to imply that studies on imitation have decreased in more recent years. However, this is more a reflection that authors have become more cautious of employing the term imitation than they have been in the past.

A. EVIDENCE FOR IMITATION IN MONKEYS

(i) ANECDOTAL EVIDENCE

As mentioned earlier, it is a common assumption that monkeys frequently copy behaviours. Perhaps because of this, the anecdotal reports of imitative events are numerous. Unfortunately most of these reports are unable to distinguish imitation from the other behavioural conformity processes mentioned earlier.

Often the expression of the behaviours can be explained more parsimoniously by the processes of stimulus enhancement and social facilitation. Romanes (1882) noted a Cebus apella learn to open a trunk with a key upon seeing this behaviour demonstrated by its caretaker and attributed this to imitative learning. Witmer (1910) noted a Macaca cynomolgus learn to open a door from observation and also attributed the learning of this behaviour to imitation. It is possible that in these cases the animal's attention was redirected towards the appropriate aspect of the environment which facilitated discovery of the solution, or, that an increase in frequency and number of behaviours facilitated the discovery of the solution. There is no evidence that the opening of the door or the opening of the trunk were indeed learnt by imitation.

Breugemann (1973) describes an incident in which a Macaca mulatta was observed to carry a coconut shell like an infant after observing her mother carrying a younger sibling. He attributes the learning of the behaviour to imitation. However, this behaviour is not necessarily even contingent upon observation of the demonstrator. The actions may be a normal part of the monkey's behavioural repertoire and the coincidental pairing in time of similar behaviours is certainly not evidence of clear imitation.

Anecdotal reports suggesting the absence of the imitative ability in non-human primates consist mainly of observations of unusual behaviours observed in one or more of a group of monkeys, and the failure of this behaviour to spread through the group. For example, Schonholzer (1950) observed two hamadrayas baboons Papio hamadrayas using their tail to soak up water for which to drink. Other baboons in the troop observed this behaviour many times, and even drank from the demonstrator's tails. However, they failed to ever learn to perform this behaviour for themselves.

(ii) EXPERIMENTAL EVIDENCE

There are many advantages to conducting laboratory studies on the phenomenon of imitation. Here it is possible to use proper controls, and to employ criteria that help to isolate imitation. However in drawing conclusions from laboratory studies, it is important to realize the dangers involved.

It is important to acknowledge that: (1) The subjects in captivity may be significantly different from those in the wild. For example Hayes and Hayes (1950) found the imitative ability of their home-raised chimpanzee significantly higher than the imitative ability of a wild-caught chimpanzee. (2) The task provided to imitate may be significantly different from tasks encountered in the wild, (3) the observational situation may not be similar enough to the situation in which an animal would imitate in the wild (Tomasello et al. 1987).

Other problems encountered in past laboratory studies specific to the study of imitative learning include (4) not providing proper controls to distinguish imitation from other forms of social learning, (5) inadequate or insufficient experimental groups, (6) the task being too simple to discriminate between alternatives (Palameta and Lefebvre 1985).

The most common laboratory experiment performed to reveal imitation in monkeys involves a demonstrator solving a task in front of a naive observer. The observer is then tested to determine if exposure to the demonstrator increases the rate at which the correct response is discovered, or decreases the number of trials needed to solve the task.

This type of testing does not control for other socially enhancing mechanisms, such as stimulus enhancement or social facilitation.

Variations of this method include (a) the Kline Single-cage method, (b) the Thorndike Observation Cage, and (c) the Warden Duplicate-Cage apparatus (Warden and Jackson 1940). In the Kline Single Cage method, the naive animal is put in the same cage and at the same time as the model M and thus is able to manipulate the object during the observation. Therefore trial-and-error activities are not eliminated (Hall 1963).

In the Thorndike Observation Cage the observer is in a different cage to the demonstrator. The demonstrator performs the task and then the observer is allowed into the cage to attempt the task. In the Warden and Jackson (1940) method an identical task is given to the observer at the *same time* as the demonstrator manipulates it (Hall 1963).

The second most common experiment designed to demonstrate imitative behaviour in the laboratory involves discrimination tasks. An observer O is allowed to watch a demonstrator D choose a correct object from a selection of two or more objects. The observer is then tested to see if it learns to choose the correct object more quickly, or in fewer number of trials than if it hadn't had the opportunity to observe the demonstrator. This type of experiment does not control for stimulus enhancement, i.e. the animal may learn to make the correct decision merely because of a change in the stimulus salience of the correct object, and thus is not convincing evidence for the demonstration of imitative behaviour.

Table 1.5. is a summary of laboratory experiments using these methods that claimed to demonstrate imitation in primates. The type of experiment and the most probable mechanism for acquisition of the behaviour are indicated.

Experimental evidence suggesting that monkeys are not proficient imitators is also extensive. However, such results are often blamed on poor experimental design and lack of controls.

Table 1.6. lists some of the many negative experimental findings of imitation in monkeys. There are probably many more studies in which imitation was not demonstrated but these are the only studies that have actually reported this.

TABLE 1.5. REVIEW OF POSITIVE LABORATORY EVIDENCE FOR IMITATION IN MONKEYS.

I. METHOD		II. MOST PROBABLE EXPLANATION		
A=Kline Single Cage Method		SE=Stimulus Enhancement		
B=Thorndike Observation Cage Method		SF=Social Facilitation		
C=Warden Duplicate Cage Method		CC=Classical Conditioning		
D=Discrimination task		T&E=Trial-and-Error		
		C=Contagion		
		I=Imitation		
		*=History of animal unknown		
REFERENCE	GENUS	TASK	I	II
Hobhouse(1901)	various	-manipulative	B	SE,SF
Kinnaman(1902)	Macaca	-pulling a plug -pressing a lever -opening a box	B	SE,SF
Haggerty(1909)	various	-manipulative, involving a rope, screen, plug, and button	A	SE,SF
Kempf(1916)	Macaca	-discrimination	D	SE
Aronowitsch and Chotin (1929)	Macaca	-learned by observation to respond opposite to training	A	CC
Warden and Jackson(1935)	Macaca	-pulling a chain to expose a raison in hole	C	SE,SF
Warden et al (1935)	various	-manipulative	C	SE.SF
Presely and Riopelle(1959)	Macaca	-avoiding an electric shock by jumping over a barrier	B	CC
Darby and Riopelle (1959)	Macaca	-discrimination task	D	SE
Miller et al. (1959)	Macaca	-fear response	A	CC
Myers (1970)	Macaca	-learned to respond on a multiple reinforcement schedule	B	CC
Beck (1976)	Macaca	-throwing action of tool at inaccessible food	A	T&E
Strayer (1976)	Macaca	-discrimination task	D	SE
Cook et al (1985)	Macaca	-fear of snakes	B	CC
Anderson(1985)	Macaca	-manipulating metal rods to reach otherwise inaccessible food	B	SE,SF
Chevalier-Skolnikoff (1989)	Ateles	-putting things in mouth ringing bells, examining objects, interactions with a bucket	A	SE
	Cebus	-banging two objects together, putting tub in a moat,draping a cloth on a branch	A	SE,T&E

TABLE 1.6. REVIEW OF NEGATIVE LABORATORY EVIDENCE FOR IMITATION IN MONKEYS.

I. METHOD

**A=Kline Single Cage Method
 B=Thorndike Observation Cage Method
 C=Warden Duplicate Cage Method
 D=Discrimination task**

REFERENCE	GENUS	TASK	I
Thorndike(1898,1901)	Cebus	-opening a box	B
Watson(1908,1914)	Cebus Macaca Papio	-manipulative	B
Feldman and Klopfer(1972)	Lemur	-discrimination	D
Beck (1972,1973a,b)	Papio	-use a tool to reach inaccessible food	A
Beck (1974)	Macaca	-reaching pan with stick	A
Antinucci and Visalberghi(1986)	Cebus	-cracking nuts	A
Visalberghi(1987)	Cebus	-cracking nuts	A
Westergaard and Frigaszy(1987)	Cebus	-probing for syrup	A
Adams-Curtis(1987)		-mechanistic puzzle	A
Visalberghi and Trinca(in press)	Cebus	-displacing reward in a horizontal tube	A

Visalberghi and Trinca (1988) compared the proficiency of imitative learning with trial-and-error learning in Capuchin monkeys. A female monkey was allowed to observe a conspecific use a stick to displace a food reward inside a tube. After the demonstration, she was still unable to retrieve the food reward. She was then presented with a novel but similar task in which a stick was used to dip in a vertical tube for liquid. After successively learning to do this task, she immediately learned to perform the previous task.

It has been suggested, however, that something more than just stimulus enhancement may be involved in social learning situations in monkeys. Visalberghi and Fragaszy (1989) have suggested this for capuchin monkeys. In an experiment Visalberghi and Trinca (1989) found after observing a conspecific displace a reward out of a horizontal tube with a rod, that although the monkeys did not learn to solve the task by imitation, there was an increase in contact of the tube with the stick. Beck (1972, 1973a) reports similar results for baboons. The subjects were observed to touch the tool and touch the food pan **with** the tool at a higher rate after observing the solution than before observing the solution. It has been suggested (Visalberghi and Trinca 1989) that perhaps something more than mere stimulus enhancement is occurring in these situations.

However, on closer examination the experiment by Visalberghi and Trinca (1989), it becomes apparent that this is probably not the case. The overall stick manipulation did not increase, although the total number of contacts with the tube increased i.e. (manipulation of the stick + touching the stick to the tube). This suggests that the normal repertoire of behaviours (including manipulation of the stick) was redirected towards the tube i.e. stimulus enhancement of the tube.

Table 1.7 gives the results from Visalberghi and Trinca (1989) and my additions of total stick manipulation and total tube contacts.

Table 1.7. Results of Visalberghi and Trinca (1989) experiment with Cebus apella.

	CONTACT TUBE	CONTACT STICK	CONTACT TUBE WITH STICK	TOTAL STICK MANIPULATION	TOTAL TUBE CONTACT
BEFORE OBSERVATION	5.5	32.25	2.25	34.50	7.75
AFTER OBSERVATION	5.5	21.50	7.00	28.50	12.50

(iii) NATURALISTIC OBSERVATIONS

Most of the natural reports of observed imitation in the wild cannot exclude explanations by (i) local specific behaviours acquired through individual trial-and-error, (ii) dietary acquisition by stimulus enhancement.

The most famous case of imitation in monkeys is the sweet potato washing behaviour of the Japanese macaques. The Koshima troop of Japanese macaques were provisioned with sweet potatoes. A young female named Imo began to carry her potatoes to the edge of the beach and wash the sand off her potato in the water. This was first observed in 1953 and by 1956 eleven other monkeys had acquired the behaviour (Kawai 1965).

A variety of evidence has accumulated to suggest that this behaviour was not in fact acquired through imitation. Visalberghi and Fragaszy (1989) have observed spontaneous food washing in captive *Cebus* monkeys. This suggests that the behaviour is not so unusual as to rule out the possibility of individual trial-and-error.

It is also possible that the monkeys' behaviours were shaped and ultimately maintained through the provisioning of the caretakers through reinforcement of those animals who expressed the unusual behaviour. Green (1975) observed that provisioning only occurred to those who exhibited the behaviour.

Galef (1988) draws attention to two important characteristics of imitative behaviours that are not characteristic of sweet potato washing behaviour. The literature suggests that (1) imitation should be rapid as compared with trial-and error learning - (Galef 1988 considers the spread of potato washing as "painfully slow"), and; (2) the literature suggests that the rate of social learning should increase with the number of individuals exhibiting the behaviour but this did not occur with the Koshima troop of Japanese macaques (Galef 1988).

Increases in range of diet through observation are often cited as imitation in the field. It has been suggested that juveniles learn to discriminate between food items from observation of their mother in order to acquire an adaptive diet. Most of these reports can be more parsimoniously be explained by stimulus enhancement to a particular food.

Table 1.8. lists various naturalistic observations claimed as imitation in monkeys.

TABLE 1.8. NATURALISTIC OBSERVATIONS CLAIMED TO BE REPORTS OF IMITATION IN MONKEYS

MOST PROBABLE EXPLANATION

SE=Stimulus Enhancement
 SF=Social Facilitation
 CC=Classical Conditioning
 T&E=Trial-and-Error
 C=Contagion
 I=Imitation
 *=History of animal unknown

REFERENCE	GENUS	OBSERVATION	MOST PROBABLE EXPLANATION
Carpenter(1887)	Macaca	-learning to open oysters with stones	SE
Tinklepaugh and Hartman (1930)	Macaca	-young induced to eat after birth after observing mother	SE
Imanishi(1951)	Macaca	-potato washing, rice throwing, caramel eating	T&E,SE
Carner (1955)	Macaca	-trained by imitation to aid experimenter in his botanical collections	SE
Hall(1962)	Papio	-dug in the same place after observing another	SE
Marais(1969)	Papio	-cracking the fruit of the baoba tree by pounding it with stones	T&E
Hamilton and Tilson(1985)	Papio	-catching fish	T&E,SE
Hauser(1988)	Cercopithecus	-dipping leaves into exudate from a tree	T&E,SE

Field reports emphasizing the absence of imitation in primates stress the importance of other learning mechanisms of behavioural acquisition. Recent evidence suggests that the process of acquisition of behaviours in monkeys is most often achieved through individual trial-and error, and perhaps enhanced by the social influences of others.

Often knowledge of location and items in the diet is assumed to arise through social processes of stimulus enhancement and social facilitation, however the method of processing is assumed to be acquired through individual trial-and-error (Whiten 1989). Cambefort(1981) found that both vervets and chacma baboons "fail to learn about palatability by demonstration but have to go through direct learning process". Boinski and Fragaszy (1988) also concluded that "differential selectivity of foraging sites or fruits is probably not directly influenced by observation of others, but rather indirectly through proximity to others". Infant squirrel monkeys have been observed to readily learn avoidance of noxious or dangerous caterpillars. However, observation of adults processing technique of rubbing the caterpillars on the tail tip to remove spines, did not seem to benefit the inexperienced monkeys. It seemed to be necessary to go through a processes of trial and error for acquisition of this form of behaviour (Boinski and Fragaszy 1988). Similarly, juvenile baboons did not seem to benefit from observing adult baboons processing corns, and individual trial-and error seemed the predominate method of behavioural acquisition (Whiten 1988).

B. EVIDENCE FOR IMITATION IN APES

Reports of imitation in apes most commonly refer to chimpanzees. Evidence for imitation in chimpanzees will be examined in the next section. Records of imitation in other apes in the literature tend to be mainly anecdotal. A list of reports of imitation in apes is presented in Table 1.9.

The lack of clear evidence and infrequent reports suggests that as in monkeys, imitation may not be as frequent in apes as commonly believed. There are a number of reports of the **non-occurrence** of imitative learning, recorded as if in surprise at the lack of a phenomenon where it might be expected (Table 1.10). Yerkes (1927) states of their gorilla Congo that "Congo simply does not imitate persons with such frequency, freedom, and explicitness that one can feel sure of it." In fact, the evidence does not even suggest that imitative behaviour in apes (excluding chimpanzees) is any more developed than in monkeys (Yerkes 1929).

Table 1.9. Reports of Imitation in Apes

MOST PROBABLE EXPLANATION

SE=Stimulus Enhancement

SF=Social Facilitation

CC=Classical Conditioning

T&E=Trial-and-Error

C=Contagion

*=History of animal unknown

Reference	Genus	Observation	Most Probable Explanation
Vosmaer (1778)	Pongo	spitting in imitation of man	T&E,*
Abel (1818)	Pongo	imitation of a kiss	T&E,*
Furness (1916)	Pongo	digging with a spade	SE
Mott (1924)	Hylobatidae	imitated sounds made by guinipigs and dogs	T&E
Yerkes (1927)	Pongo	learned by observation to lift the lid of a sewage tank	SE
Carpenter (1937)	Gorilla	synchrony of moods and play behaviour	C,T&E,CC
Harrison(1960)	Pongo	nest building and feeding habits	T&E,SE

Table 1.10. Negative reports of imitation in Apes

Reference	Genus	Observation
Boutan (1913)	Hylobatidae	never imitated sounds of caretaker
Yerkes and Yerkes (1916)	Pongo	failed to learn by imitation to stack boxes to reach an otherwise inaccessible banana
Yerkes (1927)	Gorilla	failure to imitate lock and key problems

C. EVIDENCE FOR IMITATION IN CHIMPANZEES

The only convincing evidence for imitation in non-human primates seems to exist for the chimpanzee. The evidence however, is mainly anecdotal. Attempts to experimentally show imitation in chimpanzees have failed (Tomasello et al. 1987), although this may be due to lack of motivation (Visalberghi and Fragaszy 1989).

(i) ANECDOTAL EVIDENCE

Anecdotal reports of imitation in chimpanzees include mainly reports of hand-reared chimpanzees. For example, Viki, the hand reared chimpanzee of the Hayes, showed spontaneous imitation of everyday household duties, such as brushing her teeth, putting on lipstick, brushing her hair, sharpening pencils, and painting.

The following are only two of the many especially convincing anecdotal reports of imitation in chimpanzees:

- " He was entirely absorbed in his task, washing a cloth with soap, in a bowl of water, wringing it out in exact imitation of the way the natives worked, then wetting it with a cup full of clean water, and wringing it out again." (Kearton 1925)

- " she would begin by wetting the end of the thread in her mouth, would place the eye of the needle in line with her eye, insert the thread from behind, forward, then pull the thread the remainder of the way with her lips" (Sheak 1923)

Although the evidence is still anecdotal, the unusualness of the behaviours, their complexity, and the degree to which the motor sequences are reproduced, seems to suggest strong evidence for imitation.

Whether hand-reared chimpanzees are better imitators than wild chimpanzees is not certain. Perhaps there is simply more chance of these behaviours being observed because the animals are under such close observation. Perhaps hand-reared chimpanzees have had more opportunity to manipulate, and therefore more opportunity to become familiar with objects than wild chimpanzees. Hayes and Hayes (1950) suggest that this is true. They performed an identical experiment on Viki, and another wild chimpanzee. Viki performed significantly better on these tasks. Perhaps hand-reared chimpanzees are simply more motivated, and eager to please, or perhaps less intimidated, or less afraid than wild chimpanzees.

Table 1.11 gives a summary of anecdotal reports of imitation in chimpanzees.

Table 1.11. Anecdotal reports of imitation in chimpanzees

MOST PROBABLE EXPLANATION

SE=Stimulus Enhancement
 SF=Social Facilitation
 CC=Classical Conditioning
 T&E=Trial-and-Error
 C=Contagion
 I=Imitation
 *=History of animal unknown

REFERENCE	OBSERVATION	MOST PROBABLE EXPLANATION
Roltman and Teuber(1915)	-learned to open doors, insert keys into locks, use a lever to regulate water supply, scrub floor, sweep with a broom.	SE,I
Shepeard(1915)	-opening a watch	SE
Furness(1916)	-learned to dig with a spade, screw with a screw, scrub and sweep	I
Sheak(1923)	-learned to wipe his nose with a handkerchief, drive nails with a hammer, and to sew	I
Kellogg and Kellogg(1933)	-learned to brush hair, and open cupboards	I,SE
Kohler(1925)	-learned to use a paintbrush, -learned to stack boxes in order to reach a banana	T&E
Verkes(1925)	-learned to spit, -learned to imitate facial expressions	I
Kearnton(1925)	-learned to wash clothes	I
Hayes and Hayes(1950)	-learned to brush hair, to apply lipstick, brush teeth, sharpen pencils	I
Hayes and Hayes(1951)	-imitated on command	I
Hayes and Hayes(1952)	-stick and tunnel, stick and string problems, ball throwing	SE
Hayes and Hayes(1953)	-imitation set series - patting head, clapping hands, protruding tongue	I
Gardner and Gardner(1969)	-soaping and drying a doll in imitation	I
Menzel (1972,1973)	-creation of ladders	SE
Tomasello(1989)	-throwing chips as a way of initiating play	I,SE

(ii) EXPERIMENTAL EVIDENCE

Experiments claiming to demonstrate imitation in chimpanzees are similar to those used for monkeys in that they confound other behavioural homogenizing mechanisms. Experiments claiming to demonstrate imitation in chimpanzees is given in Table 1.12.

There are still, however, experiments in which imitation has not been able to be shown (Table 1.13). In a recent experiment Tomasello et al. (1987) failed to show imitation in chimpanzees. He found that in a simpler task, observers were able to learn to retrieve food through the use of a tool. However, in a more complex task, juvenile chimpanzees were unable to imitate a two part action in order to retrieve a food reward with a rake.

It seemed, however, that more than just stimulus enhancement was occurring. As well as increased interaction with the food, there was actually increased interaction with the tool as well. In Tomasello et al.'s (1987) experiment, stimulus enhancement was occurring, not just towards the reward, but towards the tool as well. Stimulus enhancement was occurring towards two objects, and perhaps in their association as a means of achieving the reward.

This can be compared to the similar experiment with monkeys mentioned earlier (Visalberghi and Fragaszy in press), in which, although there was increased contact with the stick to the tube, there was not an overall increase in the amount of tool use behaviour, suggesting that a mere redirection of the normal behavioural repertoire was responsible for the results.

Table 1.12. Experimental evidence for imitation in chimpanzees

MOST PROBABLE EXPLANATION
SE=Stimulus Enhancement
SF=Social Facilitation
CC=Classical Conditioning
T&E=Trial-and-Error
C=Contagion
I=Imitation
*=History of animal unknown

REFERENCE	OBSERVATION	MOST PROBABLE EXPLANATION
Shepard (1923)	-raking in an otherwise inaccessible banana	SE
Yerkes (1934)	-induced to chew on filter paper from observation	SE
Crawford (1937)	-had to learn by imitation to cooperate, i.e. pull in synchrony	T&E
Crawford and Spence (1939)	-discrimination tasks	SE

Table 1.13. Negative experimental evidence for imitation in chimpanzees

REFERENCE	OBSERVATION
Kitahara-Frisch and Koshi Norikoshi (1982)	-two chimpanzees housed together and only one learned to modify the provided foliage for juice drinking
Tomasello et al.(1987)	-young chimpanzees failed to copy a two step strategy used for raking in inaccessible food
Tomasello (1989)	-lack of uniformity in gestural signals between individuals

(iii) NATURALISTIC OBSERVATIONS

It is more difficult to assess the validity of claims to "true" imitation from naturalistic observations, in that proper controls are not usually employed in the field. Often behaviours that are unusual and unique to a population are assumed to be acquired by imitation. For example, chimpanzees have been observed to use leaves to soak up water that has accumulated inside a tree trunk. The behaviour was once assumed to have been unique to the population at Gombe to have been invented by one individual and spread through the rest of the group by imitative learning (van Lawick Goodall 1973). However, recently Kitahara-Frisch and Norikoshi (1982) have observed spontaneous leaf-sponging in a captive group of chimpanzees. The behaviour has also been observed elsewhere (Visalberghi and Frigaszy in press). This suggests that each chimpanzee could have learned the behaviour by individual trial-and error. McGrew et.al. (1979) stress that "in the interest of parsimony, explanations based on environmental factors are preferable whenever possible to those invoking more complex cultural factors."

There are, however, some behaviours that do not have simple environmental explanations for their occurrence. One such example, is that of termite fishing. McGrew et al (1979) noted that although some differences between populations in the way in which they fished for termites could be accounted for by environmental differences, other differences could not be so easily explained.

Chimpanzees at Okorobiko used perforating tools, and chimpanzees at Gombe used fishing tools. Hannah and McGrew (1987) found that this was a result of the structure of the termite mounds, which was, in turn, a function of the climate. However, they also found that chimpanzees in M.Assirik used twigs and leaf stalks, whereas chimpanzees at Gombe used grass as fishing tools. They stated that "we can find no functional reasons for these differences and are forced to conclude that they

are based on cultural rather than environmental factors". However, it is important to remember that even if the expression or acquisition of a behaviour is influenced socially, this does not mean that it is necessarily learned by imitation.

Table 1.14. is a list of naturalistic observations of behaviours that have been assumed to be acquired through the process of imitation.

Table 1.14. Naturalistic reports of imitation in chimpanzees.

MOST PROBABLE EXPLANATION

SE=Stimulus Enhancement

SF=Social Facilitation

CC=Classical Conditioning

T&E=Trial-and-Error

C=Contagion

I=Imitation

*=History of animal unknown

REFERENCE	LOCAL SPECIFIC BEHAVIOUR	MOST PROBABLE EXPLANATION
vanLawick-Goodal(1971)	termite fishing	T&E,SE
Sugiyam and Koman(1979)	cracking nuts with stones, and using various techniques to reach lower branches of a tree	T&E, SE
de Waal (1982)	limping gait	I,CC
Sumita et al (1985)	cracking walnuts with stones	SE,T&E
Nishida and Hiraiwa (1982)	differences in populations in preferred ant species	T&E

Most recent observations seem to suggest that chimpanzees may be imitating only certain aspects of the demonstrators behaviour. It seems they may be learning the result to be achieved from the motor sequences of the demonstrator, but not the motor sequences used to achieve this means (Hannah and McGrew 1987, Call pers comm). Tomasello (1989) is now suggesting that chimpanzees only have the ability to "emulate" i.e. attempting to reproduce the demonstrator's result, but not to "impersonate", i.e. attempt to reproduce the form of the demonstrators behaviour.

Whiten (in press) suggests that if the imitative ability does indeed exist for chimpanzees, then this may in fact be a part of a larger pattern of cognition. There are a number of cognitive abilities that chimpanzees demonstrate which have not been observed in other non-human primates. These include such abilities as tool-making, insight, and indirect sensorimotor coordination. Whiten (in press) suggests that what separates chimpanzees in intelligence from other species of primates may be their ability for "second order representation", i.e. the ability to "represent a mental state in another's mind" (Whiten in press). It has been suggested that imitation too, may require the capacity for second order representation. This is discussed in chapter three.

1.5 EXPERIMENTAL DESIGN

Galef (1988) states that "progress in the study of learning by imitation in animals would be greatly facilitated by identification of an experimental procedure in which imitation could be unambiguously and repeatedly demonstrated." The best experimental design to date is that of Dawson and Foss (1965) because positive results unambiguously give strong evidence for imitation. It accurately controls for other types of behavioural conformity processes.

As mentioned earlier, an experiment was conducted where three motor patterns were demonstrated to three different groups of animals. To the first group, a budgerigar demonstrated using its foot to remove a lid covering a food dish. The second group observed a budgerigar nudge the lid off with its beak and the third group observed a budgerigar grasp the lid with its beak and lift it off the food dish. The groups were then tested to see if there was a significant difference in the motor pattern used to solve the task between the groups. Dawson and Foss (1965) concluded from their study that budgerigars (Melopsittacus undulatus) did in fact learn by imitation, i.e. use the same motor pattern as their respective demonstrators to solve the task. Their study, however, was based on only a sample size of five, and was described as "preliminary" and "in need of replication."

Galef et al (1986) described this methodology as "promising" and attempted to replicate the experiment. Problems in replication were encountered due to the "cursory" nature of Dawson and Foss' description of their methods. The percent concordance between the demonstrator and the observer was not found to be significant but the results were in the predicted direction.

In a second experiment Galef et al. (1986) modified Dawson and Foss' (1965) methodology in two ways. First, in order to be able to define *a priori* the probability that an animal will perform one motor pattern instead of another, they exposed equal

numbers of observers to demonstrators using one motor pattern as they did to demonstrators using another motor pattern. Therefore the a priori probability of a "match" was 0.5. Secondly they used two *clearly distinguishable* motor patterns (use of the bill or the foot to uncover the bowl) by designing a feeding apparatus that would restrict the motor patterns of the demonstrator to one or the other action.

In this second experiment they found that the per cent concordance between the demonstrator and the observer reached significance on the second trial (Figure 1.2). From this they concluded that "naive budgerigars will employ one motor pattern rather than another as a result of observing the behaviour of a conspecific demonstrator." However, they described their results as of only "marginal significance", and "limited duration".

A problem in interpretation of these results is due to the fact that the actions of the observer, when tested, are rewarded. This would immediately reinforce the first behaviour demonstrated by the observer, and thus increase the probability of its occurrence on the following trials.

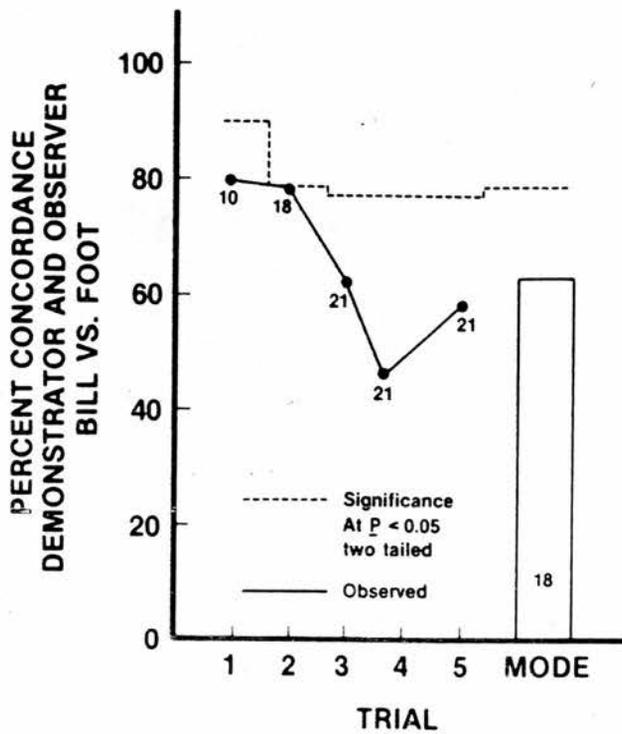


Figure 1.2. Experiment by Galef et al. (1986).
 Percentage of subjects using the same method as their
 respective demonstrator to uncover food bowls.

The only other use of this methodology is by Meltzoff (1977) who conducted a similar experiment to test for imitative ability in human infants. However, instead of demonstrating two motor patterns to two groups of observers, two motor patterns (tongue protrusions and mouth openings) were demonstrated to the *same* subjects. Thus the infant acted as their own control. If an infant demonstrated significantly more mouth openings in the mouth opening demonstration, and tongue protrusions in the tongue protrusion demonstration, then this was taken as evidence for imitation. Problems encountered in this experiment were due to difficulty in quantifying the fine oral movements of the infants.

Galef (1988) states that he "would encourage 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".

The following experiment exploits this design to test for imitation in non-human primates. An apparatus was designed similar to that used by Galef et al. (1988) in that the actions of the demonstrators were restricted to two distinct motor patterns (in this case *pulling* and *twisting* a T-bar).

Improvements were made on the experiments described above. Firstly, no reward was given for any interactions of the observer with the apparatus, thus preventing shaping of the behaviour in any direction. Because the behaviour may become extinct with no reward, the first interactions of the animal with the apparatus were considered the most important. Secondly, the apparatus was designed such that it was extremely sensitive to any movements. These movements were recorded by computer, thus quantifying the actions of the animal.

The experiment was conducted to accurately test for the imitative ability in non-human primates by excluding other forms of behavioural conformity processes.

CHAPTER 2 EXPERIMENTAL ANALYSIS

2.1. EXPERIMENT 1

Subjects

Subjects were 20 stumptail macaques (*Macaca arctoides*) at the University of St.Andrews. All subjects were captive-born. Name, sex, date of birth, and mother, or place of origin of each subject are given in Table 2.1.

Table 2.1. List of subjects I. Name, sex, age and origin of (*Macaca arctoides*) subjects.

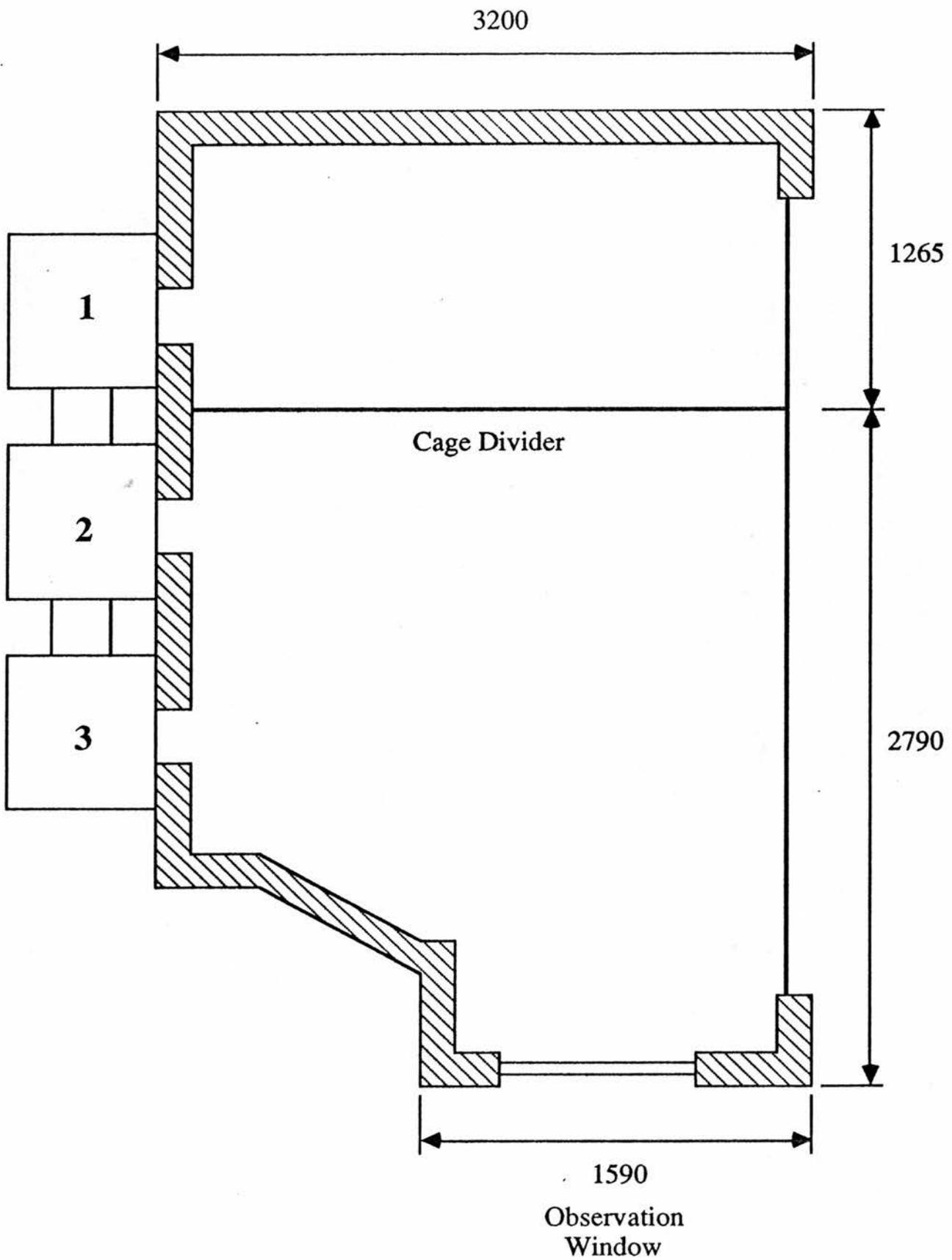
NAME	SEX	DATE OF BIRTH	ORIGIN
Jeff	M	28.03.81	Hannah
Paddy-Joe	M	18.10.82	Cath
Phil	M	14.10.84	Lita
Fred	M	24.06.85	Rhona
Neil	M	21.04.85	Monday
Jonathon	M	01.07.87	Shandy
Sam	M	24.11.87	Lita
Cath	F	29.01.74	Stirling 13.07.78
Lita	F	04.12.78	Edinburgh 05.03.82
Rosie	F	01.05.82	Stirling 79
Cola	F	12.05.82	Pepsie
Carol	F	24.11.82	Shandy
Jane	F	02.01.83	Lita
Penny	F	15.05.83	Rosie
Maureen	F	04.01.85	Cath
Ruth	F	13.10.85	Shandy
Miriam	F	13.08.86	Rosie
Jenny	F	13.10.86	Lita
Shandy	F		Shamrock Farms
Sarah	F	17.12.87	Carol

Enclosure

Monkeys were housed in a social group in a main cage divided by a wire cage wall into two sections (Figure 2.1). The smaller section was 297 cm high, 320 cm long, and 126.5 cm wide. The larger section was 297 cm high, 320 cm long, and 279 cm wide. Three hatches led from the main cage into an adjacent room containing three connecting testing cages.

The hatches were 46.5 cm high, 47 cm wide, 39 cm long, and could be opened and closed, using a pulley system, from the testing room. The middle hatch was never used. One hatch led from the small section of the main cage, and one hatch led from the larger section of the main cage into the testing cages. The hatches were usually left open to allow free passage of the monkeys between the larger and smaller sections of the main cage. The testing cages were 120 X 100 X 200 cm. Testing cages were connected at the base but could be segregated using metal dividers. Testing cages could also be divided horizontally in half.

Macaca arctoides were fed Old World monkey chow once a day at 4 pm. Fruit (apples, bananas, oranges) and vegetables (cabbage, carrots) were fed as supplements to their diet. Dried fruit was scattered around the cage in the morning. Light was provided artificially in the testing room between 6am and 6pm. Natural light was available in the main cage through a skylight in the roof. Deep wood-chip litter was used as bedding, and was changed once every three weeks. Water was available ad libitum.



(All dimensions in millimetres)

Figure 2.1. Enclosure. Diagram showing main cage and three connecting testing cages housing subjects Macaca arctoides.

APPARATUS

Apparatus was a metal T-bar 1.5 cm in diameter and 12 cm long, mounted onto a plexiglass box 24 X 24 X 24 cm (Figure 2.2a). The metal T-bar projected out 12.5 cm from the box . The design of the apparatus was such that it could be either twisted or pulled, but not the two actions simultaneously (Figure 2.2b,c).

Many experiments designed to test the imitative ability of non-human primates require the the observer to learn how to manipulate a tool in order to receive a food reward. Tool use is not a common part of the behavioural repertoire of non-human primates and is often used in itself as an indication of intelligence. Therefore imitation of tool use does not seem a fair test of imitative ability in non-human primates.

This experiment was designed to make the apparatus less like a tool by delivering a peanut reward from actually inside the T-bar itself. This was done in attempts to create a natural situation in which an animal would have to manipulate an object before gaining access to the food, as in food processing actions with nuts or fruits.

The T-bar was hollow for this experiment, allowing a peanut reward to be delivered manually from the top, and received by the monkey at a hole at the end of the tube. The bar was on an angle, thus allowing the peanut to role down to the end. The reward was given manually. During the demonstration period, a board was erected so that observer monkeys could not see the reward being inserted, although they could see it taken by the monkey at the apparatus.

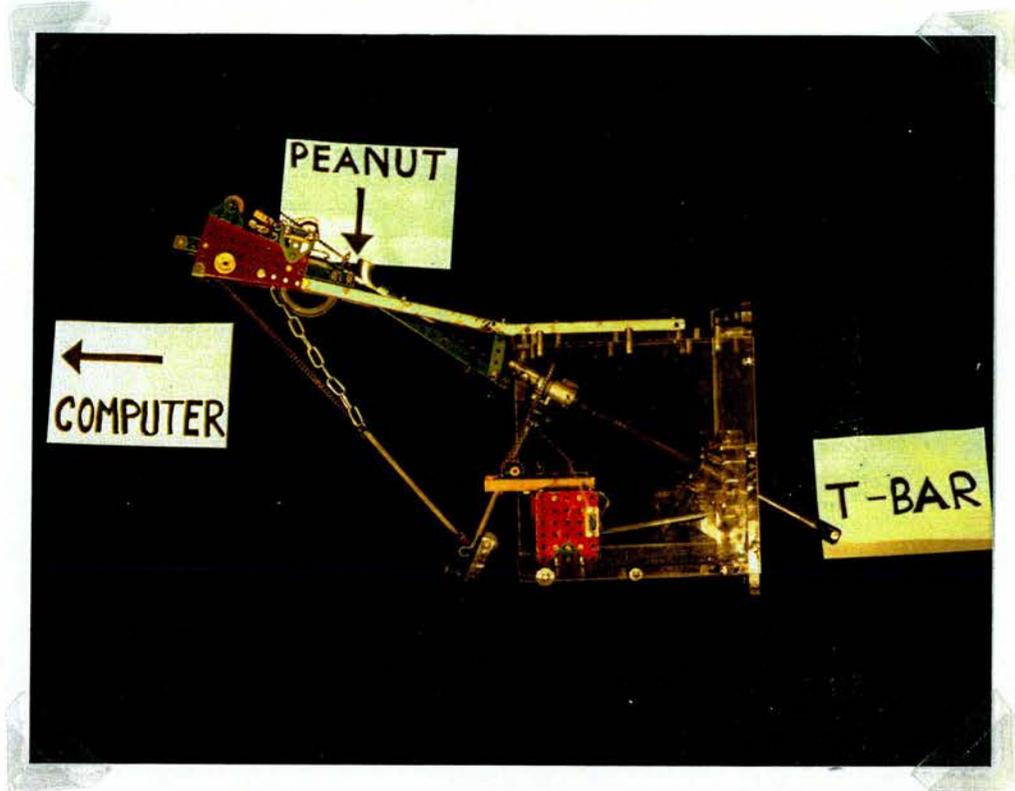


Figure 2.2.(a) Apparatus used to test for imitation. Area where reward is inserted (PEANUT), area of attachment to computer (COMPUTER) and location for manipulation by the subject (T-BAR) are indicated.

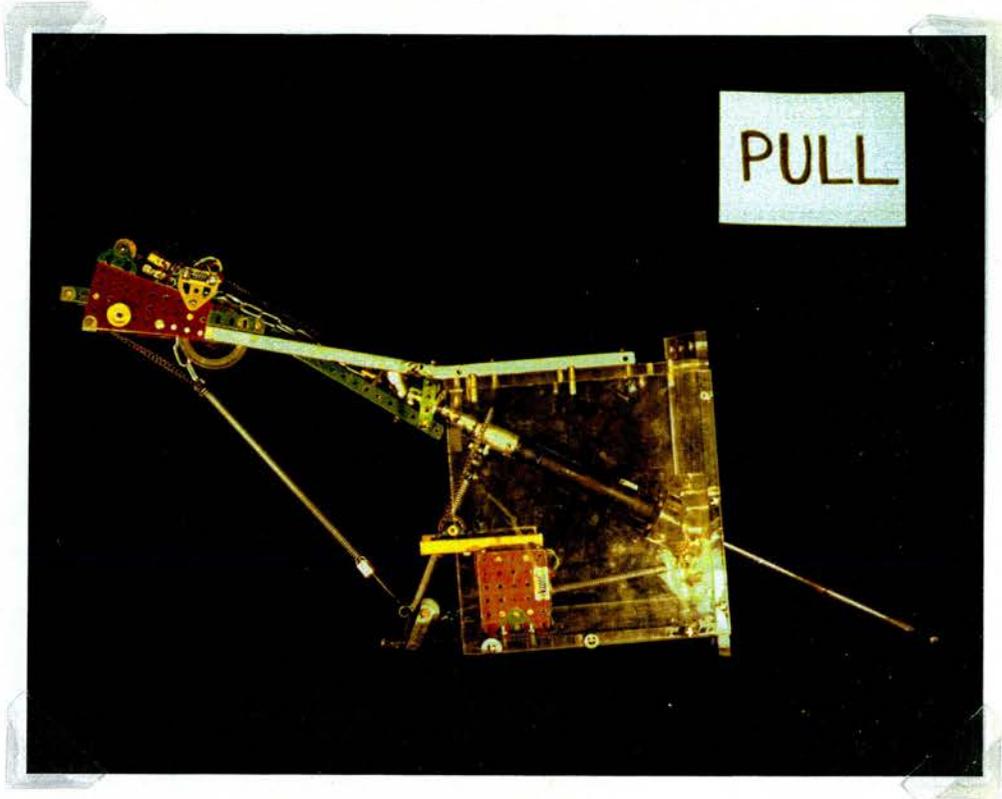


Figure 2.2.(b) Apparatus being pulled. Diagram showing metal T-bar at full extension of pull.

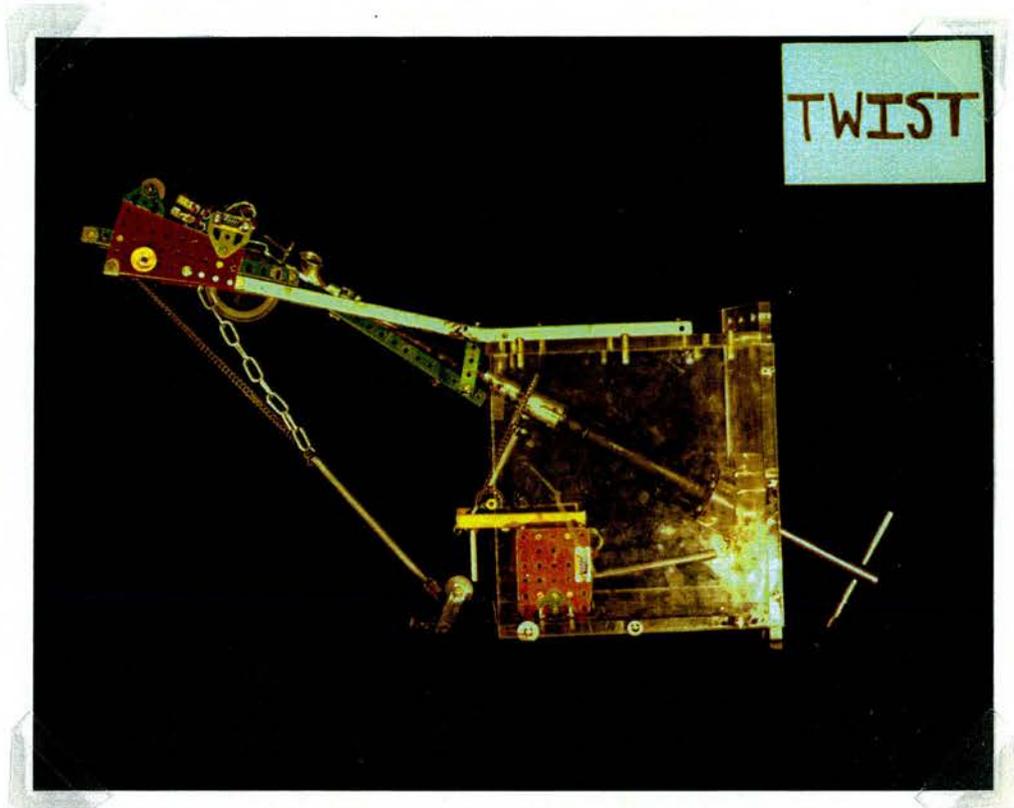


Figure 2.2.(c) Apparatus being twisted. Diagram showing metal T-bar at full extension of twist. Twisting can occur clockwise or anticlockwise.

A slotted optical disc on the apparatus detected the number of units of pull or twist performed by the monkey. Ten degrees of twisting were recorded as one unit of twist and five millimetres of pulling were recorded as one unit of pull. This information was received at an interface box which acted as a buffer before the information was passed onto a BBC computer. The computer translated the cumulative number of counts into direction, and calculated total and average extent and duration of action. The computer program is provided in Appendix I.

VHS video was used to record the behaviour of both the demonstrator and the observer in all trials.

The T-bar could be twisted or pulled from the home position. Once the T-bar had either been pulled or twisted, the other action could not be performed until the T-bar had been returned to the home position. Therefore, many small movements without returning to the home position could be recorded as one movement.

Three variables were recorded; extent, duration, and number of trials. Two variables were calculated; effort and maximum. The following is a description of these variables.

1. **NUMBER OF TRIALS.** A trial began when the apparatus was twisted or pulled away from the home position and ended when the apparatus was returned to the home position.

2. **EXTENT.** The extent of pull or twist was recorded on each trial by measuring the distance of displacement of the T-bar away from the home position.

3. **DURATION.** The duration over which the monkey pulled or twisted the apparatus for each trial was recorded in seconds.

4. **EFFORT.** The effort was calculated by dividing the extent of the pull or twist by the duration for each trial (units per second).

5. **MAXIMUM.** Maximum values for duration, extent, and effort across all trials in the three minute period were calculated for each monkey.

Procedure

A. Habituation: Preliminary observations were made between October 1 1988 and December 1 1989 in order to identify Macaca arctoides subjects and establish social bonds between monkeys. During this time monkeys were habituated to being held in the testing cages either alone, or with the demonstrator in an adjacent cage for a period of five minutes.

B. Training: Two adult females, Penny and Maureen were chosen as demonstrators (1) due to their superior problem-solving ability in a previous experiment (Thrumble 1986), (2) under recommendation of the animal technician as monkeys that would not be stressed when repeatedly isolated, and (3) because of their relatively high rank. An experiment by Strayer (1976) suggested that animals would learn by observation more readily if the demonstrator was higher ranking.

Maureen was trained to *pull* the T-bar for a peanut reward, and Penny was trained to *twist* the T-bar to receive a peanut reward. Behaviours were shaped using operant conditioning until the correct motor pattern was demonstrated for an average of 95.5 % of the total duration of interaction with the apparatus and 95.5 % of the total extent of movement of the T-bar during the three minute interval. Demonstrators initially demonstrated both motor patterns. Time required to learn the task was not recorded but was minimal. Penny demonstrated an average of 74 twists, and Maureen demonstrated an average of 21 pulls during a single demonstration period. This apparently large difference in the number of demonstrations is due to the increased sensitivity of the apparatus to twists than to pulls.

C. Demonstration: The colony was theoretically divided into two groups. The division was made such that mothers and infants were kept together as much as possible, and to equally divide the number of each sex, and ages (Table 2.2). Chesler (1969) reported that kittens who observed their mother demonstrating a task learned faster by observation than when they observed an un-related conspecific.

Table 2.2. Division of colony. Colony divided into two groups. Group A observed Penny demonstrating twisting, and group B observed Maureen demonstrating pulling. Those animals that are starred were not used in the analysis for reasons given later.

A - OBSERVED TWISTING

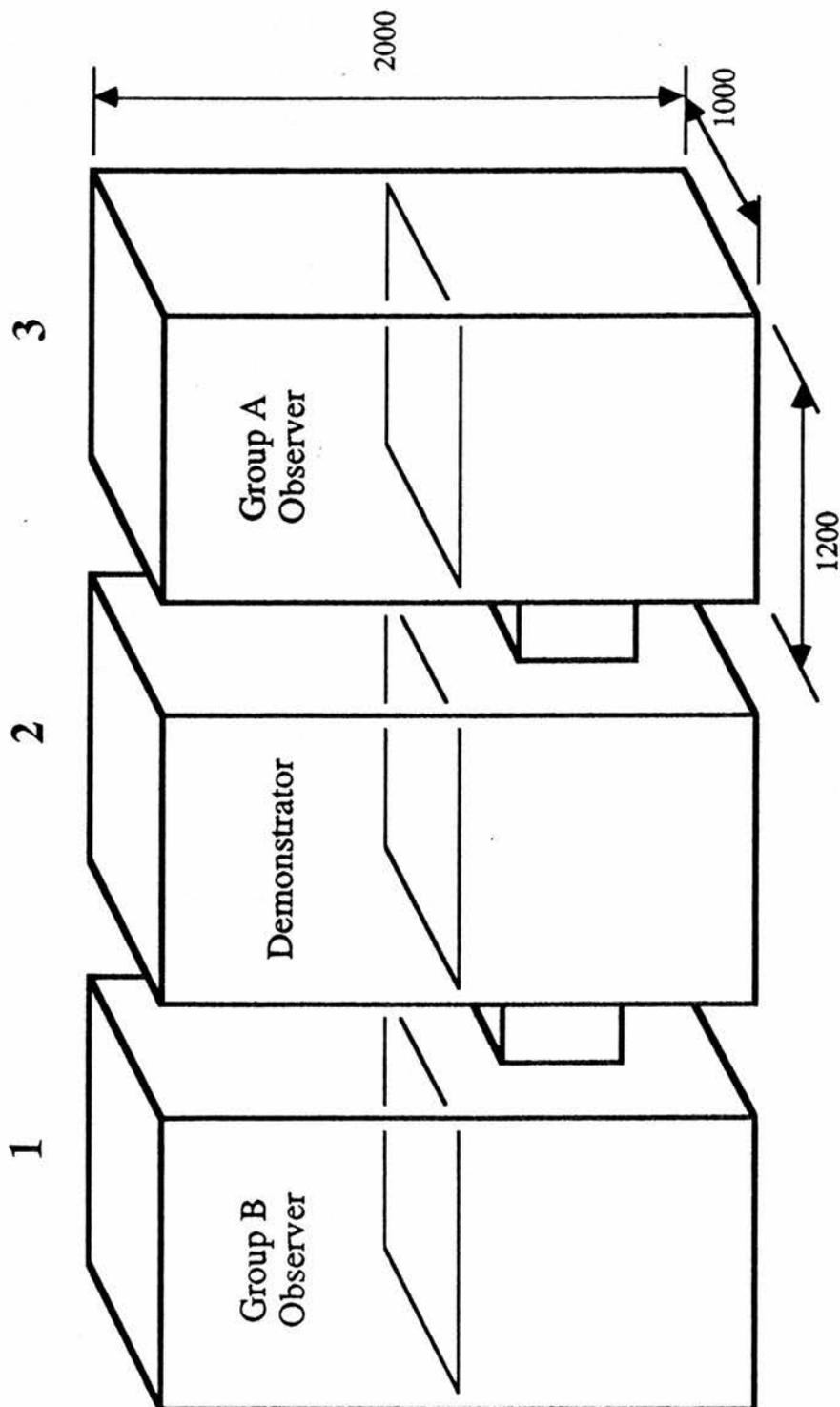
FRED
LITA
RHONA
MIRIUM
CAROL
SAM
JEFF
NEIL *
COLA *

B - OBSERVED PULLING

PHIL
JONATHON
CATH
ROSIE
JENNY
RUTH
SHANDY
PADDY-JOE *
JANE *

Group A were individually transferred to testing cage three (see Figure 2.3.) and individually exposed to Penny demonstrating twisting the T-bar to receive a peanut reward. Each monkey was allowed a three minute observation period. Figure 2.3. illustrates the position of the demonstrator and the observer in the demonstration period.

Similar procedures were used for group B. Members of this group were individually transferred to testing cage 1 to observe Maureen pulling the T-bar to receive a peanut reward through a hole in the bar.



(All dimensions in millimetres)

Figure 2.3. Testing cages. Diagram showing the three testing cages with the demonstrator in the middle cage and the observer in the adjacent cage.

D. Testing: A second demonstration was allowed for a period of three minutes and took place not more than 24 hours after the first demonstration. The demonstrator monkey was then transferred out of the testing cage, and the observer monkey was immediately transferred into the area of the testing cage 2 containing the apparatus (Figure 2.3). The testing period began as soon as the monkey entered this area, and lasted for three minutes. The testing period was recorded on VHS video. At the end of the testing period the monkey was released back into the social group.

E. Analysis of videos: was conducted using a stop watch to record the duration of attention to the relevant periods of the demonstration. A study by Visalberghi and Fragaszy (in press) suggested that the primary determinant of a monkey's success at solving a task was the attention of the monkey to the demonstrator. Those monkeys observed less than half a minute of the demonstration did not appear motivated to solve the task. Therefore it was decided that only those monkeys who observed more than 30 seconds of relevant demonstration would be used in the analysis. The most common behaviour when not observing the demonstrator was exploratory behaviour. Other behaviours demonstrated by the observer were displaying, vocalizing, pacing and resting.

B. RESULTS

Two subjects; Neil and Cola, did not observe more than 30 seconds of relevant demonstration and were thus removed from the analysis. Another monkey; Jane, was unable to be used because she became pregnant and was removed from the social group. Paddy-Joe was unable to be used because he was removed from the group due to increased aggression with Jeff. The subjects that were not used in the analysis are starred in Table 2.2. The remaining sample size was $n=7$ for both group A and group B. All raw data for each monkey's interaction with the apparatus can be found in Appendix II.

The ratio of pull/total duration, extent, number and effort, was used as the index for the calculations. A ratio was necessary because of the variance in the amount of interaction of each monkey with the apparatus, i.e. the number of trials.

I. PERCENT CONCORDANCE

The percent concordance, defined as the percent of subjects performing the same motor pattern as their respective demonstrators was calculated for each trial. This was the method of analysis used by Dawson and Foss (1965) and Galef et al (1986). In Experiment I Jeff only interacted with the apparatus for four trials. As a result the percent concordance could only be calculated for trial one to four because hereafter there was an unequal number of subjects.

The percent concordance is shown in Table 2.3. Y indicates that the observer used the same motor pattern as its demonstrator and N indicates that it did not use the same motor pattern as its demonstrator.

The percent concordance never reached significance (Binomial Test, $n=7$, $x=4$, $p<.05$), although three out of the four values were equal to, or greater than the expected 50%. Figure 2.4 is a graphical representation of these results. It is possible that this could have happened by chance alone.

Table 2.3. Experiment I Percent Concordance. The percentage of the observers that used the same motor pattern as their respective demonstrators is shown where Y=Yes, the same motor pattern was used and N=No, the observer did not use the same motor pattern as its demonstrator.

TRIAL SUBJECT	1	2	3	4	
Group A					
Lita		Y	Y	N	Y
Carol		Y	Y	N	Y
Sam		Y	N	Y	Y
Jeff		Y	N	N	Y
Fred		Y	Y	N	Y
Rhona		Y	Y	N	Y
Miriam		Y	Y	Y	Y
Group B					
Phil		N	Y	N	Y
Jon		N	Y	N	Y
Cath		Y	N	Y	N
Rosie		N	N	Y	N
Jenny		Y	N	N	N
Ruth		N	N	Y	N
Shandy		N	N	N	N
CONCORDANCE		9	7	5	9
TOTAL=14					
%CONCORDANCE		64	.50	.36	.64

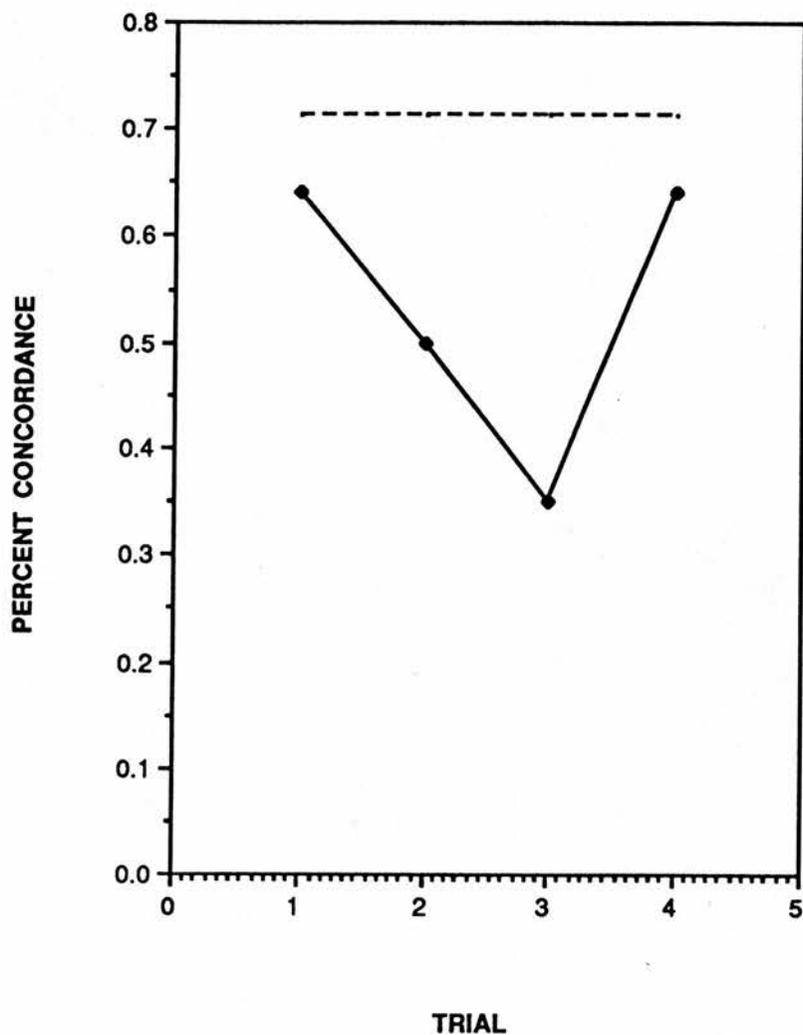


Figure 2.4. Experiment I. Percent concordance between motor pattern used by observer and demonstrator.

- Percentage of the subjects using the same motor pattern as their respective demonstrator in trial one to four.
- - - Level of significance ($p < 0.05$)

II. TEST FOR OVERALL DIFFERENCE BETWEEN GROUP A AND B

In order to test if there was an overall difference between Group A and Group B a Mann-Whitney-U-Wilcoxon Test (Minitab) was used on the pull/total ratio over the whole three minute testing period for each of the four categories; DURATION, EXTENT, NUMBER and EFFORT.

Mann-Whitney-U-Wilcoxon Test (Minitab) showed that there was no overall significant difference ($p < .05$) between the PULL/TOTAL ratio of monkeys in Group A (observed twisting) and monkeys in Group B (observed pulling) (Table 2.4).

Table 2.4. Experiment I. Test for overall difference between group A and group B. Values of W for Mann-Whitney-U-Wilcoxon Test for total pull/total DURATION, EXTENT, NUMBER and EFFORT between group A (observed twisting) and group B (observed pulling) ($n=7$).

	DURATION	EXTENT	NUMBER	EFFORT
W	57.5	53.5	58.5	58.5

Figure 2.5, illustrates the median pull/total ratio over the three minute testing period for group A (watched twisting), and group B (watched pulling), for the DURATION, EXTENT, NUMBER, AND EFFORT respectively.

Although there appears to be a large difference between the pull/total medians in each category, Figure 2.6 illustrates the great variation in pull/total ratio between subjects and therefore why Group A and Group B were not found to be significantly different. The actual numerical data for each subject can be found in Appendix IV.

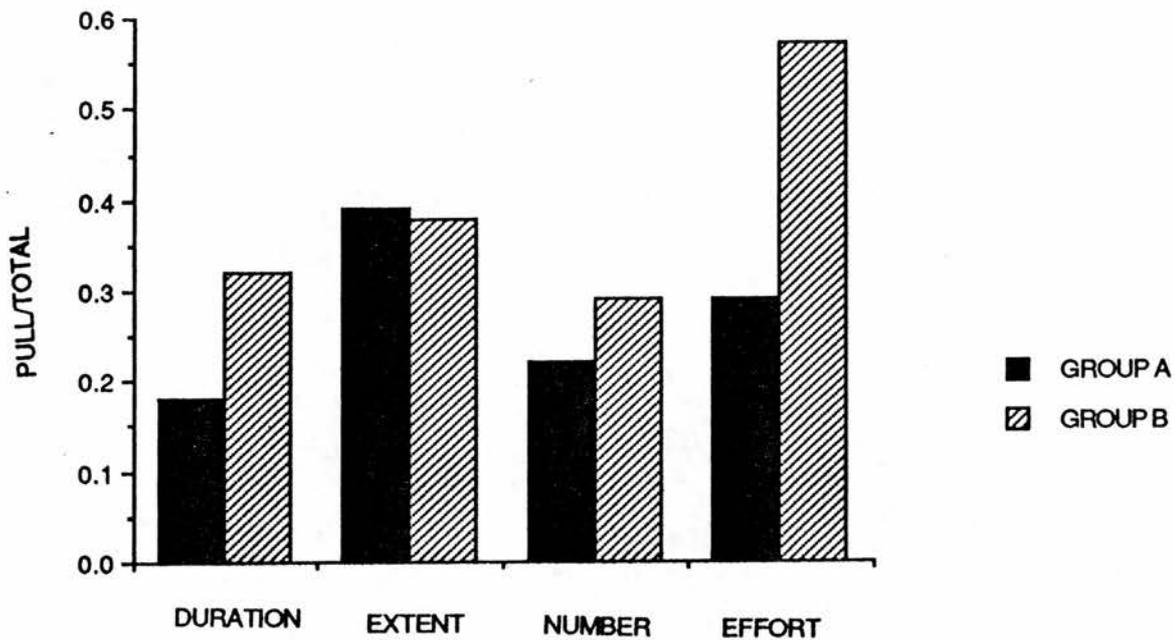


FIGURE 2.5. Experiment I. Median overall pull/total. Medians for pull/total DURATION, EXTENT, NUMBER and EFFORT calculated for the three minute testing period for group A (observed twisting) and group B (observed pulling).

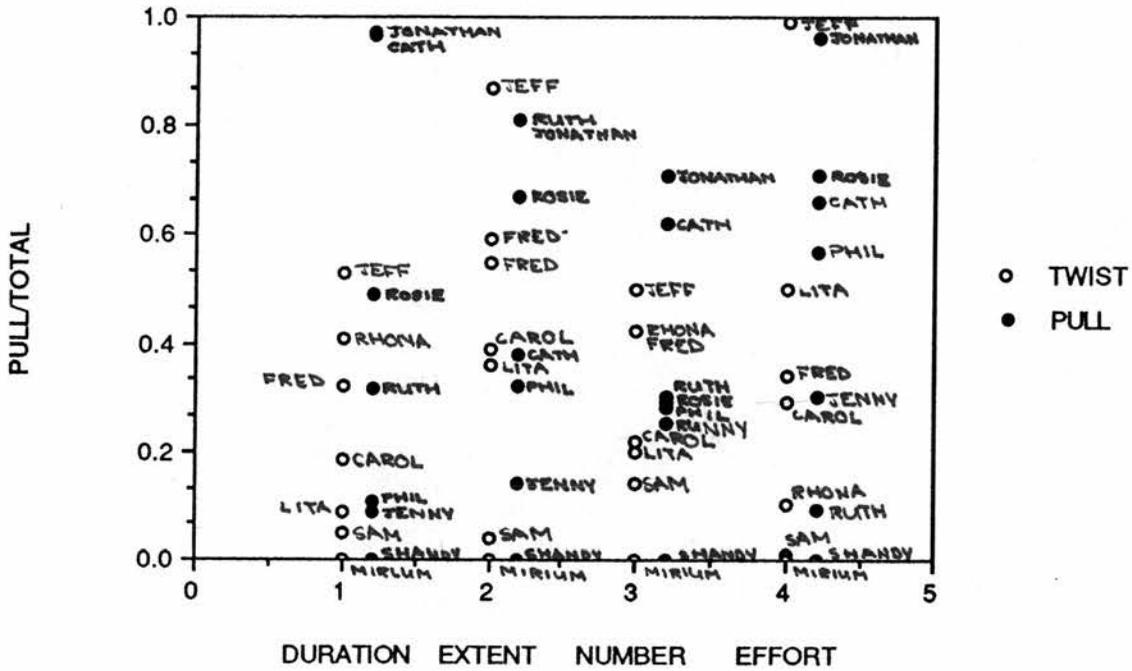


Figure 2.6. Experiment I. Overall variation.

Variation in pull/total ratio for the three minute testing period for DURATION, EXTENT, NUMBER and EFFORT for Group A (observed twisting) and Group B (observed pulling).

III. TEST FOR INITIAL DIFFERENCE BETWEEN A AND B

Even though no difference between Group A and Group B was found at the end of the three minute testing period, given that the subjects were not rewarded for their interactions with the apparatus, an earlier effect may have occurred. It is predicted that if this effect is in fact observed then it would fade over time due to the lack of reinforcement.

Therefore the pull/total ratios were calculated for the first few trials only to see if there was a difference between Group A and Group B initially. The total duration of pulling was calculated for trials one and two. This was then divided by the total duration of pull+twist for trials one and two. The total duration for trials one, two and three was then calculated and divided by the total pull+twist for trials one, two and three. This ratio was calculated up to trial seven because hereafter the sample size became too small. A similar procedure was used for EXTENT, NUMBER and EFFORT.

Because at least two values were needed for the above calculation, a pull/total ratio could not be used for trial one. These ratios were calculated for each monkey and then the median ratio for Group A and Group B for each trial for the DURATION, EXTENT, NUMBER, and EFFORT were plotted. Figure 2.7 a,b,c,d shows the difference in the pull/total ratios between Group A and Group B for the duration, extent number and effort for trials two to seven. The actual ratios for each subject are given in Appendix III.

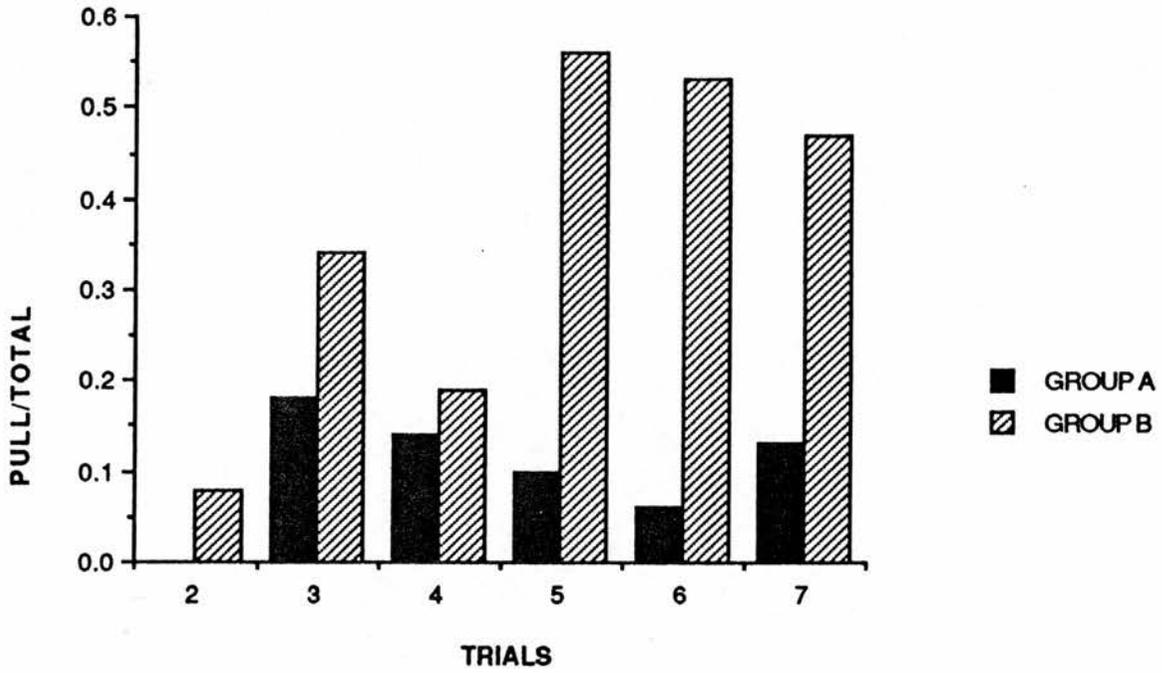


FIGURE 2.7a. Experiment I. Median Duration. Medians for cumulative trials two to seven pull/total DURATION between group A (observed twisting) and group B (observed pulling).

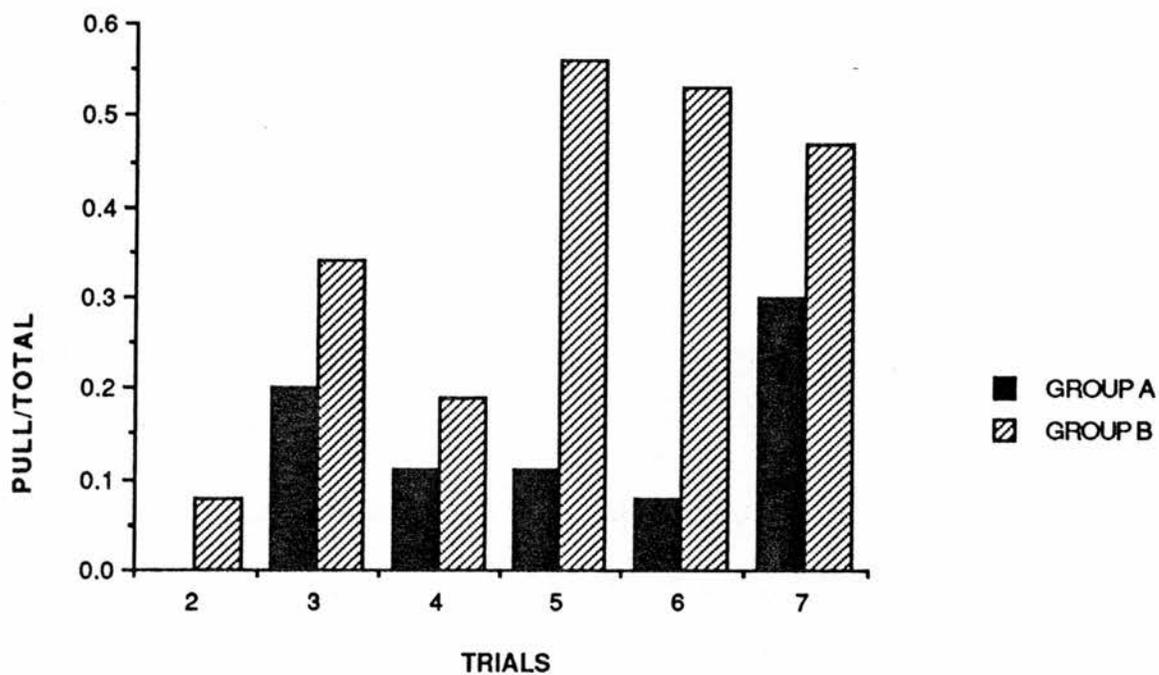


FIGURE 2.7b. Experiment I. Median Extent. Medians for cumulative trials two to seven pull/total EXTENT between group A (observed twisting) and group B (observed pulling).

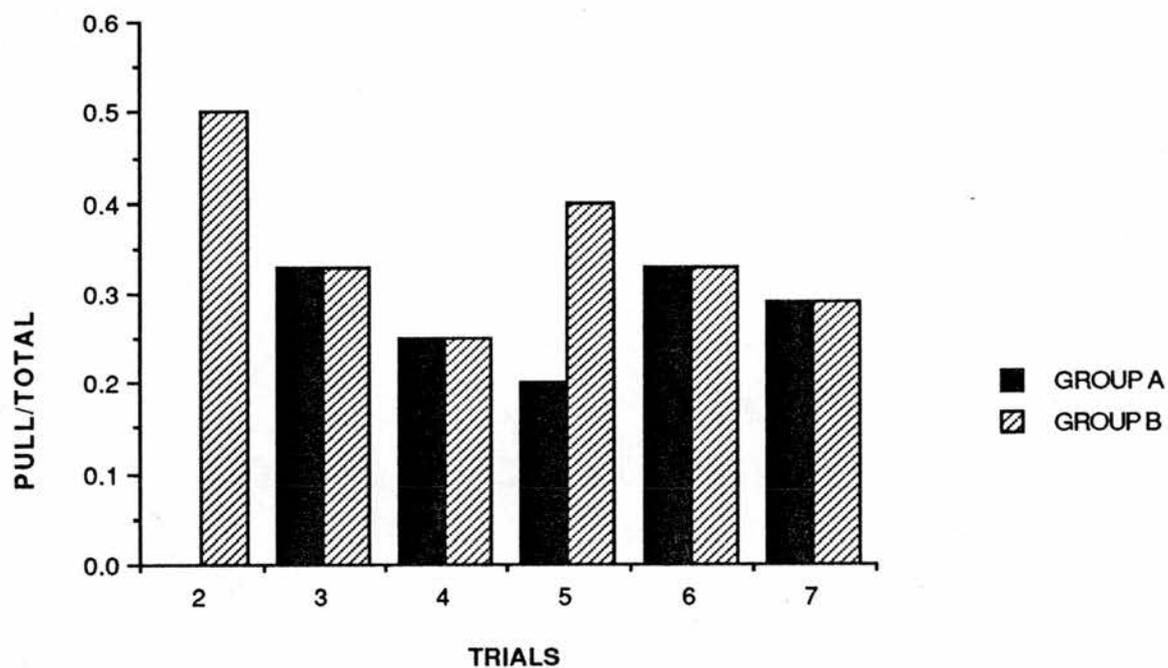


FIGURE 2.7c. Experiment I. Median Number. Medians for cumulative trials two to seven pull/total NUMBER between group A (observed twisting) and group B (observed pulling).

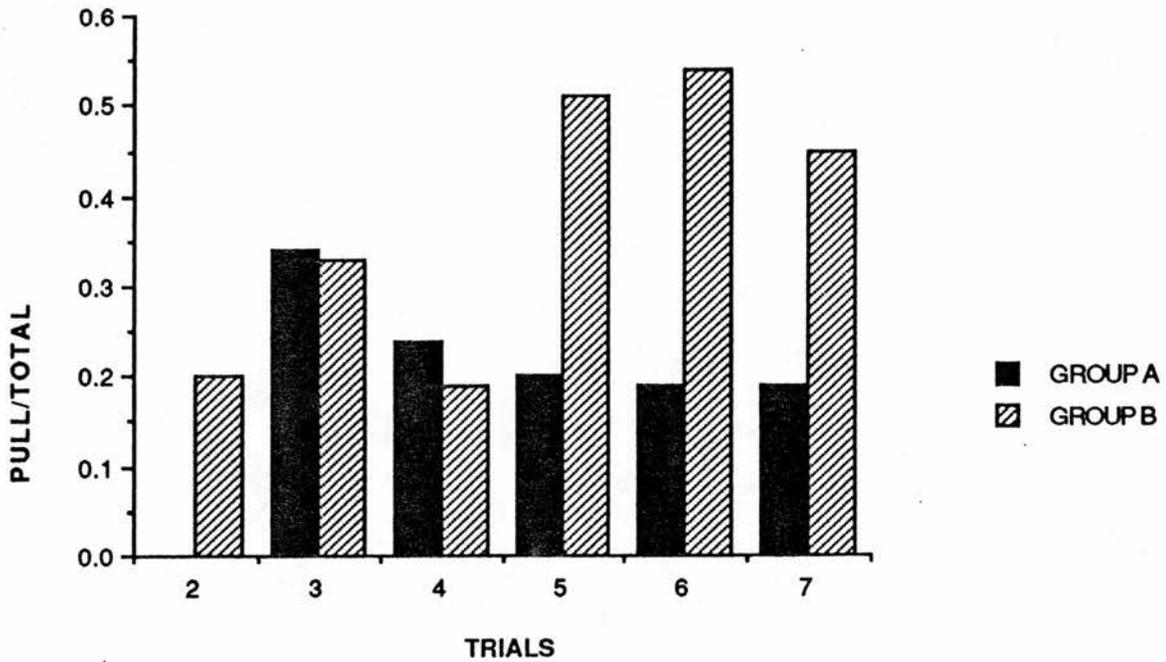


FIGURE 2.7d. Experiment I. Median Effort. Medians for cumulative trials two to seven pull/total EFFORT between group A (observed twisting) and group B (observed pulling).

A test was performed to illustrate when the difference between Group A and Group B during these initial trials was greatest.

To test for the degree of separation between the values, the pull/total ratio for Group B was divided by the pull/total ratio for Group A + Group B. The farther this calculated value was from 0.5, the greater the separation between the pull/total median for Group A and Group B. Figure 2.8 plots the proportion values.

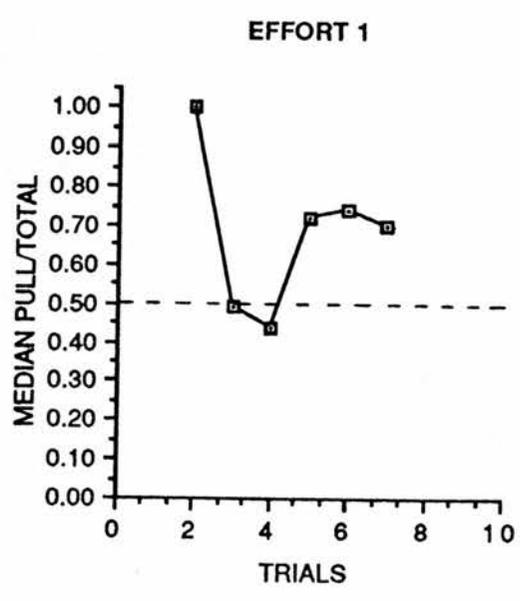
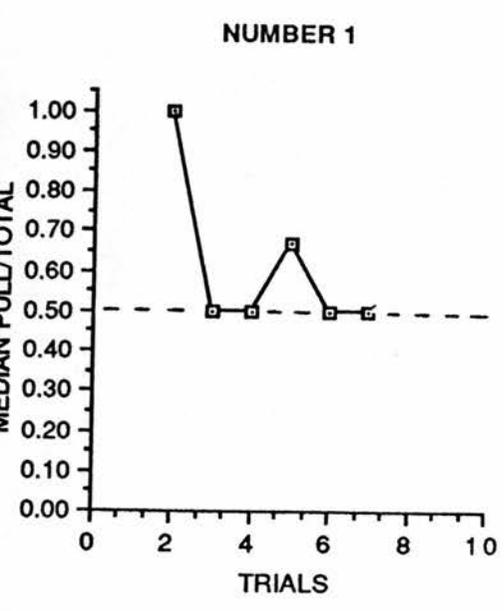
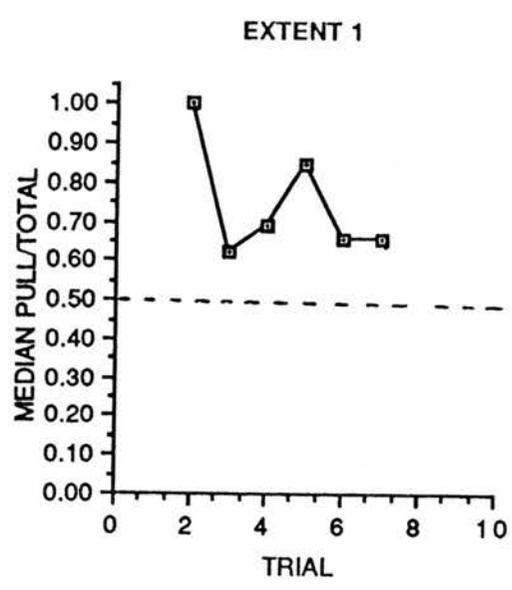
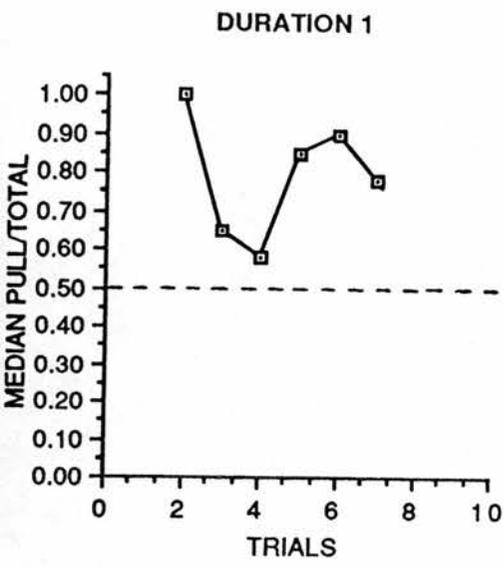


Figure 2.8. Experiment I. Test for degree of separation between the medians of Group A and B. The pull/total median for Group B divided by the pull/total median for Group A + Group B for trials one to seven. Large deviations from 0.5 indicate a large separation between the medians in Group A and Group B.

IV. TEST FOR DELAYED DIFFERENCE BETWEEN A AND B

As an alternative to the hypothesis advanced in III there may have been delayed imitation due to initial exploration or unfamiliarity with the apparatus. Therefore the trials were grouped and the pull/total ratio calculated for trials one to three and for trials four to seven. The pull/total ratios for trials one to three can be found in Appendix III and the pull/total ratios for trials four to seven can be found in Appendix V. A Mann-Whitney-U-Wilcoxon Test (Minitab) was conducted between Group A and Group B for trials one to three and then between Group A and Group B for trials four to seven. A significant difference ($p < 0.05$) was found between trials four to seven for all categories; DURATION, EXTENT, NUMBER and EFFORT (Table 2.5).

Table 2.5. Experiment I. Test for delayed difference between Group A and B. Values of W for Mann-Whitney-U-Wilcoxon Test for difference between Group A and B for trials 1-3 and between Group A and B for trials 4-7 for pull/total ratio for DURATION, EXTENT, NUMBER and EFFORT (*=significance at $p < 0.05$)

	DURATION	EXTENT	NUMBER	EFFORT
1-3	54.5	55.5	53.0	51.5
4-7	71.0*	73.0*	71.5*	72.0*

V. TEST BETWEEN MAXIMUMS

There was no significant difference between the maximum values of duration, extent, or effort, at the 0.05 level of significance for monkeys in group A and group B. (Table 2.6.)

Table 2.6. Experiment I. Test for difference between maximum values in group A and group B. Values of W for Mann-Whitney-U-Wilcoxon Test on the maximum values for the pull/total ratio of DURATION, EXTENT, NUMBER and EFFORT for each monkey, between group A (observed twisting) and group B (observed pulling) are given (n=7).

	DURATION	EXTENT	EFFORT
MAXIMUM PULL	57.5	50.5	63.0
MAXIMUM TWIST	53.0	36.5	55.0

VI. TEST FOR CONSISTENCY IN BIAS

A Spearman rank correlation was conducted between the pull/total values for trials 1-3 and 4-7 for both Group A and Group B in order to test if there was a consistency in the pull/total ratio for each monkey over time. The test was conducted to see if the same monkeys were responsible for the large variation within the groups throughout the trials.

A significant correlation was found for the DURATION and EXTENT for Group B but no significant correlation was found between the pull/total ratio in trials 1-3 and 4-7 for Group A (Table 2.7).

Table 2.7. Experiment I. Test for consistency in bias. Values of r for Spearman Rank Correlation between the pull/total ratio for trials 1-3 and 4-7 for Group A and B for DURATION, EXTENT, NUMBER and EFFORT. (*=significance at $p < 0.05$, $t = 0.714$, $n = 7$).

	DURATION	EXTENT	NUMBER	EFFORT
GROUP A	.521	.072	0.00	-.227
GROUP B	*.962	*.782	.649	.014

VII. CORRELATION BETWEEN PULL/TOTAL AND TIME SPENT OBSERVING

There was no significant correlation between the amount of time the monkey spent observing the relevant parts of the demonstration and the pull/total ratio (Table 2.8). Nineteen out of the twenty-eight correlation coefficients for both Group A and Group B were negative. The duration of observation of the relevant parts of the demonstration for each monkey are given in Appendix VI.

Table 2.8. Experiment I. Correlation between pull/total and time spent observing. Pearson's correlation coefficient for an analysis between the pull/total ratio for DURATION, EXTENT, NUMBER and EFFORT and the time spent observing relevant parts of the demonstration are given. ($t_{critical}=.714, n=7$)

GROUP B (OBSERVED PULLING)				
TRIAL	DURATION	EXTENT	EFFORT	NUMBER
2	-0.351	-0.131	0.514	0.170
3	-0.445	-0.227	0.685	0.211
4	-0.440	-0.157	0.691	0.204
5	-0.432	-0.326	0.013	-0.090
6	-0.421	-0.326	0.013	-0.090
7	-0.334	-0.155	0.012	-0.184
TOTAL	-0.413	-0.075	-0.394	-0.184
GROUP A (OBSERVED TWISTING)				
TRIAL	DURATION	EXTENT	EFFORT	NUMBER
2	-0.395	-0.347	-0.410	-0.416
3	-0.180	-0.335	0.139	-0.038
4	-0.218	-0.326	0.188	-0.038
5	-0.181	-0.330	0.179	-0.109
6	-0.139	-0.323	0.183	0.076
7	0.214	0.540	0.099	-0.241
TOTAL	-0.056	0.031	-0.092	-0.035

Analysis of the videos indicated that some of the subjects may have not observed extended periods of the demonstration because of isolation induced stress. The video revealed the presence of pacing behaviour and contact whistles, indicating that some animals were under stress at being separated from the rest of the group.

EXPERIMENT 2

A second experiment was conducted in attempts to decrease isolation induced stress of the observer monkey. A metal divider was placed between the testing cages in order to prevent movement from the small section of the main cage into the larger section of the main cage. Group A (subjects that had observed twisting) were housed in the smaller section of the enclosure, and group B (subjects that had observed pulling) were housed in the larger section of the enclosure. The division of the colony is shown in Table 2.9. When twisting was being demonstrated, the left side of the colony was left open, and the right side was closed off from the hatch. The opposite arrangement was used when twisting was being demonstrated.

Demonstration took place over a period of three weeks. Observer monkeys were filmed with VHS video. Starting on March 1, monkeys were then tested individually after a demonstration period.

Table 2.9. Division of colony II. Those monkeys in group A observe Penny twisting, and those in group B observed Maureen pulling the T-bar in order to receive a peanut reward. (* indicate those subjects not used in the analysis)

A - OBSERVED TWISTING	B - OBSERVED PULLING
FRED	PHIL
LITA	JONATHON
CAROL	CATH
SAM	ROSIE
JEFF	JENNY
COLA	RUTH
NEIL	SHANDY
RHONA*	SARAH*

RESULTS

Two of the subjects were not included in the analysis because they did not attend to 30s of relevant demonstration (as indicated by * in Table 2.9).

PERCENT CONCORDANCE

The percent of subjects performing the same motor pattern as their respective demonstrators was calculated for trial one to four. As in Experiment I no more trials could be used in this analysis because there was an unequal number of subjects in the calculation after trial four.

The percent concordance is shown in Table 2.10. Y indicates that the observer used the same motor pattern as its demonstrator and N indicates that it did not use the same motor pattern as its demonstrator.

The percent concordance never reached significance (Binomial Test , $n=7$, $x=4$ $p<.05$), although four out of the four values were equal to , or greater than the expected 50% . Figure 2.9 is a graphical representation of these results. This could have happened by chance alone.

Table 2.10. Experiment II. Percent Concordance. The percentage of the observers that used the same motor pattern as their respective demonstrators is shown where Y=Yes, the same motor pattern was used and N=No, the observer did not use the same motor pattern as its demonstrator.

TRIAL	1	2	3	4
SUBJECT				
Group A				
Lita	N	Y	Y	Y
Carol	Y	N	N	Y
Sam	Y	Y	Y	Y
Jeff	Y	Y	N	N
Fred	Y	N	Y	N
Neil	Y	Y	Y	Y
Cola	Y	Y	Y	Y
Group B				
Phil	N	N	Y	Y
Jon	N	N	N	N
Cath	N	Y	Y	N
Rosie	Y	N	N	N
Jenny	N	Y	Y	N
Ruth	N	Y	N	N
Shandy	N	Y	Y	Y
CONCORDANCE	7	9	9	7
TOTAL=14				
%CONCORDANCE	50	.64	.64	.50

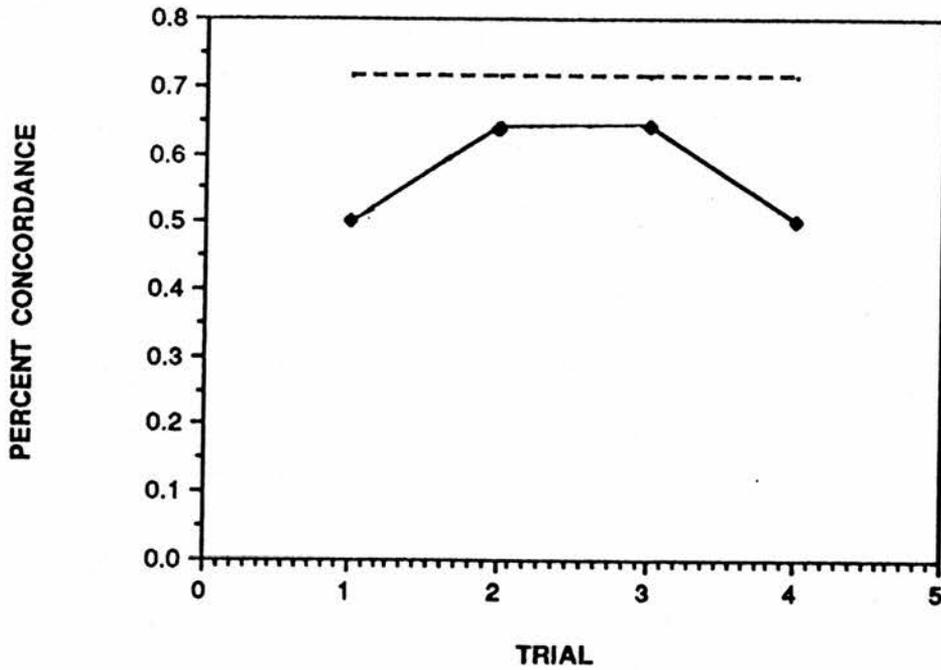


Figure 2.9. Experiment II. Percent concordance between motor pattern used by observer and demonstrator.

- Percentage of the subjects using the same motor pattern as their respective demonstrator in trial one to four.
- - - Level of significance ($p < 0.05$)

I. TEST FOR OVERALL DIFFERENCE BETWEEN GROUP A AND B

As in Experiment I, a Mann-Whitney-U-Wilcoxon Test (Minitab) was used on the pull/total ratio for the overall value at the end of the three minute testing period. The test was conducted in order to test if there was an overall difference between Group A and Group B. This calculation was performed for each of the four categories; DURATION, EXTENT, NUMBER and EFFORT.

Mann-Whitney-U-Wilcoxon Test (Minitab) showed that there was no overall significant difference ($p < .05$) between the PULL/TOTAL ratio of monkeys in Group A (observed twisting) and monkeys in Group B (observed pulling) (Table 2.11).

Table 2.11. Experiment II. Test for overall difference between group A and group B. Values of W for Mann-Whitney-U-Wilcoxon Test for total pull/total DURATION, EXTENT, NUMBER and EFFORT between group A (observed twisting) and group B (observed pulling) (n=7).

	DURATION	EXTENT	NUMBER	EFFORT
W	58.0	53.5	55.0	57.0

Figure 2.10. illustrates the median pull/total ratio over the three minute testing period for group A (watched twisting), and group B (watched pulling), for the DURATION, EXTENT, NUMBER, AND EFFORT respectively.

Although there appears to be a large difference between the pull/total medians in each category, Figure 2.11 illustrates the great variation in pull/total ratio between subjects and therefore why Group A and Group B were not found to be significantly different.

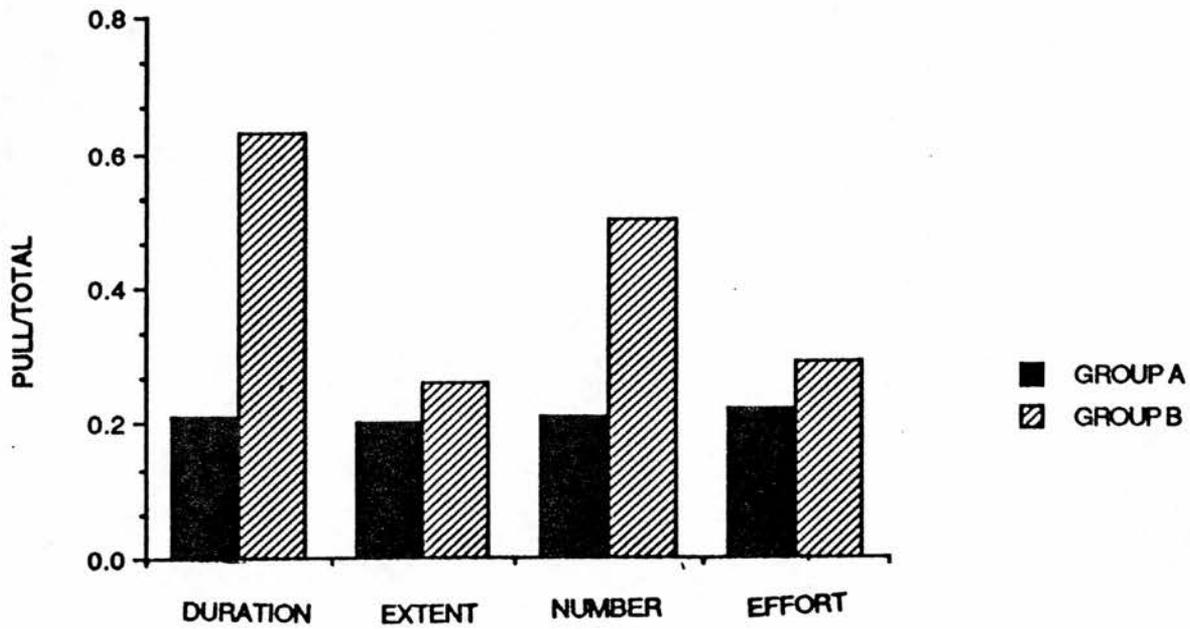


FIGURE 2.10. Experiment II. Median overall pull/total. Medians for pull/total DURATION, EXTENT, NUMBER and EFFORT calculated for the three minute testing period for group A (observed twisting) and group B (observed pulling).

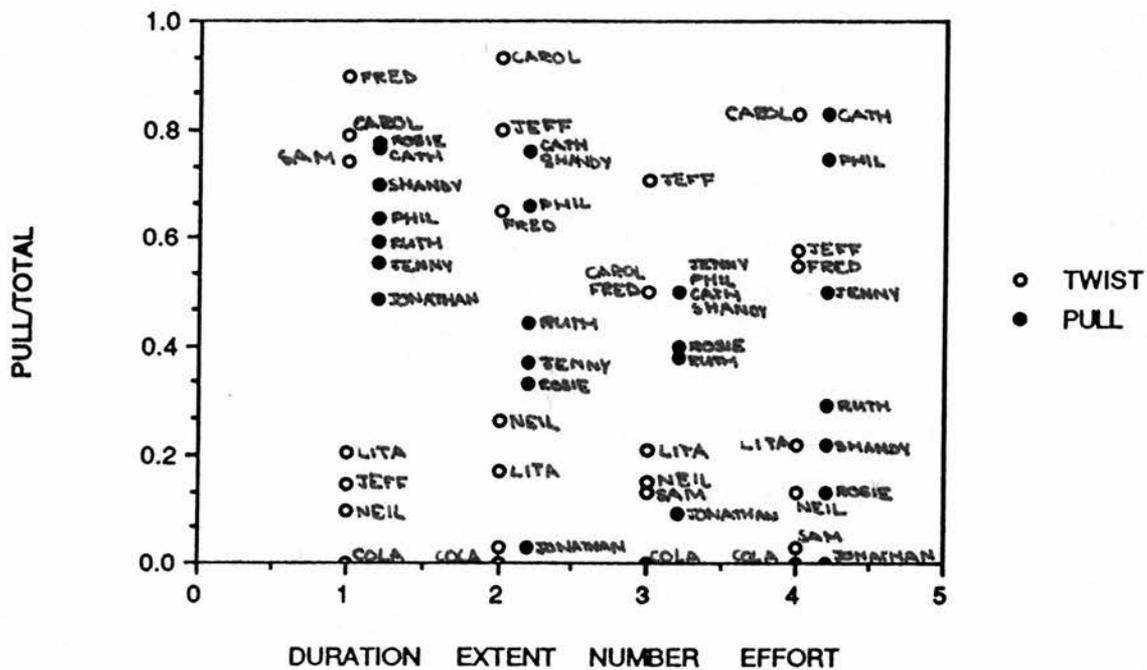


Figure 2.11. Experiment II. Overall variation. Variation in pull/total ratio for the three minute testing period for DURATION, EXTENT, NUMBER and EFFORT for Group A (observed twisting) and Group B (observed pulling).

III. TEST FOR INITIAL DIFFERENCE BETWEEN A AND B

To test for a difference between Group A and Group B that may have occurred earlier and faded with time, the pull/total ratio was calculated for cumulative trials two to seven (a more detailed description of this calculation is given in Experiment I). The median ratio for Group A and the median ratio for Group B for each trial are plotted in Figure 2.12abcd.

Figure 2.13 illustrates the amount of separation between these medians for Group A and Group B, as calculated in Experiment I.

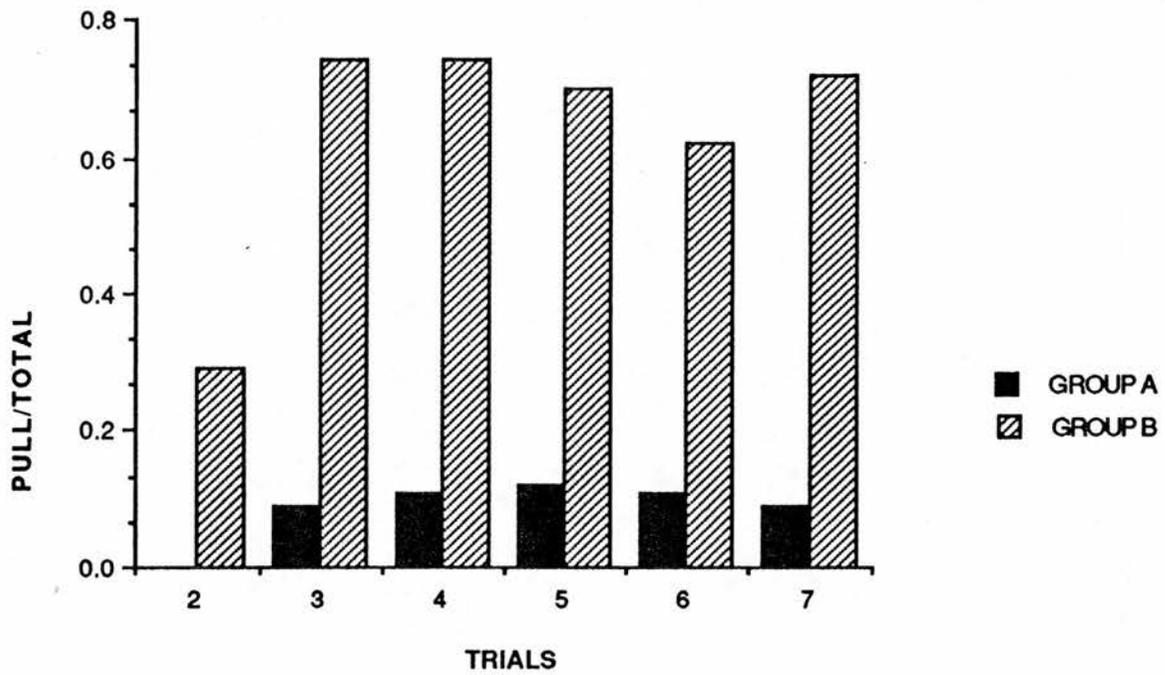


FIGURE 2.12a. Experiment II. Median Duration. Medians for cumulative trials two to seven pull/total DURATION between group A (observed twisting) and group B (observed pulling).

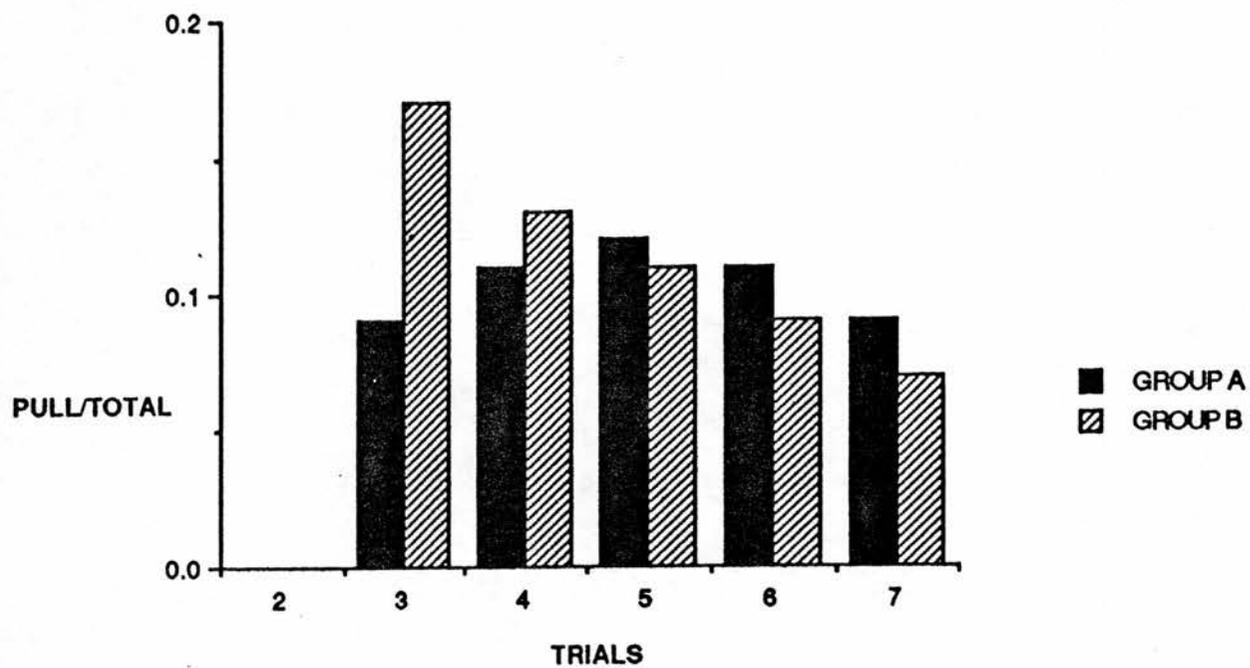


FIGURE 2.12b. Experiment II. Median Extent. Medians for cumulative trials two to seven pull/total EXTENT between group A (observed twisting) and group B (observed pulling).

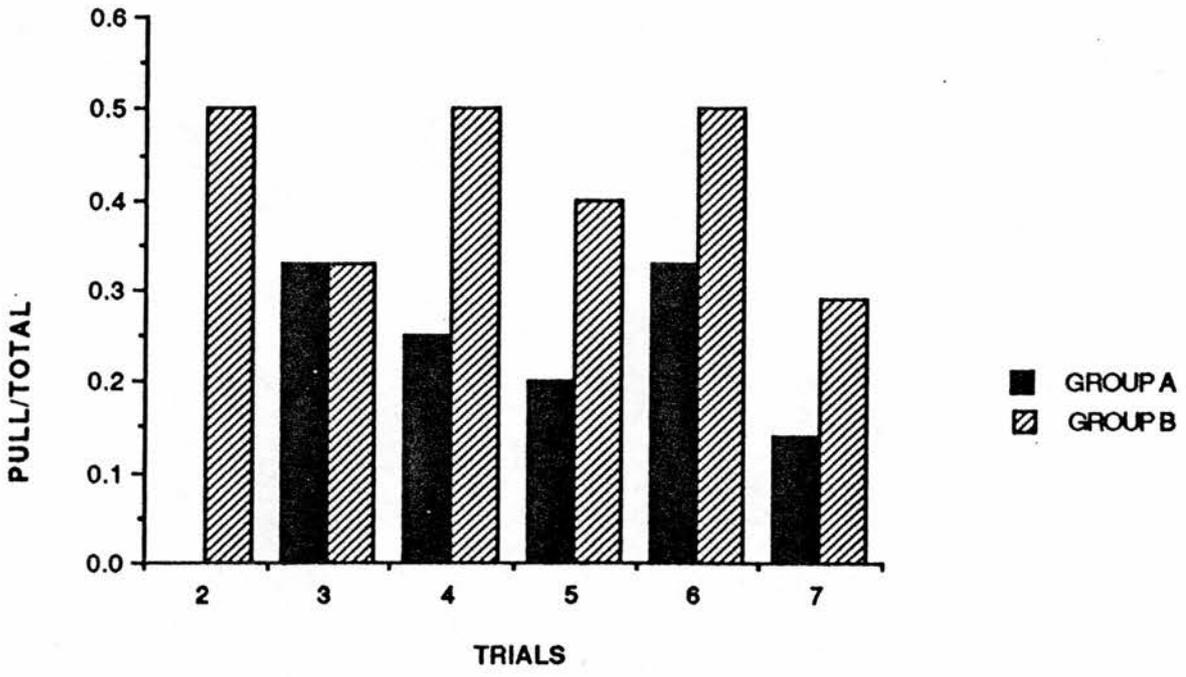


FIGURE 2.12c. Experiment II. Median Number. Medians for cumulative trials two to seven pull/total NUMBER between group A (observed twisting) and group B (observed pulling).

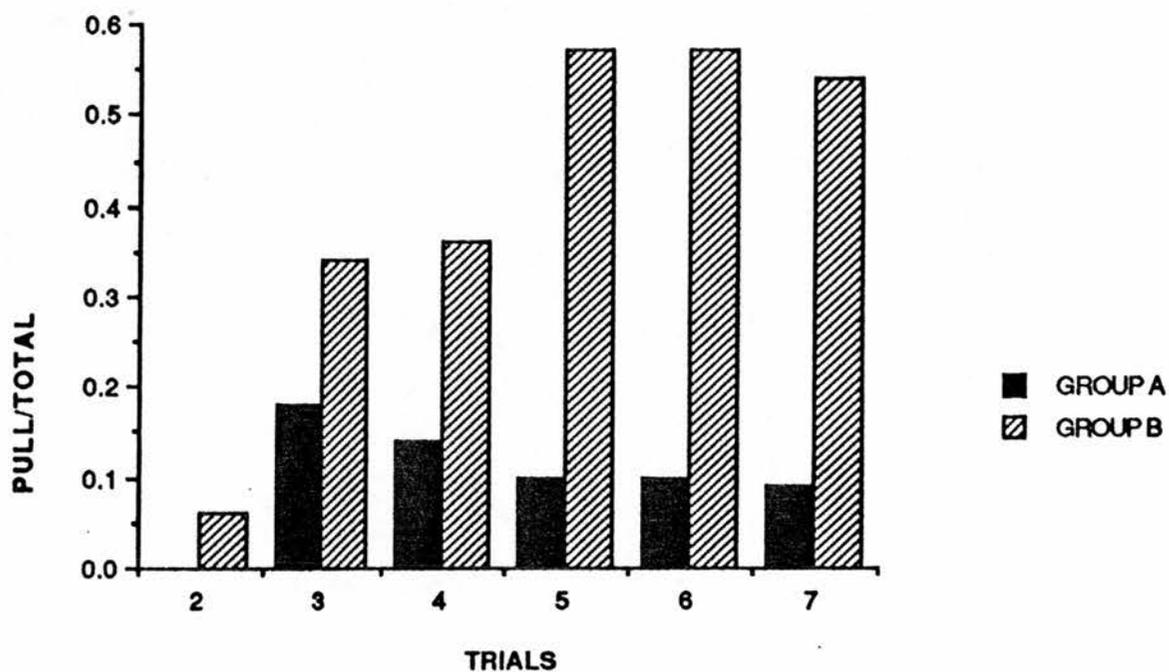
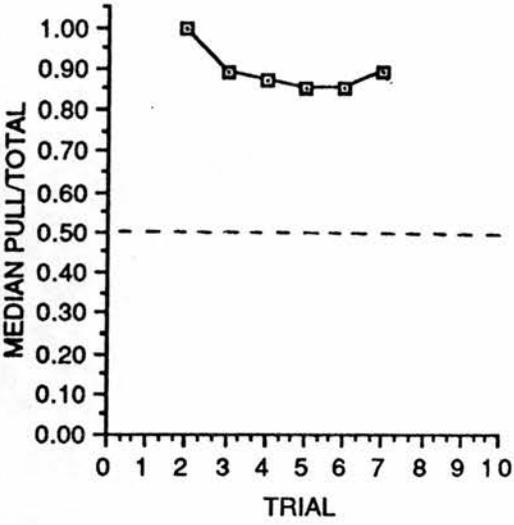
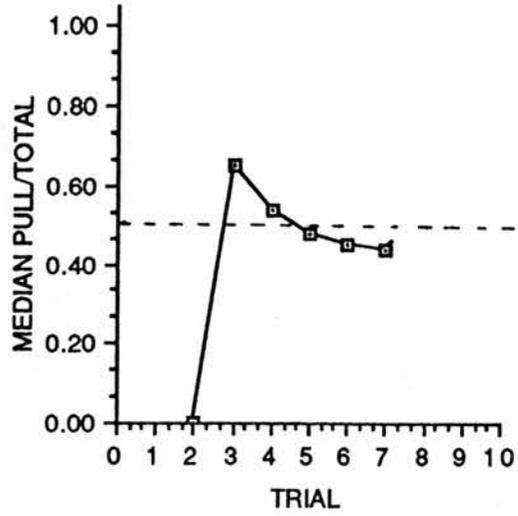


FIGURE 2.12d. Experiment II. Median Effort. Medians for cumulative trials two to seven pull/total EFFORT between Group A (observed twisting) and Group B (observed pulling).

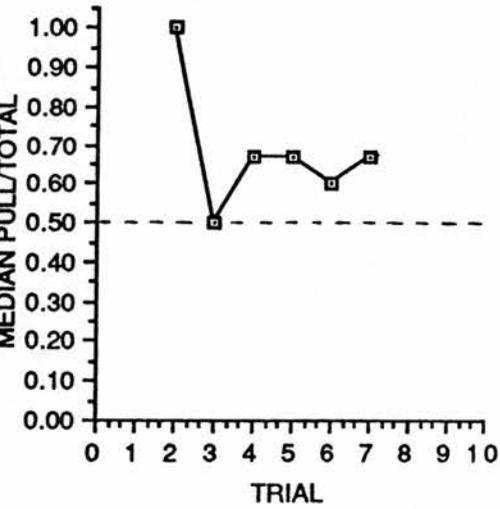
DURATION2



EXTENT 2



NUMBER 2



EFFORT 2

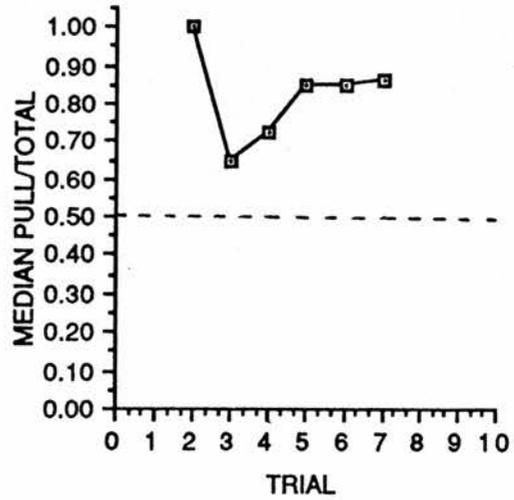


Figure 2.13. Experiment II. Test for degree of separation between the medians of Group A and B. The pull/total median for Group B divided by the pull/total median for Group A + Group B for trials one to seven. Large deviations from 0.5 indicate a large separation between the medians in Group A and Group B.

IV. TEST FOR DELAYED DIFFERENCE BETWEEN A AND B

To allow for initial exploration and unfamiliarity with the apparatus, the trials were grouped into trials 1-3 and 4-7 and the pull/total ratio calculated for each of these groups as in Experiment I. A Mann-Whitney U-Wilcoxon Test (Minitab) was conducted between Group A and Group B for these values. No significant differences ($p < .05$) was found for any categories (Table 2.12).

Table 2.12. Experiment II. Test for delayed difference between Group A and B. Values of W for Mann-Whitney-U-Wilcoxon Test for difference between Group A and B for trials 1-3 and between Group A and B for trials 4-7 grouped, for pull/total ratio for DURATION, EXTENT, NUMBER and EFFORT.

	DURATION	EXTENT	NUMBER	EFFORT
1-3	65.5	56.5	62.5	60.5
4-7	58.0	57.0	57.5	57.0

V. TEST BETWEEN MAXIMUMS

Mann-Whitney-U test (Minitab) indicated that there was no significant difference between the maximum value for duration, and extent and effort Table 2.13

Table 2.13. Experiment II. Test for difference between maximum values in group A and group B. Values of W for Mann-Whitney-U-Wilcoxon Test on the maximum values for the pull/total ratio of DURATION, EXTENT, NUMBER and EFFORT for each monkey, between group A (observed twisting) and group B (observed pulling) are given (n=7).

	DURATION	EXTENT	EFFORT
MAXIMUM PULL	55.0	50.0	56.5
MAXIMUM TWIST	45.0	42.0	40.0

VI. TEST FOR CONSISTENCY IN BIAS

A Pearson's correlation was conducted between the pull/total values for trials 1-3 and 4-7 for both Group A and Group B in order to test if the same monkeys were responsible for the large variation within the groups. A significant correlation was found for Group A for DURATION, EXTENT and EFFORT.

Table 2.14. Experiment II. Test for consistency in bias. Values of r for Spearman Rank Correlation between the pull/total ratio for trials 1-3 and 4-7 for Group A and B for DURATION, EXTENT, NUMBER and EFFORT.

	DURATION	EXTENT	NUMBER	EFFORT
GROUP A .665	.852	.491	.840	
GROUP B .334	.466	.481	.454	

V. TEST FOR DIFFERENCE BETWEEN EXPERIMENT I AND II

It is possible that either (i) there is a learning effect in which the subjects performance would improve with subsequent demonstration periods, or that (ii) performance may worsen because of boredom or because of the lack of reinforcement.

A Mann-Whitney-U was conducted in order to test if there was a significant difference between the pull/total ratio for DURATION, EXTENT, NUMBER and EFFORT between Experiment I and Experiment II for Group A and Group B.

No significant difference was found for either group A or Group B ($p < .05$) (Table 2.15)

Table 2.15. Test for difference between Experiment I and Experiment II. Values of W for Mann-Whitney-U-Wilcoxon test between Experiment I and Experiment II for the DURATION, EXTENT, NUMBER and EFFORT.

GROUP	DURATION	EXTENT	NUMBER	EFFORT
A	45.5	52.5	50.0	50.5
B	43.0	52.0	55.5	46.0

CHAPTER III. DISCUSSION

These results show that the Macaca arctoides did not demonstrate the imitative ability attributed to monkeys in earlier literature reviewed above. These findings are similar to those of Galef et al. (1986) in their experiment with budgerigars because although the overall results are not significant, a trend exists in the predicted direction.

The reduction in sample size for reasons described above was unfortunate; however, the results still confirm the "fragility" (Visalberghi and Fragaszy in press) of imitation in monkeys, if it exists at all.

Although the percent of the subjects performing the same motor pattern as their respective demonstrators never reached significance, the trend was in the predicted direction insofar as in Experiment I three out of the four values were equal to or greater than 0.5, and in Experiment II four out of the four values were either equal to or greater than 0.5.

Similarly, in Experiment I the overall pull/total ratios for DURATION, EXTENT, NUMBER and EFFORT were greater for Group B than for Group A and in Experiment II all categories but EXTENT were greater for Group B than for Group A. Again none of these values were shown to be significant. Figures 2.6 and 2.11 clearly illustrates the role of the great variation in pull/total ratio between subjects in this lack of significance. Because both of these tests give results that show trends in the predicted direction, this is consistent with a weak tendency to imitate, and suggests caution in taking these results as negative evidence for an ability to imitate.

In Experiment I all medians (except trials three and four for EFFORT) for Group B were found to be equal to, or greater than those for Group A. In Experiment II all medians (except for trials five, six and seven for EXTENT) for Group B were found to be equal to, or greater than those for Group A. Although this result is impressive, it must be remembered that each trial is a cumulative value i.e. including the previous trials and thus each value is not independent of the other. Nevertheless, the results are still predominantly in the predicted direction over trials.

The plots of the separation between these medians (Figures 2.8 and 2.13) seems to follow a sinusoidal shape for most of the categories. It is possible that the animal demonstrated the observed motor pattern initially and then tried alternative strategies when this attempt was unrewarded. When the alternative strategy was also unrewarded the motor pattern originally observed may have been attempted again. It is interesting to note that the greatest difference between Group A and Group B was found on trial number two (except fo EXTENT in Experiment II) suggesting that the first interaction of the animal with the apparatus may be the most important for measuring the ability to imitate.

When the trials 1-3 and 4-7 were combined in order to control for initial unfamiliarity and to allow for practice with the apparatus, significance was found between Group A and B for all categories; DURATION, EXTENT, NUMBER and EFFORT for trials 4-7 in Experiment I. No significance was found for this test in Experiment II. The graphs in Figures 2.8 and 2.13 do indicate that although there is an initial decrease in the difference between group A and B after trial two, the difference increases again for trials five, six and seven thus probably causing the difference between Group A and Group B to reach significance for these trials combined.

It is not surprising that there is a significant correlation between the pull/total ratio used in the first set of three trials and the second set of three trials. This indicates a constant bias in the motor pattern employed by each animal over time and trials.

No significant difference in maximum values were found for Experiment I or Experiment II suggesting that there is no strong tendency to perform the observed motor pattern even a few times for a long DURATION or to a long EXTENT.

No significant difference was found between Experiment I and II for any category, thus suggesting that neither a learning phenomenon nor extinction of behaviours due to lack of reward occurred.

It is clear from these results that even if imitation does exist in monkeys, it is certainly not as salient as once believed. As discussed in Chapter one, although there are many accounts of imitation in monkeys in the literature, attempts to demonstrate

imitation *experimentally* have failed. With reference to this experiment, just why may this be so? There are three possible answers to this question. The imitative faculty may not be observed due to (1) experimental limitations, (2) variation in learning strategies or (3) cognitive constraints. These three possibilities will be discussed below.

I. EXPERIMENTAL LIMITATIONS

Imitation may not have been observed due to experimental limitations. Possible problems could arise from lack of motivation to learn, insufficient opportunity to learn, or inadequate modelling of the natural learning situation.

It is possible that the monkeys in this experiment did not imitate due to lack of motivation. Although only those monkeys that observed at least 30 seconds or more of relevant demonstration were used, some monkeys showed increased stress after being transferred to the testing cage and therefore may not have been motivated to solve the task. The younger monkeys also gave indications of isolation induced stress. Future experiments should concentrate on increasing the level of motivation to solve the task.

A second possible limitation in experimental design may be insufficient opportunity to learn. This may be a result of the task being too novel or too complex combined with too short or too infrequent observation periods to provide adequate conditions for learning. However, the ease with which the demonstrators first learned to perform the task and the frequency with which the tested subjects performed both actions, suggest that the motor patterns were not overly complex or novel to have been learned by observation.

Although it would seem beneficial to increase the period of observation to allow the animal a greater chance for understanding the task, an increase in the observation period may also increase the boredom and inattentiveness of the observer. Likewise, if the number of testing periods with no reward is increased then there is the chance of extinction of the responses of the subject toward the apparatus. If familiarity and practice with the apparatus are necessary, one would expect to see an improvement from experiment I to experiment II and this was not found.

Another possible explanation for the lack of imitation is that the experimental situation may not be close enough to the natural learning situation to allow for the imitative ability in monkeys to be expressed. Hall(1968) warns that "by aiming at the experimental precision in the laboratory, before we have discerned some of the major problems that should be the objectives of the precision, we are in danger of setting up a science of learning that is valid only in in the experimental situation". Only further study and increased knowledge of the conditions under which learning takes place in the wild can improve experimental design in this way.

In 1986 Galef et al. conclude about their similar experiment with budgerigars that "the present preparation is not appropriate for extended analysis of the conditions under which imitation learning occurs". However, this seems contradictory to the conclusions Galef (1988) draws about the same experiment when he states;

"The Dawson and Foss procedure of requiring imitation of motor patterns, rather than of the location in which an act is to be performed or the stimuli to which the behaviour is being addressed, goes a long way toward solving problems of control for other types of social learning. Positive outcomes are, therefore, more clearly indicative of "true imitation", of "learning to do an act from seeing it done," than positive outcomes in more commonly employed procedures. Dawson and Foss' work with budgies seems among the most convincing of the scores of laboratory experiments on learning by imitation. I would encourage 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."

I agree with Galef (1988) in that further application of this experimental methodology should be encouraged, especially with primates.

II VARIATION IN LEARNING STRATEGIES

It has been suggested by Visalberghi and Frigaszy (in press) that sparse evidence for imitation in monkeys may simply "reflect variation in strategies within a population rather than the absence of the phenomenon". As discussed earlier, Boyd and Richerson (1988) and Visalberghi and Frigaszy (in press) predict the adaptiveness of social learning to be greater than individual learning when;

- (1) Learning by trial-and-error would be slow
- (2) Opportunities for practice are limited due to the costly results of making mistakes.
- (3) Opportunities to exploit another's expertise are high
- (4) The chance that the imitator's model is experiencing the same environmental conditions is high

Perhaps these criteria are not fulfilled for monkeys and the environmental conditions are such that imitation is not the most adaptive way of learning about the environment. Perhaps in chimpanzees and humans where we see evidence for the imitative ability, the physical or social environment is somehow different to cause a shift towards selection for social learning and more specifically imitation as the more adaptive learning strategy.

Primates are extremely social animals. They are extraordinary among other mammals for having extremely complex social relationships and it is often assumed because monkeys and apes are such social creatures that this would provide numerous opportunities for observing others and therefore to learn by imitation (Jolly 1966). Although an increase in sociality may suggest a greater opportunity to learn by imitation, it also suggests the opportunity for the employment of other learning strategies such as **coaction and exploitation**.

Visalberghi and Fragaszy (in press) suggest that coaction "in which the model allows the learner to participate intimately in its actions" may be an important criterion for learning in primates. Coaction is observed frequently in monkeys, especially between mother and infant as an effective method of acquiring skills. Perhaps coaction is necessary for accurate learning and in environments where the costs of making mistakes is high, would necessarily be the favored method of transmission of behaviours.

Exploitation, in which one animal takes advantage of the expertise or skill of another animal has also been suggested as an alternative mechanism to imitation. Not only has it been suggested as an alternative mechanism but it has been reported as being actually inhibitory for imitative learning (Giraldeau and Lefebvre 1986, Visalberghi and Fragaszy in press). Giraldeau and Lefebvre (1986) found that "scrounger pigeons", or those individuals that parasitized another pigeon's technique of getting food, did not learn the technique even when the demonstrators repeatedly demonstrated the technique for getting food.

Hannah and McGrew (1987) observed the acquisition and spreading of nut cracking behaviour in a group of semi-captive chimpanzees. All but three chimpanzees acquired the technique of nut-cracking. They note; "of these three Knut showed interest and sometimes he managed to eat kernels of nuts opened by Hermaphrodite, his close companion". It is possible that the reason Knut did not learn to crack nuts was because it was not necessary to learn the behaviour if he could exploit his companion's behaviour, just as we might not learn a skill ourselves if we can rely on someone else to perform this skill for us.

Fragaszy and Visalberghi (in press) report exploitation of the expertise of one animal by another with tool use in capuchin monkeys (*Cebus appella*). Quiatt (per comm) too reports observations of a troop of rhesus macaques (*Macaca mulatta*) on Cayo Santiago in which some animals lift lids to eat the provisioned grain inside, whereas others feed from the bin when a lid-lifter is present. This may be interpreted as exploitation of solvers by non-solvers, although Quiatt interprets this as a form of cooperation or simply alternative foraging strategies.

If decreased opportunity to exploit another's food resource was observed in chimpanzees and humans, then perhaps this might partially explain the increase in selective pressure for the ability to imitate. Again, perhaps there is a difference between monkeys and chimpanzees in the structure of the society such that exploitation is made more difficult, thus increasing selective pressure for learning by imitation. However, the exact role of exploitation in its suppression of imitative learning is not yet fully understood.

Because so little is known about the conditions under which the imitative ability evolved, a greater understanding of the circumstances under which natural selection would favor imitation is "crucial to our understanding of how humans fit into the general framework of evolutionary biology" (Boyd and Richerson 1988).

COGNITIVE CONSTRAINTS

Finally, it is possible that imitation was not observed in this experiment simply because monkeys do not have the cognitive ability to imitate.

It is commonly believed that in order for an animal to learn by imitation, it must have a high level of cognition (Miyadi 1964, Hauser 1989). If brain size of an adult mammal is plotted against body size on a log log scale, all but two orders fall on a single straight line (Jerrison 1973). The exceptions are the orders Cetacea and Primates, which have unusually large brains for their body size. Because there is a correlation between relative brain size and relative intelligence one might predict the imitative faculty to be more apparent in animals with larger brains (Passingham 1982). Thus we would expect to see imitation in the toothed whales and in primates.

In fact there *is* evidence to support the existence of imitation in Cetacea. Tayler and Saayman (1973) describe how Haig, an Indian bottlenose dolphin (*Tursiops aduncus*) imitated motor patterns, including flipper movements and swimming motions performed by its tank-mate a Cape Fur Seal (*Arcocephalus pusillus*).

For locomotion in the water, seals use their foreflippers in a "for and aft" stroke, then during the glide, hold the sole of the flipper briefly against their side. Dolphins

mainly use their flippers for steering, and instead use "dorsoventral strokes of the flukes to provide the forward propulsion" (Taylor and Saayman 1973). Taylor and Saayman (1973) reported that the dolphin would follow the seal around the pool, sometimes swimming normally to keep up to the seal and at other times copying the seal's flipper-like motion until she fell behind again. The following unusual incident was also reported:

"At the end of an observation session, a cloud of smoke was once deliberately released against the glass as Dolly was looking through the viewing port. 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."

Within the order primates, imitation is assumed to exist in humans, almost certainly present in chimpanzees but appears to be virtually absent in all other primates. Thus it seems that there is something especially unique to humans and chimpanzees to allow them to imitate.

Visalberghi and Fragaszy (in press) suggest that imitation "should be studied in its own right and not as an element in a larger pattern of cognition". However, it is not just the imitative capacity that is most commonly observed in chimpanzees. The appearance of imitation seems to parallel the appearance of a number of other seemingly complex cognitive abilities. It has been suggested that these abilities may be related and therefore that they may indeed be a part of a "fundamental pattern of cognition" (Whiten in press).

Little is known about the relationship between these abilities although there is much speculation. Learned tool use is an ability that is assumed to be cognitively complex, that has been observed more commonly in chimpanzees than any other non-human primate (Beck 1976). Little is known about the relationship between tool use and the imitative ability. Beck (1974) suggests that the high propensity for tool use in chimpanzees is actually *dependent* on imitation.

Chevalier-Skolnikoff (1989) suggests that a high propensity for tool use is not dependent on the ability to imitate *per se*, but rather the *stage* of imitative ability of the animal. However, she adopts the Piagetian scheme of imitation and includes *contagious* behaviour as stage one imitation and *stimulus enhancement* and *social facilitation* as stage three of imitation. These are not necessarily related processes, as discussed earlier (see also Galef 1988 and Frigaszy 1989) and thus correlations between "stages" of imitation and tool use do not provide useful information about the relationship between true imitation and tool use.

Visalberghi and Frigaszy (in press) suggest that imitation and tool use not only parallel each other in appearance because of reliance on the same cognitive abilities or motor capacities, but actually *amplify* each other in their development. They go further to suggest that imitation may in fact be a link between social intelligence and technical intelligence.

Other cognitively complex abilities that have been observed in chimpanzees more than any other non-human primate are those of *self-awareness* and *consciousness*. Awareness is a form of perception in which the animal is aware of its body parts and processes occurring within the brain (McFarland 1980). Consciousness is a special kind of self awareness involving the animal's ability to perceive that it is I who am feeling or thinking (McFarland 1980). The classical experiment to demonstrate this phenomenon is that of Gallup (1977) in which a dot was painted on the eyebrow and opposite ear of a subject. The subject was then presented with a mirror and the reaction observed. Chimpanzees tended to repeatedly touch the part of their body that had been dyed whereas monkeys did not touch the dyed part of their body with any more frequency than before the experiment.

It has been suggested that the ability to imitate is actually *dependent* on the presence of self-awareness and consciousness in animals. It is not clear whether this is actually true. For example, it is possible that the ability to imitate may only require the ability to connect a particular perception with a particular set of motor commands. A baby's ability to imitate the protrusion of a tongue may be a matching of the sight of the

tongue with its own motor instructions for sticking out a tongue. The baby does not necessarily have to be aware of its own tongue (McFarland 1980).

What makes chimpanzees so special in these abilities compared to other non-human primates? Whiten (in press) suggest that all these abilities are part of an overall pattern of cognition for which **second order representation** is the link. Second order representation is defined by Whiten (in press) as the ability to "represent a mental state in another's mind". The absence of imitation in monkeys may be a result of lack of such representational abilities. Imitation may involve second order representation in that the imitator must translate the actions of the demonstrator from what he perceives as the demonstrator's point of view, into actions from his own point of view. Thorndike first suggested this in 1911 when he stated "if the animal realizes the mental states of the other animal who before his eyes pulls the string, goes out through the door, and eats the fish, he ought to form the association, impulse to pull string, pleasure of eating fish." He also states that "I fancy that these feelings of other's feelings may be connected pretty closely with imitation, and for that reason, may begin to appear in monkeys." Bruner (1972) also argued that the ability to imitate required an ability for representation, or to use the image of another's acts to guide the observer's production of the same acts. He argues that imitation involves a high level of cognition because the imitator's perception of the behaviour of the other animal must be translated into motor acts which will look quite different from this new perspective.

However, Perrett et al (in press) have found that the observation of a monkey's own movement of an object evokes the same response in the cortical neurons of the temporal cortex as does the observation of another monkey's movement of an object. This detection of motor equivalencies has been used as evidence against the need for representational abilities in order for imitation to occur. It has been suggested as a possible underlying mechanism for imitation (Visalberghi and Fragaszy in press). However, a similar response to the two actions is not altogether surprising considering that the two actions look the same. In addition no difference in response of the neurons may be used as evidence *for* the requirement of second order representation for imitation

in that this phenomenon occurs in monkeys, where imitation is not observed. Perhaps in chimpanzees or in humans, the difference between one's own movement and another's would be in fact be detected and the cortical neurons would not fire similarly.

Because little is known about the cognitive abilities required for an animal to have the imitative capacity, the role of second order representation in imitation is still not clear. One thing is certain; "The relationship between representational abilities in these other domains and understanding the use of a tool or imitating another using a tool (or performing some other novel behaviour), must be better understood if we are to make sense of species differences in imitative capacity" (Boyd and Richerson 1988).

CONCLUSION

This study is important as the first application to non-human primates of the experimental methodology described by Dawson and Foss (1965). The experiment removed many of the problems encountered in previous studies of imitation in animals. The results imply that even if the imitative ability does exist in monkeys, it is a weak phenomenon at best and is certainly not as prominent as once believed. It lends support to the notion that "imitation is a fragile phenomenon in monkeys at best" (Visalberghi and Fragaszy in press).

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APPENDIX I. COMPUTER PROGRAM FOR TESTING FOR THE IMITATIVE
ABILITY IN MACACA ARCTOIDES (Andrew Burnley, University of
St. Andrews)

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REM BBC BASIC PROGRAM FOR MONKEY PUZZLE APPARATUS
REM PROGRAMMER ANDY BURNLEY
REM DATE : 27 FEB 1989
REM VER : 0.00
REM DISK PROGRAM FILENAME : "ARAUCAR"
REM DISK DATA FILENAMES : "MONKDn" n IS FILENUMBER
REM SET UP DATA ARRAYS & PORT NUMBERS FOR 1 MHz BUS
:
DIM DUR%(400),FLAG%(400),DIST%(400),ACT$(4)
:
PORT%=&FC00
PULL%=PORT%
PUSH%=PORT%+1
CW%=PORT%+2
ACW%=PORT%+3
CONTROL%=PORT%+6
STATUS%=PORT%+7
:
DFNAME$="MONKD" : DRV$=":1.$."
ACT$(0)="timeout" : ACT$(1)="PULL" : ACT$(2)="TWIST ACW" : ACT$(3)="TWIST
ACT$(4)="inactive"
:
MODE 7
:
PRINT"PROGRAM 'ARAUCAR' FOR MONKEY PUZZLE APPARATUS" : PRINT : PRINT
PRINT"DATA SAVED AUTOMATICALLY AT END OF EACH RUN" : PRINT : PRINT
:
REM GET I.D.,DATE,COMMENTS
INPUT"I.D. : " ID$
INPUT"DATE (DD-MM-YY) : " DATE$ : PRINT
PRINT"ENTER COMMENTS (MAX 3 LINES)"
PRINT"PRESS 'RETURN' KEY FOR UNUSED LINES : " : PRINT
INPUT LINE L1$,L2$,L3$ : PRINT
INPUT"DURATION OF RUN (MINUTES) : " EXDUR%
EXDUR%=EXDUR% * 6000
INPUT"GIVE REWARD FOR TWIST (T) , PULL (P) , NONE (N) ",REWARD$
:
REM HOME APPARATUS IF MONKEY NOT PLAYING WITH HANDLE
:
?CONTROL%=&80
REPEAT
  Z%=?STATUS% AND &05
  IF Z% <> 5 THEN PRINT"PLEASE HOME APPARATUS THEN PRESS ANY KEY" : R$=GET
UNTIL Z%=5
PRINT : PRINT"O.K." : PRINT : PRINT
?CONTROL%=&80
CNT%=1
TIME=0
STIME%=TIME
GOSUB 1030
:
REM SEE IF LAST OBSERVATION SHOULD BE A timeout
:
CNT%=CNT% - 1
IF DIST%(CNT%) = 0 THEN FLAG%(CNT%)=0
:
PRINT CHR$(7)
:
REM SORT OUT WHICH DATA FILE & DRIVE TO USE
:
DLEN%=LEN(ID$) + LEN(DATE$) + LEN(L1$) + LEN(L2$) + LEN(L3$) + LEN(REWARD$

```

```

?CONTROL%=&80
DUR%(CNT%)=(TIME - FTIME%)
FLAG%(CNT%)=1
IF TPULL% MOD 24 <= 3 AND TPULL% >= 23 AND REWARD#="P" THEN PROCfeed
ENDPROC
:
REM TWIST TASK
:
DEF PROCtwist
REPEAT
  Z%=?STATUS% AND &04
  UNTIL Z% = 0 OR FNtimeout
FTIME%=TIME
DIREC%=?STATUS% AND &08
IF DIREC% = 0 THEN F%=2 ELSE F%=3
REPEAT
  Z%=?STATUS% AND &04
  UNTIL Z% = 4 OR FNtimeout
DIST%(CNT%)=?CW% + ?ACW%
TCW%=?CW%
?CONTROL%=&80
DUR%(CNT%)=(TIME - FTIME%)
FLAG%(CNT%)=F%
IF TCW% MOD 15 <= 3 AND TCW% >= 13 AND REWARD#="T" THEN PROCfeed
ENDPROC
:
REM OPERATE FEEDER
:
DEF PROCfeed
?CONTROL%=&10
ENDPROC
:
REM TIMEOUT
:
DEF FNtimeout
IF TIME - STIME% > EXDUR% THEN =TRUE
=FALSE
:
REM NEW FILE,CHANGE DRIVE,CHANGE DISK
:
DEF PROCnewfile
CLOSE#X%
DFNO%=DFNO% + 1
IF DFNO% > 12 THEN DRNO%=3
IF DFNO% > 24 THEN PROCchdisk
PRINT#C%,DRNO%,DFNO% : PTR#C%=0
ENDPROC
:
REM CHANGE DISK IF FULL
:
DEF PROCchdisk
DFNO%=1
DRNO%=1
PRINT"DISKETTE FULL . PLEASE REPLACE WITH A NEW ONE"
PRINT"PRESS ANY KEY TO CONTINUE" : R#=GET#
ENDPROC
:
END

```

```

7 + (CNT%*15)
C%=OPENUP(" :O.#.MONKFND")
IF C%=0 THEN C%=OPENOUT(" :O.#.MONKFND") : DRNO%=1 : DFNO%=1 : PRINTED%,DRN
NO% : PTR%C%=0
INPUT%C%,DRNO%,DFNO% : PTR%C%=0
@%=10
TDRV%=LEFT$(DRV#,1) + STR$(DRNO%) + RIGHT$(DRV#,3)
DFN%=TDRV% + DFNAME% + STR$(DFNO%)
X%=OPENUP(DFN%)
IF X%=0 THEN X%=OPENOUT(DFN%)
PTR%X%=EXT%X%
IF 16383 - EXT%X% < DLEN% THEN PROCnewfile : GOTO 630
IF DFNO% > 12 THEN DRNO%=DRNO% + 2
PRINT%X%,ID#,DATE#,L1#,L2#,L3#,REWARD#,CNT%
FOR I%=1 TO CNT%
PRINT%X%,FLAG%(I%),DUR%(I%),DIST%(I%)
NEXT I%
CLOSEEO
:
REM PRINT DATA TO SCREEN
:
PRINT"PRESS A 'SHIFT' KEY FOR NEXT SCREEN OF DATA" : PRINT
PRINT"REWARD GIVEN : ";
IF REWARD#="T" THEN PRINT"TWIST"
IF REWARD#="P" THEN PRINT"PULL" ELSE PRINT"NONE" : PRINT
PRINT"ACTION DURATION EXTENT"
PRINT TAB(14);"SECS" : PRINT
VDU 14
FOR I%=1 TO CNT%
TDUR=DUR%(I%) / 100
@%=10 : PRINT ACT$(FLAG%(I%));TAB(10); : @%=&0002020A : PRINT TDUR; : @%
PRINT DIST%(I%)
NEXT I%
VDU 15
PRINT : PRINT"RUN PROGRAM AGAIN (Y=YES , N=NO) ? "; : R#=GET#
IF R#="Y" THEN GOTO 220
CLOSEEO
*DR.0
MODE 3
STOP
END
:
:
REM LOTS OF SUBROUTINES & PROCEDURES
:
REPEAT
REPEAT
Z%=?STATUS% AND &05
UNTIL Z% <> 5 OR FNtimeout
IF Z% = 4 THEN PROCpull ELSE PROCTwist
CNT%=CNT% + 1
UNTIL FNtimeout
RETURN
:
REM PULL TASK
:
DEF PROCpull
REPEAT
Z%=?STATUS% AND &01
UNTIL Z% = 0 OR FNtimeout
FTIME%=TIME
REPEAT
Z%=?STATUS% AND &01
UNTIL Z% = 1 OR FNtimeout
DISTX(CNT%)=?PULL% + ?PUSH%
TPULL%=?PULL%

```

APPENDIX II. RAW DATA FOR THREE MINUTE TESTING PERIOD FOR
EXPERIMENT I and EXPERIMENT II (GROUP A AND GROUP B)

1=TWIST

2=FULL

EXPERIMENT I LITA
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	5.35	14	2.6168
2	1	7.01	8	1.1412
3	2	2.77	48	17.3285
4	1	4.18	19	4.5455
5	1	20.32	13	0.6398
6	1	3.16	16	5.0633
7	2	3.38	46	13.6095
8	2	0.05	3	60.0000
9	1	0.92	11	11.9565
10	1	0.92	7	7.6087
11	1	0.34	4	11.7647
12	1	0.13	2	15.3846
13	1	9.24	9	0.9740
14	2	0.58	8	13.7931
15	1	0.53	7	13.2075
16	1	6.15	34	5.5285
17	1	1.16	12	10.3448
18	1	6.21	8	1.2882
19	1	1.69	8	4.7337
20	1	3.80	13	3.4211

EXPERIMENT I CAROL
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	27.65	29	1.0488
2	1	10.67	17	1.5933
3	2	6.41	5	0.7800
4	1	9.18	10	1.0893
5	1	6.35	13	2.0472
6	1	0.19	3	15.7895
7	1	3.06	18	5.8824
8	1	4.55	6	1.3187
9	2	7.50	56	7.4667

EXPERIMENT I SAM
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.52	11	21.154
2	2	0.25	2	8.000
3	1	0.26	4	15.385
4	1	0.54	6	11.111
5	1	2.73	16	5.861
6	1	0.65	7	10.769
7	1	0.01	6	600.000
7	1	0.01	6	600.000

EXPERIMENT I JEFF
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	1.05	5	4.7619
2	2	3.47	87	25.0720
3	2	0.04	3	75.0000
4	1	2.05	8	3.9024

EXPERIMENT I FRED
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	1.70	12	7.05882
2	1	0.77	5	6.49351
3	2	4.33	12	2.77136
4	1	10.90	4	0.36697
5	1	28.10	25	0.88968
6	2	7.82	5	0.63939
7	1	28.00	6	0.21429
8	2	10.18	33	3.24165
9	1	1.23	4	3.25203
10	2	4.47	15	3.35570
11	1	1.51	9	5.96027
12	2	6.87	16	2.32897

EXPERIMENT I RHONA
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	22.18	26	1.172
2	1	0.17	2	11.765
3	2	2.72	7	2.574
4	1	0.08	26	325.000
5	1	0.43	5	11.628
6	1	19.55	21	1.074
7	2	9.14	28	3.063
8	1	1.06	12	11.321
9	2	1.82	20	10.989
10	1	1.21	9	7.438
11	1	0.81	5	6.173
12	1	3.60	17	4.722
13	1	3.07	7	2.280
14	2	4.36	48	11.009
15	2	4.31	51	11.833
16	1	0.45	5	11.111
17	2	2.41	18	7.469
18	1	0.30	7	23.333
19	2	11.91	25	2.099

EXPERIMENT I MIRIUM
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.61	5	8.1967
2	1	2.55	12	4.7059
3	1	0.33	5	15.1515
4	1	0.13	7	53.8462
5	1	0.22	3	13.6364
6	1	3.64	21	5.7692
7	1	0.80	5	6.2500
8	1	0.02	1	50.0000

EXPERIMENT I PHIL
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	4.18	9	2.1531
2	2	0.36	5	13.8889
3	1	1.35	3	2.2222
4	2	0.34	5	14.7059
5	1	0.75	9	12.0000
6	1	7.34	6	0.8174
7	2	3.18	20	6.2893
8	1	0.80	10	12.5000
9	2	2.41	3	1.2448
10	1	0.67	2	2.9851
11	1	0.37	2	5.4054
12	1	0.16	2	12.5000
13	1	16.02	7	0.4370
14	1	23.68	9	0.3801
15	1	4.96	14	2.8226
16	2	1.33	5	3.7594
17	1	0.46	3	6.5217
18	1	3.34	6	1.7964

EXPERIMENT I JON
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.41	3	7.317
2	2	9.40	17	1.809
3	1	0.50	6	12.000
4	2	8.05	5	0.621
5	2	0.01	4	400.000
6	2	0.05	1	20.000
7	2	15.22	12	0.788

EXPERIMENT I CATH
OBSERVED PULLING

ROW	action	duration	extent	effort
1	2	9.05	37	4.0884
2	1	1.49	8	5.3691
3	2	3.86	45	11.6580
4	1	0.76	13	17.1053
5	2	5.71	45	7.8809
6	2	3.92	40	10.2041
7	1	0.11	2	18.1818
8	1	0.20	2	10.0000
9	2	13.24	52	3.9275
10	2	0.05	3	60.0000
11	1	0.12	4	33.3333
12	2	16.03	89	5.5521
13	1	0.77	16	20.7792
14	2	4.64	45	9.6983
15	1	0.10	1	10.0000
16	1	0.44	9	20.4545
17	2	18.94	130	6.8638
18	2	4.06	42	10.3448
19	2	0.04	3	75.0000
20	2	34.96	121	3.4611
21	2	0.02	1	50.0000

EXPERIMENT I ROSIE
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.22	3	13.636
2	1	1.03	7	6.796
3	2	1.55	5	3.226
4	1	1.34	6	4.478
5	2	18.00	107	5.944
6	1	3.24	5	1.543
7	1	7.52	18	2.394
8	1	0.03	3	100.000
9	1	0.96	12	12.500
10	1	0.53	12	22.642
11	2	14.69	63	4.289
12	2	0.01	4	400.000
13	1	16.80	9	0.536
14	1	0.61	7	11.475
15	1	1.47	6	4.082
16	1	2.60	5	1.923
17	2	0.44	12	27.273

EXPERIMENT I JENNY
OBSERVED PULLING

ROW	action	duration	extent	effort
1	2	0.16	3	18.7500
2	1	1.30	5	3.8462
3	1	1.00	3	3.0000
4	1	2.47	6	2.4291
5	1	1.40	6	4.2857
6	2	2.61	9	3.4483
7	1	0.96	3	3.1250
8	1	5.06	8	1.5810
9	2	1.57	2	1.2739
10	1	1.70	7	4.1176
11	1	1.50	9	6.0000
12	2	1.03	2	1.9417
13	1	36.59	13	0.3553
14	1	3.00	11	3.6667
15	1	0.33	6	18.1818
16	1	2.66	20	7.5188

EXPERIMENT I RUTH
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.80	4	5.000
2	1	0.41	2	4.878
3	2	0.61	3	4.918
4	1	1.34	14	10.448
5	2	2.61	27	10.345
6	1	0.25	5	20.000
7	1	0.84	9	10.714
8	2	0.71	3	4.225
9	1	2.46	9	3.659
10	1	1.33	2	1.504
11	1	1.85	13	7.027
12	1	1.26	8	6.349
13	1	0.77	9	11.688
14	1	0.60	8	13.333
15	1	9.32	6	0.644
16	1	0.70	13	18.571
17	1	2.07	6	2.899
18	2	1.84	10	5.435
19	1	1.65	5	3.030
20	2	3.57	5	1.401
21	1	2.25	10	4.444
22	1	0.88	8	9.091
23	2	1.61	2	1.242
24	1	5.19	11	2.119
25	2	2.32	2	0.862
26	2	2.42	9	3.719
27	1	0.01	2	200.000

EXPERIMENT I SHANDY
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.28	1	3.5714
2	1	3.43	2	0.5831
3	1	2.64	7	2.6515
4	1	21.82	9	0.4125
5	1	0.91	13	14.2857
6	1	0.20	6	30.0000
7	1	30.90	16	0.5178
8	1	0.12	1	8.3333
9	1	3.54	8	2.2599
10	1	33.73	9	0.2668

EXPERIMENT II LITA
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	2	1.13	4	3.5398
2	1	1.68	15	8.9286
3	1	0.71	5	7.0423
4	1	1.24	6	4.8387
5	1	0.65	6	9.2308
6	1	4.89	7	1.4315
7	1	2.13	12	5.6338
8	2	3.93	24	6.1069
9	2	0.07	3	42.8571
10	1	0.59	14	23.7288
11	2	1.43	3	2.0979
12	1	1.08	9	8.3333
13	1	2.37	11	4.6414
14	2	1.79	4	2.2346
15	1	1.00	3	3.0000
16	1	7.60	7	0.9211
17	1	0.98	12	12.2449
18	1	1.70	11	6.4706
19	1	0.33	9	27.2727
20	1	1.19	22	18.4874
21	1	2.15	20	9.3023
22	1	0.77	7	9.0909
23	1	1.10	5	4.5455
24	1	0.17	6	35.2941

EXPERIMENT II CAROL
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.14	2	14.2857
2	2	2.33	16	6.8670
3	2	14.88	56	3.7634
4	1	1.15	12	10.4348
5	2	5.43	49	9.0239
6	1	0.25	6	24.0000
7	1	5.66	7	1.2367
8	2	8.51	20	2.3502
9	2	0.04	1	25.0000
10	1	4.13	14	3.3898
11	1	3.32	22	6.6265
12	2	24.13	65	2.6937

EXPERIMENT II SAM
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	1.48	3	2.027
2	1	0.47	6	12.766
3	1	0.39	5	12.821
4	1	0.30	5	16.667
5	1	3.33	7	2.102
6	1	0.99	5	5.051
7	1	0.35	5	14.286
8	2	0.83	6	7.229
9	1	0.96	2	2.083
10	1	0.11	2	18.182
11	1	0.27	5	18.519
12	2	40.90	4	0.098
13	1	2.44	246	100.820
14	1	2.16	9	4.167
15	1	1.12	5	4.464

EXPERIMENT II JEFF
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.71	4	5.634
2	1	23.91	9	0.376
3	2	2.38	37	15.546
4	2	0.51	6	11.765
5	2	0.32	6	18.750
6	1	0.76	16	21.053
7	1	0.19	10	52.632
8	2	1.34	42	31.343
9	2	0.08	3	37.500
10	1	1.35	9	6.667
11	2	0.03	3	100.000

EXPERIMENT II NEIL
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.34	2	5.8824
2	1	0.45	5	11.1111
3	1	2.40	10	4.1667
4	1	0.04	2	50.0000
5	1	0.58	7	12.0690
6	1	1.10	8	7.2727
7	1	1.03	7	6.7961
8	1	0.20	5	25.0000
9	1	0.52	7	13.4615
10	1	3.33	29	8.7087
11	1	1.20	10	8.3333
12	1	0.28	1	3.5714
13	1	12.10	9	0.7438
14	1	1.37	5	3.6496
15	1	0.29	2	6.8966
16	1	30.46	7	0.2298
17	1	1.59	16	10.0629
18	2	6.70	49	7.3134
19	1	2.79	5	1.7921
20	1	0.73	8	10.9589
21	2	0.24	4	16.6667
22	1	0.66	3	4.5455
23	1	1.19	5	4.2017
24	2	0.42	3	7.1429
25	2	0.53	1	1.8868
26	1	0.04	1	25.0000
27	1	11.59	8	0.6903

EXPERIMENT II RUTH
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.89	9	10.1124
2	2	5.97	4	0.6700
3	1	0.32	5	15.6250
4	1	0.41	5	12.1951
5	1	12.94	9	0.6955
6	1	2.18	10	4.5872
7	2	12.63	28	2.2169
8	2	0.04	1	25.0000
9	2	9.27	4	0.4315
10	1	4.43	17	3.8375
11	1	0.19	4	21.0526
12	1	0.30	3	10.0000
13	2	3.43	11	3.2070

EXPERIMENT II COLA
OBSERVED TWISTING

ROW	action	duration	extent	effort
1	1	0.59	3	5.085
2	1	1.99	10	5.025
3	1	4.54	17	3.744
4	1	0.26	2	7.692
5	1	5.49	18	3.279
6	1	18.09	7	0.387
7	1	6.91	8	1.158
8	1	0.01	1	100.000

EXPERIMENT II PHIL
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	1.13	2	1.770
2	1	7.62	1	0.131
3	2	25.05	24	0.958
4	2	3.30	7	2.121
5	2	0.99	21	21.212
6	1	0.87	5	5.747
7	2	1.89	39	20.635
8	2	0.05	3	60.000
9	1	1.63	24	14.724
10	2	0.60	27	45.000
11	2	0.22	11	50.000
12	1	0.52	6	11.538
13	2	0.24	4	16.667
14	1	0.09	13	144.444
15	2	4.85	14	2.887
16	1	4.39	4	0.911
17	1	0.88	6	6.818
18	2	6.60	4	0.606
19	1	0.11	1	9.091
20	2	0.93	8	8.602
21	1	7.52	19	2.527
22	1	1.01	2	1.980

EXPERIMENT II JON
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	2.25	9	4.000
2	1	0.68	6	8.824
3	1	0.12	2	16.667
4	1	0.66	4	6.061
5	1	4.74	15	3.165
6	1	0.06	1	16.667
7	1	0.70	3	4.286
8	1	2.21	14	6.335
9	2	26.43	2	0.076
10	1	0.30	12	40.000
11	1	0.41	9	21.951
12	1	3.76	7	1.862
13	1	9.34	17	1.820
14	1	6.10	14	2.295
15	1	10.50	3	0.286
16	2	0.27	3	11.111
17	1	0.70	6	8.571
18	1	3.90	12	3.077
19	1	0.23	4	17.391
20	1	0.36	6	16.667
21	1	0.07	5	71.429
22	1	0.02	2	100.000

EXPERIMENT II CATH
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	0.69	13	18.841
2	2	0.96	17	17.708
3	2	0.01	1	100.000
4	1	0.19	4	21.053
5	2	1.87	35	18.717
6	2	0.07	4	57.143

EXPERIMENT II JENNY
OBSERVED PULLING

ROW	C1	C2	C3	C4
1	1	3.02	13	4.305
2	2	1.22	14	11.475
3	2	3.15	3	0.952
4	1	1.04	6	5.769
5	2	5.43	5	0.921
6	1	4.29	6	1.399
7	2	3.28	1	0.305
8	1	2.10	6	2.857
9	1	2.77	12	4.332
10	1	3.21	16	4.984
11	2	2.47	4	1.619
12	1	1.41	6	4.255
13	2	8.82	4	0.454
14	2	3.68	10	2.717
15	1	4.68	8	1.709
16	2	0.02	2	100.000

EXPERIMENT II SHANDY
OBSERVED PULLING

ROW	action	duration	extent	effort
1	1	1.30	7	5.385
2	2	0.44	13	29.545
3	2	5.02	57	11.355
4	2	0.62	4	6.452
5	1	0.61	7	11.475
6	1	1.16	7	6.034
7	1	0.84	8	9.524
8	2	1.18	16	13.559
9	2	1.87	7	3.743
10	1	0.01	2	200.000

APPENDIX IV. PULL/TOTAL RATIO FOR THREE MINUTE TESTING PERIOD FOR EXPERIMENT I AND EXPERIMENT II FOR DURATION, EXTENT, NUMBER AND EFFORT

EXPERIMENT I

GROUP A	DURATION	EXTENT	NUMBER	EFFORT
LITA	.087	.36	.20	.50
CAROL	.184	.39	.29	.22
SAM	.050	.04	.01	.14
JEFF	.531	.87	.99	.50
FRED	.318	.55	.34	.42
RHONA	.408	.59	.10	.42
MIRIUM	.000	.00	.00	.00

GROUP B

PHIL	.106	.32	.28	.57
JON	.973	.81	.71	.96
CATH	.966	.38	.62	.66
ROSIE	.488	.67	.29	.71
JENNY	.085	.14	.25	.30
RUTH	.316	.81	.30	.09
SHANDY	.000	.00	.00	.00

EXPERIMENT II

GROUP A	DURATION	EXTENT	NUMBER	EFFORT
LITA	.205	.17	.21	.22
CAROL	.791	.93	.50	.83
SAM	.744	.03	.13	.03
JEFF	.148	.80	.71	.55
FRED	.898	.65	.50	.58
NEIL	.096	.26	.15	.13
COLA	.000	.00	.00	.00

GROUP B

PHIL	.634	.66	.50	.75
JON	.487	.03	.09	.00
CATH	.768	.76	.50	.83
ROSIE	.779	.33	.40	.13
JENNY	.555	.37	.50	.50
RUTH	.591	.44	.38	.29
SHANDY	.700	.76	.50	.22

APPENDIX V. GROUPED TRIALS 4-7

EXPERIMENT I

GROUP A	DURATION	EXTENT	NUMBER	EFFORT
LITA				
CAROL	.184	.39	.29	.22
SAM	.050	.04	.01	.14
JEFF	.531	.87	.99	.50
FRED	.318	.55	.34	.42
RHONA	.408	.59	.10	.42
MIRIUM	.000	.00	.00	.00

GROUP B

PHIL	.06	.29	.33	.76
JON				
CATH	.966	.38	.62	.66
ROSIE	.488	.67	.29	.71
JENNY	.085	.14	.25	.30
RUTH	.316	.81	.30	.09
SHANDY	.000	.00	.00	.00

EXPERIMENT II

GROUP A	DURATION	EXTENT	NUMBER	EFFORT
LITA	.205	.17	.21	.22
CAROL	.791	.93	.50	.83
SAM	.744	.03	.13	.03
JEFF	.148	.80	.71	.55
FRED	.898	.65	.50	.58
NEIL	.096	.26	.15	.13
COLA	.000	.00	.00	.00

GROUP B

PHIL	.634	.66	.50	.75
JON	.487	.03	.09	.00
CATH	.768	.76	.50	.83
ROSIE	.779	.33	.40	.13
JENNY	.555	.37	.50	.50
RUTH	.591	.44	.38	.29
SHANDY	.700	.76	.50	.22

Appendix VI. Time (s) spent observing relevant parts of the demonstration for group A (observed twisting) and group B (observed pulling)

<u>SUBJECT</u>	<u>TIME</u>
GROUP A	
LITA	45
CAROL	179
SAM	34
JEFF	40
FRED	70
RHONA	50
MIRIUM	32
GROUP B	
PHIL	107
JON	38
CATH	58
ROSIE	32
JENNY	70
RUTH	103
SHANDY	30