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LEARNING AND IMITATION AS A FUNCTION OF SOCIAL STATUS IN THE MACAQUE MONKEY

by

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Abstract

Field observations of imitation among macaque monkeys suggest that direction of imitation is influenced by dominance status in the primate troop. However, the observed relation of status and spread of novel behavior through imitation learning can be attributed to differences in prior motivation and/or opportunity for observing the social model.

In order to analyze the effect of dominance upon imitation, dyadic dominance relations were assessed in two groups of 16 pigtail macaques (M. nemistrina). Both groups had rigidly linear dominance hierarchies. Four high ranking and four low ranking members of each group were selected as subjects for an observational learning experiment, using a complex cued-alternation task. An animal of middle status was selected from one group to be trained as a model. Members of the model's group were exposed to his performance prior to each of five successive training sessions. Members of the other group received comparable training, but did not observe a model.

Analysis of performance measures indicated imitation learning for both high and low status subjects in latency of initial response for each session, and percentage correct performance during latter sessions of training. Exposure to the model resulted in faster elimination of time-out errors, but had no effect upon the elimination of alternation errors. High status monkeys responded more frequently and had a higher percentage of time-out errors in both imitation and non-imitation learning groups.

Results are discussed in terms of prior social experience of the subjects, general response strategies, and differential sensitivity to multiple reinforcement contingencies. The experimental findings are related to ethological concepts of imitation, and field reports on social determinants of primate pre-culture.

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Primate Society and Social Learning

Normal primate learning and development occur within a social context. In order to survive, the infant must adapt to the group. "Survival requires it to live socially and, preeminently, to learn socially, and to do so not only in the long period of its dependence and growth, but also throughout its life." (Hall, 1968, p. 38). Although the importance of social learning in primate ontogeny is well documented by field research (Itani, 1958; Kawamura, 1959, 1953; Washburn & DeVore, 1961; Southwick, 1963; Kawai, 1963, 1956; Goodall, 1956, 1968; Kummer, 1967), detailed analysis of such learning has been hindered by methodological controversy.

Hall (1968), in a critique of early experimental research and theory, discussed the analysis of primate learning as the essential contribution of psychology to the study of primatology. He argued that lack of knowledge regarding primate learning is a direct result of conceptual and procedural restrictions imposed in psychological research. "The principles of learning, as we know them from standard texts, still have a somewhat narrow species and situational reference; it is not very clear then now naturalistic social studies and experimental studies can be integrated." (Hall, 1968, p. 383). Hall questioned whether experimental research gave adequate consideration to the social nature of the animal being studied. The experimental analysis of learning in socially isolated primates can be misleading because primate performance is usually influenced by social parameters of the natural group. Hall concluded that having failed to investigate social determinants of learning, psychological "assessments of relative learning ability or 'intelligence' in the non-human primates are usually irrelevant and inaccurate." (Hall, 1968, p. 384).

Mason (1968), replying to Hall's critique of psychological research, claimed that his conclusion "dismisses experimental literature too quickly, and by implication places it outside the realm of potentially useful information at the very time when we most need a careful and balanced appraisal of its significance." (Mason, 1968, p. 399). Mason argued that laboratory analyses of primate learning should supplement, extend and direct field findings. However, he was forced to agree that in general "experimental research has not helped the fieldworker much in the conduct of his research or in the interpretation of his results, nor have data collected in the field had an important influence on problems selected for experimental investigation in the laboratory." (Mason, 1968, p. 400). The disparity between these two approaches to social learning is well illustrated by comparing experimental and naturalistic studies of primate imitation.

Primate Imitation

The primary purpose of experimental laboratory studies on primate imitation has been to ascertain whether a particular species is able to learn through imitation. The standard method used in such studies is the observational learning paradigm (Crawford & Spence, 1939; Darby, 1959; Darby & Riopelle, 1959; Hall, 1963, 1968; Rumbaugh, 1970). This procedure entails the use of a trained animal as a model (_M_) and a naive animal as an observer (_O_). _O_ watches _M_ perform, and is subsequently tested to determine if exposure to _M_ results in more rapid response acquisition or in fewer errors on the experimental problem. According to Hall, "positive results in such a procedure are a direct confirmation of field observations, and add nothing to our knowledge of social learning.... On the other hand, a negative result....can usually be attributed to some factor, such as _O_'s inattention, and cannot be explained as an in-ability to learn by observing." (Hall, 1968, p. 392).

An experimental comparison of imitation in two chimpanzees is especially interesting in relation to Hall's emphasis on social determinants of observational learning. Hayes and Hayes (1952) reported that their home-reared chimpanzee, Vickie, readily imitated after being shown solutions to various puzzles. However, a cage-reared laboratory animal did not benefit from observing the solutions to these same problems. Rumbaugh (1970), reviewing these findings, concluded that "chimpanzees must have certain kinds of interactions with the environment in order to develop whatever imitative capacity their heredity might allow. These observations reported by Hayes and Hayes are of considerable value, and place in proper perspective the frequent failure to obtain imitation with animals raised and tested in rather barren environs." (Rumbaugh, 1970, p. 26). Hall (1967) provides a similar argument, but stresses that such interaction must be social in nature.

In contrast to experimental emphasis on demonstrating imitation, primate field research usually attempts to examine imitative behavior as part of individual adaptation to a particular environmental demand. The emphasis in naturalistic studies is upon the kinds of behavior imitated and the relation of imitation to other forms of social interaction. For example, Hall and Goswell (1964) reported that young patas monkeys avoid a previously positive stimulus after observing their mother react fearfully to it. Hall (1963) described infancy as a critical period for the development of observational learning. It is during this time that primates acquire group specific food habits, travel routes and social relationships. Hall suggested that such knowledge is learned primarily through imitation, and that subsequent tendencies for observational learning are influenced by this early learning.

The most extensive study of imitation among feral primates has been conducted by members of the Japanese Monkey Center (Kawamura, 1959, 1963; Kawai, 1963, 1956; Tsumori, 1967; Frish, 1968). During nearly twenty years of observation, these researchers have reported a series of novel behavioral phenomena which are idiosyncratic to specific troops of Japanese macaque monkeys (M. fuscata). Most of these behaviors entail unique food-related responses which have developed in various troops as a result of provisioning techniques. Since these behaviors have been imitated by a majority of troop members, and as a result distinguish these troops from other conspecific groups, the spread of such behavior has been referred to as pre-cultural adaptation (Kawai, 1956; Kummer, 1971). Field reports have related the process of pre-cultural adaptation to various aspects of macaque social organization - including sex, age, kinship, affiliative bonds and dominance status.

During the 1950's, Kawamura (1959, 1963) provisioned the troop of macaques on Koshima Islet by distributing sweet potatoes on the beaches. A young female, 16 months old, discovered that sand could be removed from this food by washing it in the sea. The originator's family and age-mates were the first to imitate this washing behavior. Next mothers of these age-mates, and then older juveniles, acquired the habit. After five years of individual propagation of the novel washing behavior, only 18% of the dominant animals over the age of seven years had acquired the habit - and these were all females who most likely had imitated their offspring. The spread of potato-washing through the troop was a slow process which seemed to occur with younger and less sominant animals first.

A second example of pre-cultural development describes the acquisition of a wheat eating habit in the MinooOB troop of Japanese macaques. Japanese researchers had discovered that it was extremely difficult to establish new food habits in a stable group of monkeys, whereas it was relatively simple to alter the feeding behavior of an isolated individual. Having captured and isolated a high ranking male of the Minoo-B troop, they taught him to eat wheat. After returning this animal, the entire troop was provisioned with wheat. Within four hours after wheat was provided, every troop member had acquired the new feeding habit. Spread of the novel activity in this example, with a high-ranking dominant male as the model, was extremely rapid; and all group members seemed to benefit from exposure to the novel activity.

These examples of pre-cultural development suggest a possible relationship between dominance status within the social group and likelihood of imitation among feral macaque monkeys. Such a relationship would not be inconsistent with Hall's speculation that during infancy, primates not only acquire novel behaviors through imitation, but also develop tendencies to imitate particular group members. These reports on imitation among macaques, as well as similar evidence from a group of captive chimpanzees, have led to suggestions that status relations among primates determine the direction of imitation within the social unit - that dominant primates tend not to imitate their subordinates. (Lorenz, 1966; Jolly, 1972).

Such a suggestion is merely a restatement of the findings and does little to elucidate the relation between dominance status and imitation among feral monkeys. Other factors in the field setting could produce this apparent relationship. For example, differential motivation levels related to group status might lead to less interest in novel food activities among high ranking animals, and consequently decrease the likelihood of their attending to the social; model. Furthermore, the reported status differences in imitation may reflect more general differences in learning ability of high and low status animals. Possible relationships between group social status and general learning ability have not been investigated. These naturalistic reports on pre-cultural adaptation pose specific questions which require supplementary experimental analysis.

If one assumes that dominant animals do not imitate their subordinates, then even when motivation and attention are controlled in a laboratory experiment, monkeys dominant to a model should not benefit from observing his performance; only surbordinate monkeys should show an observational learning effect. Due to the possibility of general differences in learning ability as a function of dominance, performance of imitation subjects must be evaluated in relation to performance of subjects with comparable social status who do not observe a model. Analysis of learning among such non-imitation subjects can provide information on the relationship of social status to non-social learning.

If Hall's (1968) contentions about the ubiquitous effects of social parameters in primate learning are correct, we might expect significant differences in learning performance as a function of social status in both imitation and non-imitation groups.

By employing a complex learning task which permits multiple assessments of performance differences, the observational learning paradigm can provide a more detailed analysis of the parameters of imitation, rather than merely demonstrate the ability of animals to benefit from exposure to a model. Such a detailed analysis would be more compatible with conceptions of imitation based upon naturalistic studies of social learning.

Observational Method

Subjects: Thirty-two pigtail macaque monkeys (M. nemistrina) were subjects in the research project. Pigtail macaques are closely related to Japanese macaques (M. fuscata) and share common patterns of social interaction and social organization (Bernstein, 1967). In addition, these animals are reported to benefit from exposure to a model in an observational learning paradigm (Cole, 1963). The monkeys were obtained from the breeding colony maintained by the University of Washington Regional Primate Center. All monkeys were born in captivity, and ranged in age from two to four years. Twelve of the animals were concurrently subjects in a longitudinal dentition study. However, with respect to psychological research, all monkeys were experimentally naive. Throughout the period of this research, the animals were exclusively assigned to this project.

Procedure: The monkeys were divided into two groups of sixteen. Each group contained eight males and eight females. Throughout the observational phase of the project these groups were housed in adjacent colony compounds at the Primate Center (see Fig. 1). To facilitate identification of individuals in each group, all monkeys were marked with a unique binary symbol. Markings consisted of dark

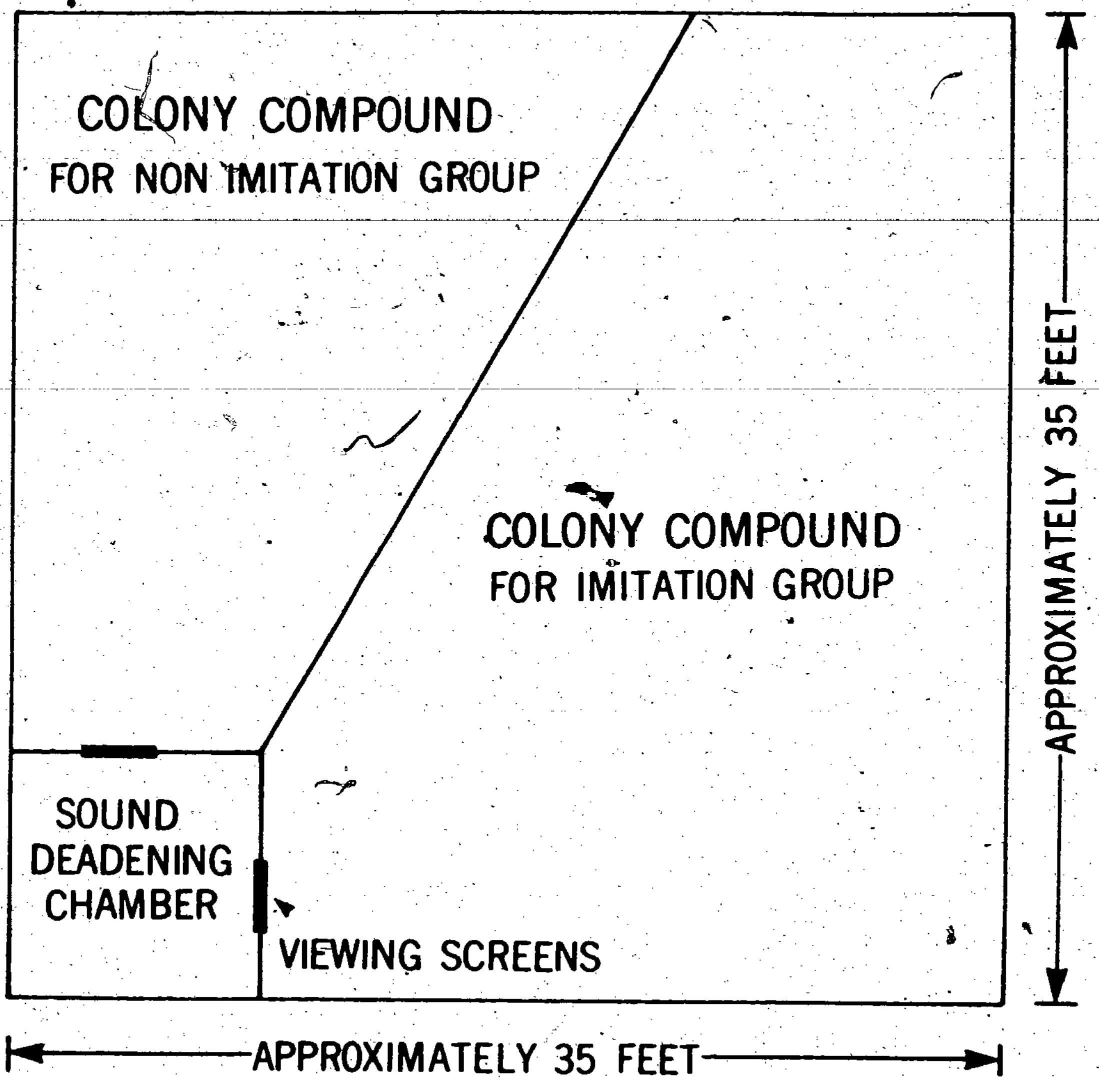

Fig. 1: Observational holding areas

bands of dyed fur on either the arms or legs. In addition, each monkey received a group symbol - a dyed patch of fur on either the bakc or neck. This marking system permitted rapid identification of individual monkeys throughout the period of observation from almost all perspectives.

After marking all animals, both groups were returned to their respective compounds and allowed three weeks to adapt to the observational setting. During this adaptation period, preliminary observations of dyadic agonistic interactions in both groups were conducted daily using procedures reported by Alexander and Bowers (1969. This initial observation resulted in the development of a slightly revised set of behavioral categories which described the full range of dyadic agonistic interactions observed within both groups. Agonistic interactions involved one of the following forms of attack, plus an observable submissive response by the recipient.

1. Assaults - biting with vigorous shaking of the head, or biting while holding the victim.

   Submissive Response - fear grimace, scream, agitated withdrawal, or cringe.
2. Bites - physical contact of teeth to body of victim.

   Submissive Response - fear grimace, scream, agitated withdrawal, or cringe.

3. <u>Chases</u> - rapid pursuit of victim.
   <u>Submissive Response</u> - fear grimace, scream, agitated withdrawal, or cringe.
4. <u>Clasp-pulls</u> - sharp manual hair pull.
   <u>Submissive Response</u> - fear grimace, scream, agitated withdrawal, or cringe.
5. <u>Threats</u> - a prolonged stare with a gaping mouth, pout-face, or lunge; or biting, clasp-pull, or slapping movements which did not result in physical contact.
   <u>Submissive Response</u> - fear grimace, scream, agitated withdrawal, or cringe.
6. <u>Displacements</u> - physically supplanting another animal.
   <u>Submissive Response</u> - fear grimace, agitated withdrawal, or cringe.
7. <u>Exclusions</u> - usurping an object, or activity of another group member.
   <u>Submissive Response</u> - attentive withdrawal.

All regular observations took place from inside a sound-deadening chamber equipped with one-way viewing screens into both colony compounds (see Fig. 1). The observational schedule provided two hours of data collection per group for fifteen days. During second hour of observation, a basketball was introduced into the colony compounds in order to increase competitive interactions. All observations occurred during the late morning hours. Descriptions of agonistic interactions were tape-recorded and transcribed immediately following the observational session. During hours of observation, all personnel at the Primate Center were restricted from the colony compound area.

Observational Results and Discussion

Total observed agonism, and subtotals for each of the behavioral categories, are presented in Table 1. A greater number of agonistic interactions were observed in the imitation learning group - 632 observations compared with 513 in the non-imitation group. Subtotals for each of the behavioral categories, as well as frequency of interactions per observational hour, indicates that this group difference includes in all recorded forms of conflict. The frequency of each form of conflict relative to total observed agonism (see Table 1) suggests similar patterns of conflict within the two groups. Two forms of interaction - threats and exclusions - account for well over half of the total observations. Two other behaviors - clasp-pulls and displacements - occur at nearly the same relative frequency in the two groups. The more aggressive forms of interaction -

Table 1. Summary of Observed Agonism for Imitation and Non-Imitation Groups

	Imitation Group:			Non-Imitation Group:		
Agonistic Categories	Number of Observations	Frequency Per Hour	Percent of Total Agonism	Number of Observations	Frequency Per Hour	Percent of Total Agonism
Assaults	20	0.67	3%	10	0.33	2%
Bites	69	2.30	11%	29	0.97	6%
Chases	48	1.60	7%	20	0.67	4%
Clasp-Pulls	51	1.70	8%	40	1.33	8%
Threats	206	6.87	33%	197	6.57	38%
Displaces	48	1.60	7%	47	1.57	9%
Exclusions	190	6.33	31%	170	5.67	33%
Total	632	21.07	100%	513	17.10	100%

assaults, bites and chases - account for nearly two-thirds of the group differences in total observed agonism. In the imitation group, 137 of these more aggressive interactions were recorded; while in the non-imitation group only 59 such interactions were observed.

Examination of direction and frequency of agonistic interaction for each group permitted assessment of social dominance at two levels: dyadic dominance and group dominance. Initially, dyadic dominance was determined by noting the direction of interactions between members of the 120 possible dyads in each of the two groups. The animal which initiated the greater number of agonistic interactions for a specific dyad was assessed as dominant over the other member. Since the scoring procedures required observation of both a particular form of attack and a corresponding submissive response, the subordinate member also necessarily submitted more often to the dominant animal.

After determining dyadic dominance for all possible pairs of animals in each group, the structure of intra-group conflict was assessed by comparing the relative dominance of all group members. The latter level of analysis entailed fitting the observed agonistic interactions to a linear dominance hierarchy model. The rule for generating the linear dominance hierarchy was that if animal A was dominant to animal B, and animal B was dominant to C, then A was also dominant to C. Both groups appeared to have rigid linear status structures. Dominance hierarchies, based upon all observed agonism, are shown for the imitation group in Table 2, and for the non-imitation group in Table 3.

In the imitation group, agonistic interactions were observed among 106 of the 120 dyads. Dyadic dominance was evident among 105 of these pairs of animals. In one dyad (L2-L1), each member initiated one interaction with the other animal; thus their dyadic dominance was equivocal. In the remaining 14 dyads, no agonistic interaction was observed. Analysis of diminance relations at the group level resulted in the rank orderings shown in Table 2. This analysis provides an estimate of dyadic dominance for 13 of the 14 dyads where there were no observed interactions, as well as for the dyad (L2-L1) with equivocal dominance. The dyad A2-A4 provides an example of such an estimate. No agonism was observed between these two animals, but A4 was assigned lower status since A2 is dominant to all 9 animals which dominated A4. Members of the dyad L7=L1 are tied for tenth position in this hierarchy, since there is no intermediate animal with which to estimate their relative group status. This group analysis of dominance relations corres-

Table 2: Imitation Group Dominance Hierarchy

Recipients

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		31	56	29	9	3	7	3	2	3	1	5	5	14		5	173
A3 ♀			20	27	6	15	15	5	5	5	3	5	1	7	3	3	120
A1 ♂		2		35	6	7	3	3	1	3		1	1	5		3	70
A5 ♂					8	15	6	2	6	3	4	5	1	2	1	1	54
A6 ♀						7	7		3	2	5	5		1	2	3	36
A0 ♀							8	2	7	10	1	3	1	4	2	4	42
L2 ♂								3	4	***	(1)	***	6	15	2	1	32
L4 ♂									1					1		2	4
L6 ♀										2	7	5		7	2	10	33
L7 ♂				1			1 ***					2	2	12	1	4	23
L1 ♂							(1)					2		1	***	2	6
L5 ♀				1			1 ***						1	3	1	1	8
A7 ♀														2		15	17
L0 ♀															4	2	6
A4 ♂											2 ***					6	8
L3 ♀										1							1
TOTALS	0	33	76	93	29	47	49	18	29	29	24	33	18	74	18	62	632

Initiators

( ) = equivocal dyadic dominance
*** = reversal of dyadic dominance

Table 3: Non -Imitation Group Dominance Hierarchy

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂		5	17	6	7	7	7	3	2	7	5	4	3	4	3	6	86
L5 ♀	1		13	3	4	2	4	1	1	1		6	1		1	2	40
A3 ♂	1			24	19	18	20	22	4	8	6	13	5	8	4	7	151
A0 ♀		1			4	5	9	2	2	1		2	3	6		1	36
A1 ♂						6	7	4	5	3	2	3	4	2	5	3	44
A2 ♀			2	1	1		3	3	2	8	7	11	2	2	1	7	50
A4 ♀				2				5	5	5	4	8	2	1	4	4	39
L4 ♂							1		1	4	3	2	4	2	1	1	18
L3 ♀										3				1		5	9
L1 ♂								1			2			1	2	3	10
L7 ♂														5	4	2	10
L2 ♀								1						1	3	4	9
L6 ♂															1	3	4
L0 ♂															2	3	5
A7 ♀																	0
A6 ♀																	0
TOTALS	2	5	32	36	35	38	50	42	22	40	29	49	24	33	32	51	513

ponds with dyadic assessments in 103 of the 106 cases. Group status rankings do not agree with dyadic dominance relations for three pairs of animals in the imitation group (L2-L7; L2-L5; and L1-A4).

In the non-imitation group, agonistic interactions were observed among 105 of the possible 120 dyads. Dyadic dominance was evident from examination of frequency and direction of conflict for each of these pairs of animals. All of these dominance assessments corresponded exactly with the group linear rank ordering shown in Table 3. Analysis at the group level provided estimates of dyadic dominance for twelve of the remaining 15 pairs of animals. Relative dyadic dominance could not be determined due to lack of observed interaction among three pairs of animals (L7-L2; L0-L6; and A7-A6). These pairs are tied for their respective positions in the group rank ordering of Table 3.

The extent to which the linear dominance model provides an appropriate description of social conflict within each of the groups is indicated by the extremely low number of observed interactions which are in a direction opposite to that predicted by a linear rank ordering (see Table 4). In the imitation group, only ten of 632 agonistic interactions (1.6%) were not in the direction predicted by the dominance hierarchy in Table 2. In the non-imitation group

Table 4. Number of Observations in Each Category Which Do Not Correspond to a Linear Ranking

	Imitation Group:		Non-Imitation Group:	
Agonistic Categories	Number	Per Cent Reversals	Number	Per Cent Reversals
Assaults	0	0.0%	0	0.0%
Bites	0	0.0%	0	0.0%
Chases	0	0.0%	0	0.0%
Clasp-Pulls	1	2.0%	1	2.5%
Threats	5	2.4%	3	1.5%
Displaces	2	4.2%	1	2.1%
Excludes	2	1.1%	7	4.1%
Total Agonism	10	1.6%	12	2.3%

twelve of the 513 observed interactions (2.3%) were not in the direction predicted by rank order status of Table 3. For both groups, the occasional reversal of dominance interactions occurred in the less intense forms of agonism - clasp-pulls, threats, displacements, and exclusions. The extremely low percentage of observed reversals for each category of agonism indicates that dominance structures based upon any one of these measures would be quite similar to the hierarchies presented in Tables 2 and 4.

In general, social status was most well defined among the more dominant animals. Collectively the five highest ranking members of each group initiated over two-thirds of the observed agonistic interactions. In addition, they were most often the initiators of the more aggressive interactions - especially assaults. Dominance relations among these five animals were apparent even from casual observation; and in each group their relative dyadic dominance was clearly evident from examination of observed conflict. In contrast, group ranking and dyadic dominance was less obvious among the lower ranking members of both groups. The five most subordinate animals in each group initiated less than one-tenth of aginistic interactions. Such differences in status and social power readily distinguished these sub-groups throughout the observational period. The more dominant group members seemed more confident; they would approach, and even threaten, caretakers and observers. They also appeared to move more freely about the colony compound. On the other hand, subordinate group members seemed more timid. These animals often relinquished food and other objects, as well as preferred resting places, merely upon the approach of another group member. Although these animals were not attacked more frequently than some of the more dominant animals, they were victimized by a greater number of group members, and were more often the target for simultaneous attacks by small sub-groups of animals. These subordinate animals engaged more frequently in submissive behavior, even when there was no apparent attack by another group member.

In both groups, there was a tendency for older animals to rank higher in dominance than younger group members. Among experimental imitation subjects, the rank order correlation between age and status was .57. Among the non-imitation subjects the rank order correlation was .50. However, differences in learning as a function of age within the range of the present sample have not been reported. Research on the ontogeny of macaque discrimination learning generally does not indicate significant variation in discrimination performance as a function of age after the first few months of life (Zimmerman and Torrey, 1965). Although early research suggested age differences in formation of learning set, more recent work indicates similar learning set formation among year-old and adult macaques (Zimmerman, 1969).

Experimental Method

Subjects: Four of the highest ranking and four of the lowest ranking monkeys were selected as learning subjects. In the imitation group, the high dominant subjects were A3, A1, A5 and A6; the low dominant subjects were L5, A7, L0 and L3. L7, who was tied for the tenth position in the imitation group dominance hierarchy, was selected to be trained as the observational learning model. Animals selected from the non-imitation group corresponded in group status ranking to imitation subjects. High dominant, non-imitation subjects were L5, A3, A0 and A1; low dominant subjects were L2, L6, L0 and A6.

Apparatus: Experimental testing occurred in a modified Self-Selection Circus (Sackett, et al, 1965; see Fig. 2). This enclosure was adapted as an observational learning apparatus by surrounding one of the edge compartments, and the central chamber, with opaque walls. The edge compartment served as the observation chamber. This compartment was connected to the central chamber with a transparent plexi-glass door, which allowed visual observation between the observer and model. A speaker and two operant panels equipped with lip-levers were installed in

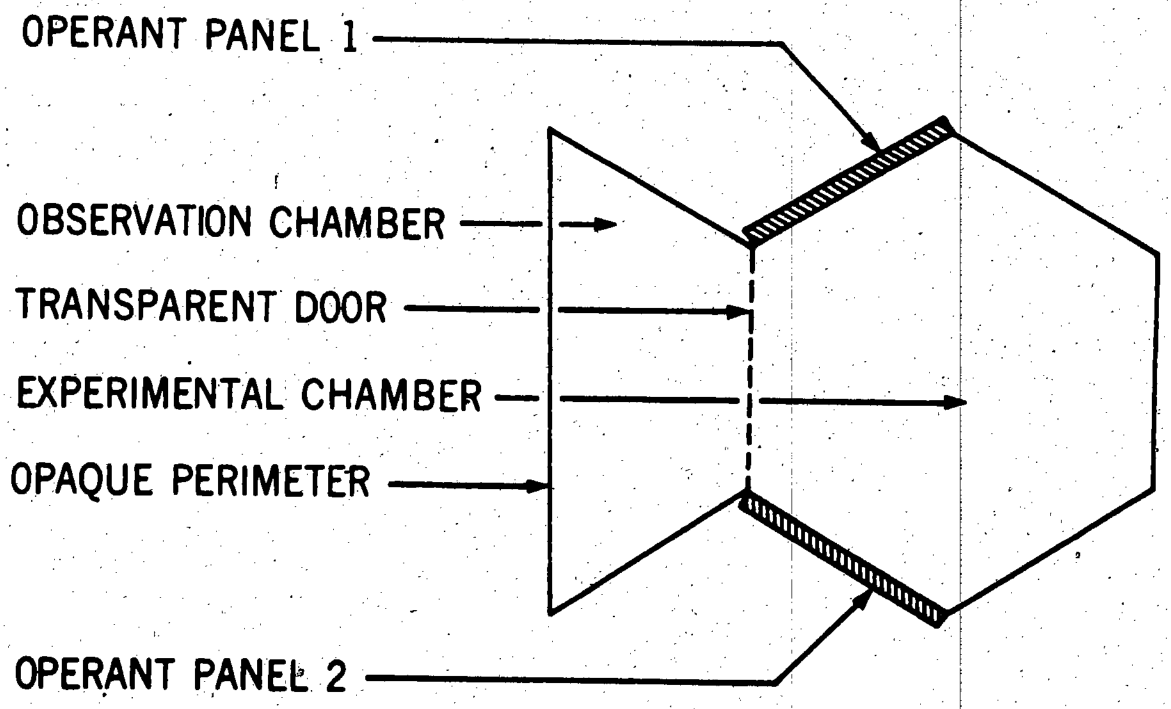

Fig. 2: Experimental testing apparatus

the central area, behind moveable tranparent barriers placed immediately adjacent to the door of the observation chamber (see Fig. 2). These barriers could be raised automatically to permit access to the operant panels. A video camera mounted above the apparatus enabled continuous monitoring of the behavior of both subject and model from the experimental control area. Grayson-Stadler modular programming equipment controlled experimental conditions, and automatically collected learning data. A Heathkit audio-generator produced the auditory stimulus necessary for the time-out discrimination part of the learning task.

Procedure: Following the observational phase of the research project, the imitation group was removed from the colony compound area and housed in individual, visually isolated cages. These subjects were housed in this new area throughout the period of testing for this group.

The experimental learning task, a cued-alternation problem (see Fig. 3), required the subjects to respond at the appropriate operant panel after the onset of a tone. A low intensity, 450-cycle per second tone was used as a discriminatory cue. Pre-tests with this tone indicated that it was a salient cue, and had no apparent aversive effect upon the monkeys. At the beginning of each learning session, tone onset occurred simultaneously with access to

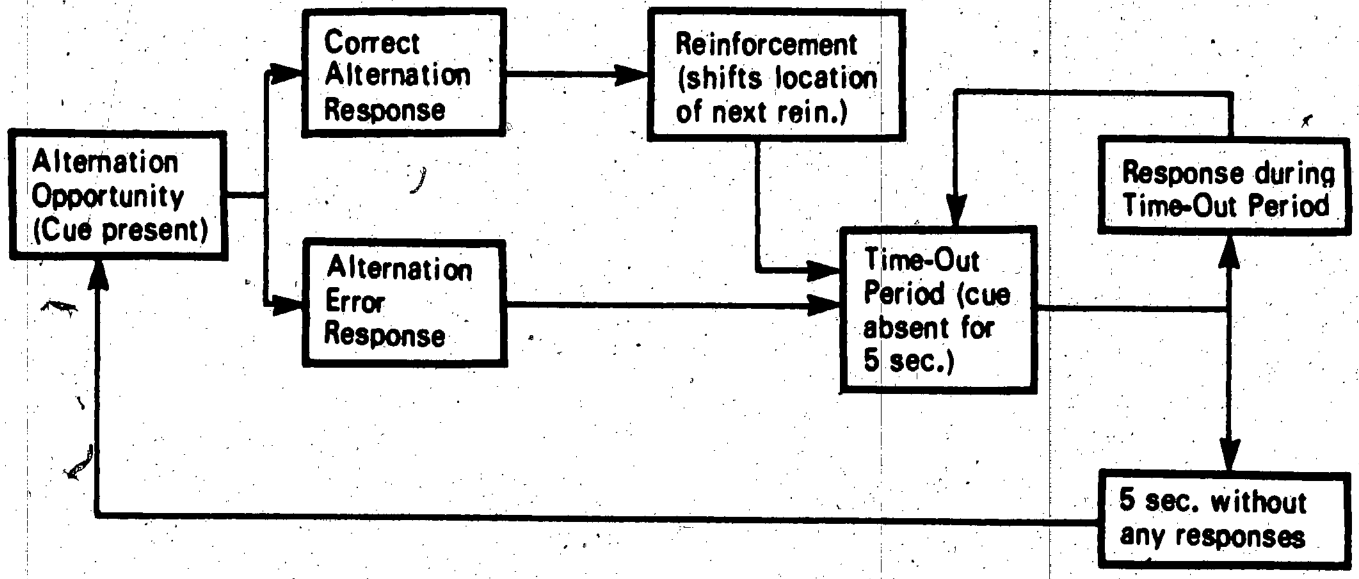

Fig. 3: Flow diagram of cued – alternation problem

the operant panels. Subsequently, any lip-lever response automatically turned the tone off for five seconds. After tone onset, a response at the correct operant panel was recorded as a <u>correct alternation</u>, and reinforced with 1.0 cc of apple juice. Such a response automatically changed the programming equipment so that the next reinforcement was available at the opposite operant panel. A response, after tone onset, at the inappropriate panel was recorded as an <u>alternation error</u>. Such errors were not reinforced, and had no effect on position of reinforcements. Responses which occurred at either panel while the tone was off were scored as <u>time-out errors</u>. This type of response did not influence position of positive reinforcement, but extended the time-out period and delayed the possibility of obtaining reward for five additional seconds. In addition to these performance measures, initial response latency was recorded for each subject in all learning sessions.

The monkey selected as model for the imitation group was trained to solve the cued-alternation problem through the use of a graded series of tasks. Initially, the lip-lever response was shaped using the method of successive approximations. All shaping occurred with the tone-off for only a fraction of a second. Gradually the tone-off duration was increased to the required five seconds. Alternation behavior was trained by alternately allowing access to only one operant panel. During this phase of training, each response automatically turned off the tone and lowered the barrier in front of the operant panel. After five seconds, the barrier in front of the opposite panel was raised simultaneously with tone onset. Finally, the monkey was given extensive practice with uninterrupted access to both panels. During this final phase of training the model was given an opportunity to practice with another group member (L4) in the observational chamber of the learning apparatus. During early practice with an observer the model's level of performance declined substantially. Consequently, deprivation procedures were employed in all subsequent training and modelling sessions. Training with an observer continued until the model's performance in two successive sessions of 100 alternation responses was 95% correct.

Experimental testing of imitation and non-imitation subjexts occurred with all animals water deprived for 23 hours. Each subject was given five consecutive learning sessions during a single day (see Fig. 4). For imitation subjects each session consisted of: (1) an initial five minute adaptation period in the observational chamber; (2) a five minute observation period during which the model

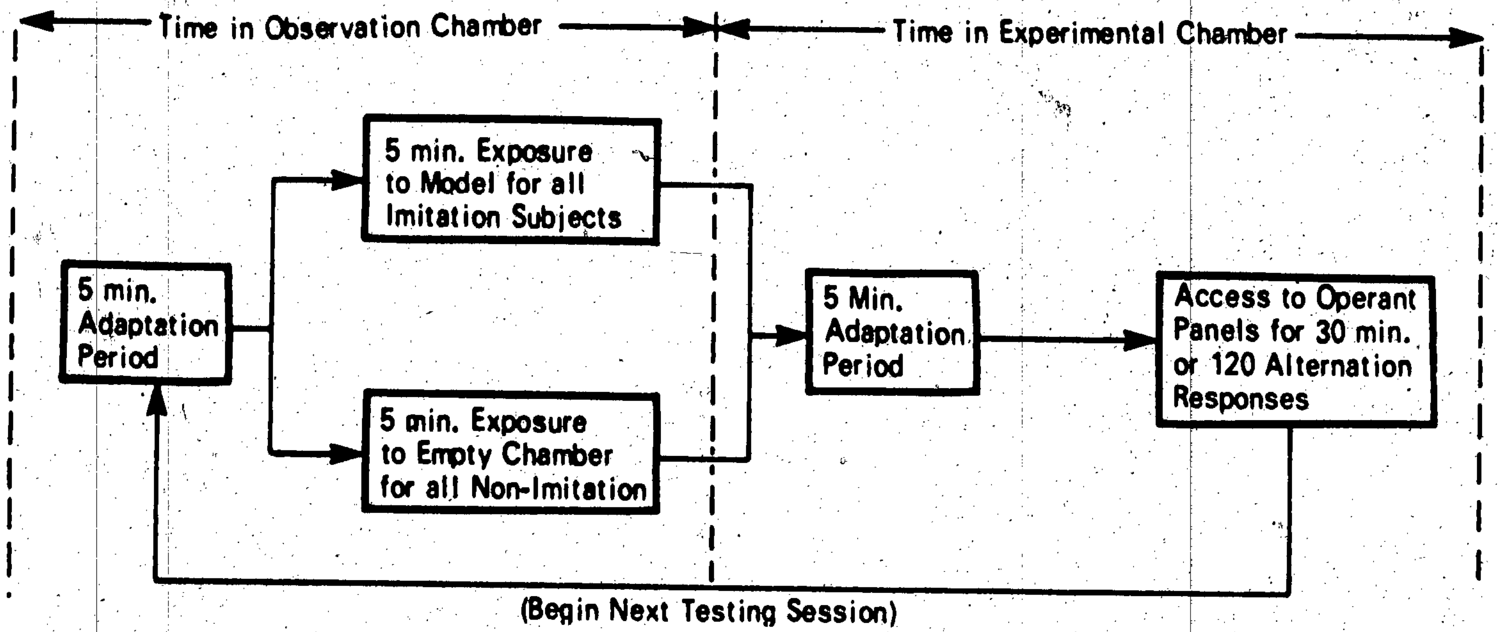

Fig.4: Flow diagram of experimental testing procedure

was able to emit approximately 50 alternation responses; (3) a five minute adaptation period in the experimental chamber after the model had been removed; and (4) a 30 minute period of continued access to the operant panels, or 120 alternation responses, whichever occurred first. After testing, the imitation group was returned to the colony compound area; then the non-imitation learning subjects were moved to individual, visually isolated cages. The testing procedure for this group was the same as that for the imitation group, except that during the observational period of each session the experimental chamber was empty. Thus these non-imitation subjects spent ten minutes alone in the observation chamber prior to entering the central area of the apparatus.

Experimental Results

Adaptation to the Learning Apparatus

During the initial 20 minutes of each learning session observational records were made describing the general behavior of each subject. These records were compared to determine possible differences in general activity levels and resulting differential adaptation to the testing apparatus. Table 5 shows the comparison of activity levels

Table 5. Comparison of General Activity of Subjects in Observation Chamber of Testing Apparatus*

	Imitation Group:		Non-Imitation Group:	
	High Dominant	Low Dominant	High Dominant	Low Dominant
Withdrawn/ Inactive	0	0	0	0
Calm/Moderately Active	20	20	19	20
Hyperactive/ Agitated	0	0	1	0

*Total of 20 observations per group computed on the basis of four subjects each observed during five sessions.

for each group while the animals were in the observational chamber of the apparatus. Most subjects were calm to moderately active during the initial ten minute period. The predominant activity for all subjects during this period was exploration and manupulation of the observational chamber. A3, a high dominant animal from the non-imitation group, succeeded in partially opening the door into the experimental chamber during the second learning session, and became quite agitated when further efforts did not result in access to the central chamber. However, in subsequent sessions this activity was not observed, and this animal also appeared calm to moderately active.

Tabel 6 shows general activity for all learning subjects during the initial ten minutes in the experimental chamber. Here again, most animals seemed well adapted to the apparatus, and engaged primarily in task-oriented or exploratory behavior. However, the frequency of agitation, or hyperactivity, is greater during these periods. Some of this hyperactivity seemed task-related, since often animals which were not reinforced for a long series of error responses would engage in bursts of emotional activity which appeared to be expressions of frustration. Twice, L5, a subject in the low dominant imitation group, became quite agitated when she was unable to remove the barriers in

Table 6. General Activity of Subjects in Experimental Chamber of Testing Apparatus*

	Imitation Group:		Non-Imitation Group:	
	High Dominant	Low Dominant	High Dominant	Low Dominant
Withdrawn/ Inactive	0	1	0	0
Calm/Moderately Active	18	13	18	17
Hyperactive/ Agitated	2	6	2	3

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*Total of 20 observations per group computed on the basis of four subjects each observed during five sessions.

front of the operant panels during the initial five minute waiting period. Another member of this group, LO, was quite withdrawn throughout the first testing session; she cringed in the corner of the apparatus. This was the only case of withdrawn, or inactive, behavior during the testing procedure.

In general, all subjects seemed to adapt equally well to the testing apparatus. The few deviations from calm, moderate activity occurred only during the first two testing sessions, and were distributed among members of both the imitation and non-imitation groups.

Model's Performance

During the observational learning sessions of the experiment, the model's level of correct alternation performance decreased slightly from the pre-trained criterion. His average performance as a model during all sessions of the experiment was approximately 90% correct. The number of reinforced responses ranged from 35 to 51, with an average of 45.25 per session. Alternation errors ranged from zero to nine, with an average of 4.33 per session. Time-out errors ranged from zero to five, with an average per session of 1.15. The model's correct alternations, alter-

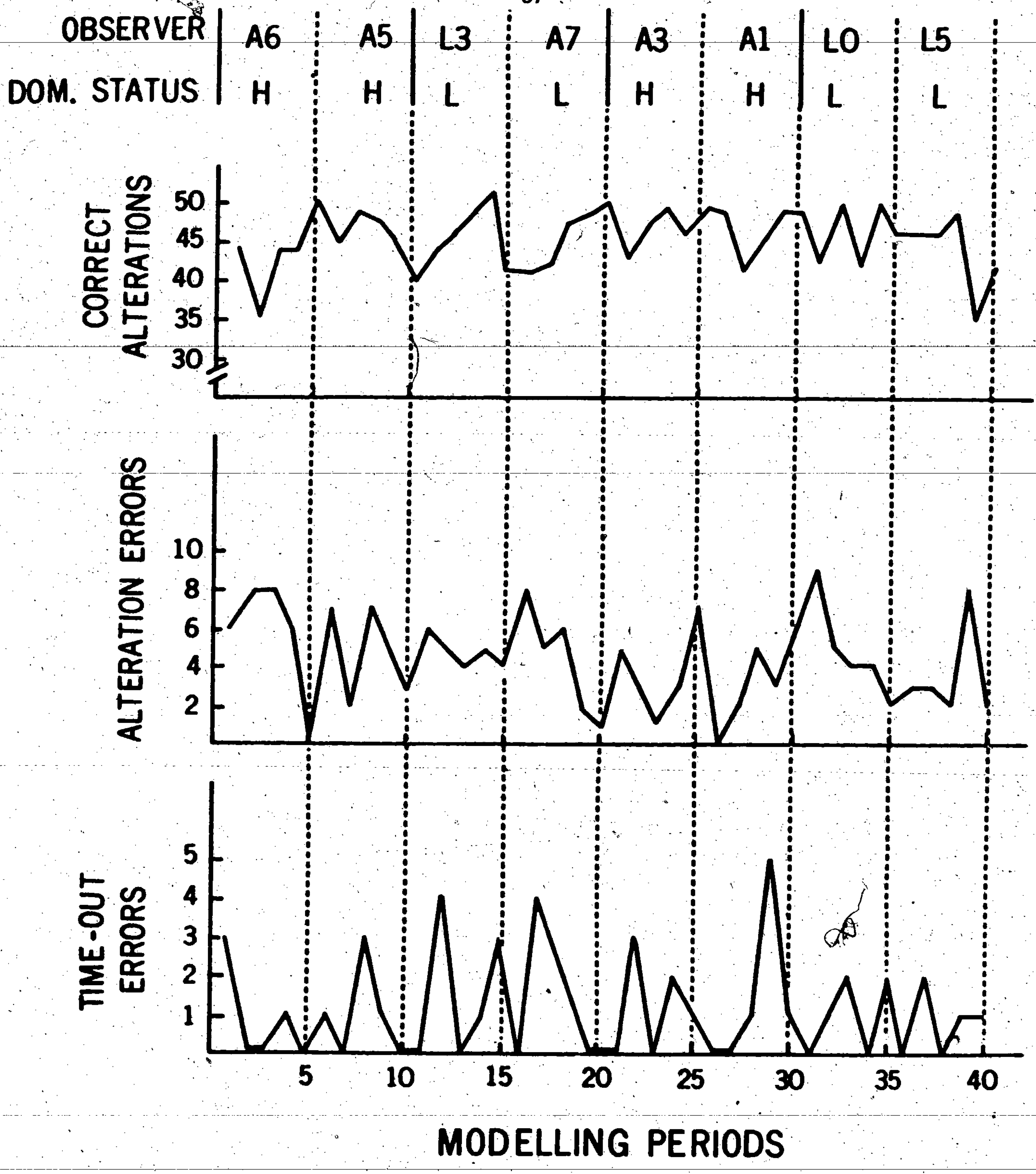

Fig. 5: Performance of model during observational learning sessions of the experiment

nation errors, and time-out errors are shown in Figure 5 as a function fo successive modelling periods and observing group members. Three-way analyses of variance on each of these performance measures were conducted to determine if the model's behavior varied significantly as a function of practice, observing subject, or status of the animal in the observational chamber. These analyses showed no significant main effect or interaction of these variables.

Learning Results

Experimentally independent analyses of each of the learning measures revealed significant performance differences as a function of one, or more, of the independent variables - dominance status, learning group (imitation versus non-imitation), and testing sessions. These findings are presented under the following topical headings: Response Acquisition; Response Efficiency; and Error Analysis.

Response Acquisition

Measures which reflected acquisition of the operant lip-lever response included initial response latency, and total response output in each session. Analysis of these data revealed significant differences in performance which persisted throughout all testing sessions. However, in presenting these results special consideration is given to performance during the first session when the lip-lever response was novel to all subjects.

During the first testing session, response latencies ranged from 1.9 to 1800.0 seconds. The range of latencies was considerably smaller for the imitation learning group - 1.9 to 118.8 seconds (mean = 30.2 seconds). Non-imitation learning subjects showed greater variability in latency scores during this session; the group range was 33.6 to 1800.0 seconds (mean = 419.1 seconds). These latter subjects had consistently longer response latencies; and one member of this group failed to respond during the first session. Examination of first session initial latencies indicated a positively skewed distribution of scores, with all but one of the non-imitation subjects exceeding the median latency of 51.7 seconds. Although the range of response latencies decreased during the subsequent sessions, group differences in time for first response persisted throughout training.

Since the distribution of latency scores was skewed, these data were transformed to rate measures (the reciprocal of response latency) which were amenable to analysis of variance. The transformed data provided a measure of speed of first response in each testing session. A three-way analysis of variance, with dominance status, learning group and testing session as indices, was conducted on the transformed data. This analysis indicated significant differences in response rate only as a function of learning group ($F = 13.31$, $df = 1,12$; $p < .005$). Figure 6, which shows group mean rates as a function of testing sessions, illustrates this significant main effect. Post-hoc comparisons of group mean scores indicated that imitation learning subjects responded significantly faster than non-imitation subjects throughout the five experimental sessions (Tukey HSD Test: $q = 5.09$, $a = 2$, $df = 14$; $p < .01$). In addition, the first session mean response rate for imitation subjects was compared with the mean response rate for non-imitation subjects during the fifth session (which was the best session for the latter group). This comparison showed that even after extensive practice with the learning task, performance of non-imitation subjects was significantly slower than that of imitation subjects during initial access to the operant panels (Tukey HSD Test: $q = 3.13$, $a = 2$, $df = 14$; $p < .05$).

The second measure of operant response acquisition was total number of responses emitted during each testing session. Total response output varied greatly between

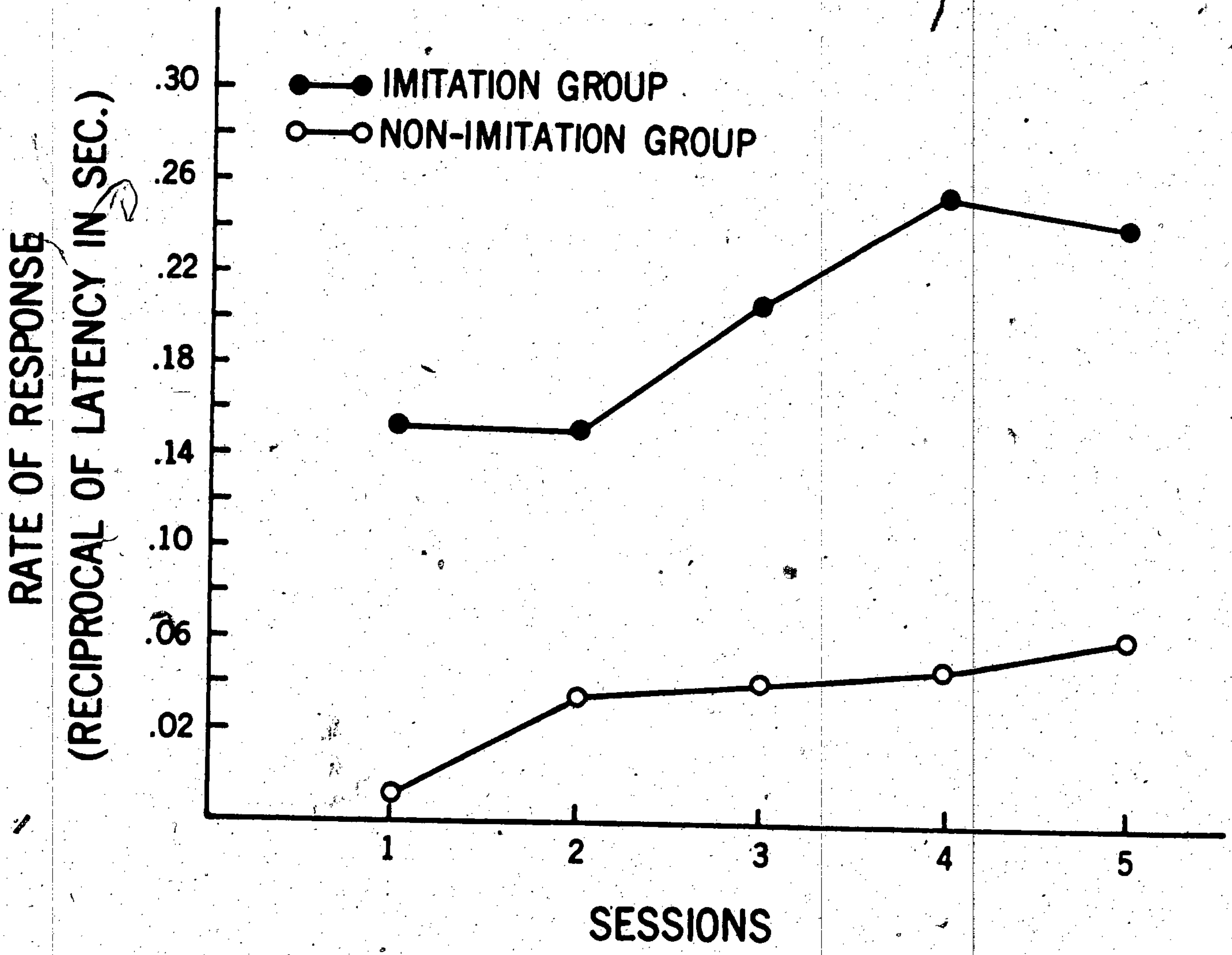

Fig. 6: Response rate as a function of sessions for each learning group

subjects throughout the five sessions. The widest range of responses occurred during the first session - zero to 355 responses (mean = 150 responses). High dominant subjects generally emitted more responses during this session - ranging from 46 to 355 responses (mean = 199 responses); while low dominant subjects tended to emit fewer responses - ranging from zero to 106 responses (mean = 43 responses). In later sessions, the between-subject range decreased, as low dominant subjects tended to increase their total output. Three-way analysis of variance on total response data showed significant differences in response output only as a function of dominance status ($F = 25.27$, $df = 1.12$; $p < .001$). This significant main effect of dominance status is evident in Figure 7, which shows mean total responses as a function of testing sessions for both high and low status subjects. Post-hoc comparisons of mean total responses for each dominance level indicated that high status subjects emitted significantly more responses throughout the five testing sessions (Tukey HSD Test: $q = 6.96$, $a = 2$, $df = 14$; $p < .01$).

Response Efficiency

Response efficiency was distinguished from operant acquisition, since it reflected the extent to which the lip-lever response was under the control of both time-out and

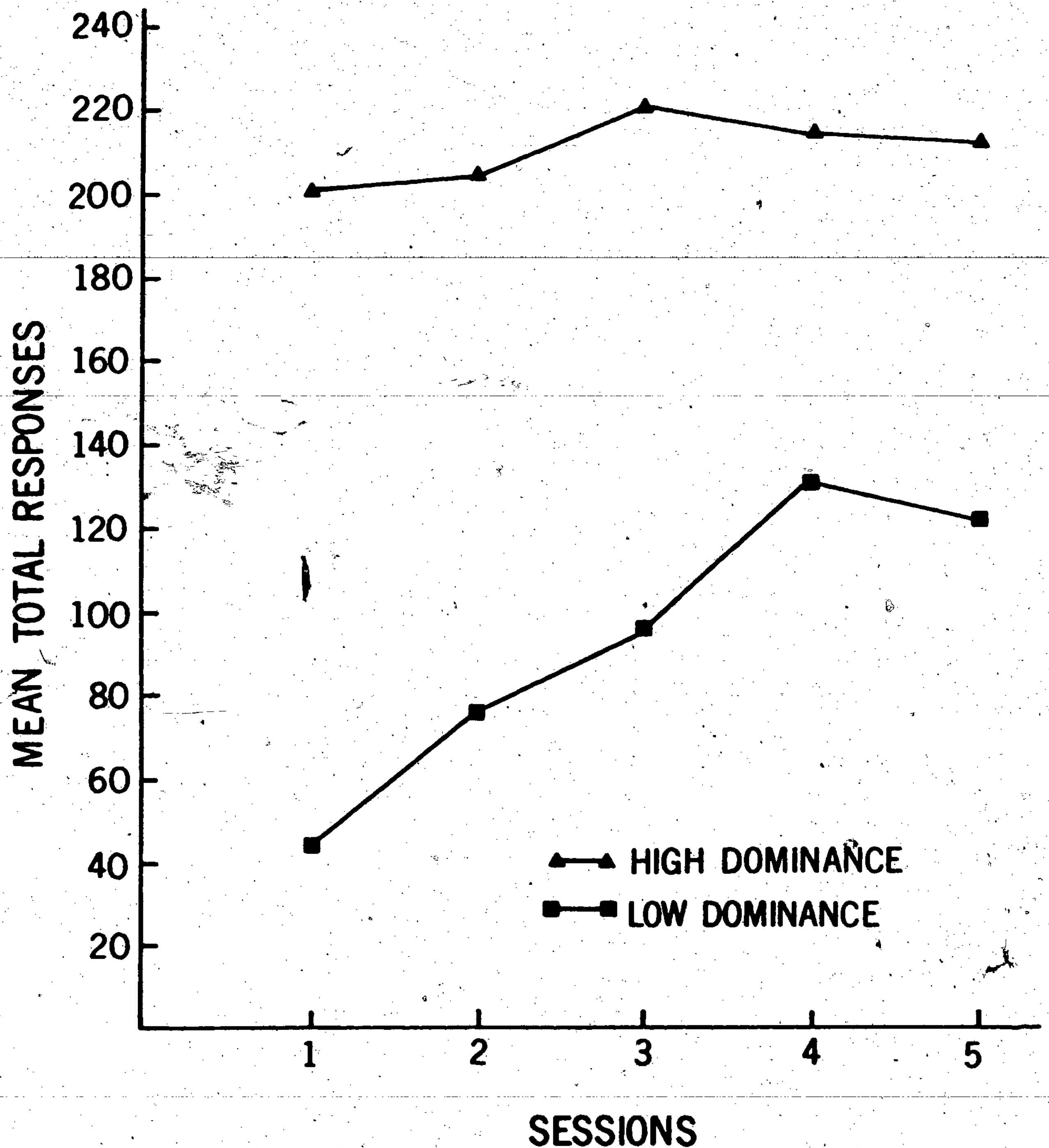

Fig. 7: Total response as a function of sessions for each dominance level

alternation contingencies of the learning task. Response efficiency was evaluated as the percentage correct of total responses (i.e., the ratio of correct responses to total responses in each session). For this, and all subsequent ratio measures of learning, a score was estimated for the non-imitation group member who failed to respond during the first training session. Estimates were derived using Meyer's correction formula for missing data (1966, p. 171).

Although an arc sine transformation is often recommended prior to analysis of percentage data, it is not necessarily appropriate for the present measures. This transformation produces homogeneity of variance by eliminating dependence of the population variance upon the population mean. The variance of the transformed scores is inversely proportional to the total number of observations, and thus is homogeneous when the number of observations used to determine each score is constant. However, with the present scores, the number of total observations differed for each subject in each training session. Since the number of observations were not constant, the arc sine transformation cannot guarantee homogeneity of variance. Instead it might actually increase heterogeneity by overemphasizing the importance of differences in total number of observations. If number of observations as a function of percentage scores approximated a U-distribution, then the transformation would still be advisable, since it might reduce heterogeneity, without necessarily providing complete homogeneity. However, this is not the case with the present measures. Large numbers of observations were usually associated with mid-range percentage scores; while both very high and very low percentage scores occurred most often at lower response levels. Consequently, all percentage measures were analyzed directly without transformation.

Three-way analysis of variance on response efficiency scores indicated two significant sources of variance: a sessions main effect ($F = 16.89$, $df = 4,47$; $p < .001$); and a learning group by sessions interaction ($F = 2.63$, $df = 4,47$; $p < .05$). Comparison of variance estimates for the means of populations defined by sampling levels in this analysis showed that the sessions main effect was the more important source of variance (for sessions main effect - $\theta^2 = 67.51$; for group by sessions interaction - $\theta^2 = 13.81$). These results are illustrated in Figure 8, which shows mean percentage correct as a function of testing sessions for each learning group.

Post-hoc one-way analyses of variance for each learning group as a function of sessions indicated improve-

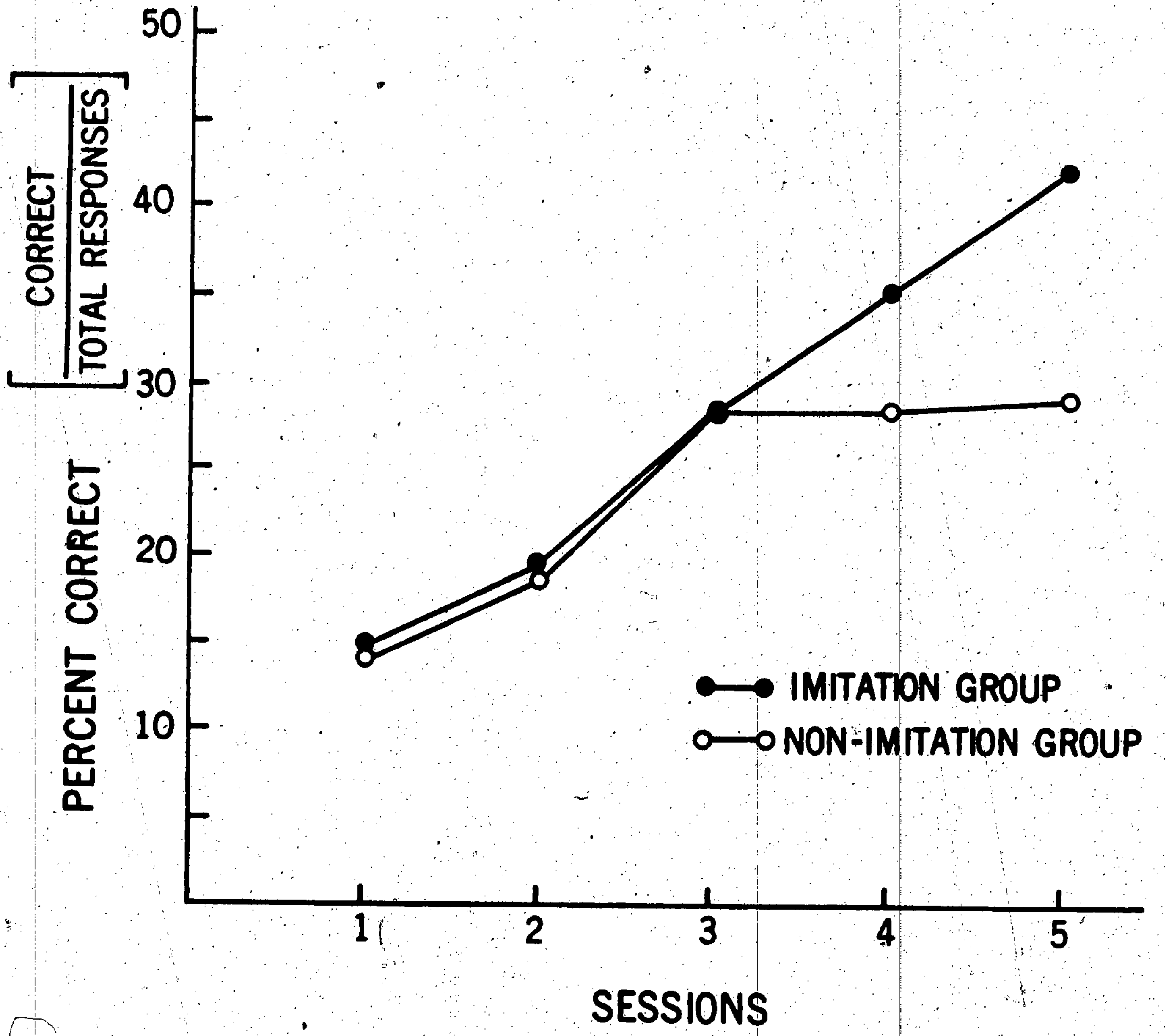

Fig. 8: Percent correct as a function of sessions for each learning group

ment in response efficiency as a function of testing sessions bor both groups (for imitation subjects, $F = 25.21$, $df = 4,28$; $p < .001$; for non-imitation subjects, $F = 3.07$, $df = 4,27$; $p < .05$). However, comparison of variance estimates in these two analyses indicated that the effect of sessions was over four times as powerful among imitation subjects (for sessions effect among imitation subjects - $\theta^2 = 120.84$; while for sessions effect among non-imitation subjects - $\theta^2 = 27.98$). The differential effect of sessions upon performance of the two learning groups is also shown by post-hoc comparisons of group means for each testing session. Although in the first three sessions the groups did not differ, imitation subjects performed significantly better in the last two testing sessions (Tukey HSD Test: $q = 3.34$, $A = 2$, $df = 14$; $p < .05$). These analyses of percentage correct scores indicate improvement as a function of sessions for both learning groups, but relative superiority in response efficiency for the imitation subjects in the final two sessions of training.

Error Analyses

In order to clarify the basis of group differences in response efficiency, both time-out and alternation errors were examined. Since total response output varied as a function of dominance status, ratio scores were again utilized to evaluate both types of error. The ratio of time-out responses to total response output per session provided a percentage measure of time-out errors. The ratio of incorrect alternations to total alternation responses (total responses less time-out errors) was used as a percentage measure of alternation errors.

Three-way analyses of variance on percentage time-out errors revealed three significant sources of variance: a dominance main effect ($F = 27.39$, $df = 1,11$; $p < .001$); a group by dominance interaction ($F = 6.97$, $df = 1,11$; $p < .01$); and a group by sessions interaction ($F = 3.19$, $df = 4,47$; $p < .01$). Comparison of variance estimates for population means defined by this analysis showed that the dominance amin effect was the most powerful source of variance, and that the group by dominance interaction was more powerful than the group by sessions interaction (for the dominance main effect - $\theta^2 = 224.76$; for the group by dominance interaction - $\theta^2 = 101.78$; and for the group by sessions interaction - $\theta^2 = 42.02$).

The dominance main effect and the group by dominance interaction are evident in Figure 9, which shows mean percentage time-out errors as a function of sessions for dominance levels within each learning group. Post-hoc

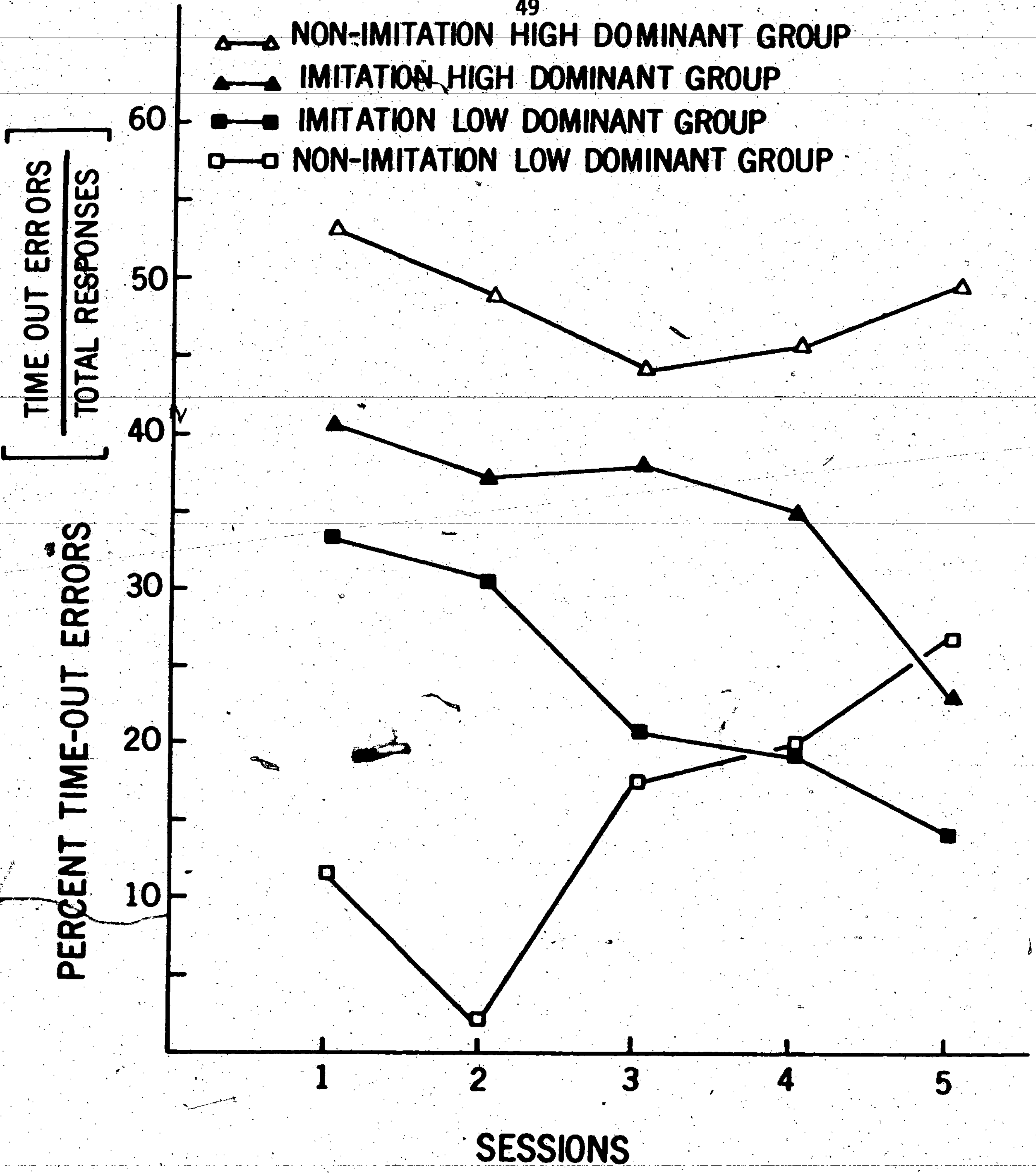

Fig. 9: Percent time-out errors as a function of sessions for dominance levels in each learning group

comparisons of mean percentage time-out errors for high and low dominant subjects in all testing sessions showed that high status subjects had significantly greater scores throughout training (Tukey HSD Test: $q = 7.39$, $a = 2$, $df = 14$; $p < .01$). However, the group by dominance interaction indicates that this tendency was less evident among imitation subjects. Post-hoc comparisons of mean percentage time-out errors for dominance levels within learning groups supported this interpretation of the group by dominance interaction. Comparison of average performance over the five testing sessions showed no significant difference between high and low dominant imitation subjects (Tukey HSD Test: $q = 1.16$, $a = 2$, $df = 6$; n.s.); while the same comparison for the non-imitation group indicated significantly greater percentage time-out error scores among high dominant subjects (Tukey HSD Test: $q = 3.52$, $a = 2$, $df = 6$; $p < .05$).

The significant group by sessions interaction in analysis of percentage time-out error data reflects different effects of training upon the two learning groups, with only imitation subjects showing improvement as a function of sessions. Figure 10 shows the mean performance of each group as a function of testing sessions. Post-hoc two-way analyses of variance were conducted separately for each of the learning groups. Analysis for the imitation group in-

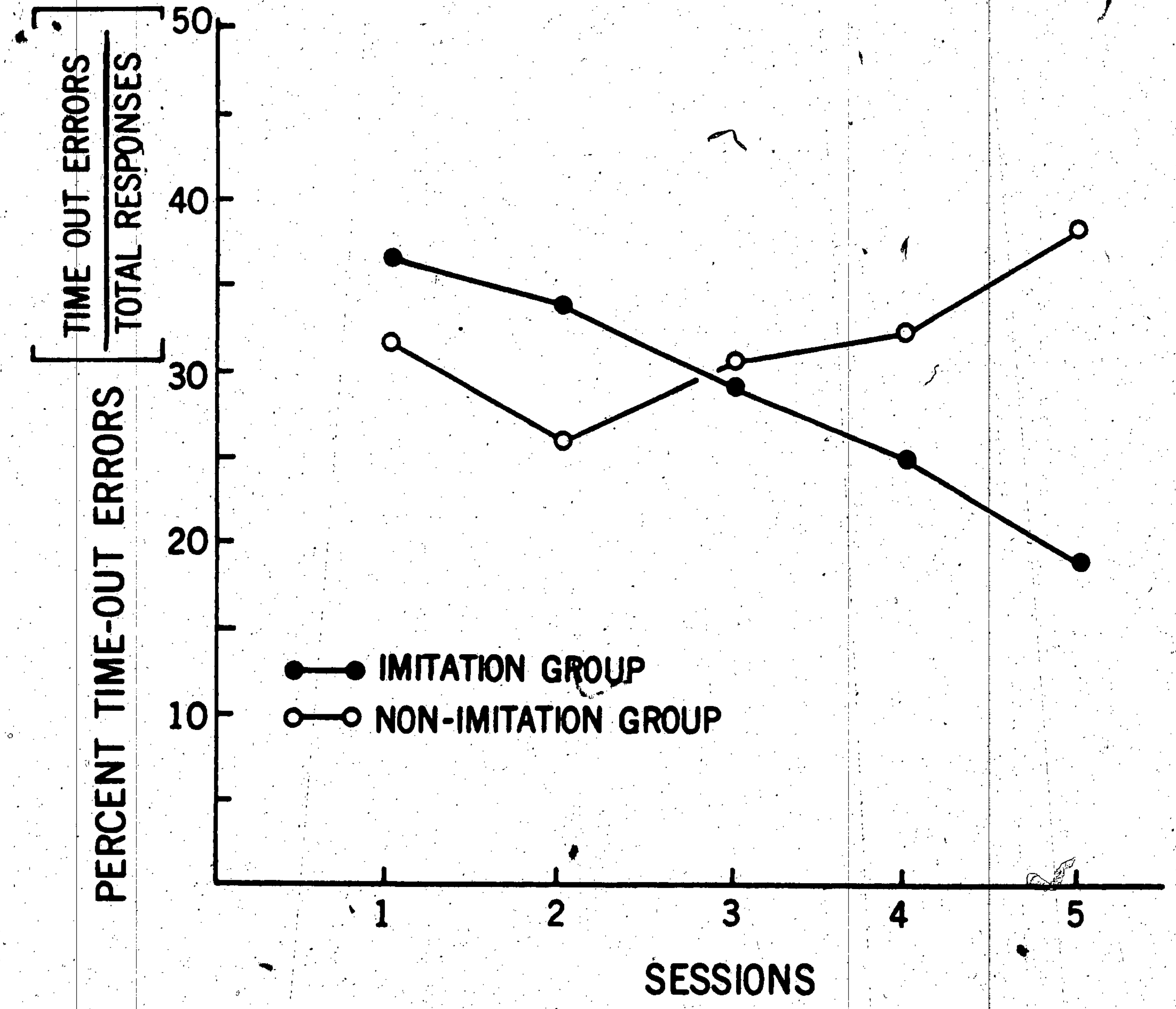

Fig.10: Percent time-out errors as a function of sessions for each learning group

dicated two significant sources of variance: a dominance main effect ($F = 8.43$, df = 1,6; $p < .025$); and a sessions main effect ($F = 2.96$, df = 4,24; $p < .05$). Similar analysis of non-imitation group scores revealed only a significant dominance main effect ($F = 19.36$, df = 1,5; $p < .01$). In the latter analysis, neither source of variance which related to sessions was significant ($F = 0.99$, and $F = 1.38$, df = 4,23; $p > .20$).

These analyses indicate greater variability in performance among non-imitation subjects, since the error term (variance between subjects within dominance levels) was larger in the latter analysis. Greater variability rendered the apparent trend for increased percentage time-out errors among non-imitation subjects non-significant (see Fig. 9). Moreover, separation of error variance for each learning group reveals differences in performance between high and low status imitation subjects which correspond to general dominance differences in the initial overall analysis. These differences were obscured in the post-hoc comparison and analysis of the group by dominance interaction due to pooling of error variance for the two learning groups.

Three-way analysis of variance on percentage alternation errors indicated only a significant sessions main effect (F = 16.74, df = 4,47; p < .001). This effect, illustrated in Figure 11, reflects a decreasing trend in percentage alternation errors for all subjects as a function of testing sessions. However, post-hoc comparisons between session means showed a significant change in alternation performance between the second and third sessions. Only the difference between mean performance in these two successive sessions was significant (Scheffe Test: F = 2.78, df = 4,47; p < .05).

Results Summary

Five performance measures were examined as reflecting specific task demands of the cued-alternation problem. There were pervasive learning group differences in initial response latencies throughout training which favored imitation subjects. Analysis of total responses per session revealed equally strong and consistent differences in favor of high dominant subjects. The ratio of reinforced responses to total response output was analyzed as an index of response efficiency. Analysis of these data indicated a general trend for improvement among all subjects, but better performance by imitation group members in the last two testing sessions. Finally, analyses of

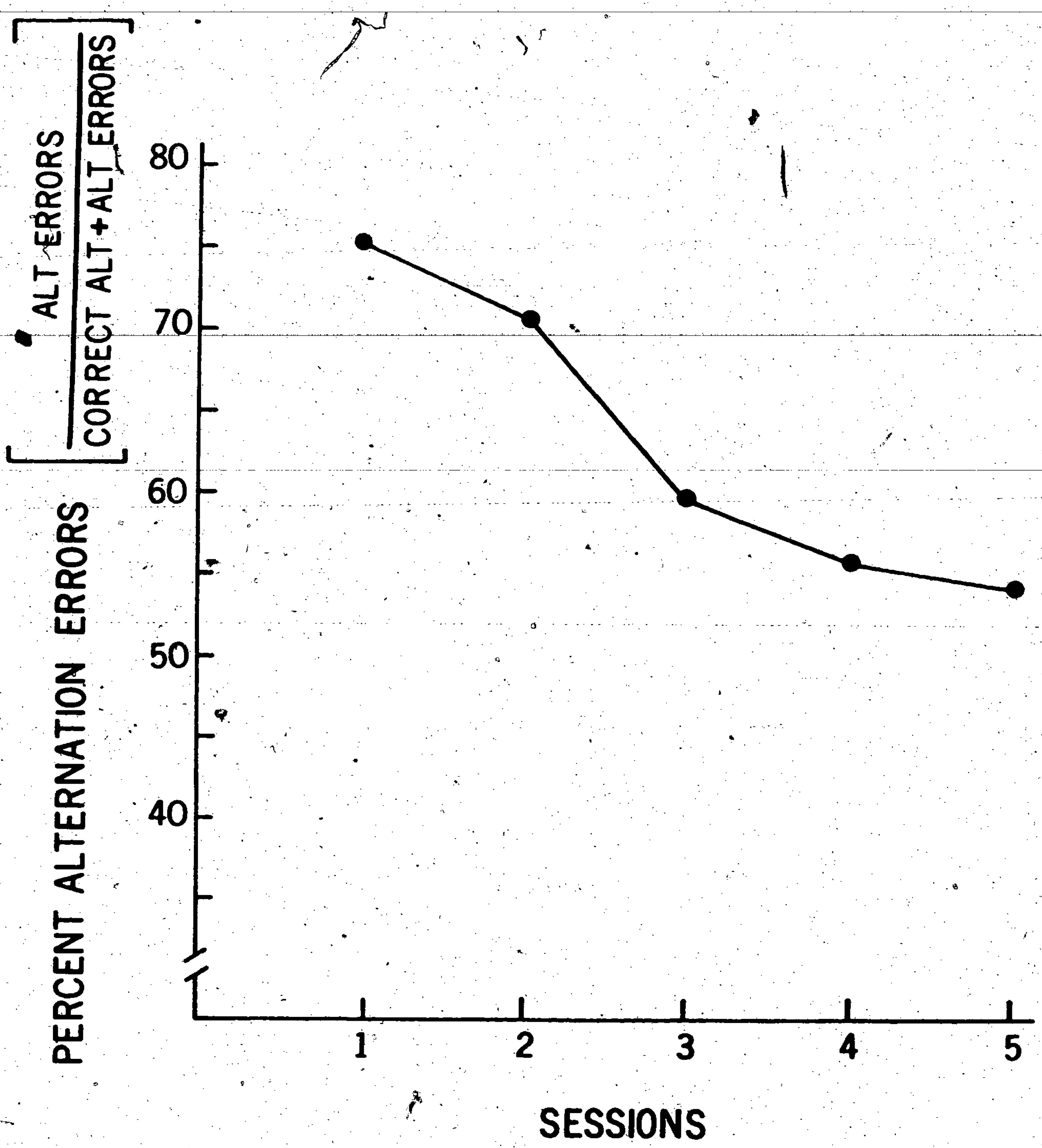

Fig. 11: Percent alternation errors as a function of sessions for all learning subjects

error measures indicated general improvement among all subjects on alternation demands of the learning task, but group and dominance differences on success with the time-out requirement. Examination of percentage time-out errors indicated: significantly greater percentage errors among high dominant subjects, especially in the non-imitation group; and a significant decrease in error scores as a function of testing sessions only for members of the imitation learning group.

Discussion

Learning and Imitation

Three measures of learning performance provide evidence of imitation in the present study. Latency of initial response, percentage correct of total response output, and percentage time-out errors indicate that exposure to the model improved both response acquisition and response efficiency on the learning task.

Prior observation of the model could have improved initial response latency in at least two different ways. Exposure to the model's performance might result in closer attention by the observer to important features of the learning environment, and thus facilitate early discovery of the appropriate instrumental response. On the other hand, the observer may attend primarily to the consequences of the model's performance. Such attention might result in vicarious reinforcement and strengthen modeling activity (Bandura, 1965). However, since the magnitude of reward was quite small, the model's drinking movements were minimal. Thus it is questionable whether the observer could associate delivery of reinforcement with the model's behavior prior to his own experience with the reinforcing mechanism. This consideration indicates that initial exposure to the model probably resulted in better attention by the observer to important features of the learning environment.

More general difficulties with the vicarious reinforcement interpretation of imitation effects on response latency arise due to the lack of significant change in this parameter as a function of repeated xperience according to a vicarious reinforcement hypothesis. Repeated exposures to the model should have provided additional vicarious reinforcement, and ultimately have led to better performance by imitation subjects. However, mean response latencies did not improve as a function of practice for either learning group.

The general lack of practice effects can be explained in terms of the multiple reinforcement contingencies in the cued-alternation task. The time-out procedure functioned as an aversive contingency, which usually produces decreased total response emission (Millenson, 1967) or slower rates of response (Ferster, 1958). In addition, the alternation contingency also led to frequent aversive consequences. Often an appropriately delayed response resulted in an alternation error. Such errors reinstated the time out period, and further delayed delivery of the next reinforcement. In this sense, alternation errors were functionally equivalent to time-out errors. The aversive effects of these latter task demands may have obscured any effect of either vicarious, or experienced reward upon initial response latency.

However, the latency measure does provide striking evidence on the relative importance of trial-and-error and imitation learning. Comparison of first session mean latency for imitation subjects with fifth session mean performance for non-imitation subjects indicates that prior exposure to a group member's activity was a more salient determinant of initial response latency than was considerable trial-and-error experience with the reinforcement contingencies of the learning task. This finding supports Hall's (1968) comments on the extreme importance of social learning to normal primate development.

The percentage correct measure of learning was more clearly affected by trial-and-error experience. Both learning groups significantly improved on this parameter as a function of practice. In addition, this measure indicated that exposure to the model resulted in relatively better response efficiency later in training. Comparison of mean percentage correct scores for the two learning groups suggests that practice with the learning task had more immediate effect upon response efficiency, and that additional exposures to the model were necessary to exceed the benefits of trial-and-error learning.

Exposure to the model may facilitate learning by permitting more efficient use of information gained during trial-and-error practice. Without some experience in the learning situation subjects may not attend to critical aspects of the model's behavior. For example, initially the observers may fail to attend to the model's rate of performance, or to the correlation of his responses with the onset of the tone. Alternatively, the trail-and-error experience may provide opportunity for the observer to associate the model's behavior with delivery of reward. This latter association would result in vicarious reinforcement during the later observational periods, and thus lead to improved efficiency late in training.

It is also possible that the effect of model exposure upon response efficiency reflects some form of delayed imitation. This interpretation would suggest that the superior response efficiency of imitation subjects does not necessarily entail an interaction of trial-and-error learning with subsequent opportunity for observing correct performance. However, only a second imitation group without repeated model exposures could provide definitive evidence for delayed imitation. This additional group might provide an important experimental demonstration of unexpected imitation capacities among macaque monkeys.

Examination of performance on the two error measures clarifies the interpretation of learning group differences in response efficiency. There were no differences in percentage alternation errors between the two learning groups; all subjects improved in alternation performance as a function of testing sessions. In fact, by the last session, the number of correct alternations was similar for most subjects, regardless of status or learning group. However, analysis of percentage time-out errors indicated that exposure to the model led to significant decreases in error scores as a function of practice only among imitation subjects. This finding indicates that differences in learning group response efficiency resulted primarily from a smaller percentage of time-out errors among imitation subjects. Failure of non-imitation subjects to improve time-out error performance implies that exposure to the model was necessary for acquisition of appropriate response timing. However, it is likely that with additional training, members of the non-imitation group would have developed the necessary response inhibition, since the time-out procedure has been used successfully with macaque monkeys in non-social earning experiments

(Stebbins, 1971).

Demonstration of imitation effects on time-out performance has interesting theoretical implications. An account of this effect in terms of vicarious reinforcement requires the assumption that observers vicariously experienced the aversive effects of the model's time-out errors. Given the model's extremely low level of such errors, this assumption seems unjustified. Imitation subjects could improve on this parameter if they attended to the association of tone-onset with the model's response, or if they attended to the model's rate of response and used this information to pace their own activity in the experimental chamber. In either case, imitation effects on the time-out parameter suggest that improved learning performance resulted from observer attention to the model's performance in the learning environment, rather than vicarious reinforcement.

In summary, opportunity to observe a model improves learning of a complex task by enhancing initial response latency and acquisition of appropriate response timing. Model exposure did not improve acquisition of single alternation behavior. Thus in the cued-alternation problem, imitation facilitates performance on temporal, rather than spatial parameters of learning. Finally, imitation effects provide no direct evidence for a vicarious reinforcement view of modeling, but rather suggest that opportunity to observe a model results in better attention to relevant features of the learning situation.

Social Status as a Parameter of Learning

Two performance measures, total response output and percentage time-out errors, indicate that social status is an important determinant of learning performance. Dominant animals responded more often during each training session, regardless of experimental treatment. Such status differences in total responses parallel differences in initiation of agonistic interaction in the social group. In both situations, a higher frequency of response characterized high status animals. This comparison invites speculation about generalized response dispositions associated with social dominance. However, status differences in total responses should first be considered in relation to similar differences in time-out performance.

Correct performance with respect to time-out demands of the learning task required that subjects inhibit responses during the time-out period. Status differences in this performance suggest differing response strategies with respect to the multiple contingencies of the cued-alternation task. High status subjects maximized total number of rewards by increasing total response output. This strategy is most sensitive to reward contingencies, and relatively insensitive to the punitive time-out procedure. Such an emphasis on reward leads to a greater percentage time-out error score for dominant animals. In contrast, low status subjects maintained an equivalent response efficiency at a lower level of total response output. Rather than maximizing reward, these subjects appear to minimize aversive time-out errors. Their strategy is most sensitive to punitive consequences of the time-out procedure, and thus results in better temporal spacing of response emission. Although such low response rates yield fewer rewards early in training, by the fifth session subordinate animals achieve a level of correct alternation performance equivalent to that of dominant animals.

The learning group by social status interaction on the time-out parameter indicates that the effect of model exposure differed according to dominance status of the observer. High status animals exposed to the model had fewer time-out errors during training than high status, non-imitation subjects. However, low status, imitation subjects had more time-out errors than low-status, non-imitation subjects. This latter difference was especially evident during the early training sessions. Observation of the model apparently altered inappropriate status related performance patterns, and led to a better approximation of correct cued-alternation performance. The resulting similarity in performance of high and low status observers may reflect an essential feature of social learning - the tendency for such learning to produce greater behavioral conformity among group members.

The preceding discussion has focused primarily upon behavior in the experimental setting. It is appropriate to speculate about the origins of such performance differences as a function of previous learning histories in the social group. The provocative parallel between total response output and frequency of initiated agonism suggests that status differences in response dispositions may reflect adaptations to group living.

Although dominance status was assessed in terms of dyadic social conflict, dominance relations pervaded most social interactions. High dominance status provided a variety of social prerogatives, e.g. priority to food, toys, preferred resting places. Dominant animals often interfered in activities of other group members, and were able to effectively control much of the behavior of their subordinates. Moreover, when a high ranking animal was attacked by a superior, he often redirected aggression toward a subordinate. As a result, high dominant animals seldom were forced to completely inhibit activity. In contrast, the lowest ranking group members were continually exposed to aversive social control which demanded inhibition of specific responses. Due to their relative status, subordinate animals were commonly forced to wait for access to desired goals. In addition, since these animals were harassed by almost all other group members, they had few subordinates toward whom they could redirect aggression.

Such social dynamics could easily produce specific differences in response dispositions, as well as differences in learning ability and individual temperament. However, such individual differences also could provide a basis for the development of this type of social interaction. Animals with greater tendencies for response inhibition are more likely to provide positive reinforcement for opponents during agonistic interaction. This latter consideration emphasizes the responsiveness of the victim as the primary determinant of relative status. In a fairly closed, permanent society, like that of macaque monkeys, genetic differences in social temperament could provide a basis for the maintenance of intra-group power relations necessary for group survival. Although dominance structure in feral troops is undoubtedly the result of many converging factors, more extensive analysis of learning differences as a function of social status could offer fundamental insights into both the ontogenetic and phyletic determinants of linear dominance hierarchies.

Ethological Concepts of Imitation

A major criticism of early observational learning research focuses upon the difficulty of relating experimental results to forms of imitation observed in the social group (Hall, 1963, 1968). The more comprehensive formulations of animal imitation have been derived from naturalistic, rather than experimental, studies of social learning. However, results from the present experimental analysis can be related to learning concepts derived primarily from field observation.

Ethological views of learning distinguish three forms of imitation: social facilitation; local enhancement; and true-imitation (Thorpe, 1963; Kummer, 1971). Social facilitation involves the elicitation by a social model of a response already in the observer's repertoire; it is a form of imitation in which no novel response is acquired.

The report of avoidance learning among young Patas monkeys (Hall & Goswell, 1964) provides an example of primate social facilitation, since the fear response was elicited by observation of the mother's reaction. Local enhancement refers to the ability of a social model to direct the attention of an observer to some salient feature of the environment, and consequently to accelerate trial-and-error learning. This form of imitation has been viewed as a special case of social facilitation, but it usually implies some form of perceptual learning (Thorpe, 1963). Propagation of the wheat-eating habit among members of the Minoo-B troop of Japanese macaques (Kawamura, 1963) can be interpreted as a form of local enhancement, since these animals had to learn that wheat was an edible substance.

True-imitation is distinguished from the above forms of imitation, since it entails sudden acquisition of a novel response by the observer through insight learning (Thorpe, 1963). This definition stresses the observer's sudden reorganization of prior experience during observation of the model's activity. Individual propagation of placer-mining of wheat and potato-washing in the Koshima troop of Japanese macaques provides the best example of true-imitation among feral monkeys (Kummer, 1971). Both of these novel activities require delay of normal appetitive responses, as well as insight into the consequences of the behavioral elements added to the old feeding pattern. The pre-cultural transmission of novel patterns from parent to offspring usually is distinguished from individual propagation of novel habits (Kawai, 1965). The former process usually entails trial-and-error learning, and thus can be viewed as an example of local enhancement.

Only two of these forms of imitation are evident in the present experimental analysis. First session imitation effects on response latency can be interpreted as evidence for local enhancement. Activity of the model during the first observation period provided cues for the imitation subjects which led to early discovery of the appropriate instrumental response. Learning group differences in latency performance during later sessions, when all subjects had acquired the appropriate response, indicates social facilitation. Even after all subjects had learned how and where to respond, pre-session exposure to the model resulted in faster initial performance in all cases.

Imitation effects on time-out performance can be interpreted as either local enhancement or social facilitation. If improvement on this parameter resulted from association of tone-onset with the model's response, then this imitation effect would be an example of local enhancement. For in this case, the model would have directed the observer's attention to a salient feature of the environment - i.e., the tone. If improvement resulted from the observer's attention to the temporal aspects of the model's response pattern, then the imitation effect could be an example of social facilitation. However, since the observers may have been using either of these two cues, it is not possible to state generally which form of imitation underlies improvement on the time-out parameter.

Implication for Field Research

The present results indicate imitation effects on performance of both high and low status subjects when prior motivation and exposure to the model are controlled. This finding suggests that factors in the natural setting, other than social status, may produce the apparent lack of imitation among dominant group members. Since most of the field reports on pre-cultural development focus upon food-related activities, prior deprivation levels are likely to be important determinants of imitation of these novel behaviors. Observation of feeding habits among macaque monkeys indicates that higher status animals have first access to food resources, and that lower status animals often approach the feeding area only after the higher ranking animals have departed (Itani, 1958; Frisch, 1968). Such feeding habits would lead to lower food motivation among high status group members when a subordinate model demonstrated the novel activity. Moreover, the reticence of subordinate animals to feed in the presence of higher status group members would minimize the likelihood of dominant animals being exposed to any novel food-related activities.

Thus, primate social dominance may indirectly influence imitation in the field through its impact on distribution of food resources, and social spacing of group members which result in differential opportunity for exposure to the social model. Access to food resources and social proximity are also influenced by other dimensions of primate social organization which have been related to pre-cultural development. Kinship bonds generally increase the likelihood of social proximity and mutual feeding. Thus a proximity principle may provide a general explanation of the effect of social relations upon imitation in feral primates.

An additional determinant of exposure to novel activities is the impact of the observer on the performance of the model. Results from the present research indicate that subordinate animals are more successful than dominant animals in delaying responses. Close proximity of a high status animal often results in loss of desirable objects by subordinate group members. Consequently, low dominant animals may have learned not to respond in the presence of higher ranking group members. Such learning would prevent the high status animal from observing the novel activity of subordinates. Reports from field studies (Goodall, 1971) indicate that subordinate chimpanzees do inhibit food-related problem solving activities when in proximity to higher status animals. In the present experiment, observer interference with the activity of the model was prevented by the design of the learning apparatus. Adequate exposure to the subordinate model's activity led to demonstration of imitation learning in high status subjects. Perhaps the apparent imitation deficits among dominant feral monkeys only reflect modeling deficits among their social subordinates.

Since the present research did not demonstrate true-imitation, the above proximity interpretation of pre-cultural development must be applied more tentatively to the examples of potato-washing and placer-mining of wheat. If these activities require an ability to inhibit normal appetitive behavior, a tolerance of delay in consummatory responses may facilitate acquisition of such novel patterns. Greater concern with immediate food consumption may prevent high status animals from discovering the benefits of the washing habit. Furthermore, both of these examples of true-imitation entail novel responses incompatible with normal feeding behavior (Tsumori, 1967; Frisch, 1968). The food must be thrown away or submerged before it is eaten. Perhaps acquisition of such incompatible response patterns requires an unusual ability to tolerate the occasional loss of the goal object. Such tolerance may be more characteristic of subordinate group members, and consequently result in their more rapid acquisition of novel feeding patterns.

APPENDICES

Appendix A:

Observed Agonism for the Imitation Group.

A1	Assaults
A2	Bites
A3	Chases
A4	Clasp-Pulls
A5	Threats
A6	Displaces
A7	Excludes

( ) = Same number of initiated interaction for each member of the dyad.

*** = Reversal of dyadic dominance when compared to group dominance ranking.

Appendix A1: Assaults

Recipients

Initiators

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂			3			1						1	1				6
A3 ♀				3		1						1	1	1			7
A1 ♂				1					1					2			4
A5 ♂													1				1
A6 ♀							1				1						2
A0 ♀																	0
L2 ♂																	0
L4 ♂																	0
L6 ♀																	0
L7 ♂																	0
L1 ♂																	0
L5 ♀																	0
A7 ♀																	0
L0 ♀																	0
A4 ♂																	0
L3 ♀																	0
TOTALS	0	0	3	4	0	2	1	0	1	0	1	2	3	3	0	0	20

Appendix A2: Bites

Recipients

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		2	1	6	1		1						1	2			14
A3 ♀			3	1		2	2		1						1		10
A1 ♂				4				1				1		2			8
A5 ♂						2			1	1		2					6
A6 ♀											2	1			1		4
A0 ♀									1	3			1	3		1	9
L2 ♂									2								2
L4 ♂																1	1
L6 ♀											1					4	5
L7 ♂												1					1
L1 ♂														1		1	2
L5 ♀														1			1
A7 ♀																2	2
L0 ♀																1	1
A4 ♂																3	3
L3 ♀																	0
TOTALS	0	2	4	11	1	4	3	1	5	4	3	5	2	9	2	13	69

Initiators

Appendix A3: Chases

Recipients

Initiators

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		3	2										2	4		1	12
A3 ♀				3			3					1					8
A1 ♂				1	1					1							3
A5 ♂					1	1			1								3
A6 ♀						1	2					2					5
A0 ♀										1							1
L2 ♂													3	5	1		9
L4 ♂																	0
L6 ♀																	0
L7 ♂																1	1
L1 ♂																	0
L5 ♀													1	1			2
A7 ♀																3	3
L0 ♀																	0
A4 ♂																1	1
L3 ♀																	0
TOTALS	0	3	2	4	2	2	5	0	1	3	0	3	6	10	1	6	48

Appendix A4: Clasp-pulls

Recipients

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		1	5		1									2			9
A3 ♀				2			1				1			2			6
A1 ♂				2													2
A5 ♂						2	1										3
A6 ♀						1					1	1		1		1	5
A0 ♀							1		1							1	3
L2 ♂											(1)		1	3			5
L4 ♂																1	1
L6 ♀											3				1	3	7
L7 ♂														1		2	3
L1 ♂							(1)										1
L5 ♀																	0
A7 ♀																6	6
L0 ♀																	0
A4 ♂																	0
L3 ♀																	0
TOTALS	0	1	5	4	1	3	4	0	1	0	6	1	1	9	1	14	51

Initiators

Appendix A5: Threats

Recipients

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		4	15	9	4	2	2	1	2	2		4	1	3		1	50
A3 ♀			9	10	2	6	5	2	3	3	1	2			2	2	47
A1 ♂				8	3	2		1		1							15
A5 ♂					4	8	3	2	2	2	4	2		1		1	29
A6 ♀							2		1	22							5
A0 ♀							5	1	3	3	1				2	1	16
L2 ♂								1	2	•••			2	6			11
L4 ♂									1								1
L6 ♀										2	2	2		4	1		11
L7 ♂							1 •••							8		•••	9
L1 ♂												2			•••	1	3
L5 ♀				1												1	2
A7 ♀														1		2	3
L0 ♀																	0
A4 ♂											2 •••					1	1
L3 ♀										1 •••							1
TOTALS	0	4	24	28	13	18	18	8	14	16	10	12	3	23	5	10	206

Initiators

Appendix A6: Displacements

Recipients

Initiators

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		1	1	3						1				1		3	10
A3 ♀			(1)	2		2	3	1				1				1	11
A1 ♂		(1)		2		2		1						1			7
A5 ♂							1		1			1					3
A6 ♀						2	2									1	5
A0 ♀										1		1		1		1	4
L2 ♂												• • •		1			1
L4 ♂																	0
L6 ♀												2					2
L7 ♂														1		1	2
L1 ♂																	0
L5 ♀							1 • • •							1			2
A7 ♀																1	1
L0 ♀																	0
A4 ♂																	0
L3 ♀																	0
TOTALS	0	2	2	7	0	6	7	2	1	2	0	5	0	6	0	8	43

Appendix A7: Exclusions

Recipients

Initiators

ANIMALS	A2	A3	A1	A5	A6	A0	L2	L4	L6	L7	L1	L5	A7	L0	A4	L3	TOT
A2 ♂		20	29	11	3		4	2			1			2			72
A3 ♀			7	6	4	4	1	2	1	1	1			4			31
A1 ♂		1		17	2	3	3			1			1			2	30
A5 ♂					3	2	1		1	•••				1	1		9
A6 ♀						3			2		1	2			1	1	10
A0 ♀							2	1	2	2		2					9
L2 ♂								2							1	1	4
L4 ♂														1			1
L6 ♀											1	1		3		3	8
L7 ♂				1 •••								1	2	2	1		7
L1 ♂																	0
L5 ♀															1		1
A7 ♀														1		1	2
L0 ♀															4	1	5
A4 ♂																1	1
L3 ♀																	0
TOTALS	0	21	36	35	12	12	11	7	6	4	4	6	3	14	9	10	190

Appendix B:

Observed Agonism for the Non-Imitation Group

B1	Assaults
B2	Bites
B3	Chases
B4	Clasp-pulls
B5	Threats
B6	Displaces
B7	Excludes

( ) = Same number of initiated interaction for each member of the dyad.

*** = Reversal of dyadic dominance when compared to group dominance ranking.

Appendix B1: Assaults

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂				1											1	1	3
L5 ♀			1												1		2
A3 ♂												1			1		2
A0 ♀						1											1
A1 ♂															1		1
A2 ♀																	0
A4 ♀																	0
L4 ♂															1		1
L3 ♀																	0
L1 ♂																	0
L7 ♂																	0
L2 ♀																	0
L6 ♂																	0
L0 ♂																	0
A7 ♀																	0
A6 ♀																	0
TOTALS	0	0	1	1	0	1	0	0	0	0	0	1	0	0	5	1	10

Appendix B2: Bites

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂										1		1		2			4
L5 ♀						2						1					3
A3 ♂				1			2	2									5
A0 ♀													1				1
A1 ♂							1		2	1					1	1	6
A2 ♀							1				1	1			1		4
A4 ♀																	0
L4 ♂														1		1	2
L3 ♀										1						1	2
L1 ♂													1			1	2
L7 ♂																	0
L2 ♀																	0
L6 ♂																	0
L0 ♂																	0
A7 ♀																	0
A6 ♀																	0
TOTALS	0	0	0	1	0	2	4	2	2	3	1	3	2	3	2	4	29

Appendix B3: Chases

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂																	
L5 ♀												2					2
A3 ♂				1	1			1				1					4
A0 ♀																	
A1 ♂						1											1
A2 ♀										2		2				1	5
A4 ♀																	
L4 ♂										1							1
L3 ♀																	
L1 ♂														1			1
L7 ♂															1		1
L2 ♀															2	2	4
L6 ♂																	
L0 ♂																1	1
A7 ♀																	
A6 ♀																	
TOTALS	0	0	0	1	1	1	0	1	0	3	0	5	0	1	3	4	20

Appendix B4: Clasp-pulls

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂			1		1			1			1					1	5
L5 ♀				1	1				1			1				1	5
A3 ♂				1		1		1	1	1							5
A0 ♀							1			1							2
A1 ♂						1	1					1	2	1			6
A2 ♀								1			1	1		1			4
A4 ♀								(1)		1		1			1	1	5
L4 ♂							(1)			1							2
L3 ♀																2	2
L1 ♂																	0
L7 ♂														2			2
L2 ♀																	0
L6 ♂															1		1
L0 ♂															1		1
A7 ♀																	0
A6 ♀																	0
TOTALS	0	0	1	2	2	2	3	4	2	4	2	4	2	4	3	5	40

Appendix B5: Threats

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂			7	3	3	2	4	1		3	3	1	2			1	30
L5 ♀			3	2	2		3			1		2	1				14
A3 ♂				13	9	9	8	7	2	4	3	8	4	4	2	2	67
A0 ♀					2	•••	5	1	1			1	1	3			14
A1 ♂						2	2	1	1	1	1	1		1	2	2	14
A2 ♀			1	1 •••			1	1	2	5	2	5		1		5	24
A4 ♀								3	1	2	4	4		1	3		18
L4 ♂									1	1		1	2				5
L3 ♀																	0
L1 ♂												(1)				2	3
L7 ♂														1		1	2
L2 ♀									(1)						1	1	3
L6 ♂																2	2
L0 ♂																1	1
A7 ♀																	0
A6 ♀																	0
TOTALS	0	0	11	19	16	13	23	15	8	17	14	23	10	11	8	17	197

Appendix B6: Displacements

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂				1			1		1		1		1		1	1	7
L5 ♀							1										1
A3 ♂				2	3	3	1			1	2	2		1	1	2	18
A0 ♀						1	(1)						1	1		1	5
A1 ♂											1		1		1		3
A2 ♀										1	3	1					5
A4 ♀				(1)									1				2
L4 ♂																	0
L3 ♀														1		2	3
L1 ♂																	0
L7 ♂															1		1
L2 ♀														1		1	2
L6 ♂																	0
L0 ♂																	0
A7 ♀																	0
A6 ♀																	0
TOTALS	0	0	0	4	3	4	4	0	1	2	7	3	4	4	4	7	47

Appendix B7: Exclusions

Recipients

Initiators

ANIMALS	A5	L5	A3	A0	A1	A2	A4	L4	L3	L1	L7	L2	L6	L0	A7	A6	TOT
A5 ♂		5	9	1	3	5	2	1	1	3		2		2	1	2	37
L5 ♀	1		9		1			1								1	13
A3 ♂	1			6	6	5	9	11	1	2	1	1	1	3		3	50
A0 ♀		1			2	3	2	1	1			1		2			13
A1 ♂						2	3	3	2	1		1	1				13
A2 ♀			1		1		1	1				1	2			1	8
A4 ♀				1				1	4	2		2	1			3	14
L4 ♂										(1)	3	1	2	1			8
L3 ♀										2							2
L1 ♂								(1)			1				2		4
L7 ♂														2	2	1	5
L2 ♀																	0
L6 ♂																1	1
L0 ♂															1	1	2
A7 ♀																	0
A6 ♀																	0
TOTALS	2	6	19	8	13	15	17	20	9	11	5	9	7	10	6	13	170

Appendix C:

Performance of the Model

C1 Model's Preliminary Performance during Alternation Training

C2 Model's Performance during Observational Learning:

- A. High Dominant Subjects
- B. Low Dominant Subjects

Appendix C1. Model's Performance during Alternation Training

Blocks: 100

Alternation Trials	Number Correct	Timing Errors
1	41	51
2	42	54
3	49	119
4	52	92
5	71	19
6	71	18
7	71	27
8	73	5
9	80	8
	With Observer L4;	
10	44	75
11	48	66
12	58	50
	With Observer L4 and Deprived:	
13	60	46
14	71	28
15	73	22
16	87	11
17	85	12
18	90	6
19	94	2
20	98	5
21	96	3

Appendix C2. Model's Performance during Observational Learning Experiment

A. High Dominant Subjects:

Observer	Session	Correct Alternations	Alternation Errors	Timing Errors
A3	1	43	5	0
	2	47	3	3
	3	49	1	0
	4	46	3	2
	5	49	7	1
A1	1	48	0	0
	2	41	2	0
	3	45	5	1
	4	48	3	5
	5	48	6	1
A5	1	45	7	1
	2	48	2	0
	3	47	7	3
	4	45	5	1
	5	40	3	0
A6	1	44	6	3
	2	35	8	0
	3	44	8	0
	4	44	6	1
	5	50	0	0

Appendix C2. Model's Performance during Observational Learning Experiment

B. Low Dominant Subjects:

Observer	Session	Correct Alternations	Alternation Errors	Timing Errors
L5	1	46	3	0
	2	46	3	2
	3	48	2	0
	4	35	8	1
	5	41	2	1
A7	1	41	2	0
	2	42		4
	3	47	6	2
	4	48	2	1
	5	50	1	0
L0	1	42	9	0
	2	50	5	1
	3	42	4	2
	4	50	4	0
	5	46	2	2
L3	1	44	6	0
	2	46	5	4
	3	48	4	0
	4	51	5	1
	5	41	4	3

Appendix D:

Experimental Performance and Learning Scores for all Subjects

D1 High Dominant Imitation Subjects

D2 Low Dominant Imitation Subjects

D3 High Dominant Non-Imitation Subjects

D4 Low Dominant Non-Imitation Subjects

Appendix D1: High Dominant Imitation Subjects

Sub-ject	Corr. Alt.	Alt. Err.	T/O Err.	Tot. Resp.	Resp. Lat.	Resp. Rate	% Tot. Corr.	% T/O Err.	% Alt. Err.
A3	32	88	93	213	1.9	.526	15	44	73
	48	72	66	186	3.9	.256	26	35	60
	58	62	56	176	5.6	.179	33	32	52
	63	57	30	150	1.6	.625	42	20	48
	72	48	19	139	6.5	.154	52	14	40
A1	10	22	14	46	4.1	.244	22	30	69
	5	49	20	74	3.9	.255	7	27	91
	27	93	90	210	16.4	.061	13	43	78
	43	77	39	159	4.1	.244	27	25	64
	45	75	20	140	8.6	.116	32	14	63
A5	55	65	212	332	9.7	.103	17	64	54
	78	42	174	294	2.5	.400	27	59	35
	81	39	143	263	1.7	.588	31	34	33
	82	38	45	165	2.6	.385	50	27	32
	96	24	21	141	8.0	.125	68	15	20
A6	7	36	13	56	18.4	.054	13	23	84
	4	40	16	60	123.1	.008	7	27	91
	26	94	90	210	10.3	.097	12	43	78
	60	60	166	286	6.1	.164	21	58	50
	64	56	118	238	4.7	.213	27	50	46

Appendix D2: Low Dominant Imitation Subjects

Sub-ject	Corr. Alt.	Alt. Err.	T/O Err.	Tot. Resp.	Resp. Lat.	Resp. Rate	% Tot. Corr.	% T/O Err.	% Alt. Err.
L5	9	30	25	64	47.1	.021	14	39	77
	47	73	64	184	36.0	.028	26	35	61
	62	47	38	147	12.4	.081	42	26	43
	69	51	25	145	10.1	.099	48	17	43
	66	54	17	137	2.2	.455	48	12	45
A7	17	56	33	106	3.8	.267	16	31	73
	41	67	47	155	6.3	.159	26	30	62
	45	75	25	145	3.6	.278	31	17	63
	54	66	15	135	2.5	.400	40	11	55
	51	69	10	130	1.5	.667	39	8	58
L0	4	29	19	52	118.8	.008	8	34	88
	10	39	12	61	11.3	.088	16	20	80
	24	48	26	98	3.0	.333	24	21	62
	30	52	23	105	8.9	.112	29	22	63
	34	40	16	90	10.6	.094	38	18	54
L3	3	15	7	25	38.0	.026	12	28	83
	3	14	12	29	28.8	.035	10	41	82
	3	7	2	12	46.3	.022	25	17	70
	37	83	43	163	38.8	.026	23	26	69
	55	65	25	145	21.0	.048	31	17	54

Appendix D3: High Dominant Non-Imitation Subjects

Subject	Corr. Alt.	Alt. Err.	T/O Err.	Tot. Resp.	Resp. Lat.	Resp. Rate	% Tot. Corr.	% T/O Err.	% Alt. Err.
L5 ♀	27	44	52	123	128.6	.008	22	42	62
	50	70	196	316	14.0	.071	16	62	58
	49	71	146	266	23.3	.043	18	55	59
	62	58	180	300	12.5	.080	21	60	48
	63	57	145	265	11.7	.085	24	55	48
A3	50	70	107	227	106.1	.009	22	47	58
	70	50	48	168	15.2	.066	42	29	42
	70	50	27	147	12.7	.077	48	18	42
	68	52	32	152	28.3	.035	45	21	43
	76	44	57	177	15.0	.067	43	32	37
A0	36	84	126	246	33.6	.030	15	51	70
	55	65	129	249	13.3	.075	22	52	54
	60	60	125	245	13.6	.074	24	51	50
	49	71	173	293	15.7	.064	17	59	59
	49	71	131	251	14.6	.068	20	52	59
A1 ♂	39	64	242	355	144.3	.007	11	71	62
	33	87	124	244	120.0	.008	14	51	73
	38	82	125	245	64.7	.015	16	51	68
	38	82	82	202	40.2	.025	19	41	68
	45	75	165	285	14.5	.069	16	58	63

Appendix D4: Low Dominant Non-Imitation Subjects
(* = estimated score)

Sub-ject	Corr. Alt.	Alt. Err.	T/O Err.	Tot. Resp.	Resp. Lat.	Resp. Rate	% Tot. Corr.	% T/O Err.	% Alt. Err.
L2	0	0	0	0	1800.0	.001	13*	9*	84*
	6	32	1	39	478.4	.002	15	3	84
	33	67	32	132	27.7	.036	25	24	67
	37	83	22	142	17.0	.058	26	15	69
	56	64	20	140	31.1	.032	40	14	53
L6	4	17	7	28	313.6	.003	14	25	81
	0	2	0	2	545.2	.002	0	0	100
	7	11	2	20	590.3	.002	35	10	61
	4	15	1	20	32.6	.031	20	5	78
	0	1	2	3	351.3	.003	0	66	100
L0	0	6	0	6	774.2	.001	0	0	100
	0	1	0	1	1668.8	.001	0	0	100
	2	13	0	15	201.0	.005	13	0	87
	38	82	24	144	331.9	.003	33	17	68
	55	55	10	120	11.0	.091	46	8	50
A6	8	42	6	56	56.2	.018	14	11	84
	43	77	7	127	42.6	.024	34	5	64
	61	59	67	187	13.5	.074	33	36	49
	58	62	83	203	15.8	.063	29	41	52
	52	68	76	196	12.7	.079	27	39	57

Appendix E:

Analysis of Variance Tables.

E1	Model's Correct Alternation Performance
E2	Model's Alternation Errors
E3	Model's Time-Out Errors
E4	Experimental Response Rate
E5	Experimental Total Responses
E6	Experimental Percentage Correct of Total
E7	Imitation Group Percentage Correct of Total
E8	Non-Imitation Group Percentage Correct of Total
E9	Experimental Percentage Time-Out Errors
E10	Imitation Group Percentage Time-Out Errors
E11	Non-Imitation Group Percentage Time-Out Errors
E12	Experimental Percentage Alternation Errors

Appendix E1: Model's Correct AlternationaPerformance

	Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1	Dominance		.100	.100	1		
2	Sessions	OS(D)	28.500	7.125	4	.385	n.s.
3	Observer (D)	OS(D)	59.400	9.900	6	.535	n.s.
4	DS	OS(D)	37.400	9.350	4	.505	n.s.
5	OS(D)		444.100	18.500	24		

Appendix E2: Model's Alternation Errors

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Dominance		.250	.250	1		
Sessions	OS(D)	25.150	6.290	4	.984	n.s.
3 Observer(D)	OS(D)	22.350	3.730	6	.583	n.s.
4. DS	OS(D)	17.850	4.463	4	.698	n.s.
5 OS(D)		153.400	6.390	24		

Appendix E3: Model's Time-Out Errors

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Dominance		.100	.100	1		
2 Sessions	OS(D)	.850	.213	4	.089	n.s.
3 Observer(D)	OS(D)	3.000	.500	6	.211	n.s.
4 DS	OS(D)	10.150	2.540	4	1.068	n.s.
5 OS(D)		57.000	2.370	24		

Appendix E4: Experimental Response Rate

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Group	M(GD)	.534	.534	1	13.310	.005
2 Dominance	M(GD)	.501	.501	1	1.248	n.s.
3 Sessions	MS(GD)	.623	.160	4	1.420	n.s.
4 GD	M(GD)	.153	.153	1	.382	n.s.
5 GS	MS(GD)	.177	.442	4	.402	n.s.
6 DS	MS(GD)	.850	.212	4	1.931	n.s.
7 Monkey(GD)		.481	.401	12		
8 GDS	MS(GD)	.850	.213	4	1.938	n.s.
9 MS(GD)		.530	.190	48		

Appendix E5: Experimental Total Responses

Source of Variance		Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1	Group	M(GD)	5695.313	5695.313	1	.535	n.s.
2	Dominance	M(GD)	258212.800	258212.800	1	24.269	.001
3	Sessions	MS(GD)	27110.900	6777.734	4	2.040	n.s.
4	GD	M(GD)	40815.600	40815.600	1	3.836	n.s.
5	GS	MS(GD)	2550.223	637.600	4	.192	n.s.
6	DS	MS(GD)	16909.600	4227.400	4	1.273	n.s.
7	Monkey(GD)	MS	127674.900	10639.600	12		
8	GDS	MS(GD)	10272.100	2568.023	4	.773	n.s.
9	MS(GD)		159439.500	3321.700	48		

Appendix E6: Experimental Percentage Correct of Total

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Group	M(GD)	480.200	480.200	1	1.192	n.s.
2 Dominance	M(GD)	36.450	36.450	1	.090	n.s.
3 Sessions	MS(GD)	4592.371	1148.093	4	16.890	.001
4 GD	M(GD)	48.050	48.050	1	.119	n.s.
5 GS	MS(GD)	713.672	178.418	4	2.625	.05
6 DS	MS(GD)	248.922	62.231	4	.915	n.s.
7 M(GD)		4835.090	402.924	11		
8 GDS	MS(GD)	295,321	73,831	4	1.086	n.s.
9 MS(GD)		3262.769	67.975	47		

Appendix E7: Imitation Group Percentage Correct of Total

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedeom	F=	P<
1 Monkey		2464.000	352.000	7		
2 Sessions	MS	4138.900	1034.725		25.205	.001
3 MS		1149.453	41.052	28		

Appendix E8: Non-Imitation Group Percentage Correct of Total

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedeom	F=	P<
1 Monkey		2455.600	350.800	7		
2 Sessions	MS	1167.148	291.787	4	3.074	.05
3 MS		2657.627	94.915	27		

Appendix E9: Experimental Percentage Time-Out Errors

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Group	M(GD)	156.800	156.800	1	.460	n.s.
2 Dominance	M(GD)	9331.199	9331.199	1	27.388	.001
3 Sessions	MS(GD)	356.875	89.219	4	.581	n.s.
4 GD	M(GD)	2376.199	2376.199	1	6.974	.01
5 GS	MS(GD)	1958.323	489.581	4	3.190	.01
6 DS	MS(GD)	249.910	62.478	4	.407	n.s.
7 M(GD)		4088.398	340.700	11		
8 GDS	MS(GD)	869.184	217.296	4	1.416	n.s.
9 MS(GD)		7365.961	153.458	47		

Appendix E10: Imitation Group Percentage Time-Out Errors

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Dominance	M(D)	1144.900	1144.900	1	8.429	.025
2 Sessions	MS(D)	1651.349	412.837	4	2.956	.05
3 Monkey(D)		815.000	135.833	6		
4 DS	MS(D)	195.848	48.962	4	.351	n.s.
5 MS(D)		3351.957	139.665	24		

Appendix E11: Non-Imitation Group Percentage Time-Out Errors

Source of Variance	Error Term	Sum of Squares 1	Mean Square	Degrees of Freedom	F=	P<
1 Dominance	M(D)	10562.500	10562.500	1	19.361	.01
2 Sessions	MS(D)	663.850	165.962	4	.992	n.s.
3 Monkey(D)		3273.398	545.567	5		
4 DS	MS(D)	923.244	230.811	4	1.380	n.s.
5 MS(D)		4014.041	167.252	23		

Appendix E12: Experimental Percentage Alternation Errors

Source of Variance	Error Term	Sum of Squares	Mean Square	Degrees of Freedom	F=	P<
1 Group	M(GD)	340.313	340.313	1	.485	n.s.
2 Dominance	M(GD)	2989.012	2989.012	1	4.258	n.s.
3 Sessions	MS(GD)	5753.574	1438.394	4	16.741	.001
4 GD	M(GD)	726.013	726.013	1	1.034	n.s.
5 GS	MS(GD)	376.871	94.218	4	1.097	n.s.
6 DS	MS(GD)	367.160	91.790	4	1.068	n.s.
7 M(GD)		8424.043	702.003	11		
8 GDS	MS(GD)	430.183	107.546	4	1.252	n.s.
9 MS(GD)		4124.070	85.918	47		

References

Alexander, B.K., & Bowers, J.M. The social organization of Japanese monkeys in a two-acre corral. *Folia Primatologica*, 1969, *10*, 320-242.

Bandura, A. Behavioral modification through modelling procedures. In L. Krasner & L. Allman (Eds.), *Research and Behavior Modification*. New York: Holt, 1965.

Bernstein, I.S. A field study of the pigtail monkey (*Macaca nemistrina*). *Primates*, 1967, *8*, 217-228.

Cole, J. Macaca nemistrina in captivity. *Symposium of the London Zoological Society*, 1963. London.

Crawford, M.P., & Spence, K.W. Observational learning of discrimination problems by chimpanzees. *Journal of Comparative Psychology*, 1939, *27*, 133-147.

Darby, C.L. Observational learning in the Rhesus monkey, *Dissertation Abstracts*, 1959, *19*, 1664.

Darby, C.L., & Riopelle, A.J. Observational earning in the Rhesus monkey. *Journal of Comparative and Physiological Psychology*, 1959, *52*, 94-98.

Ferster, C.B. Control of behavior in chimpanzees and pigeons by time out from positive reinforcement. *Psychological Monographs*, 1968, *72*.

Frisch, J.E. Individual behavior and intertroop variability in Japanese macaques. In P. Jay (Ed.), *Primates: Studies in Adaptation and Variability*. New York: Holt, Rinehart, & Winston, 1968.

Goodall, J. Chimpanzees of the Gombe Stream Reserve. In I. DeVore (Ed.), *Primate Behavior: Field Studies of Monkeys and Apes*. New York: Holt, Rinehart, & Winston, 1965.

Goodall, J. Expressive movements and communication in chimpanzees. In P. Jay (Ed.), *Primates: Studies in Adaptation and Variability*. New York: Holt, Rinehart, & Winston, 1968.

Goodall, J. *In the shadow of man.* Toronto: Collins, 1971.

Hall, K.R.L. Observational learning in monkeys and apes. *British Journal of Psychology*, 1963, *54*, 201-226.

Hall, K.R.L. Social organization of the old-world monkeys and apes. *Symposium of the London Zoological Society*. London, 1965.

Hall, K.R.L. Social learning in monkeys. In P. Jay (Ed.), *Primates: Studies in Adaptation and Variability.* New York: Holt, Rinehart & Winston, 1968.

Hall, K.R.L., & Goswell, M.J. Aspects of social learning in captive Patas monkeys. *Primates*, 1964, *5*, 59-70.

Hayes, K.J., & Hayes, C. Imitation in a home-raised chimpanzee. *Journal of Comparative and Physiological Psychology*, 1952, *45*, 450-459.

Itani, J. On the acquisition and propagation of a new food habit in the natural group of the Japanese monkeys at Takasakiyama. *Primates*, 1958, 1, 84-98 (In Japanese with English summary).

Jolly, A. *The evolution of primate behavior.* London: Collier-McMillan, 1972.

Kawai, M. On newly acquired behaviors of the natural troop of Japanese monkeys on Koshima Island. *Primates*, 1963, *4*, 113-114.

Kawai, M. Newly acquired pre-cultural behavior of the natural troop of Japanese monkeys on Koshima Islet. *Primates*, 1956, *6*, 1-30.

Kawamura, S. The process of sub-cultural propagation among Japanese monkeys. *Primates*, 1959, *3*, 45-60.

Kawamura, S. The process of sub-cultural propagation among Japanese macaques. In C. Southwick (Ed.), *Primate Social Behavior.* Toronto: Van Nostrand, 1963.

Kummer, H. Tripartite relations in Hamadryas baboons. In S. Altmann (Ed.), *Social Communication among Primates.* Chicago: University of Chicago Press, 1967.

Kummer, H. Primate societies: Group techniques in ecological adaptation. Chicago: Aldine-Atherton Press, 1971.

Lorenz, K. On Aggression. New York: Harcourt, Brace, & World, 1966.

Mason, W.A. Naturalistic and experimental investigations of the social behavior of monkeys and apes. In P. Jay (Ed.), Primates: Studies in Adaptation and Variability. New York: Holt, Rinehart, & Winston, 1968.

Millenson, J.R. Principles of behavioral analysis. New York: McMillan, 1967.

Myers, J.L. Fundamentals of experimental design. Boston: Allyn and Bacon, 1966.

Rumbaugh, D.M. Learning skills of anthropoids. In L.A. Rosenblum (Ed.), Primate Behavior: Developments in Field and Laboratory Research. New York: Academic Press, 1970.

Sackett, G.P., Porter, M., & Holmes, H. Choice behavior in Rhesus monkeys: Effects of stimulation during the first six months of life. Science, 1965, 147, 304-306.

Schusterman, R.J. Transfer effects of successive discrimination-reversal training in chimpanzees. Science, 1962, 137, 422-423.

Southwick, C.H. Primate social behavior. Toronto: Van Nostrand, 1963.

Stebbins, W.C. Hearing. In A. Schrier & F. Stollnitz (Eds.), Behavior of Nonhuman Primates, 3. New York: Academic Press, 1971.

Thorpe, W.H. Learning and instincts in animals (3rd edition). London: Methuen, 1963.

Tsumori, A. Newly acquired behavior and social interactions of Japanese monkeys. In S. Altmann (Ed.), Social Communication among Primates. Chicago: University of Chicago Press, 1967.

Washburn, S.L., & DeVore, I. Social life of baboons. *Scientific American*. 1961, *204*, 62-71.

Zimmerman, R.R. Failure to find infant-adult differences in formation of learning set. *Perceptual and Motor Skills*, 1969, *28*, 721-722.

Zimmerman, R.R., & Torrey, C.C. Ontogeny of learning. In A.M. Schrier, H.F. Harlow, & F. Stollnitz (Eds.), *Behavior of Nonhuman Primates*, *2*. New York: Academic Press, 1965.