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THE MOSS-HARLOW EFFECT IN ASL PROFICIENT CHIMPANZEES AS A FUNCTION OF AGE

A DISSERTATION

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GEORGE HARRIS KIMBALL

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APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

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GEORGE HARRIS KIMBALL

ABSTRACT

Four chimpanzees varying in age from infant to adult, and varying in sign language proficiency from no signs to 240 reliable signs, were tested on a series of discrimination problems (using nonsense objects) which were preceded by an information trial. The information trial informed the subject that the presented object would subsequently become the correct (S+) or incorrect (S-) object in the two-choice discrimination trial. The Moss-Harlow effect was produced except for the oldest ASL using chimpanzee. The infant ASL chimpanzees as well as the adult chimpanzee with no sign language training performed significantly better in the condition where the incorrect (S-) object was presented in the information trial, as opposed to the correct (S+) object, or both objects (B) conditions. Washoe, the only adolescent chimpanzee with sign language training, performed significantly better in the condition where the correct object (S+) was presented during the information trial. The chorono-

logical age by linguistic competence interaction is consistent with explanations of human children's performance in similar tasks.

THE MOSS-HARLOW EFFECT IN ASL PROFICIENT CHIMPANZEES AS A FUNCTION OF AGE

INTRODUCTION

Harlow (1959) has shown that the performance of nonhuman primates given information trials to a non-rewarded object (S-) will, in subsequent two-object discrimination trials, be superior to animals given comparable information trials with a rewarded object (S+). This phenomenon has been called the Moss-Harlow effect (Moss and Harlow, 1947). With human children, however, the Moss-Harlow effect has been characterized quite differently. Vaughter and Cross (1965) found that five year old children showed an increase in accuracy of discrimination performance following either mixed (both positive and negative) information trials or positive information trials in a discrimination-reversal situation. Negative information trials alone, unaccompanied by positive trials, were no more beneficial than a control situation involving no pre-reversal experience.

Cross and Vaughter (1966) showed that the Moss-Harlow effect was apparently age-dependent for human children. Children under the age of 4 1/2 years showed improved performance in discrimination learning when presented with prior negative information trials (like nonhuman primates), while children older than 4 1/2 showed superior acquisition after positive information trials (replicating Vaughter and Cross, 1965). This led the authors to conclude that the emerging role of language facilitates the transfer of learning strategies from a more primitive or "associative" mode of learning, to a more "cognitive" mode (i.e., Kendler and Kendler, 1962, and White, 1965). It is also reasonable to hypothesize that the reason the nonhuman primate remains in an avoidance strategy of learning rather than a more cognitive (approach) mode could be because the symbolic manipulation of language units is not possible.

Kendler and Kendler (1962) characterized this transition period as when the child begins to have the capability to be guided by a mediating response to the presented stimulus as well as by the stimulus itself. Kendler and Kendler further feel that the usual, but not only, mediation is linguistic in nature. Even though children can label cues prior to the transition point, they apparently do not utilize these cues when problem solving. Reese (1962) states that younger children have a "mediational deficiency" because overlearning of a word must take place before that word can be used to mediate.

Kendler and Kendler (1962) also state that the act of mediating is part of a "horizontal process" (represented by a series of S-R behavioral chains). Ontogenetic development then establishes linguistic "vertical" (referring to the fact that the horizontal chains are occuring simultaneously) connections between the horizontal processes. Older children can, given this vertical connection, use the word they generate to select stimulus and response components from different behavioral chains. In so doing, their behavior supposedly becomes conceptual (Kendler, 1964).

White's (1965) "hierarchical stacking" hypothesis asserts that human adult thought may be characterized as "layered." According to White, we all have an "associative level," laid down early in development, which is relatively fast acting and follows conventional associative principles. However, this associative layer exists more as a potential in the adult human, and is inhibited by the subsequent "cognitive layer." White (1965) states,

> These two levels are taken to be temporally stacked, the faster associative mode having precedence over the cognitive mode, and conditions which influence a subject's tempo of response and/or his ability to restrain a first-available response will influence which mode determines his response (White, 1965, p. 216).

Other authors (Grabbe and Campione, 1969) claim that the transition period is not characterized by a developmental change in the type of information per se which is primarily used (older approach S+, and younger avoid S-). Instead, Grabbe and Campione propose a "novelty" or "exploratory tendency" explanation. Considering first the younger children, if it is assumed that they will always tend to choose the more novel of the two stimuli on the test trials, the number of correct responses will be greater for those children who were presented with the negative stimulus during training.

Grabbe and Campione state,

> If novelty is the important variable for younger children, the developmental change reported by Cross and Vaughter (1966) may be in response to novelty, rather than in the changing relation effectiveness of rewarded and nonrewarded trials. It may be that the younger children tend to respond to the novel stimulus, independent of prior reward contingencies, whereas the older children are able to inhibit their response to novel stimuli (Grabbe and Campione, 1969, p. 1078).

Grabbe and Campione (1969) do not attempt to identify the causal agent that occurs during the transition period which enables the children to inhibit his novelty responding, and separates the older human child from nonhuman primate's learning strategies. They do allude to their interpretation being consistent with White's (1965) "stacking" or "layering" hypothesis.

Regardless of the precise mechanism involved, it is apparent that humans do undergo a transition period in their learning strategies, which coincides with the onset of many other cognitive capabilities. Whether this change is strictly developmental, environmental, or species specific, and whether the causal agent is the emerging influence of language is yet unknown.

D'Amata and Jagoda (1961) have proposed a somewhat more basic explanation, based on more environmental or evolutionary constraints. For a nonhuman primate growing up in the wild, mechanisms of inhibition are adaptive. To survive, it is of primary importance to learn to avoid all new stimuli until it is learned that it is safe to approach. A logical extension indicates that because the natural environment of the adolescent or adult primate differs only slightly from the environment encountered as a child, a switch in primary learning strategies is both unnecessary and (perhaps) counterproductive. In contrast, beyond the shelter of infancy, a human encounters an almost bewildering array of stimuli, and a primary learning strategy based on avoiding all stimuli until it is determined which are safe to approach would be inefficient and presumably nonadaptive.

Recent research in teaching chimpanzees a human language (American Sign Language or Ameslan) by the Gardners (1969, 1971) and Fouts (1973, 1974) makes possible a more direct comparison of potential environmental or language-influenced learning strategies across species. Kimball, Couch, Kanak and Fouts (1978) showed that a five year old chimpanzee could rapidly learn an 18 pair concurrent discrimination task (analogous to human verbal discrimination paradigms) using Ameslan as his mode of responding. In a series of experiments, Kimball, et al (1978), demonstrated that knowledge of the name (sign) of the objects to be discriminated greatly facilitated the rate of acquisition of the entire task, relative to a control task in which the names (signs) of the objects were not known (to the subject). Within-task manipulations (designed to control the amount of information available about the correct and incorrect items of the pairs) yielded other interesting data. Studies utilizing an analogous learning task (verbal discrimination learning) with humans have hypothesized that discrimination learning is facilitated when the perceived frequency of occurance of the individual items (within the pair) becomes recognizably different. Frequency theory (Ekstrand, Wallace, and Underwood, 1966) allows several ways in which "frequency units" are "added" to the items within the pair to make the correct item more easily distinguishable (i.e., recognition, rehearsal, implicit associations, etc.). As the humans recognize, rehearse, and say the name of the item perceived to be correct, "frequency units" are added, making that particular discrimination easier in subsequent presentations. By repairing (or repeating) the correct (S+) item with a new incorrect (S-) item, the correct item would retain its frequency units, therefore becoming even more discriminable than either of the incorrect items it is paired with. Again, the Kimball, et al, (1978) study with the chimpanzee showed data contrary to predictions of human performance. Even though knowledge of the name (signs) of the objects facilitated rate of task (list) acquisition relative to control tasks (no name signs for the items were known), within list (regardless of name availability) the chimpanzee made far fewer errors in the condition where the incorrect (S-) item was repeated with a new correct (S+) item relative to either the "repeat S+" condition or the "control" condition (no repeating or repairing of items). Again the nonhuman primate apparently utilizes the information concerning which item is incorrect, rather than which item is correct. The faster acquisition of the task in which the name (sign) of the object was known indicates that the chimpanzee is capable of linguistic mediation, but it is incorporated into his own species learning strategy.

Because this chimpanzee was raised in a human home (presumably an enriched environment) and had a sign language vocabulary of 120 words, it might have been assumed that these environmental influences would shape his learning strategy toward a more cognitive (approach) style. However, chronological development is a potential confounding influence. It is important to note that the chimpanzee subject was only five years old at the time of the study, and, his performance may not be indicative of the cognitive manipulations possible by a more mature chimpanzee with a much larger vocabulary, and expanded linguistic and environmental experience in all types of situations.

The present experiment was designed to explore the role of environment, linguistic competence, developmental age, and their possible interactions in the learning strategies of the chimpanzee.

METHOD

Subjects

The subjects were Nim (a 5 year old male chimpanzee with an Ameslan vocabulary of 120 reliable signs[1]), Ally (a 9 year old male chimpanzee with an Ameslan vocabulary of 130 reliable signs), Washoe (a 13 year old female chimpanzee with 240 reliable signs), and Mona (a 18 year old female chimpanzee with no sign language training). Because of the nature of the task, and the presupposed environment x linguistic ability x developmental age interaction, a description of each subject's background and rearing details are appropriate.

Nim

Nim was born at the Institute for Primate Studies of the University of Oklahoma and removed from his mother almost immediately. The first 4 years of his life he resided in a human home, where he was constantly surrounded by human companions (Dr. H. Terrace of Columbia University and his staff of graduate research assistants). Training in Ameslan was an integral facet of his rearing, and while in his

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[1] A reliable sign is defined as one that has been spontaneously and correctly used by the chimpanzee for 15 consecutive daily sessions.

presence, spoken English was never used. All humans present communicated solely via Ameslan. Nim returned to the Institute at age 4, and currently resides on an island enclosure with six other young chimpanzees.

Ally

Ally was born earlier at the Institute for Primate Studies (from the same parents), and was relocated to a human home almost immediately. Although any human home environment can be considered enriched in comparison to a caged environment, Ally's rearing differed considerably from Nim's. Ally initially was raised more as a pet by his human "mother," who spoke English in his presence. Ally's "mother" did not institute or participate in Ameslan training until Ally was approximately 2 years of age. At that time, Dr. Roger Fouts of the University of Oklahoma and his graduate research assistants began teaching Ameslan to Ally in his home. By the time Ameslan instruction began, Ally was quite proficient in spoken English comprehension. Ally's Ameslan training was continued after his return to the Institute at age 5. Ally is currently housed with Washoe in the Institute's main laboratory building.

Washoe

Washoe was born in the wild, and subsequently raised in a human home environment from approximately age 10 months to 6 years. She, like Nim, was constantly surrounded by human companions (Dr's. Allen and Beatrice Gardner of the University of Nevada and their staff of research assistants) during her waking hours. Washoe was immersed in Ameslan immediately, and spoken English was never used in her presence (while in her human home). All humans communicated solely via Ameslan. Washoe came to the Institute at age 6, and currently is housed with Ally.

Mona

Mona's background is much less certain. She is a mature, 18 year old female who came to the Institute as a young adolescent. Prior to her arrival, she was a performing chimpanzee in a circus. Her spoken English comprehension appears good, but she has no Ameslan signs, and has never been instructed in Ameslan. Mona is housed with five other adult females and their infants in the Institute's main laboratory building.

Apparatus

The apparatus is diagrammed in Figure 1. The partitions were constructed of plywood, and were approximately 1.2 meters in height, and approximately 1.2 meters in length. The stimulus presentation box was constructed of wood, and was approximately .8 meters in length, and .3 meters in width. The stimuli were nonsense objects constructed of wood (see Figure 1), and were painted one of four colors: red, white, green, or gray. Each object had a 10 cm. square base which covered the reward trays (holes). The raisable door was also constructed of plywood.

Procedure

General

A double blind procedure was in effect throughout the experiment. As shown in Figure 1, the experimenter arranged the object or objects on the stimulus presentation box, then turned away. The observer then raised the door and announced the chimpanzee's selection by color (e.g., "he chose gray"). The observer then closed the door (after the appropriate reward was procured from the food well by the subject). The experimenter recorded the response, and arranged the next trial. The intertrial interval (ITI) was maintained at 15-20 seconds.

The stimulus objects were grouped in a manner to provide maximum discriminability between the pair. The objects were first grouped by color and subdivided by general shape (i.e., more rounded vs. straight, sharp lines). The objects were then randomly paired to form 30 pairs, with the only restrictions being that same colors were not paired, and the paired items were of easily discriminable different shapes.

Phase I

The list of items consisted of three conditions, each with 10 pairs of objects. In the "familiarize S+"

condition, two information trials were given using the item of the pair that had been randomly designated as the correct item. On the information trials, the item was presented alone over the center food well, and a food reward (slice of fruit) was available for the subject to eat (S+ condition). On the third trial, both items of the pair were presented (on the outside wells, randomized for position of S+) and the subject made a single choice. The subject received the food reward only if he chose the S+ item first.

For the "familiarize S-" condition, two information trials were given using the designated incorrect item of the pair in the center food well. There was no fruit under this item. The subject was allowed to displace the item and see that no reward was available. Again, on the discrimination trial (trial 3) both items were presented on the outside food wells with a slice of fruit under the correct item.

For the "both" condition, both the correct and incorrect items were presented, and the subject was allowed to look under both items for both information trials (and to receive the reward under the correct item). The spatial locations (right or left hand) of the correct objects were counterbalanced for both information trials and the discrimination trial. Only the third (discrimination) trial was recorded for analysis.

The order of presentation for all three conditions, as well as the spatial location of the correct items were randomized with the restriction that no more than two consecutive trials could be from the same condition, and no more than two consecutive trials could have the correct object in the same spatial location (left vs. right). After the single discrimination trial (triral 3), the experimenter immediately proceeded to the first information trial of the next pair of objects. The entire corpus (30 pairs) was conducted at a single setting. Prior to beginning, each subject was given two practice trials (one S+ and one S-) on pairs of items not to be used during the experiment. The subjects were verbally instructed in English, that the name of the game was to "find the fruit." The practice trials showed them that they would sometimes be shown which was the correct item, and sometimes be shown which was the incorrect item. Trial 1 of the corpus began immediately after the practice trials.

Phase II

Ally and Nim were the only subjects run utilizing the procedures discussed in Phase I. Unforeseen complications arose from our attempt to duplicate closely the procedures used the human children in similar experiments (i.e., Cross and Vaughter, 1966). Primarily, the problems were two-fold. First, the study was being run in an open area with few restrictions on the subject's mobility during the ITI (except for preventing their gaining a vantage point from which they could see over or around the partitions). This resulted in too many distractions. Second, the second information trial was rarely attended to by either subject, and occasionally the observer would practically have to force the subject to look under the S- object (for a second time). Ally and Nim were perceived as bored and agitated, and after approximately midway through the corpus of items they began behaving somewhat apathetically.

Therefore, during Phase II the following changes in procedure were instituted. First, all the subjects were confined to a small cage adjoining their home cage to restrict their movements, and their playing. It was also decided to give only a single information trial followed immediately by the discrimination trial. This, hopefully, would keep the "game" more challenging, and interesting, which, coupled with the less stimulating environment, would produce sustained attention and "trying." All other procedures were identical to those described in Phase I. It was not felt probable that the associations between any two items would be remembered by the subjects, but to insure this, one-half of the pairs of objects of each condition were reversed, so that the S+ became the S-, and the corpus of items was re-randomized (with the same restrictions as before). All other procedures remained as before.

Phase III

A final concern which prompted the instigation of a third phase in this study was the possibility that Washoe's performance during Phase II could have been a "chance" occurrence, on a given day, etc. Because Washoe is the only chimpanzee alive with the presumed necessary linguistic capacity and age required to engage in mediation, no outside replication was possible. It was therefore decided to utilize Washoe as her own control.

All procedures during Phase III were identical to the procedures utilized during Phase II. The list of items was re-paired by reversing one-half of the items in each condition, and re-randomizing the order of item presentation.

RESULTS

The results of Phase I are shown in Figure 2. During the earlier trials (first 15 trials) attention was better, and the results indicate that both subjects were utilizing the information better in the "familiarize S-" condition (Ally: 5 of 5 correct, S-, as opposed to 1 of 5, S+, 4 of 5, Both; Nim: 4 of 5 correct, S-, 2 of 5, S+, 3 of 5, Both). The order of presentation precluded any possibility of a disproportionate amount of any condition occurring earlier or later in the first 15 trials. As the list progressed, the before-mentioned attitude problems resulted in less than satisfactory "forced choice" behaviors. If pre-occupied (by climbing, exploring, etc.), the subjects occasionally did not even want to make a choice during the third trial (discrimination trial). When forced to sit down and make a selection, they often selected the right hand item for several items in succession, without apparent regard to previous information, and also occasionally did not even try to take the food reward. This essentially resulted in random selection behavior (see Figure 2, 30 trials) and brought the incidence of selection of each condition toward chance (Ally: 8 of 10, S-, 5 of 10, S+, 6 of 10, Both; Nim: 6 of 10, S-, 6 of 10, S+, 4 of 10, Both). Using the binomial expansion, only Ally performed better than chance ($p < .05$) on any condition ("familiarize S-" condition only).

The results of Phase II are shown in Figure 3. The attention problems encountered in Phase I were not experienced in Phase II. All four subjects were very attentive and appeared to try very hard on all trials. In fact they often became extremely agitated when they missed a problem.

Immediately apparent is that only Washoe did not exhibit the Moss-Harlow effect. Except for Washoe ($p < .001$), all performances in the "familiarize S+" condition were no better than chance (with Nim being significantly poorer than chance, $p < .05$). In the "familiarize S-" condition, Washoe was no better than chance, while Ally, Nim, and Mona were superior to chance responding ($p < .001$, $p < .01$, and $p < .01$ respectively). The "Both" condition responses were distributed around chance except for Mona ($p < .05$).

The results of Phase III are shown in Figure 4. Washoe again responded significantly better than chance ($p < .05$) only in the "familiarize S+" condition (5 of 10, S-, 8 of 10, S+, and 3 of 10, Both).

Since one half of the items were re-paired, it is possible that the prior association of items could have interfered with performance on the switched pairs (for Ally and Nim between Phase I and II, and for Washoe between Phase II and II). Because the objects were nonsense items, and were only seen once, this was not believed to be a problem. Comparison of performance of switched versus non-switched items showed that the prior associations were not a factor in selection errors (see Figure 5). Ally got all 5 switched pairs correct, as well as all 5 unswitched (S- condition). Nim got 4 of 5 switched, and 5 of 5 unswitched correct (S- condition), and Washoe got 4 of 5 switched and 4 of 5 unswitched (S+ condition) correct.

DISCUSSION

The important question is why did Washoe not exhibit the Moss-Harlow effect while the other chimpanzees did. Because of the unusual number of subjects per cell available, statistical analysis of the age x linguistic ability interaction was not possible. However, it appears that neither of the two factors (age and language) alone is sufficient to support a change in strategy from an associative (avoid S-) to a cognitive (approach S+) mode of responding. Washoe was the only adolescent subject with linguistic capabilities, which tends to support the necessity of a developmental age x linguistic competence mediation hypothesis.

The lack of the Moss-Harlow effect during the replication indicates that Washoe's performance is reliable. Also, the fact that she completed a total of 60 trials makes possible a comparison of her's, Ally's, and Nim's performance across 60 trials (see Figure 6). The graphs are striking in the percentages correct of the "favored" information condition, as well as the opposite condition, and "Both" condition. It is obvious that Washoe has a very strong tendency to use an approach strategy, and Ally and Nim use an avoidance strategy.

This study did not resolve whether the switch from an associative mode of learning to a cognitive mode results from a qualitative shift in strategies, or by the ability to inhibit "exploratory" or "novelty" reactions. It does imply that whatever mechanisms or capacities inherent in humans which allow such a cognitive change to occur are also present in man's closest evolutionary neighbor. When comparable environmental experiences are equated, the chimpanzee can apparently adapt to a more complex, adaptive learning strategy which the environment demands.

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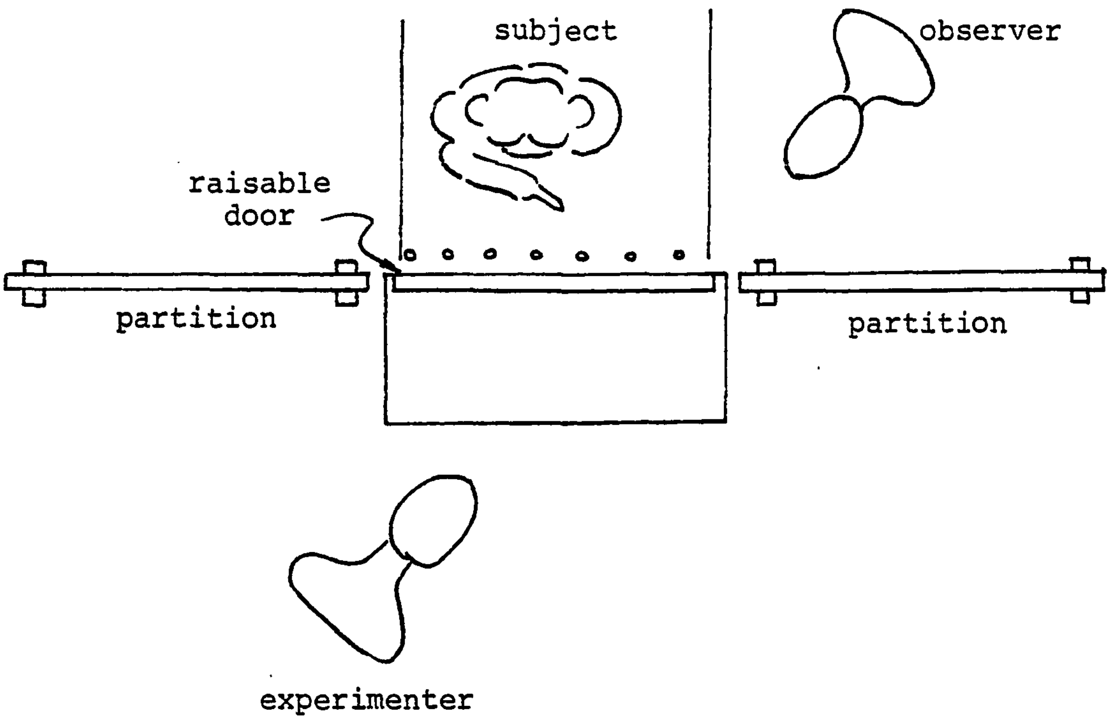
APPENDIX

FIGURES

FIGURE 1

APPARATUS



STIMULUS OBJECTS

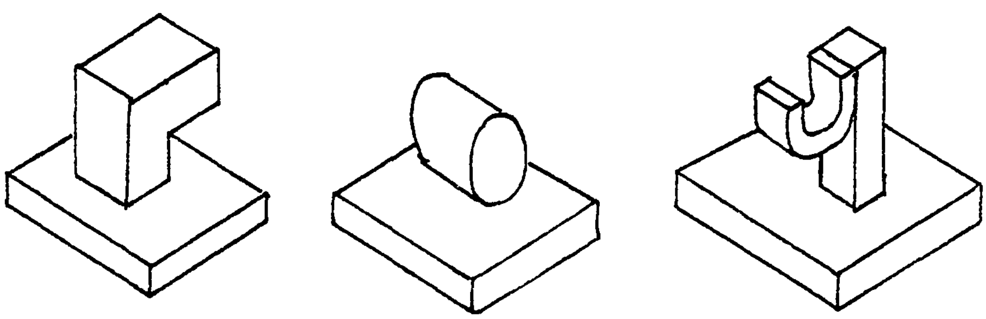
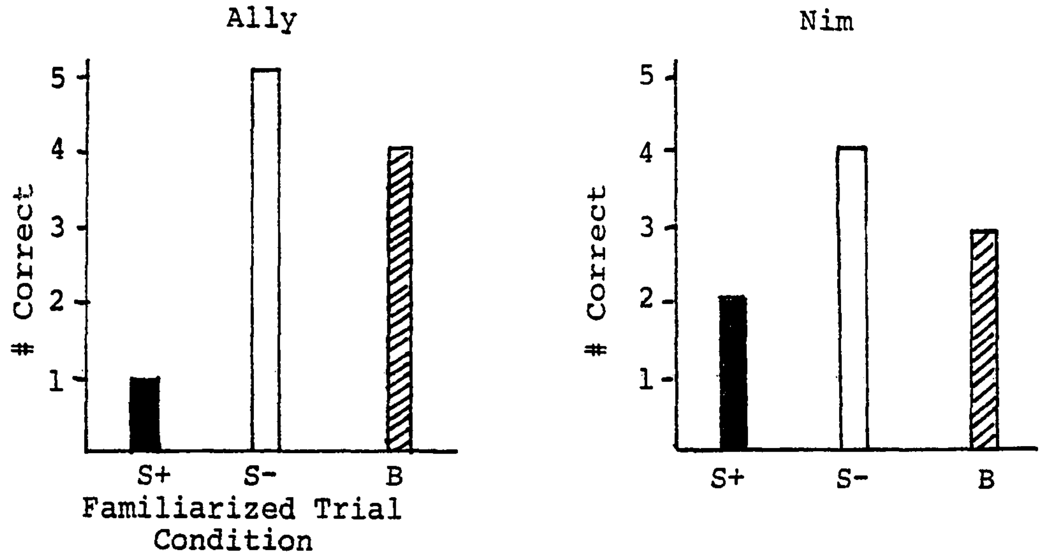


FIGURE 2

Phase I

First 15 Trials



30 Trials

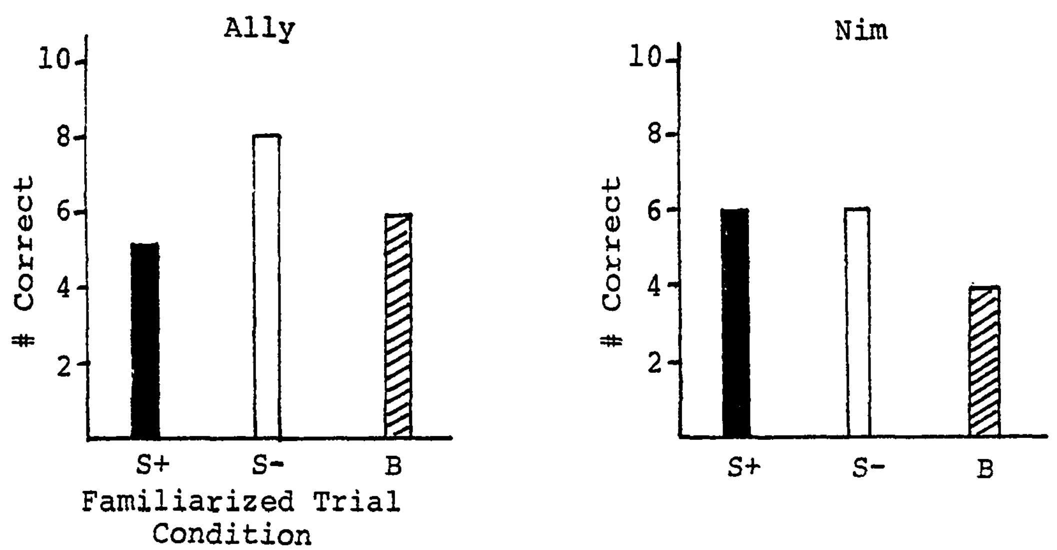


FIGURE 3

Phase II (30 Trials)

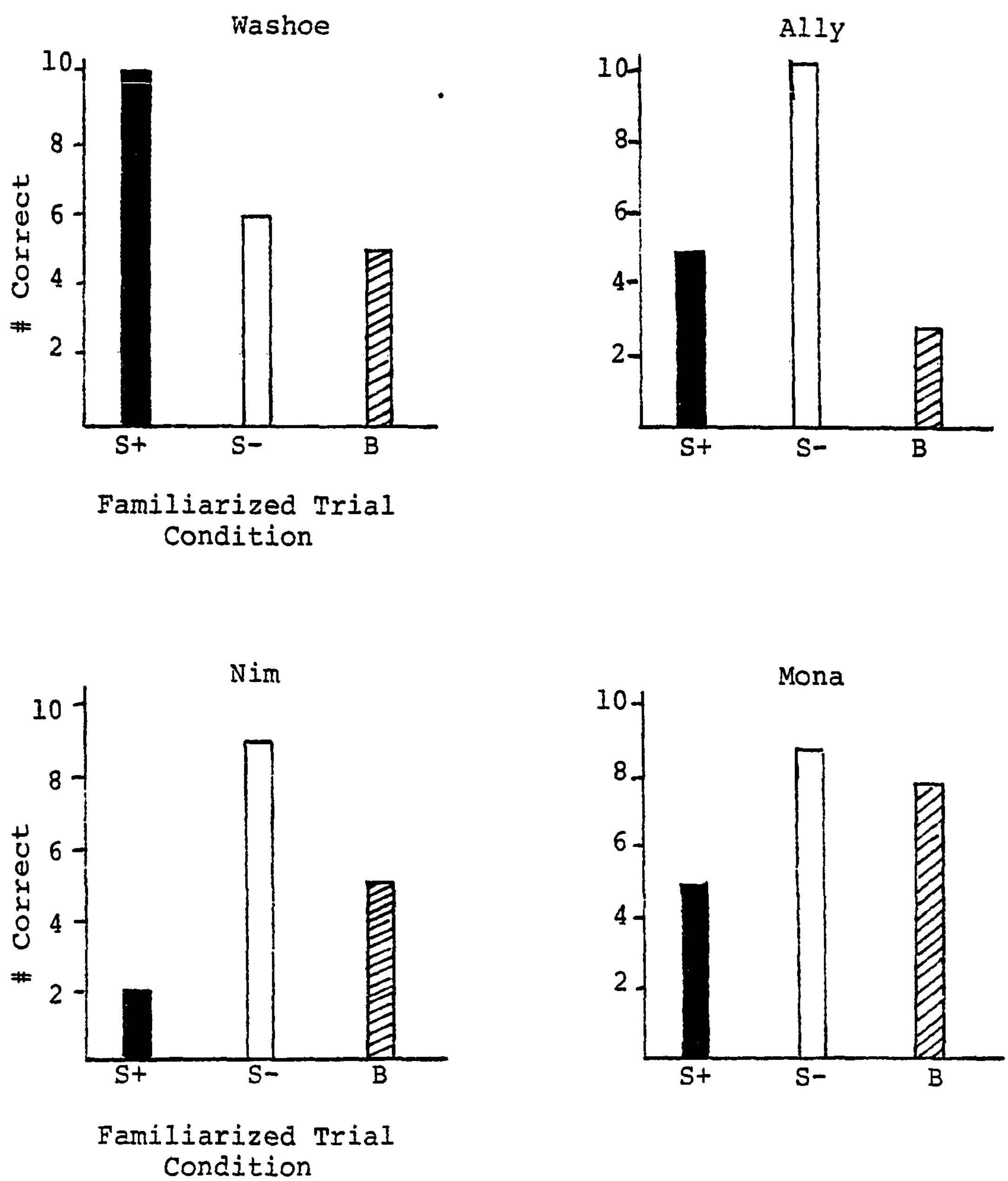


FIGURE 4

Phase III (30 Trials)

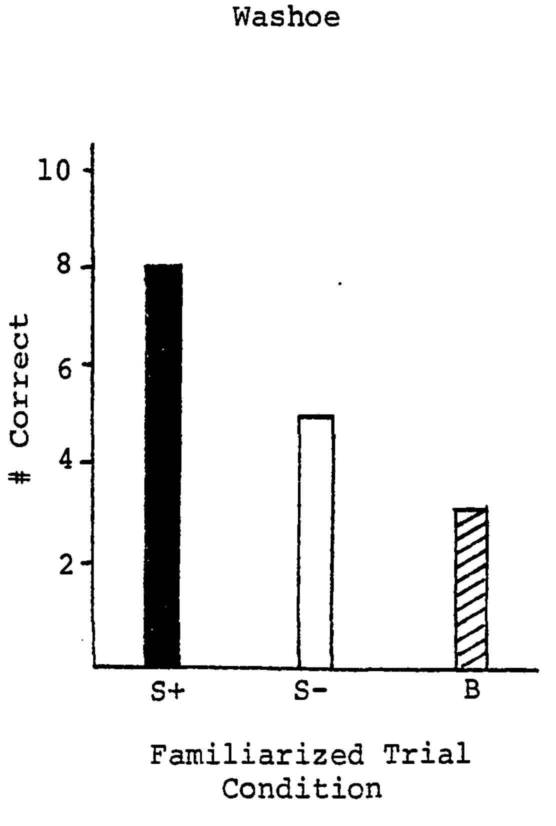


FIGURE 5

Switched Item Analysis

Number of Items Correct
On Second List Presentation

Subject	Stayed Same (5 possible correct)	Switched (5 possible correct)
Ally:	(S+) = 2	(S+) = 3
	(S-) = 5	(S-) = 5
	(B) = 2	(B) = 1
Nim:	(S+) = 2	(S+) = 0
	(S-) = 5	(S-) = 4
	(B) = 3	(B) = 2
Washoe:	(S+) = 4	(S+) = 4
	(S=) = 2	(S-) = 3
	(B) = 3	(B) = 0

FIGURE 6

ASL Chimpanzees (60 Trials)