The effect of relational learning on the development of reversal and nonreversal shifts.

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THE EFFECT OF RELATIONAL LEARNING ON THE DEVELOPMENT 
OF REVERSAL AND NONREVERSAL SHIFTS

by

ROBERT EDWARD REA

M.A., Miami University, 1965

A Thesis
Submitted to the Faculty of Graduate Studies Through the 
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Abstract

In general adult humans can learn a reversal shift faster than they can learn a nonreversal shift, whereas young children and animals do just the opposite. This difference is often explained in terms of the adult's use of verbal concepts as mediators. This study attempted to teach rats a nonverbal concept and thereby to facilitate their acquisition of reversal shifts. The results indicated that the rats did, in fact, attain the concept, but they were unable to use it as a mediator.
Acknowledgments

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Chapter I
Introduction

A number of researchers over the past twenty years have presented different species with a two-choice discrimination problem in which the stimuli vary simultaneously along two dimensions, e.g., brightness and size, only one of which is relevant to problem solution [e.g., Brookshire, Warren, & Ball, 1961 (chickens and rats); Kelleher, 1956 (rats); Kendler & Kendler, 1959 (humans); Tighe, 1964 (monkeys)]. Once Ss reach criterion on the initial problem they are split into two groups. The problem is then changed so that for one group the same dimension remains relevant, but positive and negative cues are interchanged (reversal shift). For the other group, the previously irrelevant dimension becomes relevant (nonreversal shift). For example, employing a \[ Y \] maze, one may place cards upon a swinging door leading to each alley. Upon these cards may be painted squares of either of two sizes, and each square may be either black or white. Initially, Ss may be reinforced for going through a door upon which is painted a large square regardless of brightness. Once they are responding consistently to "large," they may be switched to being reinforced for choosing "small" regardless of

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brightness (a reversal shift) or to being reinforced for choosing "black" regardless of size (a nonreversal shift).

It has been found that rats, chickens, and monkeys will generally solve a nonreversal shift problem faster than a reversal problem. Kelleher (1956), for example, used food deprived Wistar rats and a Y maze with brightness of alleys (black or white) and presence or absence of chain curtains at the entrance of the alleys as the two stimulus dimensions. A noncorrection procedure was used with the performance criterion set at 18 correct responses in 20 consecutive trials. Kelleher found that the nonreversal group made fewer errors in shifting than did the reversal group, and that both of these groups shifted more slowly than a control group initially trained with a different discrimination than the experimental group (hurdles in alley vs. no hurdles) and then tested on the same discrimination as the experimental group.

Tighe (1964), using rhesus monkeys with a Grice discrimination box and a Wisconsin General Test Apparatus, found that with both apparatuses monkeys also learned a nonreversal shift faster than a reversal one. His stimulus dimensions were flat vs. raised stimuli, and horizontal vs. vertical stripes.

Brookshire, Warren, & Ball (1961) used leghorn chickens and Sprague-Dawley rats with a cross maze devised by Tolman, Ritchie, and Kalish (1946). The two stimulus dimensions were place vs. response learning. These investigators
found that chickens, as well as rats, learn nonreversal shifts much faster than reversal shifts.

Not only will animals learn a nonreversal shift much more rapidly than a reversal one, but given a choice to reverse or nonreverse, they will more likely nonreverse. A design which offers such a choice is an optional shift design. Kendler, Kendler, & Silfen (1964) used food deprived albino rats and a two-choice discrimination chamber designed by Gibson and Walk (1956). The stimuli in this study were squares in which were cut hinged doors leading to the goal box. The squares varied both in brightness (black or white) and size (7.0 cm. sq. or 3.8 cm. sq.). In the initial training the S was presented with two pairs of stimuli, a large black and a small white or a large white and a small black. The Ss were reinforced for choosing black regardless of size. After criterion was reached, a second discrimination, an optional shift, was presented. This optional shift consisted of the presentation of only one of the two pairs, say, large black and small white. But for this pair the reinforcement pattern was reversed, i.e., the white (now always small) was reinforced. Since both dimensions were now relevant, S could attend to the previously negative cue white, to the previously irrelevant cue small, or to both. After criterion was reached for this optional shift, a test was administered consisting of ten presentations of the pair of stimuli not used in the optional shift, in this instance large white and small.
black, with both stimuli rewarded. If during this test
S responded eight or more times to the initially non-
reinforced large white, its shift was classified as rever-
sal. If S responded eight or more times to the initially
irrelevant stimulus small, its shift was classified as
nonreversal. Fewer than eight responses to either stimulus
was classified as nonselective. The results showed the
following: 62.5% nonselective shifts, 33.3% nonreversal
shifts, and 04.2% reversal shifts. The authors calculated
that, by chance, nonselective shifts should have occurred
89% of the time, nonreversal, 05.5%, and reversal, 05.5%.
They concluded that any departure from a nonselective
hypothesis was toward nonreversal shifts.

Rea & Dietrich (1969) in a similar study with rhesus
monkeys working in a Wisconsin General Test Apparatus,
found that when these animals were tested after an optional
shift, they nonreversed on 90% of the test trials, and
reversed on 10%.

In contrast to the results obtained with animals,
many studies have found that adult humans solve reversal
problems faster than nonreversal problems. Kendler and
D'Amato (1955), presented male undergraduates with a card
sorting task. The task employed a deck of cards which
varied along three dimensions: shape (circle, crescent,
square, and a bracket shaped figure), color (black, gray,
yellow, and red), and size (1 in. or 2 in.). The two
dimensions used were shape and color. To test for a shape concept, the experimenter required each S to sort rectilinear shapes below a large orange diamond card and to sort curvilinear shapes below a small gray ellipse card. For the color concept, Ss put chromatic figures below a large orange diamond and achromatic figures below a small gray ellipse. If S placed the card correctly, the experimenter would say, "right"; if incorrectly, the experimenter would say, "wrong." After Ss reached criterion, they were presented with a second problem. Four groups were thus formed: Group One learned a shape discrimination on the first problem and a reversal shape discrimination on the second problem. Group Two learned a color discrimination followed by a reversal of the color discrimination. Group Three learned a shape discrimination, then a color discrimination, and Group Four learned a color discrimination, then a shape discrimination.

In a design such as this, Ss in the nonreversal groups during the learning of the second task would receive fortuitous partial reinforcement of responses learned in the first problem. For example, placing a yellow square below the large orange diamond card would be a correct color response for Group Four during the first problem. It would also be a correct shape response for Group Four during the learning of the second problem. In fact, all rectilinear chromatic and curvilinear achromatic cards
would provide partial reinforcement effects for the non-reversal Ss during their learning of the second problem. Kendler and D'Amato, therefore, eliminated these cards during the initial stage of learning the second problem. Thus, Ss in both the reversal and nonreversal groups received 100% nonreinforcement of their sorting responses which had been correct for the first problem. A comparison of the relative speed of the reversal and nonreversal shifts indicated that in both instances, comparing Group One with Three and Group Two with Four, the reversal shift occurred at a significantly faster rate than did the nonreversal shift.

Buss (1956), using the optional shift paradigm, presented undergraduates with wooden blocks, one at a time, and asked them whether or not each block was a member of a category designated "Vec." Ss were informed whether they were correct or incorrect after each response. Three series of stimuli were used. The first series consisted of blocks which were circular, square, or triangular. Color, height, and area were evenly divided among the various shapes. Ss were required to learn to respond in terms of shape (circular-positive ("Vec"), angular-negative ("non-Vec")). A second series, an optional shift, was then presented to the Ss in which all circular stimuli were dark, and angular stimuli were light. The Ss were then reinforced for either performing a reversal shift (circular-
negative, angular-positive) or a nonreversal shift (light-positive, dark-negative).

Since the reversal shape and nonreversal color concepts were completely confounded in the second series, it was necessary to have a third series to determine which concept was being learned. For the third series, all circular stimuli were light and all angular stimuli were dark. Ss were told to continue responding in series three as they had in series two. Those who had learned a reverse shape discrimination in series two should respond to dark angular stimuli, while those who had learned a color discrimination should respond to the light circular stimuli. Eighteen Ss were, thus, classified as making a reversal in series two with seven making a nonreversal shift. Thus, when given the option of learning a reversal or nonreversal concept, a significant majority of Ss learned the reversal concept.

Ontogenetic studies, however, suggest that the humans' affinity for learning reversal shifts is related to level of maturation; and that young children, like subhuman species, have a tendency to learn nonreversal shifts with greater ease than reversal shifts. Kendler and Kendler (1959), using kindergarten children as Ss and metal cups varying in height and brightness as stimuli, placed a pair of the cups in front of the child and instructed him to pick one up. If he chose the correct one, he would find a marble under
it. For the initial discrimination, the Ss were divided into two experimental groups and one control group. Experimental Group One was presented with the cups paired short black, tall white and tall black, short white, and reinforced for choosing on the brightness dimension. Experimental Group Two received the same pairings as Group One but were reinforced for choosing along the height dimension. The control group was presented with an extraneous shape discrimination consisting of diamond and circular cookie cutters.

The shifts were presented immediately after criterion was reached, with no change in instructions. Each of the experimental groups was divided into a reversal and a non-reversal group, equated for speed of initial learning. The reversal Ss were now required to respond to a stimulus feature which had been consistently nonreinforced. The nonreversal Ss were required to respond to a stimulus feature that had received approximately the same number of reinforcements as nonreinforcements. For the control group, half were presented with the pairs tall black, tall white and short black, short white, with one quarter rewarded for black and the quarter rewarded for white. The other half of the control group was presented with short white, tall white and short black, tall black, with one quarter rewarded for tall and the other quarter rewarded for short.

Neither of the main effects, the type of transfer or
the dimensions transferred to, nor the interaction between them was statistically significant. The children showed no tendency to reverse faster than nonreverse or vice versa. In an attempt to interpret these results, the Kendlers point out that a theory based on the assumption of a direct connection between the physical stimulus and the overt response—a single unit theory—would predict that a reversal should be slower than a nonreversal. For example, using a simplification of Spence's single unit statement of simple discrimination learning (Spence, 1960), the more often a response is given to a stimulus, the greater the excitatory tendency to give the response whenever the stimulus occurs, and the higher the probability the response will be given when the stimulus is presented in the future, given some minimal level of reinforcement. Excitatory tendency to respond to a reinforced stimulus accrues. However, if no reinforcement occurs, inhibition to responding builds up faster than the positive component of excitatory potential. In a two-choice discrimination situation, therefore, excitatory tendency builds up to respond to the reinforced stimulus, and inhibitory tendency builds up to respond to the nonreinforced one. A reversal shift should take place slower than a nonreversal shift because in a reversal shift, excitatory tendency to respond to the previously reinforced stimulus has to be reduced as well as inhibitory tendency to responding to the previously
nonreinforced stimulus. In the nonreversal shift, however, these response tendencies spread themselves evenly over what was the previously irrelevant, but is now the relevant stimulus dimension.

In contrast, a mediational theory, such as the Kendlers proposed (Kendler & Kendler, 1959), would predict that a reversal shift should be faster than a nonreversal shift. The Kendlers' mediation theory, more completely stated in 1962 (Kendler & Kendler, 1962), contends that the adult human does not learn a series of simple S-R habits in discrimination situations where stimuli vary along a dimension but, instead, develops a concept (possibly a verbal label) relating the stimuli. It is this mediating label to which he subsequently responds and not directly to the stimuli themselves. For example, if two stimuli are alike in all respects except that stimulus A (reinforced) weighs 500 gm., and stimulus B (nonreinforced) weighs 100 gm., the S does not learn "choose A" and "don't choose B" as a single unit hypothesis suggests, but instead learns something functionally equivalent to "choose heavier." Since humans obviously do learn such concepts as heaviness, the Kendlers hypothesize that a reversal shift should be learned faster than a nonreversal one because, in the reversal shift, the Ss still can use their mediator (a concept of weight), with only the values of the stimulus cues to be switched. The nonreversal shift, in contrast, entails the development of a new mediator.
as well as cue reassociation. It will be remembered that
the results of the work with kindergarten children (Kendler
& Kendler, 1959) confirmed neither prediction. The Kendlers
point out that one conclusion which could be drawn is that
both theories are applicable. They suggest that this failure
to achieve results consistent with either those obtained
from animals or from college students may be due to the
children being in a transitional stage of development in
which these tasks lead some to function on a single unit
S-R basis, and others to function on a mediated response
basis. If these two groups were about evenly divided, they
would yield total results such as were obtained as an
artifact of averaging across groups.

The Kendlers (1959), therefore, sorted their Ss into
two groups on the basis of their initial performance on
each dimension. Those scoring above the median, i.e. taking
more trials to learn, formed one group, and those scoring
below the median, the other group. The difference between
fast and slow learners could be accounted for in at least
two ways. First, the speed of initial learning may reflect
differences in general intelligence or ability to learn.
If this were the case, it would be expected that results of
the control group would show a difference that reflected
the ability displayed in the initial discrimination. Since
the obtained difference was negligible, some doubt was cast
on a general learning ability explanation.
A second possible hypothesis for explaining this data is that fast learners approached the experimental task with verbal labels for the correct stimulus already strongly attached due to prior experience with these stimuli. Liublinskaya (1957) demonstrated that attaching a verbal label to the distinguishing feature of the stimulus greatly facilitated learning. The slow learners may not have had appropriate verbal labels as strongly attached to the relevant stimulus as did the fast learners.

The Kendlers' expectation, therefore, was that fast learners, like adults, would perform according to the mediational S-R theory; hence, reversal would be faster than nonreversal. These expectations were confirmed. The analysis of the transformed scores showed the predicted interaction to be statistically significant. The variation in this term arose almost exclusively from the shift in the relative efficiency of the reversal and nonreversal conditions for the fast and slow learners.

On the basis of the results of the total groups and the analysis into fast and slow learners, the Kendlers concluded that these children, taken as a group, were in the process of developing mediating responses relevant to this task and that some were further along than were others.

The Kendlers' interpretation of the differences between animal and human behavior in these tasks would seem to be that animals learn to associate a response directly to a
particular stimulus, whereas adult humans employ a conceptual mediator. Thus, for animals, in a nonreversal shift from large positive, regardless of brightness, to black positive, regardless of size, the large black and small white stimuli would still be responded to in the same way as in the initial set. In a reversal shift, however, no stimuli of the second set would be responded to in the same way as the first set; therefore, no positive transfer could take place in terms of stimulus-response associations.

With adult humans, however, a mediation response would be present which allows the S to attend to a concept of, say, size in abstract, i.e., not directly tied to any specific external stimulus. Therefore, after a reversal shift, this concept of size would still be relevant; only the specific cues, referring to which point along the size dimension is reinforced, would be changed. After a nonreversal shift, however, where a previously irrelevant dimension became relevant, both the new mediating response plus specific cue responses must be built up. In this instance for adult humans, using mediational responses, the nonreversal response would be more difficult.

The Kendlers' verbal mediation hypothesis is a plausible, though certainly not an exhaustive explanation of the results of the above studies, as they readily admit themselves. An example of a phenomenon which cannot be handled by a verbal mediation explanation is the over-
learning reversal effect, a condition under which animals do learn the reversal shift faster than a nonreversal one. This phenomenon was well described by an experiment by Mackintosh (1962). In this experiment, rats learned a black-white discrimination. Group One performed the task to a criterion of 18 correct responses out of 20. Group Two was given 75 (approximately 100%) overlearning trials, and Group Three, 150 (approximately 200%) overlearning trials. All groups were then split and trained, half on a reversal problem and half on a nonreversal problem. Group One (no overlearning) learned the nonreversal shift faster, as had generally been found with rats. However, Groups Two and Three (the overlearning groups) learned the reversal shift considerably faster than the nonreversal shift. Thus, these overlearning rats performed as do human adults without overlearning.

While some investigators failed to confirm Mackintosh's finding (Hill & Spear, 1963; Tighe & Tighe, 1966), enough did (Pubols, 1956; Furth & Youniss, 1964) to suggest that the phenomenon is reliable, though quite sensitive to certain variables [e.g., most studies failing to demonstrate a facilitation of reversal by overlearning employ a non-correction method; whereas, those demonstrating the effect use some type of correction procedure (Paul, 1966)]. This suggests that perhaps one difference between human and animal behavior in shifting is that humans probably over-
learn such a simple problem quite rapidly so that, apart from verbal differences across species, there exists a difference in level of learning of the initial discrimination, a factor which apparently can affect shift performance.

Even given that one assumes a mediation response to exist, the nature of such a response is quite open to speculation. Of course, at the human level, it seems quite probable that any mediators would contain verbal elements. Kendler and Kendler (1962) suggest that, since children's transition from nonmediational responding to mediational responding roughly correlates with their transition from being nonverbal to being verbal, perhaps the crucial mediational response in reversal-nonreversal learning is a verbal one. An implication of such a verbal mediation hypothesis would be that animals learn nonreversal shifts more rapidly than reversal shifts due in part to their inability to form a verbal mediational concept of dimensionality.

That, under certain conditions, conceptual elements necessary for such mediations can be formed without verbal ability is well known, however. Harlow's (1949) discovery that monkeys can acquire concepts equivalent to "if not reinforced for initial response, switch stimulus values," is a case in point. Also, Köhler's (1929) transposition problems where chickens and chimpanzees learn to respond to the larger of any two stimuli within a certain range, and
Lawrence and DeRivera (1954) evidence of acquisition of a concept of a dimension of brightness in rats provide further evidence that nonverbal organisms can acquire and use concepts of dimensionality in solving discrimination problems. Both Youniss (1964) and Pufall (1965) found that deaf children who were extremely restricted in verbal ability could solve shift and double alternation problems, probably requiring mediation responses, as well as normal children. Youniss (1964) demonstrated that deaf children of age seven and older could solve reversal shifts faster than non-reversal shifts just as do normal humans of that age. It hardly seems justified to assume that children older than six have no usable verbal knowledge or abilities, however, even though they do not speak.

There also exists a body of evidence which suggests that, at times, normal humans can respond in ways indicating they have acquired concepts which they are unable to verbalize. Smoke (1932), for example, presented Ss with a list of 16 patterns, eight of which fit a criterion of belonging to a single conceptual category, and eight of which did not. The Ss were required to go through the list until they could correctly discriminate all eight of the category members from the eight nonmembers. After 128 instances of perfect performance on this task, Smoke found 39 instances where the S could not correctly verbalize the determining features of the concept. Piaget (1960), having
conducted numerous interviews with children, reported that they consistently pass through a developmental stage whereby they can respond in ways evidencing knowledge of a concept before being able to verbalize it.

A mediation hypothesis which attempts to explain why adult humans mediate in bi-dimensional shift problems whereas children and nonhumans do not, must assume that either (a) the non-adult humans cannot form the concepts necessary for mediation and/or (b) such concepts, if formed, cannot, or at least are not, employed for purposes of mediation. Evidence has just been provided that, at least in certain circumstances, (a) above is not the case. What seems needed, therefore, is a test of whether or not (b) is perhaps true, given that one can conclude with some certainty that for the particular situation (a) is not true.

One might begin such a test by pointing out that, in the above studies, relatively naive animals reared in an extremely restricted environment were being compared to sophisticated adult humans, living in an environment filled with complex stimuli. Granted that the human development of a concept of size may be facilitated by humans' verbal abilities, it is possible that repeated contact with stimuli varying along a size dimension, which they are exposed to daily, contributes somewhat to their ability to form and employ such a concept. The animal Ss, in contrast, have no opportunity to develop such a concept, so it is not
surprising that they cannot use such concepts as mediators. Perhaps, if animals were given more experience with relevant stimulus dimensions (but not the specific stimuli, as in overlearning) in a way maximizing the probability of their acquiring a conception of the relevant dimension before the learning of a task and its reversal, their postswitching behavior would more closely resemble that of adult human Ss.

The present study is an attempt to provide this increase in concept acquisition experience by exposing rats to a set of relational learning problems requiring the rats to attend to the relevant dimension and to make discriminations in terms of that dimension. Given that strong evidence then exists that Ss have mastered this relational learning problem (size will be the dimension used), the rats can then be presented with a bi-dimensional discrimination problem being reinforced for large regardless of brightness, then being split into reversal and nonreversal subgroups. Any variance in their performance of these shifts compared to naive animals would be necessarily attributed to their previous experience in developing discriminations based upon relational concepts.
Chapter II

Method

Subjects

The Ss were 39 naive male rats of Long-Evans Hood strain. Sixteen Ss were assigned to the experimental group and 16 to the control group by assigning numbers to each, placing the numbers in a container, and then drawing numbers for each group. The Ss who completed the experiment consisted of eight reversal and eight nonreversal experimental animals, and six reversal and six nonreversal control animals. Of the 39 Ss, four were eliminated for failure to respond for 10 consecutive times during pretraining, five reached the terminal number of errors during one of the tasks (of these, four were controls and one experimental), and two died. At the beginning of the experiment, these Ss ranged from 65 to 117 days of age with an average of 83 days. Their weights ranged from 212 to 394 gm. with an average of 277 gm. There were no significant differences among subgroups in either age or weight. The rats were kept on food deprivation starting one week prior to the experiment and continuing throughout, being fed approximately 14 gm. of Lab Chow per day immediately after the daily experimental session. The Ss were caged individually in the experimental room at 75°F. and allowed water ad lib. They
were kept on a 12 hour light-dark cycle, being run during their dark period for six days each week.

**Apparatus**

A discrimination box $71.5 \times 39.0 \times 25.5$ cm. made of $3/4$ in. plywood painted flat gray was used (see Figure 1). The box consisted of a starting compartment $17.0 \times 10.5 \times 10.5$ cm. which led into a discrimination chamber $45.0 \times 39.0 \times 25.5$ cm. which in turn led to two goal boxes each $24.5 \times 19.0 \times 25.5$ cm. The starting compartment was covered by a clear $1/8$ in. plexiglass sliding door, and was separated from the discrimination chamber by a clear, $1/8$ in. plexiglass hand operated guillotine door. The discrimination chamber was open at the top to allow full of S's behavior and was lighted by a single 100 watt bulb 50 cm. above the floor of the apparatus. On the wall of the discrimination chamber opposite the starting compartment were two doorways $11.5 \times 11.5$ cm. leading to the two goal boxes. These doors were separated by 3.4 cm. In these doorways were hung detachable 0.6 cm. thick plywood doors, also flat gray upon which were affixed the cardboard stimuli. These doors were free swinging from the outer side to swing into the goal box when pushed. They could also be locked when desired.

The stimuli consisted of one $7.5$ cm. square and one $2.7$ cm. square of Munsell paper no. 1 (black), one $7.5$ cm.
Fig. 1 Discrimination apparatus.
square and one 2.7 cm. square of Munsell paper no. 10 (white); one 6 cm. square cardboard with black and white .6 cm. vertical stripes and one 6 cm. square cardboard with black and white horizontal stripes. Also used were four red semicircles with the flat side as the base and measuring 2, 4, 7, and 11 cm. along the base. A stopwatch was used to measure running speeds.

Procedure

The feeding schedule was begun one week before the start of the experiment and maintained throughout. On the first and second day of each S's experimental sessions, he was gentled for five minutes to adapt to and explore the maze with the stimulus doors absent. A number of sucrose pellets were scattered in both reward compartments for these sessions. After the second day, the rats were run 12 correction trials per day, these trials being separated by no less than five minutes. For each trial, E placed S into the starting compartment, remaining directly behind the compartment at all times. E would then wait for S to face the front of the compartment, at which time he would give S approximately four seconds to observe the stimuli before raising the transparent guillotine door. As soon as S left the starting compartment, E lowered the door and, with the stopwatch, timed S's running speed from the starting compartment until S bumped a stimulus door open one
centimeter. S was given a maximum of two minutes to make such a response. If no response was made in this time, S was removed and a "no response" recorded for the trial. Each time S made a correct response, he found three 45 mg. sucrose pellets in the reward compartment which he was allowed to eat, thus completing the trial. If S bumped the incorrect door, of course no food was present, and S was immediately removed and restarted using the same stimuli. S was given four chances to make a correct response for each trial. If S made three incorrect runs, the incorrect door was locked on the fourth run. The fourth run was recorded as an error if S pressed against the incorrect door before going through the correct one. S was discarded if he completed 300 trials without reaching criterion during any of Stages II, III, or IV. The above general procedure applied to all groups for all stages of the experiment. The procedures specific to each stage will be covered individually in the following paragraphs.

A flow diagram of the experimental procedure is presented in Figure 2. This diagram follows experimental and control, reversal and nonreversal groups through the stages of the procedure.

Treatment of Experimental Animals

Stage I: Pretraining. During the first day of running, S was exposed to 12 pretraining trials with no stimulus
Fig. 2 Flow diagram of procedure. Experimental and control animals yoked at Y.
doors on the first four trials, and flat gray doors having no stimuli affixed to them on the last eight trials. Food was available in both reward compartments during this pre-training stage. Forced choices were employed (locking one door) to insure that S went to each reward compartment six times. If, for any three consecutive trials, S pushed open a stimulus door and ate at least one pellet, he proceeded on the second day to Stage II of the experiment. If he did not reach this criterion during the first day, this pre-training task was continued on subsequent days until this criterion was met or until 10 consecutive no-response trials occurred, at which time the animal was discarded and replaced with another.

**Stage II: Relational learning.** After pretraining was successfully completed, the experimental group was given a relational learning task. Four red semicircles, varying in size, with the straight side down were presented to S in random pairs. These stimuli will be referred to subsequently as A (2 cm. base), B (4 cm.), C (7 cm.), and D (11 cm.). Each stimulus appeared on the right door and left door an equal number of times each day randomly. Since there were four stimuli, there were six possible combinations. However, two of the pairs, B, C and A, D were not used during this task for reasons explained later. Each of the four remaining pairs was presented three times randomly in a day's running. The correction procedure was used, with S being reinforced...
with three 45 mg. sucrose pellets for choosing the larger of the two stimuli. The solution of this problem required that $S$ not attend to the absolute size of the stimulus, but to its size relative to the stimulus with which it was paired. For example, with the stimuli labeled A through D from smallest to largest and the larger of a pair always reinforced, A would never be reinforced (0%), B would be reinforced when paired with A but not when paired with D (50%), C would be reinforced when paired with A but not with D (50%), and D would always be reinforced (100%).

Each $S$ was run until he chose the larger semicircle nine trials out of 12 for two consecutive days. This somewhat lenient criterion was employed to prevent over-learning with all of its unpredictable consequences (pages 13-14 above). Once criterion was attained, one could still not assert that relational learning had occurred. The single unit theorist could simply point out that since, through the course of training, stimulus A had been reinforced 0% of the time, B, 50%, C, 50%, and D, 100%, there was a corresponding increase in probability of responding to the larger stimuli. Even if $S$ learned to respond only to D, for example, and got 100% correct of the trials in which D appeared (50% of all trials) and responded randomly to the remaining trials, obtaining an additional 25% correct, he would be correct 75% of the time, which was the criterion.

Two attempts were made at checking what was actually
being learned, a relational concept functionally equivalent to "larger," or an increased habit to respond to the larger stimuli and/or not to respond to the smaller. One check was simply to inspect the data and record the number of trials each pair was responded to correctly. If each pair containing D, for example, was responded to correctly and the rest, randomly, or if each pair containing A was responded to correctly more often than the others, some information is provided as to what was being learned, i.e., a habit to respond to D and/or not to respond to A.

Secondly, after each S had reached criterion, he was immediately given two nonreinforced trials with a pair not previously experienced, B,C. It will be recalled that during training, both stimulus B and C were reinforced 50% of the time (they were both positive when presented with A but negative when presented with D. If the Ss had learned a relation concept, "larger," they should now choose C even though the pair B,C had never been previously experienced.

One could argue that Spence's single unit theory could predict higher proportion of responses to C than B because total positive stimulus generalization would be greater to C than to B. This would be true because C is closer to D (100% reinforced) whereas B is closer to A (0% reinforced). However, as has been summarized by Hull's concept of stimulus intensity dynamism (Hull, 1949), generalization is less from a stimulus of greater intensity to one of less
intensity than vice versa. Grice and Saltz (1950) demonstrated there is very little generalization from a 79 sq. cm. stimulus to a 20 sq. cm. one. This is the approximate area of stimulus D and C, respectively. Grice and Hunter (1964) further demonstrated that this generalization is reduced further by exposing Ss to varying stimulus intensities as was done in the present study. Existing evidence, therefore, suggests that generalization across stimuli in the present experiment should be slight.

**Stage III: Bi-dimensional learning.** On the day after the relational task was completed, _S_ was presented with the following problem. Using the same discrimination apparatus and correction procedure, _S_ was presented with a series of two pairs of stimuli: a black 7.5 cm. square with a white 2.7 cm. square, and a white 7.5 cm. square with a black 2.7 cm. square. Each stimulus appeared on the right and left door an equal number of times each day randomly. _S_ was reinforced for choosing the larger stimulus regardless of brightness. Then, once a criterion of nine correct out of ten was attained, members of the experimental group were assigned to either a reversal or a nonreversal group. These two groups were equated as closely as possible for number of errors made while learning Stage II and the initial problem in Stage III.

**Stage IV: Bi-dimensional shift.** The reversal (R) group was then given a reversal shift, whereby they were
reinforced for choosing small regardless of brightness; and the members of the nonreversal (NR) group were given a nonreversal shift, whereby they were reinforced for white regardless of size (black for one half of the Ss). During this shift, stimuli were allowed to vary along only one dimension, the (R) group being presented with the pairs large black and small black, or large white and small white with small positive in both cases. The (NR) group were presented with the pairs large black and large white or small black and small white with white reinforced in both cases (black for one half of the Ss). These shifts varied along only one dimension to eliminate a continued partial reinforcement of a previously reinforced stimulus for the nonreversal group, which retards learning of the shift task. For example, if large were reinforced during the first problem, and then black during the shift, and large black was paired with small white during the shift (a two dimensional variant) the S would continue to be reinforced for large black. Ss were again run to a criterion of nine correct responses out of ten during this shift stage.

Treatment of Control Animals

Stage I: Pretraining. The control group was treated in an identical fashion to the experimental group during this apparatus adaptation stage.

Stage II: Irrelevant Learning. The control group was
given an irrelevant task in place of the four semicircle problem of the experimental group to equate for maze experience. This task consisted of two 6 cm. squares, one with vertical black and white .6 cm. stripes and the other horizontal black and white stripes. Members of the control group were exposed to this problem for the same number of days on the average as members of the experimental group were exposed to the semicircle problem. Each control animal was yoked to an experimental partner by being reinforced on each trial his partner was reinforced regardless of the control animal's response. Thus, both number of trials and number of reinforcements were equated across experimental and control animals for Stage II, with the control animals being nonselectively reinforced for any discrimination hypotheses which the animals might entertain. During this stage, an attempt was made to prevent the development of strong position preferences by not allowing any S to respond in the same direction for more than three trials in succession.

**Stage III: Bi-dimensional learning.** The control group was given the same large black and small white, large white and small black discrimination problem as the experimental group for this stage.

**Stage IV: Bi-dimensional shift.** The control Ss, again parallel to the experimental Ss, were divided into a reversal and nonreversal group equated as closely as pos-
sible for number of errors made during Stage III. The (R) group was then given a reversal shift, and the (NR) group a nonreversal shift in the same manner as the experimental group. Ss were again run to a criterion of nine correct responses out of the last ten for Stages III and IV.
Chapter III

Results

The results section has been divided into seven parts. Parts I through III examine the experimental animals' performance on the relational task. Part IV examines the performance of all Ss on the bi-dimensional task, and Part V examines the shift task. Parts VI and VII provide data of interest ancillary to the primary purpose of the experiment.

Part I: Relational learning. The experimental group learned Stage II, the relation learning task consisting of the four red semicircles, making an average of 29 errors with a s.d. of 18.9. The mean number of errors for what would subsequently be reversal and nonreversal groups were 26 and 32 respectively. A comparison of these two groups yielded a t of 0.62, providing no indication that the groups differed significantly in number of errors made during relational learning.

Part II: Relational test. The presentation of the pair of red semicircles B,C following the completion of Stage II provided evidence of a preference for C (as a relational hypothesis would predict). The test consisted of two presentations of this pair to each of the 16 ex-
perimental animals, for a total of 32 responses. Out of these 32 responses, 26 were to C, and six were to B. A \( \chi^2 \) test comparing these results with that predicted by a single unit theory (16 responses to C and 16 to B) yielded a \( \chi^2 \) of 12.50, d.f. = 1, \( p < .01 \). A \( \chi^2 \) was also conducted comparing the obtained results with that predicted by a mediation hypothesis. A mediation hypothesis actually predicts 32 to C and zero to B with 100% learning. The performance criterion for Stage II was only 75% correct, however, so a \( \chi^2 \) was calculated comparing the obtained results with 24 responses to C. This \( \chi^2 \) showed no significant departure from the mediation prediction (\( \chi^2 = 0.67 \), d.f. = 1).

Part III: Inspection of relational data. The inspection of the data in Stage II to determine how often each stimulus pair was responded to correctly during the last 24 trials is presented in table 1. The experimental group averaged 82.81% correct responses during this period. The range was from 78.13% correct for pair C,D to 86.46% correct for pair A,C. Such a constricted range suggested that all sets were learned to about the same level, as opposed to some being learned completely, some not at all. This constricted range was also present at the individual level and was, therefore, not an artifact of averaging across Ss as can be seen by the individual scores in Appendix A. An inspection of the percentage of times an
Table 1

Group Responses to Each Pair of Semicircles
During Last 24 Trials of Relational Task

<table>
<thead>
<tr>
<th>Set</th>
<th>% Correct</th>
<th>% Incorrect</th>
<th>No. Correct</th>
<th>No. Incorrect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>B,D</td>
<td>82.29</td>
<td>17.71</td>
<td>79</td>
<td>17</td>
<td>96</td>
</tr>
<tr>
<td>C,D</td>
<td>78.13</td>
<td>21.88</td>
<td>75</td>
<td>21</td>
<td>96</td>
</tr>
<tr>
<td>A,C</td>
<td>86.46</td>
<td>13.54</td>
<td>83</td>
<td>13</td>
<td>96</td>
</tr>
<tr>
<td>A,B</td>
<td>84.38</td>
<td>15.63</td>
<td>81</td>
<td>15</td>
<td>96</td>
</tr>
<tr>
<td>Average</td>
<td>82.81</td>
<td>17.18</td>
<td>79.50</td>
<td>16.50</td>
<td>96</td>
</tr>
</tbody>
</table>

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individual stimulus was responded to correctly regardless of its partner again revealed a very constricted range from 80.21% correct for stimulus D to 85.42% correct for stimulus A (see table 2). Again, as shown in Appendix B, this was an individual phenomenon, and not a result of averaging across Ss.

**Part IV: Bi-dimensional learning.** The mean number of errors made by each group while learning the bi-dimensional task is shown in table 3. An analysis of variance showed that the experimental animals in general mastered this task faster than the controls (F = 24.15, d.f. = 1, 24, p < .001). There were, however, no significant differences between reversal and nonreversal animals, nor was the interaction significant.

**Part V: Shift behavior.** The number of errors made by each group while learning the shift task is shown in table 4. An analysis of variance of this data is shown in table 5. The experimental reversal group did not shift faster than the nonreversal group. In fact, in both the experimental and control groups, the nonreversal shift was learned with less errors than the reversal shift (F = 7.22, d.f. = 1, 24, p < .02). This analysis also points out that across reversal and nonreversal groups, the experimental animals learned the shift task faster than did the controls (F = 8.28, d.f. = 1, 24, p < .01). The AB interaction for this analysis was nonsignificant (F = 0.01, d.f. = 1, 24).
Table 2
Group Responses to Individual Semicircles During Last 24 Trials of Relational Task

<table>
<thead>
<tr>
<th>Set</th>
<th>% Correct</th>
<th>% Incorrect</th>
<th>No. Correct</th>
<th>No. Incorrect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>85.42</td>
<td>14.58</td>
<td>164</td>
<td>28</td>
<td>192</td>
</tr>
<tr>
<td>B</td>
<td>83.33</td>
<td>16.67</td>
<td>160</td>
<td>32</td>
<td>192</td>
</tr>
<tr>
<td>C</td>
<td>82.29</td>
<td>17.71</td>
<td>158</td>
<td>34</td>
<td>192</td>
</tr>
<tr>
<td>D</td>
<td>80.21</td>
<td>19.79</td>
<td>154</td>
<td>38</td>
<td>192</td>
</tr>
</tbody>
</table>

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Table 3

Errors on Initial Bi-dimensional Task

<table>
<thead>
<tr>
<th></th>
<th>Reversal</th>
<th></th>
<th>Nonreversal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{X} )</td>
<td>s.d.</td>
<td>( \bar{X} )</td>
<td>s.d.</td>
</tr>
<tr>
<td>Experimental</td>
<td>8.39</td>
<td>7.07</td>
<td>6.50</td>
<td>4.96</td>
</tr>
<tr>
<td>Control</td>
<td>41.83</td>
<td>16.02</td>
<td>49.33</td>
<td>33.57</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Reversal</th>
<th>Nonreversal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>5</td>
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<td></td>
<td>36</td>
<td>9</td>
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<td></td>
<td>19</td>
<td>14</td>
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<tr>
<td></td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>( \bar{x} = 22.38 )</td>
<td>( \bar{x} = 8.63 )</td>
<td></td>
</tr>
<tr>
<td>( \text{s.d.} = 8.32 )</td>
<td>( \text{s.d.} = 3.19 )</td>
<td></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>4</td>
</tr>
<tr>
<td>( \bar{x} = 37.03 )</td>
<td>( \bar{x} = 23.33 )</td>
<td></td>
</tr>
<tr>
<td>( \text{s.d.} = 10.02 )</td>
<td>( \text{s.d.} = 22.05 )</td>
<td></td>
</tr>
</tbody>
</table>
Table 5
Analysis of Shift Errors

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp.- Con. (A)</td>
<td>1573.02</td>
<td>1</td>
<td>1573.02</td>
<td>8.28 **</td>
</tr>
<tr>
<td>Rev.- Nrev. (B)</td>
<td>1372.00</td>
<td>1</td>
<td>1372.00</td>
<td>7.22 *</td>
</tr>
<tr>
<td>A X B</td>
<td>1.30</td>
<td>1</td>
<td>1.30</td>
<td>0.01</td>
</tr>
<tr>
<td>Error</td>
<td>4555.54</td>
<td>24</td>
<td>169.81</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7501.86</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p. < .01
*p. < .02
Part VI: Shifts for fast vs. slow learners. In view of the discovery of Kendler and Kendler (1959) and Smiley and Weir (1966) of a qualitative difference in shift performance of fast and slow learners of the initial task, Ss were divided into fast and slow learners on the bi-dimensional task. As can be seen from table 6, all subgroups still made more errors while reversing than while non-reversing.

Part VII: Multiple errors. During running, it was felt by the experimenter that one qualitative difference between groups might be that, with this correction procedure, reversal animals made more multiple errors (repeated errors during one trial) than did nonreversals in the shift task, and controls made more multiple errors than did experimentals. An analysis comparing scores of the proportion of multiple errors to single errors transformed by the arcsin transformation revealed that reversals made more multiple errors than nonreversals ($F = 6.55$, d.f. = 1, 24, p. < .02). No difference was found between experimentals and controls, nor was the interaction significant.
Table 6
Mean Shift Errors of Fast & Slow Learners

<table>
<thead>
<tr>
<th></th>
<th>Reversal</th>
<th>Nonreversal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fast</td>
<td>Slow</td>
</tr>
<tr>
<td>Experimental</td>
<td>20.25</td>
<td>24.50</td>
</tr>
<tr>
<td>Control</td>
<td>35.67</td>
<td>40.00</td>
</tr>
</tbody>
</table>
Chapter IV
Discussion

A current explanation of the oft observed characteristic of adult humans to master a reversal shift more readily than a nonreversal shift, while young children and nonhumans do the opposite, is that only adults have formed and can use verbal dimensional concepts as mediators. This explanation is the verbal mediation hypothesis.

However, evidence exists that dimensional concepts need not be verbal (e.g., Smoke, 1932; Lawrence & DeRivera, 1954). If, therefore, a nonverbal concept could be learned by rats, the rats might be able to use such a concept as a mediator and to perform reversal shifts in more nearly human manner.

The experimental animals in the present study were trained in the use of a dimensional concept (size), and evidence from the relational test and inspection of relational data strongly suggests that they did, in fact, acquire this relational concept. It seems apparent from the shift results, however, that any conception of size which may have been developed during the semicircle problem did not facilitate reversal over nonreversal shifting for the experimental group. Even though the relational task seemed to reduce overall errors in the experimental group, it did so as much
for the nonreversal as for the reversal animals, still leaving the nonreversals with less errors. The added experience and development of dimensional concepts before the bi-dimensional task did not cause these animals to behave in ways qualitatively different from animals in this and other studies without such experience. If reversal shifts are facilitated by a mediation process as Furth and Youniss (1964), Kendler and Kendler (1959), and Mackintosh (1962) suggest, then these rats apparently did not use the concept which they acquired as a mediator. This experiment, therefore, provided no evidence which contradicts a verbal mediation hypothesis. In fact, another instance has been provided whereby nonverbal organisms fail to learn reversal shifts faster than nonreversal ones.

Even though the results of the present study are consistent with the predictions of a verbal mediation hypothesis, they are not a crucial test of such a hypothesis and should not cause acceptance of verbal mediation as the necessary and sufficient cause of rapid reversal learning. There may be other reasons why this experiment failed to provide conditions whereby rats could learn reversal shifts more rapidly than nonreversal shifts. Human adults have qualities other than more dimensional experience and verbal ability which distinguish them from nonhumans and children. These differences must be controlled for before
one can assert that verbal mediation is the crucial variable in reversal learning. It may still be that nonverbal factors such as overlearning and boredom can account for human shift behavior.

One nonverbal factor that is difficult to equate or control across species, and which the present experiment did not use as a variable, is level of learning of the initial bi-dimensional task. Since overlearning has been shown to facilitate reversing over nonreversing even in animals, and since humans learn faster than animals, the probability is always greater that adult humans overlearn any such simple discrimination task than that animals overlearn them. The probability is consequently greater that humans will reverse faster than nonreverse, all else held equal, simply due to overlearning. It might be interesting, employing the design of the present experiment, to vary the experimental group's level of learning of the relational learning task to a criterion of 100% correct, and to 150 or 200 trials beyond (overlearning). This rehearsal of the dimensional concept might yield results different from the present results, and/or different from simple overlearning of the initial bi-dimensional task with this experimental situation.

A second nonverbal and nonmediational factor which needs to be examined, which is closely related to this overlearning reversal effect, is boredom or curiosity drives
in humans which may supplant the motivation which the experimenter is attempting to exploit (e.g., acquisition of food, money, or marbles). To explain the results of the present experiment, one must assume that such a boredom drive is more predominant in humans than in rats. Butler (1960) provides such evidence based upon a number of studies that, in general, show curiosity-investigative motives to be more prevalent in primates than in subprimates. This boredom, therefore, would cause human Ss to be more likely to abandon a pattern of "correct" responses in the initial bidimensional task. Such a readiness to change response patterns should reduce any negative transfer resulting from this initial response pattern. Since it is the reversal group which experiences more negative transfer during shifts, their errors should be reduced more than the nonreversal group. Such a lack of drive to keep responding as in the initial task should reduce the reversal Ss' errors more than the nonreversal Ss' during shifting. It is quite possible, in fact, that such a reduction in negative transfer could allow the reversals to be faster at shifting than the nonreversals. Faster reversing could happen if other factors exist which render reversal shifts easier, such factors having been previously counteracted by stronger negative transfer factors acting in the opposite direction. At least this reduction of negative transfer would contribute to the
trend of faster reversals for humans.

A third possible reason why this experiment failed to alter traditional rat shifting behavior may simply be that even though the semicircle problem increased the pre-shift experience of the animals with the relevant dimension, this experience in no way approached the complexity and amount of experience which adult humans have with such dimensional concepts. The effects of experiential factors, therefore, have by no means been exhaustively pursued.

Other interesting results of this study ancillary to the shift results include the considerable positive transfer from the relational task to the initial bi-dimensional task for the experimental animals. This transfer is reflected by their making an average of 1/5 as many errors as the control group while mastering the bi-dimensional task. This smaller number of errors is not surprising since (a) in both tasks, the larger of two stimuli was reinforced allowing stimulus generalization, and (b) there would also be a general learning-to-learn effect from previously learning a discrimination task in the same apparatus.

Also contributing to this difference between experimental and control animals would be any negative transfer which the control group might have experienced from their insoluble filler Stage II task. This task being insoluble may have engendered habits not to attend to the
stimuli in the bi-dimensional task. Also bad habits such as strong positional preferences were acquired by some control animals during this filler stage despite efforts to discourage such preferences. This overall superiority of the experimental group was carried over into the shift task where they once again learned much faster than the controls.

It should be noted that the control nonreversal group was bimodally distributed for the shift task (see table 4). An F-Max. test for homogeneity of variance indicated that the subgroups of this table had variances that differed significantly from one another. Inspection of the standard deviations of the subgroups suggests that much of the difference in variances could be attributed to the difference between the control nonreversal group and the other three groups. The extremeness of the bimodality of this cell can best be appreciated by pointing out that the average number of errors of the smallest three Ss was 3.7, and of the largest three was 43.0. Inspection of the raw data shows that the low error controls had no strong position preferences during the irrelevant task, whereas the rest of the controls, both reversal and nonreversal, did. It is interesting that while these position perseverations had no correlation with speed of learning the initial bi-dimensional task, they did correlate positively with errors made during the
shift task. Those animals who had developed position perseveration during the irrelevant task, initially reverted back to this positional mode of responding during the shift task, which apparently retarded shifting. This dichotomization of rats into positional perseveraters vs. non-positional perseveraters suggests that future investigators in shift experimentation might be well advised to attend to changes in variance and shape of distribution of shift responses as well as means, since many such changes in distribution are obscured by averaging.

Breaking the experimental group into fast and slow learners for the initial bi-dimensional shift (Part VI of the results) gave no indication that fast learners shifted differently than slow learners, as did the Kendlers' (1959) children. While this breakdown is meaningless in terms of examining the rats' development of verbal ability, it does serve to test a hypothesis advanced by Smiley and Weir (1966) that dimensional preferences reflected in speed of initial learning might affect the speed of subsequent shifts. Smiley and Weir hypothesize that fast or slow learning during original discrimination and subsequent reversal or nonreversal shifts could be due to initial dimensional preference measured by initial probability of attending to a dimension, which they show does exist. These investigators found that kindergarten children trained with their dominant dimension relevant learned the discrimination more rapidly.
and also learned a reversal shift faster than a nonreversal one. The converse was true when the dominant dimension was irrelevant during initial learning. This dimensional preference explanation does not rule out mediation as a factor, but points out that slow learners may be mediating to the irrelevant dimension rather than not at all.

The results of the present experiment also provide evidence that a perceptual hypothesis proposed by Tighe and Tighe (1966) does not apply to rats. These theorists suggest that if an $S$ has reached a level of perceptual development enabling him to analyze stimuli into dimensions, he should learn reversal shifts more swiftly than nonreversal shifts. If, however, $S$ is functioning at a level of development characterized by analyzing stimuli into less differentiated complexes such as stimulus compounds (e.g., large-black, small-white), he should execute nonreversal shifts more rapidly than reversal shifts because a greater number of stimulus-reward relationships must be relearned in the latter paradigm than in the former. Tighe and Tighe contend, therefore, that helping an organism isolate the distinguishing dimensions in a discrimination task (as the present experiment has done) should increase the ease of reversal shifts over nonreversal shifts. To test this interpretation, Tighe (1965) presented first grade children with several training stimuli similar to one used in the shift task, and

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asked Ss to judge from memory whether succeeding stimuli differed from a standard stimulus in terms of one or both of the dimensions employed in the shift task. He found that perceptual pretraining did facilitate reversal shifts, but had no significant effect on nonreversal shifts. The present experiment, of course, found no such reversal facilitation.

Regardless of which theory one wishes to adopt to explain differences in shift performance across species and between infant and adult humans, the fact remains that such differences do exist; that adult humans use concepts which they acquire in a different way for future shift learning than do children and nonhumans. It seems to remain for two types of experiments to be carried out to explain these differences: (a) more experiments on humans with limited ability to form concepts (especially verbal concepts since verbal ability still seems to be an important variable in concept formation). As Furth (1966, p. 160) suggests, deaf mutes with no verbal training (if such could be found) would seem to be ideal Ss to test a verbal mediation hypothesis. (b) Experiments such as the present one which attempt to build in more sophisticated concept ability in nonverbal organisms to observe the effect this has on shift behavior, and attempt to explore different conditions like the overlearning reversal effect which are known to alter shift performance.
To improve the procedure of the present experiment and any similar future experiments, the author would suggest not using an insoluble task for the control group during Stage II to equate for maze experience with the experimental group. An alternative procedure might be to partially reinforce (equating for amount of reinforced trials with the experimental partner) just one of the two stimuli (horizontal vs. vertical stripes seem appropriate), and to never reinforce the other. This procedure would both equate for maze experience and amount of reinforcement, and make the problem solvable, though still irrelevant to the subsequent bi-dimensional shift tasks.

It might also be interesting to perform this experiment using the optional shift paradigm. The optional shift paradigm has the advantages of (a) all experimental and control Ss need not be divided into reversal and nonreversal groups for purposes of analysis, thus allowing larger Ns per cell; and (b) one does not run into the partial reinforcement problem which necessitates eliminating one dimension during the shift task as the present experiment did. A big disadvantage of the optional shift paradigm, of course, is the high probability of inconclusive results. It is only when the S elects the extreme mode of responding 80% to 100% to one stimulus in the shift test that one can assert that anything conclusive has happened.
Chapter V

Summary

Twenty eight hooded rats were given a series of two-choice discrimination problems. An experimental group was first given a relational learning task of four semicircles presented two at a time with the larger of any two reinforced. The solution of this problem required attending to the relationship of the stimuli rather than to any one stimulus. After learning this task, these rats were given a bi-dimensional problem whereby they were reinforced for choosing the larger of two squares regardless of brightness. After learning this task, one-half were given a reversal shift (small reinforced regardless of brightness), and one-half were given a nonreversal shift (e.g., black reinforced regardless of size). It was predicted by an experiential mediation hypothesis that this group, which had an opportunity to develop a concept of size during the relational task, would employ this concept as a mediator and reverse faster than nonreverse. Both this experimental group and a control group without relational experience nonreversed faster, however, as has generally been found in rats.
Appendix A

Individual Correct* Responses to Each Pair of Semicircles During Last 24 Trials of Relational Learning

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*Each pair is presented six times in these 24 trials.
Appendix B

Individual Correct* Responses to Each Semicircle

During Last 24 Trials of Relational Learning

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*Each semicircle is presented 12 times in these 24 trials
Footnotes

1. Thanks are due to Jerome Cohen, who suggested the use of this apparatus, and who made this particular one available.

2. Throughout the experiment some rats would not initially eat the sucrose pellets. These rats were started on .45 gm. pellets of Lab Chow, and gradually switched over to .45 gm. pellets of sucrose.
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