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A STUDY OF WEIGL ODDITY

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A STUDY OF WEIGL ODDITY

by

Pamela Henderson-Medelis

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
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STATEMENT BY AUTHOR

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ABSTRACT

Weigl oddity problems typically consist of three stimuli; one is color odd, one is object odd, and one is irrelevant to the problem involved. A cue indicates whether color or object is the relevant dimension on each trial.

This study, used a WGTA to present Weigl oddity problems to five capuchin monkeys (Cebus appella). In Phase 1, the monkeys were presented 25 continuous color trials on a black tray and 25 continuous object odd trials on a white tray. Two color stimuli and two object stimuli were used. During the final phase, 144 stimuli were presented on three-choice trays and color and object odd trials were randomly interspersed. All but one monkey completed the task to the set criterion. Initial phases showed color odd performance exceeding object odd performance for all subjects.

This study provides the first conclusive evidence that New World monkeys can learn Weigl principal problems.

CHAPTER 1

INTRODUCTION

By the late 1930's Harry Harlow had begun measuring the capabilities of monkeys to solve complex learning problems. In 1940 he attended a seminar given by the eminent neurologist Kurt Goldstein (see Harlow, Gluck, and Suomi, 1972). Goldstein took a skeptical view about the validity of generalizations between animals and humans. He did not believe in evolution. As far as Goldstein was concerned, there were humans and there were animals, not humans and other animals. Humans alone, according to Goldstein, were capable of abstract thinking. One problem which Goldstein was convinced measured abstraction abilities was Weigl principle problems. Harlow, a vigorous and vociferous advocate of primate thinking abilities, took Goldstein's challenge and demonstrated that rhesus monkeys could indeed master Weigl oddity problems (Young and Harlow, 1943a, 1943b). Harlow lamented many years later (Harlow et al., 1972) that despite the interesting nature of the monkey Weigl principle learning, few psychologists were interested-except, of course, for Goldstein.

Complex learning problems have been the subject of numerous research studies. Many situations encountered by humans, as well as animals, have multiple meanings based on the context in which they occur. Animals must constantly discriminate these contextual cues and determine the appropriate response. Lashley (1938) has proposed a classification based on the number of variables (cues) needed to define the correct response. He stated that second order generalization is when "one variable determines the reaction to another." Examples of second order generalization include oddity and matching-from-sample. In a two-odd problem, first introduced by Robinson (1933), two identical pairs of stimuli are used. Each stimulus type appears equally often as the odd stimulus. Although this problem was learned by Robinson's monkeys, later research has pointed out that perhaps a strategy was involved that was not oddity learning. For example, the monkeys may have learned "if two squares are present, pick the triangle; if two triangles are present, pick the square," (French, 1965). Further evidence that this may indeed be the case was presented by Noble and Thomas (1970). These researchers found that squirrel monkeys had significantly higher performances on one configuration as compared to the other.

A procedure which shows irrefutable oddity learning is the multiple two-odd problem. Many problems are presented, all solvable by a similar rule, but any one problem is only presented a limited number of times. Thus, it is unlikely that any two part rule, as previously mentioned, could be developed. Furthermore, Meyer and Harlow (1949) saw Trial 1 performance on multiple problems exceed chance levels. And, there is no way a conditional rule could account for this finding.

If Lashley's classification is extended to situations in which three or four variables determine the appropriate response, then highly complex concepts emerge. Complex learning of this type was demonstrated by Spaet and Harlow (1943). Three rhesus monkeys successfully learned concepts involving oddity, nonoddity, sign-discriminated-antagonistic-position habit (SDAPH) and its converse, reversed sign-discriminated-antagonistic-position habit (RSDAPH). The monkeys solved these problems based on the configuration of the objects, the actual objects present, and the color of the tray.

Another type of higher order sign problem is based on the Weigl test for abstraction (Weigl, 1941). This test was originally devised as a diagnostic tool to test for brain damage in humans. Harlow adapted it for use with monkeys. His procedure involved presenting a sign cue that indicated which of two dimensions was relevant on any one trial. This cue, in turn, defined the correct stimulus object. One type of Weigl problem is Weigl oddity. In this type of problem a specific cue tells the animal which of two dimensions is the relevant one and thus should be used to define the odd object. Young and Harlow (1943a), demonstrated that rhesus monkeys could successfully perform such a problem. Three stimuli appeared on each trial. One was an odd color, one was on odd shape and the other was not odd with respect to either dimension. If the stimuli appeared on an orange tray, the correct stimulus was the odd colored one. However, if the identical stimuli appeared on a cream tray, the odd shaped one was correct. These experimenters later showed that rhesus monkeys could respond correctly when new identical and nonidentical stimuli were introduced or the position or the number of foodwheels on the tray was increased (1943b). Unfortunately, a stimulus set of only 25 objects was used in these two studies. With the limited set, some configurational learning may have occurred.

The present research was designed to be an extension of the Young and Harlow studies. It will determine if these abstraction abilities are also possessed by New World monkeys, specifically Cebus appella. Additionally, the study will use a much wider set of objects to show that configurational learning is definitely not responsible for above chance performance.

CHAPTER 2

METHOD

Subjects

Five adult capuchin monkeys (*Cebus appella*), four male and one female, were subjects. All five monkeys were previously adapted to the Wisconsin General Test Apparatus (WGTA) and had had previous experience with a variety of discrimination and sameness-difference problems. However, none had had any prior oddity training. The monkeys were housed in individual cages at the University of Arizona primate colony.

Apparatus

The apparatus was a WGTA with both five choice and three choice stimulus presentation trays. The foodwells were 3.5 cm. apart and 5.5 cm. in diameter. An opaque door was lowered between trials blocking the monkey's view while the tester arranged the objects and reinforcement for the next trial. Additionally, a one way screen was interposed between subject and tester. Initially, the stimuli were 36 wooden squares, three each of 12 different colors, and 36 wooden squares, three each with 12 different objects attached to them. In the final three phases, the stimuli were wooden squares of 12 possible colors and with one of 12 possible objects attached.

Experimental Design

Initial Training

At the outset, the traditional three choice tray was utilized. After four weeks of training, no significant learning occurred on what should have been a simple oddity problem. The monkeys seemed to be responding to different stimulus configurations rather than the underlying concept of oddity. For example, if there were two blue stimuli and one orange stimulus, the animal picked the orange stimulus. But, if there were two orange stimuli and one blue stimulus, the animal was baffled as to the correct response. Thus, the switch was made to a five choice tray in hopes that this would make the odd stimulus appear more obvious.

Phase 1

During Phase 1, the animals were trained on two separate types of oddity problems. In color oddity problems, the monkey saw five identically shaped wooden stimuli on a black tray. Four of these stimuli were also identically colored, either orange or blue, and the fifth had a different color, again orange or blue. Displacement of the odd colored stimulus yielded a small food reward.

On object oddity problems, the monkeys saw five identically colored stimuli on a white tray. Four of these stimuli now had identical objects attached and the fifth a different object. The two objects in use were golf tees and rubber bands. Displacement of the odd stimulus, now with respect to object, yielded a small food reward. In all cases, the position of the odd stimulus was randomly varied so that it occurred equally often at all five locations. Two additional stipulations were that each color and each object be equally often rewarded and that the odd stimulus not occur in the same location more than three consecutive times. On each test day there was a block of 25 color oddity trials and a block of 25 object oddity trials but it varied daily as to which block occurred first.

Phase 2

The only change in Phase 2 training was the addition of 10 colors and 10 objects so that 12 possible colors were used to construct color problems and 12 possible objects were used in object problems. The stimulus objects presented on any trial were based on computer generated random number sequences of all possible combinations of the 12 colors for color trials and the 12 objects for the object trials. All five choice positions were equally often baited but none occurred more than three times consecutively. The

25 color relevant trials were still separate from the 25 object relevant trials but it varied day to day as to which group of trials came first.

Phase 3

Random mixing of color and object oddity was initiated in Phase 3. The animals still received 50 trials during each daily test, however the trials were not distinctly separated into color relevant problems and object relevant problems. Instead, a Gellerman series was used to determine whether each individual trial would be a color problem or an object problem. Again all five choice positions were equally often baited.

Phase 4

Reduction to three choice trials instead of five choice trials occurred in Phase 4 and remained in effect during all subsequent phases. The animals received 48 trials per day with 12 possible colors and objects but, again, the problems were discrete; a block of 24 continuous color trials and a block of 24 continuous object trials was presented daily. On any day only four different colors and four different objects were used. The stimulus objects were randomly selected from all possible choices two at a time. Twelve color trials were constructed using the first two colors drawn and 12 more with the next two colors.

Then, two objects were chosen and 12 trials made with these objects followed by two different objects and 12 more trials. Each of the three choice positions was equally often baited.

Phase 5

In phase 5 of training the color and object relevant trials were again randomly intermixed. Each animal received 24 color problems and 24 object problems daily but their occurrence was based on a Gellerman series. Each choice position was equally often baited.

Phase 6

True Weigl oddity training began in Phase 6. Only two colors and two object types were used. Color oddity, 24 trials, and object oddity, 24 trials, were separated, but it varied daily as to which block of trials occurred first. On each trial there were now two odd stimuli, one odd with respect to color and the other odd with respect to object. For example, if the monkey saw a black stimulus with stars, a yellow stimulus with stars and a yellow stimulus with a nut, all on a black tray, the odd colored stimulus, in this case, black with stars, was the correct choice. The stimulus with the odd object attached, in this case, yellow with a nut, would be the ambiguous but incorrect choice and the remaining block, yellow with stars would be called the unambiguously incorrect stimulus. However, if this same configuration appeared on a white tray, the odd colored stimulus, black with stars, would become the ambiguously incorrect choice, the odd object stimulus, yellow with a nut, would be the correct choice and the remaining block would stay unambiguously incorrect. The position of the correct choice appeared equally often in all three locations.

Phase 7

In Phase 7, all 12 possible colors and objects were reintroduced but color and object trials were kept separated. The animals received a block of 24 color relevant problems and a block of 24 object relevant problems but it varied daily as to which block preceded the other. The odd stimulus, as well as the ambiguously incorrect stimulus, were controlled so that they occurred equally often in all three locations.

Phase 8

In Phase 8, color and object problems were again intermixed according to Gellerman series instructions. A day's test consisted of 48 trials with each of the 12 colors and 12 objects possible on any one trial. The odd stimulus and the ambiguously incorrect stimulus occurred with equal frequency at all three locations.

During all phases of testing, the animals had to meet or exceed an 80% criterion on any one test day. Before they proceeded to the next phase. That is, they had to correctly complete 40 out of 50 trials or 38 out of 48 trials, depending on the phase, all during the same test session. A second criterion was instituted for one animal in Phase 1. This criterion was that the animal maintain 37 correct out of 50 possible trials for three consecutive days in order to proceed to the next phase. All training was conducted five days per week for approximately 36 weeks. The intertrial interval was 10 seconds and the reward was marshmellows during the first 28 weeks and raisins during the last eight weeks. For each day's test the animals were taken to a test room in a combination test and transport cage. White noise was used to block distracting noises from the hallway. Following testing, the monkey was returned to its home cage and given its daily ration of monkey chow supplemented with fresh fruit.

CHAPTER 3

RESULTS

Phase 1

All subjects achieved the 80% criterion in Phase 1. However, individual z-test analyses showed that four out of five animals made significantly more correct responses on blue odd trials than orange odd trials. The remaining subject made significantly more correct responses on orange odd trials. Thus, the monkeys seemed to be initially affected by color preferences.

In addition, color oddity was learned with fewer errors than object oddity ($t = 3.24$, $df = 4$, $p < .05$). Individual z-tests also showed that four of the five subjects made significantly fewer errors on color problems than on object problems. The individual deviant had no significant difference in the learning of color and object oddity (see Table 1).

Phase 2-Introduction of All Colors

Phase 2 again showed all animals mastering the 80% criterion. As in Phase 1, the difference between color and object learning appeared. For all monkeys, color oddity problems were learned more readily than object oddity problems ($t = 4.42$, $df = 4$, $p < .02$) (see Table 2).

Table 1. Percentage Scores and Individual z-Values for Phase 1.

Subject	Blue Odd Correct	vs.	Orange Odd Correct	Individual z-Values
Itch	41.5%		57.6%	-6.541**
Ralph	82.5%		45.2%	4.344**
Eugene	73.9%		52.0%	6.208**
Claude	80.8%		72.3%	3.362**
Jr.	78.8%		69.8%	2.626*

* p < .01

** p < .001

Subject	Color Odd Correct	vs.	Object Odd Correct	Individual z-Values
Itch	49.6%		30.7%	11.074
Ralph	64.0%		60.0%	.6515
Eugene	62.9%		45.5%	6.763
Claude	76.5%		35.0%	19.823
Jr.	74.3%		28.5%	16.518

p < .001

Table 2. Percentage Scores and Individual z-Values for Phase 2.

Subject	Color Odd Correct	vs.	Object Odd Correct	Individual z-Values
Itch	71.0%		58.5%	2.617
Ralph	76.6%		65.7%	2.249
Eugene	72.5%		61.4%	3.999
Claude	76.4%		45.3%	6.760
Jr.	71.0%		50.3%	5.939

($p < .02$)

Phase 3-Intermixing Color and Object Problems

This phase only lasted an average of 1.4 days and was therefore too short for meaningful analysis.

Phase 4-Reduction to 3 Choices

All animals mastered the 80% criterion once again. As in Phases 1 and 2, the difference between color and object learning was significant ($t = 10.07$, $df = 4$, $p < .001$). However, individual z-tests showed only three out of five animals made significantly more responses to color oddity problems than to object oddity problems. The other two animals showed no significant differences between these two types of oddity (see Table 3).

Phase 5-Intermixing Color and Object Problem

This phase only lasted an average of 2.6 days and was therefore too short for meaningful analysis.

Phase 6-Beginnings of True Weigl Oddity

All subjects completed Phase 6 to the 80% criterion. Correlated t-tests showed that learning was not significant on object oddity trials when the correct stimulus was compared to the ambiguous stimulus. However, learning was significant on object trials when the correct stimulus was compared to the unambiguously incorrect stimulus (UIS) and when the ambiguous stimulus was compared to the UIS ($p < .01$, $p < .05$ respectively). On color trials, the proportions

Table 3. Percentage Scores and Individual z-Values for Phase 4.

Subject	Color Odd Correct	vs.	Object Odd Correct	Individual z-Values
Itch	67.6%		57.9%	3.808
Ralph	76.9%		69.9%	1.404
Eugene	67.9%		59.6%	1.892
Claude	66.1%		55.8%	2.832
Jr.	68.8%		62.9%	2.475

($p < .001$)

were significant when the correct stimulus was compared to either incorrect stimulus ($p < .001$) but no significant learning appeared between the ambiguous stimulus and the UIS. (See Figure 1).

Phase 7-Introduction of All Colors and Objects

Testing of one monkey was terminated in Phase 7 when he failed to reach criterion in 816 trials when the mean for all other monkeys was 638 trials. Data from this subject were not included in the analyses of Phases 7 or 8. The remaining four animals successfully met the 80% criterion. Correlated t-tests showed that significant learning occurred in all cases on both color relevant problems ($p < .05$) and object relevant problems ($p < .01$). The monkeys could make correct choices in the case of the correct stimulus vs. the ambiguous stimulus, the correct stimulus vs. the UIS and the ambiguous stimulus vs. the UIS (see Figure 2).

Phase 8-True Weigl Oddity

Phase 8 only lasted an average of 1.5 days and was therefore too short for meaningful analysis. (See Figure 3 for complete days to criterion for each phase.)

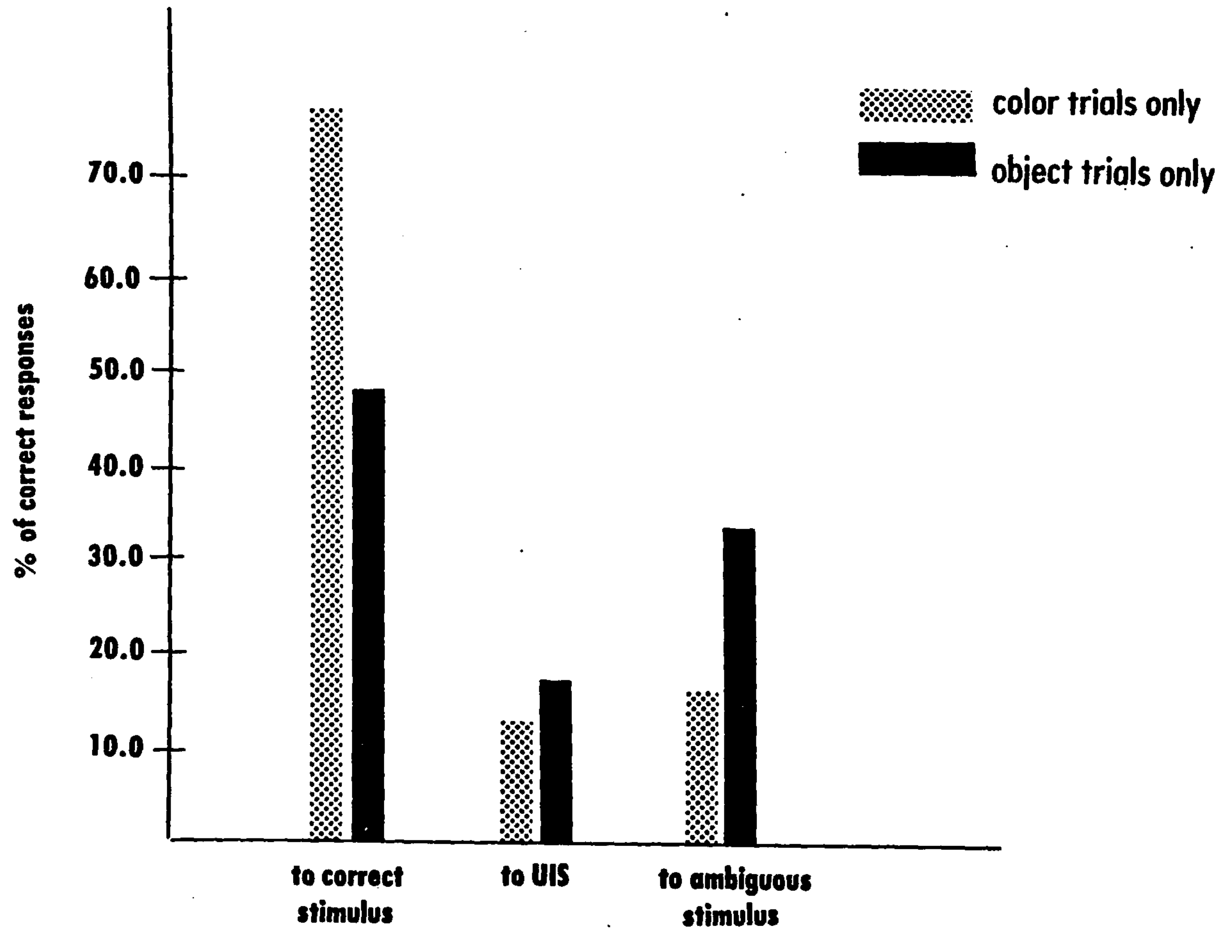

Figure 1. Distribution of correct responses to stimulus types in Phase 6.

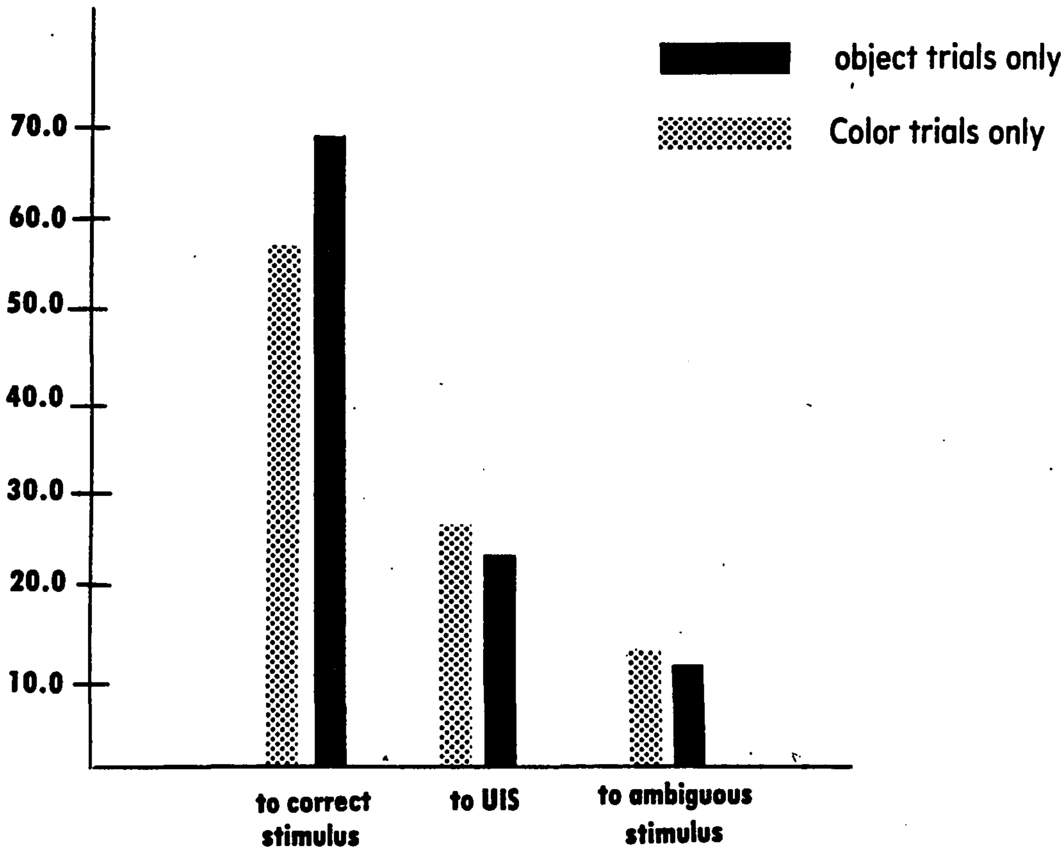

Figure 2. Distribution of correct responses to stimulus types in Phase 7.

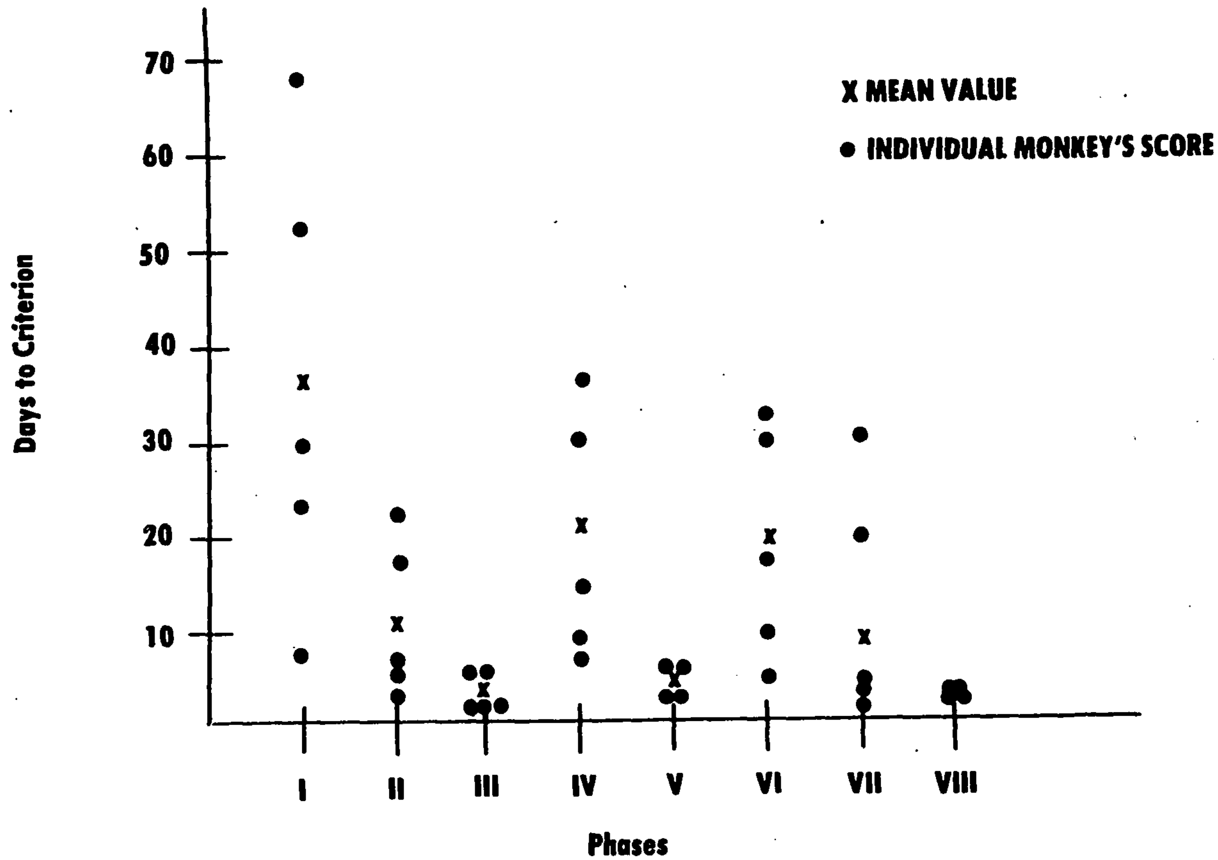

Figure 3. Days to criterion by phase for each monkey with mean days calculated.

CHAPTER 4

DISCUSSION

The results of the present research clearly demonstrated that capuchin monkeys can successfully master a generalized form of the Weigl oddity concept in a multiple problem context. These results mean that the capuchin monkey can shift from object oddity to color oddity, and vise versa. Because of the multiple objects utilized, configurational learning was eliminated and thus tray color served as the only reliable cue for these correct responses. Additionally, the study dramatically demonstrated the correct color odd and correct object odd stimuli were preferred even to the ambiguous or irrelevant odd stimuli. This significant difference between correct and irrelevant stimuli for both color and object oddity showed the completeness of learning. Furthermore, when choices were made to these incorrect stimuli, the ambiguously odd stimuli received more responses than the unambiguously incorrect stimuli in Phase 6 and significantly more responses than the unambiguously incorrect stimuli in Phase 7.

The present work extended that of Young and Harlow (1943a, 1943b) by employing a much larger set of stimulus objects and New World monkeys rather than Old World monkeys.

Young and Harlow determined that rhesus monkeys could indeed choose the odd stimulus with respect to either shape or color based solely on tray color. However, they only used 25 stimuli in their stimulus set and could possibly have gotten some configurational learning rather than true oddity because of this limited set. The present study followed basically the same procedure using capuchin monkeys. The stimulus set consisted of 144 blocks thereby virtually eliminating any possibility of configurational learning, especially since a new configuration was presented on each trial and therefore was virtually never seen more than once.

Furthermore, the Young and Harlow studies saw color oddity learning exceed shape oddity learning throughout the entire experiment. As a contrast, in the present work the superiority of color oddity learning seen in Phase 1 disappeared by Phase 7. Thus, a discussion of this initial, and sometimes total, use of color as the salient cue warrants mention. The present findings concerning color could have been due to the extensive number of trials in the previous phases. These trials could have enhanced the saliency of the object differences in the object odd problems. Or perhaps, this change was due to the fact that the New World monkeys used here view colored stimuli as more desaturated than do the Old World monkeys used by Young and Harlow.

Therefore, color is probably a less salient cue to the New World monkey (DeValois and Jacobs, 1971).

Other researchers have found this same tendency to use color as the salient cue. Draper (1965) noted that rhesus monkeys showed significant oddity learning when the stimuli differed in color but not when they were differentiated by size, form or size and form. Furthermore, the addition of size and form cues did not improve their performance. Additionally Warren (1954) proved that rhesus monkeys previously trained to discriminate based on color, size and form showed superior performance on generalization trials with only one dimension retained, only if that dimension was color. There are no comparable studies on salience of color cues for New World monkeys but based on their color vision, as previously mentioned, one might assume that the same results may not be discovered.

All in all, the present study proved that non-human primates can indeed master the abstract concept of Weigl oddity. Additional research is needed to extend the observations of abstraction abilities to other animal species, further investigate color saliency cues in New World monkeys and to compare the monkey's results with those of children learning the same task.

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