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The effects of intelligence, stimulus complexity, and negative instances on concept attainment.

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THE EFFECTS OF INTELLIGENCE, STIMULUS COMPLEXITY, AND NEGATIVE INSTANCES ON CONCEPT ATTAINMENT

A Dissertation Presented

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The purpose of this investigation will be to determine whether children of high intelligence are superior to children of average intelligence on a concept attainment task with different levels of stimulus complexity. Another goal is to determine what effects verbalization and the frequency of different negative instances will have on the concept attainment performance of high and average intelligence children.

Theories of Concept Attainment

Bourne (1966) notes that theories of concept attainment can be divided into two groups, the associationistic, and the hypothesis testing. The assumptions of these two groups of theories will be discussed below as they relate to the problem under consideration in this study.

The associationistic theories of concept attainment assume that the subject in a concept attainment situation is a passive participant in the process. According to these theories the subject learns the concept through the building up of the positively reinforced instances, and the dropping out of the non-reinforced instances. Concept attainment is viewed as a more complex form of discrimination learning. The subject learns to discriminate between the relevant and irrelevant aspects of the stimuli on the basis of reinforcement or non-reinforcement of a response. Gradually the connection is established between a particular stimulus and response (based on reinforcement), and the problem is solved.

The hypothesis testing theories make several different assumptions. These theories view the subject as an active participant in the concept attainment process. The subject at all times has a hypothesis (or strategy) which he is constantly testing out in order to arrive at a solution. The subject modifies his current hypothesis on the basis of the incoming information which either confirms or infirms his current hypothesis. Based upon such information the subject continuously modifies his hypothesis until he arrives at the correct hypothesis, and solves the problem.

The subject who uses hypothesis testing to attain a concept selects the aspects he considers relevant, tests the adequacy of his hypothesis, and then alters his hypothdesis until it fits the data. While some associations develop in this process, they are viewed as the by-product of the testing procedure. The actual attainment of the concept may involve the recognition and understanding of the principle which is required by the given problem.

Riley (1968) in his recent comprehensive and cogent review of the literature concerning discrimination learning raises some theoretical and empirical issues which have relevance to the present discussion of concept attainment. He notes that if the subject in a discrimination learning situation is following what has been referred to as an associationistic method of solution, the learning curve for that subject could be described as continuous. However, if the subject is following the hypothesis testing method, his learning curve would be of a discountinuous nature.

If the associationistic method is followed, then the subject, according to this theory, will associate all the stimuli striking receptors at the time a response is made if this event is followed by a satisfying state of affairs (reinforcement).

On the other hand, a subject using the hypothesis testing approach will associate only some of the stimuli striking the receptors, those that he is attending to. Riley also raises a third alternative, that the subject can switch the selectivity of response from one aspect of the stimulus to another.

Riley cites empirical support for each of these theoretical points of view cited above. While much of the research has been done with animals (e.g., rats) as subjects, it appears to have relevance to the process of concept attainment. The intent here however is not to become involved in a rather complex debate over the various positions, but rather to note that there may be different processes by which a subject may attain a concept. The more precise relation of these points of view to the concept attainment behavior of high and average intelligence subjects will be discussed in a following section.

Intelligence and Concept Attainment

While many investigators and theorists acknowledge the relevance and importance of intelligence in the process of concept attainment, the literature does not abound with studies of this nature. In his recent review, Bourne (1966) provides a thorough report on concept attainment research and theory. In summing up his findings, Bourne notes that, "Much remains to be learned about the relationship between intelligence and conceptual behavior (p. 92)." Van de Geer and Jaspers (1966) concur with Bourne's suggestion, indicating that more research is needed in dealing with the highly related variables of cognition and intelligence.

Several significant and well-controlled research studies in the area of concept attainment and intelligence have been conducted by Osler and her associates (Osler and Fivel, 1961; Osler and Trautman, 1961; and Osler and Weiss, 1962) and Yudin (1966). An attempt will be undertaken here to discuss the results they have obtained, and how they serve to direct new research toward firmer and more valid conclusions about the relationship between intelligence and concept attainment.

In the first study, Osler and her associates (Osler and Fivel, 1961) investigated the relationship between intelligence and age on a concept attainment task. Six, ten, and fourteen year old children were required to attain a concept of either bird, animal, or living thing, typifying what Osler called naturalistic stimuli. Subjects were reinforced with marbles (which they later exchanged for a toy) until they reached a criterion of ten consecutive correct responses or 150 trials, whichever occurred first. With number of errors to criterion as the measure of performance, the high intelligence subjects performed significantly better than the average intelligence subjects. Her results also showed better performance with increasing age.

Osler justified her use of naturalistic stimuli by noting that the older and more intelligent subjects, because of their familiarity with verbal symbols, might be favored by more formal types of stimuli. Possibly the ability to manipulate and make use of verbal symbols is an important determinant of effective concept attainment, and her selection of naturalistic stimulus materials may have reduced the obtained superiority of concept attainment performance of the older and more intelligent subjects.

In order to investigate further the specific mechanism by which higher intelligence subjects manifested their superior performance, Osler divided her subjects into gradual and sudden learners. She assumed that gradual learners build up S-R associations, a process probably associated with lower intelligence, and that sudden learners test successive hypotheses, a mediating process probably related to higher intelligence. She found that the number of sudden learners in the high intelligence group was significantly greater than in the average intelligence group. Osler claims that these results support the notion that the relationship between intelligence and concept attainment is a function of the high frequency of hypotheses testing in the high intelligence subjects.

The second study in this series (Osler and Trautman, 1961) was concerned with examining the level of stimulus complexity and how it affected the concept attainment performance of average and high intelligence children. Osler reasoned that if hypothesis testing is more frequent among subjects of higher intelligence, it should be possible to impair the performance of the superior group by increasing the number of irrelevant dimensions upon which hypotheses can be based. On the other hand, the performance of subjects of average intelligence, who are supposed to achieve solution by the gradual build up of S-R associations, should not be influenced by the large number of irrelevant stimulus dimensions.

Osler varied stimulus complexity through the use of two different sets of stimuli. The simple set (formal two) consisted of black circles which varied in both pattern and number, while her complex set (object two) was a series of pictures of common objects. The common object set was assumed to be more complex because of the greater number of irrelevant stimulus attributes present. Osler's results showed that the high intelligence children were able to perform in a superior manner only on the simple set. Their performance on the complex set was approximately equivalent to the performance of the average intelligence subjects.

Wolff (1967a) noted some relevant criticisms, and then subjected Osler and Trautman's (1961) study to replication. Wolff criticized the reasoning employed by Osler and Trautman on the following grounds: he noted that hypothesis mediated learning is more frequent among older than younger children, and therefore that stimulus complexity should differentially affect subjects of different ages (i.e., there should be an interaction between age and stimulus complexity with the older children performing better with more complex stimuli). No effect of this sort was found in Osler and Trautman's data.

The data Wolff (1967a) obtained by replicating Osler and Trautman's (1961) study did not support Osler and Trautman's data. Wolff found significant main effects for both intelligence (high intelligence subjects performed better) and complexity (the more complex stimuli reduced concept attainment performance). In addition, Wolff claims that while his obtained interaction between these two variables was not significant, it tended to be in the opposite direction of Osler and Trautman's.

However, a careful examination of Wolff's data shows that some of his claims were not entirely justified. Since Wolff used only 11 year old children and Osler and Trautman used 6, 10, and 14 year olds in order to make a more valid comparison between the two studies, one must examine only Osler and Trautman's data for their ten year olds. This examination reveals that Wolff's subjects on the simple stimulus materials performed approximately twice as well as Osler and Trautman's subjects. On the complex stimuli Wolff's data show that the performance of his high intelligence group was significantly better than Osler and Trautman's subjects, while the average intelligence subjects in both studies performed about the same.

What caused Wolff's simple stimuli to induce such improved performance? One may speculate that it could have been due to one of the following: (1) the intelligence test used to select subjects (Wolff used the Henmon-Nelson, Osler and Trautman, the WISC); (2) the use of different instructions which Wolff did not publish; or (3) the stimulus materials in the two studies were slightly different (Wolff's circles were ½" in diameter, Osler and Trautman's ¼" in diameter, and Wolff's card area was twice as large).

However, none of these explanations can be firmly established, so that we must take Wolff's aberrant data on the simple set into consideration in any discussion of his results.

Wolff chose to ignore the difference between his and Osler and Trautman's results on the simple stimuli and concentrated his discussion on the obtained differences with the complex stimuli. Wolff's explanation comes from Podell's (1958) study which found that a large variety of positive stimuli aids hypothesis testing learning (i.e., high intelligence subjects) while it hinders associative learning (i.e., average intelligence subjects).

Wolff also found that Osler and Trautman had used unequal numbers of "one instance" negative instances in their sets of stimuli (25% in the simple set, but 75% in the complex set), whereas he had used equal proportions (25%) of the negative instances in both the simple and complex sets. Wolff reasoned that any increase in the variety of positive or negative stimuli aids the hypothesis tester, i.e., the high intelligence subjects, and hinders the performance of the average intelligence subjects, and thus provided an explanation for his results with the complex stimuli.

Wolff's data also suggests an alternative hypothesis regarding the effect of the variety of negative instances. For subjects who achieve concept attainment via S-R associations, the 75% one instance condition would allow for more efficient solution because the disproportionality of negative instances would allow the average intelligence subjects to eliminate one possible alternative quickly and then concentrate on the others. This mode of solution would also hold true for the high intelligence subjects with the 75% one instance condition.

However, when equal numbers of negative instances exist, the solution via S-R associations becomes less efficient because there is no quick method to eliminate even one negative instance. Solution for the average intelligence subjects is then necessarily less efficient than under the 75% one instance condition. High intelligence subjects, on the other hand, because they achieve solution by the testing of successive hypotheses could solve the problem more efficiently since they are not dependent upon the reinforcement contingencies operating at the time.

One could also ask why high intelligence children are hindered by hypothesis testing only with the object two set and not possibly by a formal two set of greater stimulus complexity. Osler claims that the use of a formal two set with increased stimulus dimensions would assist the high intelligence subjects more than the average intelligence subjects because of the former's greater familiarity with verbal labels. This increase in complexity, whether it is a more complex formal two set or the object two set, should according to Osler's reasoning provide more opportunities for hypothesis testing, and therefore hinder the high intelligence subjects.

What Osler seems to imply, but never states, is one of the following arguments: (1) The object two set, because of its greater number of irrelevant stimuli which have to be tested (by hypotheses for the high intelligence subjects), overloads the capacity of the high intelligence subjects in such a way that they can no longer maintain their superiority over the average intelligence subjects; (2) since the object two stimuli are more familiar to all children, the verbal labels for these stimuli are equally available to both high and average intelligence children. Familiarity with verbal labels aids in more efficient concept attainment, and therefore the average intelligence subjects are able to perform at the same level as the high intelligence subjects.

Yudin (1966) found significant differences in favor of high over average and low intelligence subjects, and average over low intelligence subjects. The subjects used in Yudin's study were adolescents, and he did not address himself to a study of the specific learning mechanism that was associated with intelligence. He did however note that the ability to acquire and transform information from current and previous conceptual instances was related to better performance.

In a study reported by Kates and Weiner (1967) there was an attempt to investigate whether the conceptual superiority of high intelligence children (ages 10, 12, and 14) was due to the use of a wholist rule. It was discovered that teaching this rule benefited superior as well as bright, normal, and average intelligence children. The conclusion appears to be that the use of a wholist rule for mediating conceptual information was not the basis for the conceptual superiority of the superior intelligence children.

Stimulus Complexity and Concept Attainment

While the previous section dealt with studied concerned with both stimulus complexity and intelligence, it appears to be worthwhile to note briefly some of the research dealing with stimulus complexity and concept attainment.

The vast majority of the research in the area of stimulus complexity and concept attainment (or identification) has been directed primarily at mathematical learning theory. While the present review does not necessitate a presentation of the intricacies of the models involved, it is worthwhile to review briefly some of the more prominent studies involving stimulus complexity.

Bourne and Restle (1959) proposed a model which states that the difficulty of concept attainment is directly related to the number of irrelevant cues, and inversely related to the number of redundant relevant cues. According to their model the relevant stimuli become conditioned (learned), while the irrelevant cues adapt out (they become suppressed). The probability of a correct response is thus a joint function of the state of both conditioning and adaptation processes.

Much of the subsequent research in this area has been directed at a test of the model proposed by Bourne and Restle. The majority of these studies have shown that the greater the complexity of the stimuli, the more difficult the attainment of the concept, thus supporting the Bourne and Restle model.

Bourne (1957) used a concept identification task with one, three, and five bits of irrelevant information. He found that there was an increase in mean solution time, mean number of errors, and mean number of trials with increasing amounts of irrelevant information. Brown and Archer (1956) and Archer, Bourne, and Brown (1955) all obtained results similar to those of Bourne (1957) using problems with varying amounts of irrelevant dimensions. Bourne and Haygood (1959, 1961) found that as the number of relevant dimensions increased the mean number of errors decreased. In addition, they found the previous effect of irrelevant information to hold.

Despite the vast number of concept identification studies concerned with the effect of complexity, either relevant or irrelevant information, none have sought to partial out the effects of intelligence. On the basis of the research reported in the previous section (Osler and Trautman, 1961; and Wolff, 1967a), one would expect a differential effect of complexity and intelligence upon concept identification.

Denny (1966) feels that the task complexity specifies the stimulus demands placed upon the organism, while intelligence refers to the organism's capacity to learn useful habits for responding to the stimuli of the task. He goes on to speculate that, "...a lower level of task complexity and higher intelligence will favor the development of correct habits and vice versa (p. 600)." While the above inferences were made by Denny, he did not test them in any empirical manner.

Verbalization and Concept Attainment Performance

For Luria (1957) speech plays an important part in children's thought processes. It is through the use of speech that the child orients himself to his environment, organizes his past experiences, and helps to regulate his actions. Language acts as a mediator of connections, and is a crucial aspect of normal development. He states, "The normal child of 5½ years and upwards forms new connections in these conditions largely by using a verbal system, which enables him to abstract and generalize the significant elements in the signals and to find his bearing among them (p. 119)."

Liublinskaya (1957) feels that the learning of concepts is facilitated and conceptual transfer is extended through the use of verbal labels. In addition, he states that giving a verbal label to a relevant dimension is more effective in terms of future performance than training on that dimension.

Clearly then, verbalization and the ready availability of verbal labels are critical in efficient concept attainment. Osler and Trautman (1961) cited better verbal abilities as one possibility for the anticipated superior performance of the high intelligence subjects on a more complex formal two task.

Weir and Stevenson (1959) used a discrimination learning task to test the hypothesis that verbalization would improve subsequent learning performance. They found that their experimental group which had learned to verbalize the names of the stimuli (pictures of animals) before making their response had significantly more correct answers when compared to the group which did not verbalize the response. This significant difference was noted in all the continuous age groups studied, from three to nine years. Their explanation was that verbalization requires the subject to orient to the relevant stimulus, and thus enhances the likelihood of his sampling the correct cues and making the correct hypothesis.

Kendler and Kendler (1959) posited a verbal mediating response as central to concept attainment. S-R theory predicts that a reversal (intradimensional) shift would be more difficult than a nonreversal (interdimensional) shift.

Kendler and Kendler (1959) found that the reversal shift was easier for older than for younger children. Their explanation was that older children were better able to make use of a verbal (covert) mediating response than were the younger children. All their subjects were subsequently divided into two groups, a group of slow learners and a group of fast learners, similar to the division Osler and Fivel (1961) made. Kendler and Kendler's (1959) results showed that the fast learners group made the reversal shift on significantly fewer trials than did the group of slow learners. Thus, if we integrate these results with those of Osler and Fivel (1961), who found a significantly greater number of high intelligence children in their group of fast learners, we could hypothesize that the higher intelligence children were more successful because they could make use of a verbal mediating response.

Kendler (1964) found that children who had been instructed to verbally represent the cues in a discrimination problem had significantly fewer trials to criterion when they made an optional reversal shift than those subjects who were not required to verbalize. Kendler notes, "Relatively mature humans are likely to respond to a discrimination learning or concept formation situation by making covert responses which mediate <u>both</u> learning and transfer (1964, p. 435)." Although Kendler obtained IQ scores for all subjects in this study, she did not report any results with regard to these scores. The reader is left to suppose that the IQ scores were used for control purposes.

Eifermann (1965) required subjects in a concept attainment task to give a reason for their choice after each guess they made. The subject was then informed whether or not his choice was correct. Her results showed that subjects who could not justify correctly their choices had more inefficient solutions to the problems than did the subjects who were able to correctly justify their choices.

In a recent paper, Wolff (1967b) found that overt verbalization facilitated the concept attainment performance of children in an Osler-type task. Wolff hypothesizes "... in the overt verbalization condition a number of Ss are forced to label the stimuli who would not have done so otherwise (p. 25)."

The relevant points of the literature reviewed above are as follows. High intelligence children have significantly better concept attainment performance and are presumed to use hypothesis testing in order to solve the problems presented to them. The possible explanation for their superior performance is that they have available, and make use of, verbal symbols or cues which enable them to solve the problem more efficiently. Implicit in this reasoning is that through the use of verbal labels the hypotheses are more easily and efficiently generated and tested, thus leading to superior concept attainment performance.

Children of average intelligence, on the other hand, apparently do not have the verbal labels as readily available, and consequently their mode of concept attainment is assumed to be made on the basis of S-R associations and the reinforcement contingencies operating at the time.

However, when irrelevant stimuli (through the use of more complex stimuli) are added to the concept attainment task, the result is a decrement in the performance of the high intelligence subjects, possibly due to the fact that there are more hypotheses to be tested. Thus, through the introduction of more complex stimuli, the concept attainment performance of high and average intelligence subjects becomes essentially equal.

The effect of verbalization of responses during concept attainment is to increase the performance efficiency because verbal cues are brought into and kept in awareness.

If this is the case, and it appears to be so (Wolff, 1967b), the performance of average intelligence subjects who verbalize their responses during a concept attainment task should improve when compared to average intelligence subjects who do not verbalize. That is, the verbalization of a response should induce greater hypothesis testing behavior on the part of average intelligence children who apparently do not engage in this mode of solution normally.

Furthermore, when these average intelligence subjects verbalize their responses, their performance should improve on a task composed of equal numbers of negative instances, where previously hypotheses testing has proven to be the more efficient mode of solution.

Problem

The problem this study seeks to investigate is whether high intelligence subjects are more efficient in their concept attainment performance than average intelligence subjects. In addition, the differential effects of both stimulus complexity and verbalization upon the concept attainment performance of subjects of both high and average intelligence will be explored. This study will also examine the effects of the frequency of different negative instances and how it affects the concept attainment performance of high and average intelligence subjects.

Hypotheses

Specifically, the hypotheses are as follows:

1. High intelligence subjects will have significantly fewer errors than the average intelligence subjects.

2. The simple stimulus set will give significantly fewer errors than the complex stimulus set, which in turn will be fewer than the object two set.

3. The verbalization group will have significantly fewer errors than the control group.

4. There will be a significant interaction between intelligence and complexity. The high intelligence subjects will have fewer errors than the average intelligence subjects on the simple and complex stimulus sets and approximately the same on the object two set.

5. There will be a significant interaction between intelligence and the frequency of different negative instances. The average intelligence subjects will have more errors than the high intelligence subjects when there is an equal frequency of each negative instance (Set 2), while the performance of the high and average intelligence subjects will be approximately equal when there is a disproportionate frequency of each negative instance (Set 1).

METHOD

Subjects

The subjects were 96 second grade boys and girls from the Worcester, Massachusetts public schools. They were classified as high or average intelligence subjects on the following basis. Prior to the administration of the experimental task, the school group intelligence scores (Otis-Lennon) were obtained by an individual other than the experimenter. Then this individual randomly assigned the subjects to the experimental conditions based on this group intelligence test. The high group had a range of 115-125, the average group had a range of 95-105. Following the experimental task each subject was administered two subtests from the Wechsler Intelligence Scale for Children (WISC), vocabulary and block design, which correlate .874 with the full scale score (Simpson and Bridges, 1959). If the two intelligence measures were not within five points of each other the subject was not included in the data analyses. In addition, no subject was included who had failed any grade in school.

The high intelligence group had a mean IQ of 119.02 (SD = 3.18), while the average intelligence group had a mean of 100.87 (SD = 3.11). In addition, the subjects were matched for age and socio-economic status using the Hollingshead Index of Social Position. Appendix 1 contains the means and standard deviations for these two measures.

Apparatus

A self-supporting wooden frame 18" by 22" contained the stimulus cards. Each stimulus card contained both positive and negative instances, which were separated by a solid black line down the center of the card. Below each instance there was a button which the subjects used to signal their responses. Each of the two buttons controlled one of the two lights visible only to the experimenter which allowed him to record the responses. The marbles were dispensed down a chute on the right hand side of the frame as the subject faced it. The experimenter changed each of the stimulus cards, dispensed the marbles, and recorded the subjects' responses.

Stimuli

The concept attainment stimuli used were modeled after those used by Osler and Trautman (1961) and Wolff (1967a). The simple set (formal two) consisted of solid black circles ½" in diameter, in random patterns, placed upon half of a 5" by 8" white index card. The positive instances consisted of only two black circles, while the negative instances had either 1, 3, 4, or 5 black circles. The negative and positive instances were presented simultaneously, one instance on each half of the 5" by 8" index card.

The second set of stimulus cards was similar to the object two set of Osler and Trautman (1961). The positive stimuli for this set consisted of two identical pictures of common objects (e.g., airplanes, dogs), pasted upon half of a 5" by 8" white index card, identical to those of the simple set. The negative stimuli for this set consisted of the same type of pictures in numbers of 1, 3, 4, or 5. The pictures were matched for general area, brightness, and color combinations.

In addition to the object two set used by Osler and Trautman (1961), a complex set was used which had better control of the irrelevant stimulus dimensions than Osler and Trautman's object two set. The complex set was presented in the same manner as the simple and object two sets, but consisted of different shapes, circles, squares, or triangles, and of different colors, red, green, or black.

All stimulus sets, the simple, the object two, and the complex contained 100 cards (200 instances), and for all sets the correct concept was the concept of two-ness. The negative and positive instances appeared equally often on each side of the card and were randomized over trial blocks of 12 instances so as to avoid any sequence effects. In addition, the presentation order was randomized.

Each of the three stimulus sets described above had two different forms which varied systematically the relative frequency of the types of different negative stimuli. In Set 1, 76 trials had 'one instance' as the negative instance, while 3, 4, and 5 instances appeared on 8 trials each. Set 2 had all negative instances appearing on an equal number of trials, 25.

Procedure

Each subject was tested individually. The subjects were told that they were going to play a "game." Once in the experimental room they were shown several small toys and were asked to select one that they would like to have as a prize. The selected toy was put aside, and then the subject was seated in front of the apparatus, and given one of the following experimental instructions:

Control Condition

> Listen carefully and I will tell you how to win (name of selected toy). Watch these pictures. You see there is a button under each one of them. Pick one of the pictures and push the button under it like this (E demonstrated). Now you push the

> button. If you get a marble, leave it in the tray.
> Now watch the pictures and push the button and see if you can win many marbles. When you fill your tray with marbles, you can have the (name of toy). If you watch the pictures carefully, you can learn how the machine gives marbles.

Verbalization Condition

> Listen carefully and I will tell you how to win the (name of selected toy). Watch these pictures. You see there is a button under each one of them. Pick one of the pictures and push the button under it like this (E demonstrated). After you push the button, tell me what is in the picture above the button you pushed. Now push the button. If you get a marble, leave it in the tray.
> Now watch the pictures and push the button and tell me what is in the picture, and see if you can win many marbles. When you fill your tray with marbles, you can have the (name of toy). If you watch the pictures carefully, you can learn how the machine gives marbles.

Any subject who, after inquiry, indicated that he did not understand the instructions was not included in the study. Each subject was tested until he reached a criterion of ten consecutive correct trials or failed to solve the problem within the 100 trial maximum. Following the experimental task the subjects were administered the short form of the WISC.

After completion of the experimental task each subject was asked, "How did you know how to get a marble every time?" In addition, following the experiment each subject was warned not to discuss the "game" with his friends or classmates.

Dependent Variables

The dependent variable used to determine concept attainment efficiency was the number of errors made during the concept attainment task.

Each subject was also classified as a gradual or a sudden learner based on his performance over the ten trials preceeding the ten criterion trials. Gradual learners were those subjects whose percentage of correct trials was greater than the median (50%), and the sudden learners were those subjects whose percentage of correct trials fell below the median.

Experimental Design

A 2 x 3 x 2 x 2 factorial design was used. The factorial combination of intelligence level (high, average), stimulus complexity (simple, complex, object two), verbalization (verbalization, control), and frequency of different negative instances (Set 1, Set 2) yielded 24 experimental groups of 4 subjects each (2 males, 2 females), and a total of 96 subjects (see Table 1).

Chi Square Analyses were used to compare the performance of the gradual vs. sudden learners, for comparing the performance of the subjects who could correctly verbalize

Table 1

Experimental Design

Intelligence	Complexity	Freq. of Negative Instance	Verbalization
High	Simple	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control
	Complex	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control
	OT	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control
Average	Simple	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control
	Complex	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control
	OT	Set 1	Verbalization
			Control
		Set 2	Verbalization
			Control

the answer to the task and those subjects who could not verbalize the correct answer, and for comparing the high and average intelligence subjects on whether they verbalized the correct answer following the task.

RESULTS

The total number of errors was obtained for each subject, and then an analysis of variance was performed on these scores. The results of this analysis are shown in Table 2, while Tables 3 and 4 display the means and standard deviations for all the groups.

The analysis of the data found a significant ($p < .005$) effect for intelligence. The high intelligence subjects made significantly fewer errors than the average intelligence subjects (see Table 3). This data supports Hypothesis 1.

In addition, there was a significant ($p < .025$) effect for the frequency of different negative instances. The subjects who were exposed to the Set 1 (76% one instance) condition made fewer errors than did the subjects exposed to the Set 2 (25% each negative instance) condition (see Table 3).

There were no significant effects due to verbalization, complexity, the interaction between intelligence and complexity, and the interaction between intelligence and the frequency of different negative instances (see Tables 2 and 3). Such data did not support Hypotheses 2, 3, 4, and 5.

Table 2

Analysis of Variance for the Number of Errors on the Concept Attainment Task

Source	df	SS	MS	F	p <
A (Intelligence)	1	4916.00	4916.00	11.35	.005
B (Complexity)	2	1786.43	893.21	2.06	ns
C (Verbalization)	1	565.51	565.51	1.30	ns
D (Frequency of Different Negative Instances)	1	2915.01	2915.01	6.72	.025
AB	2	410.28	205.14	1 <	ns
AC	1	111.17	111.17	1 <	ns
AD	1	90.85	90.85	1 <	ns
BC	2	986.99	493.49	1.14	ns
BD	2	120.02	60.01	1 <	ns
CD	1	158.00	158.00	1 <	ns
ABC	2	107.42	53.71	1 <	ns
ABD	2	461.68	230.84	1 <	ns
ACD	1	8.49	8.49	1 <	ns
BCD	2	143.71	71.85	1 <	ns
ABCD	2	107.34	53.67	1 <	ns
Ss/ABCD	72	31211.00	433.49		
Total	95	44099.90			

Table 3

Means and Standard Deviations for Main Effects and Predicted Interactions for Number of Errors on the Concept Attainment Task

	Mean	Standard Deviation
High	21.27	18.46
Average	35.58	21.79
Simple	23.41	21.94
Complex	27.94	20.21
Object Two	33.94	20.75
Verbalization	26.00	22.59
Control	30.85	19.94
Set 1	22.92	20.01
Set 2	33.94	21.36
High		
Simple	13.44	15.85
Complex	22.87	27.28
Object Two	27.50	18.87
Average		
Simple	33.37	22.78
Complex	33.00	21.22
Object Two	40.37	18.61

Table 3 (cont'd)

	Mean	Standard Deviation
High		
Set 1	14.79	13.66
Set 2	27.75	20.13
Average		
Set 1	31.04	21.85
Set 2	40.13	20.74

Table 4

Means and Standard Deviations for Number of Errors on the Concept Attainment Task

	Mean	Standard Deviation
High		
Simple		
Set 1		
Verbalization	5.25	3.32
Control	13.50	15.33
Set 2		
Verbalization	13.50	8.13
Control	21.50	23.69
Complex		
Set 1		
Verbalization	10.57	11.09
Control	23.00	10.44
Set 2		
Verbalization	36.00	19.78
Control	21.75	4.79
Object Two		
Set 1		
Verbalization	19.50	15.43
Control	16.75	15.26

Table 4 (cont'd)

	Mean	Standard Deviation
Set Two		
Verbalization	36.50	17.56
Control	39.25	11.62
Average		
Simple		
Set 1		
Verbalization	23.50	20.33
Control	26.75	14.16
Set 2		
Verbalization	42.75	25.14
Control	40.50	23.47
Complex		
Set 1		
Verbalization	22.75	18.01
Control	39.50	20.70
Set 2		
Verbalization	27.25	27.22
Control	42.50	8.96
Object Two		
Set 1		

Table 4 (cont'd)

	Mean	Standard Deviation
Verbalization	33.50	32.85
Control	40.25	10.69
Set 2		
Verbalization	42.75	4.93
Control	45.00	19.75

The Chi Square analysis (Table 5) for the number of gradual and sudden learners in the two intelligence groups reveals that there was not a significant difference in the proportion of the number of gradual and sudden learners in the high or average intelligence groups.

Table 6 shows that there was a significant ($p < .001$) difference between the number of subjects who solved the problem and those who did not solve the problem when they were required to verbalize the answer to the concept attainment problem.

Table 7 presents the analysis for the correct and incorrect verbalizers following the task in the high and average intelligence groups. This analysis shows that the high intelligence subjects were able to correctly verbalize the answer to the task significantly ($p < .05$) more than the average intelligence subjects.

Due to the extreme heterogeneity of variance (Hartley's test, Myers, 1966, $F_{max} = 63.39$) a square root transformation was applied to the original data, and an analysis of variance was performed on the transformed data. The results of this analysis are shown in Table 8, and show no differences from the original analysis of variance.

Table 5

Chi Square Analysis for the Number of Gradual vs. Sudden Learners in the High and Average Intelligence Groups

	Sudden Learners	Gradual Learners	
High Intelligence	10	17	27
Average Intelligence	7	11	18
	17	28	45

χ^2 = .035 (not significant)

Table 6

Chi Square Analysis for Correct or Incorrect Verbalization Following the Task for Solvers and Nonsolvers

	Solved Task	Did Not Solve Task	
Correct Verbalization	51	2	53
Incorrect Verbalization	7	40	47
	58	42	100

$\chi^2 = 64.35$ $(p < .001)$

Table 7

Chi Square Analysis for High and Average Intelligence Subjects and Ability to Correctly Verbalize the Answer to the Problem Following the Task

	Correct Verbalizers	Incorrect Verbalizers	
High	31	17	48
Average	20	28	48
	51	45	96

$\chi^2 = 5.06$ $(p < .05)$

Table 8

Analysis of Variance for the Square Root Transformation of the Number of Errors on the Concept Attainment Task

Source	df	SS	MS	F	p <
A (Intelligence)	1	51.00	51.00	9.24	.005
B (Complexity)	2	24.77	12.39	2.24	ns
C (Verbalization)	1	7.94	7.94	1.44	ns
D (Frequency of Different Negative Instances)	1	40.18	40.18	7.28	.01
AB	2	18.33	9.17	1.66	ns
AC	1	2.14	2.14	1 <	ns
AD	1	2.98	2.98	1 <	ns
BC	2	2.28	1.14	1 <	ns
BD	2	1.90	.95	1 <	ns
CD	1	6.18	6.18	1.12	ns
ABC	2	1.02	.51	1 <	ns
ABD	2	1.31	.65	1 <	ns
ACD	1	.97	.97	1 <	ns
BCD	2	1.42	.71	1 <	ns
ABCD	2	.41	.20	1 <	ns
Ss/ABCD	72	397.77	5.52		
Total	95	560.60			

DISCUSSION

The obtained superiority of the high over the average intelligence subjects has several empirical and theoretical implications which warrant discussion.

It now appears that children of high intelligence have superior concept attainment performance when compared to children of average intelligence. Apparently they, the high intelligence subjects, had better ability when they were required to deal with and solve the problem presented. If conceptual abilities, such as memory, attention, and the ability to transform incoming information are associated with better concept attainment, then these skills apparently contributed to the superior performance of the high intelligence subjects.

In an attempt to more carefully determine the relationship between this investigation and those of Wolff and Osler, an analysis of variance was performed on the original data, but omitting the data of the complex stimuli (colored geometric shapes) and collapsing over the verbalization variable which was not significant. The results of this analysis are shown in Appendices 2 and 3.

This subsequent analysis found results which are consistent with the data obtained by Wolff (1967a) and inconsistent with the data obtained by Osler and Trautman (1961). There were significant effects due to intelligence and complexity, as well as for the frequency of different negative instances.

We must now ask the questions why did this investigation obtain results similar to Wolff's (1967a), and why did it fail to support Osler's studies? In her first study (Osler and Fivel, 1961) Osler found superior performance for high intelligence subjects using stimuli which had characteristics similar to those she later called more complex (object two) in a later study (Osler and Trautman, 1961). When she failed to obtain superior performance for the high intelligence subjects using stimuli which had characteristics similar to those in the previous study, Osler explained these discrepant results by asserting that the increased complexity impaired the performance of the high intelligence group.

The current investigation, however, shows that the use of more complex stimuli did not overload (with extensive hypothesis testing) the abilities of the high intelligence subjects. It was found that the high intelligence subjects were able to perform in a superior manner to the subjects of average intelligence even when the complexity of the stimulus materials was increased. If hypothesis testing is central to the concept attainment behavior of the high intelligence subject, as Osler believed, then increased complexity would lead to more hypothesis testing by the high intelligence subjects, and therefore impair their performance. Further, our findings with regard to the effect of complexity on the performance of the high intelligence subjects do not necessarily invalidate the notion that high intelligence subjects tend to achieve concept attainment solution through the use of hypothesis testing more than average intelligence subjects. What these results do establish is that the complexity of the stimuli did not differentially affect the performance of the high and average intelligence subjects.

To evaluate further whether high intelligence subjects solve concept attainment problems through the use of hypothesis testing, Osler had divided her subjects who solved the task into gradual and sudden learners based on their performance over the ten trials preceding the ten criterion trials. She found that the number of sudden learners in the high intelligence group was significantly greater than in the average intelligence group. A similar test was attempted in the present study even though Osler did not obtain significant differences for the age level used in this investigation. We failed to achieve significance in this evaluation of the number of sudden learners in the two intelligence groups.

It is not clear at this point what the failure to obtain differences between high and average intelligence subjects on the test of gradual vs. sudden learners indicates. One possibility is that high intelligence subjects do not use hypothesis testing as a means of solving concept attainment problems significantly more often than average intelligence subjects, and the question of different types of learning as mediating the process of concept attainment in different intelligence levels is still open to investigation. An alternative explanation is that the method of evaluation of hypothesis testing was not sufficiently precise to determine the extent and scope of the hypotheses formulated by the two intelligence groups.

Still another possibility is that the sudden vs. gradual learners is not a valid method for tapping hypothesis testing as a means of concept attainment. It is quite possible that a high intelligence subject (or even an average intelligence subject) may be testing an hypothesis which is correct 70, 80, or 90% of the time, and thus would be classified as a gradual learner when he shifts and solves the problem. This would be especially true under the Set 1 (76% one instance) condition where the hypothesis of larger number would be correct 75% of the time over a trial block of twelve trials, even though the subject had made the shift to the correct hypothesis. Thus, one can see that the sudden vs. gradual test may not necessarily be a good test for this type of task and may, in fact, lead to some spurious results.

One possible conclusion of the failure to find differences in the number of gradual and sudden learners is that both high and average intelligence subjects use hypothesis testing. Apparently hypothesis testing behavior is not peculiar to subjects of high intelligence who are seven to eight years of age. Average intelligence subjects also employ hypothesis testing in order to solve conceptual problems. If subjects of both high and average intelligence of this age level make use of hypothesis testing, what are the underlying processes used by the high intelligence subjects to solve the problem more efficiently? One possibility is the point raised by Riley (1968). He stated that it is possible for subjects to make use of hypothesis testing, but only to consider one hypothesis at a time, and to focus solely on the information relevant to that one hypothesis. It is possible then that subjects of average intelligence formulate a limited number of hypotheses, do not shift as quickly with the non-reinforcement of a hypothesis, and may stay with a hypothesis longer even though it is not reinforced 100% of the time. High intelligence subjects, on the other hand, may assimilate information relevant to hypotheses other than the one they are currently testing, and may be able to shift more quickly following the non-reinforcement of an hypothesis. These speculations will be discussed below.

Each subject, following completion of the task, was asked how he knew how to get a marble every time. While such reports are purely qualitative and based upon introspective data, they are relevant to the differences between the high and average intelligence subjects formulated above. Analysis of the data showed that those subjects who solved the task were able to give the correct answer significantly more than the subjects who failed to solve the task. In addition, it was found that the high intelligence subjects were able to give the correct answer significantly more than were the subjects of average intelligence. Such results suggest that the high intelligence subjects were more able to put their hypotheses into verbal terms than were the average intelligence subjects.

Also worthy of mention is the qualitative aspect of the answers to the question, as well as the observations of the experimenter. Most of the subjects who solved the task answered the question by stating, "By pressing the one (button) with the two," or a slight variation of that statement. When questioned further in an attempt to get information about previous hypotheses before they arrived at the correct principle, some of the subjects who solved the problem were able to verbalize another hypothesis which they had been testing. The most frequent of the other hypotheses was the "larger number" hypothesis.

Of even greater interest was the performance of the subjects who failed to solve the problem. Almost invariably the hypothesis used by these subjects was an alternation strategy or some slight variation of one. They would use an alternation procedure until they got a marble. They then would continue with such an hypothesis until they met a non-reinforced trial. Then their behavior became random until they reached another reinforced trial, and following the reinforced trial they continued with alternating responses and repeated the entire process through to the completion of the task.

These subjects when questioned following the task replied either with an "I don't know," or would tell the experimenter that you got a marble every time by going back and forth between the two choices. When questioned further as to whether or not they got a marble every time using this procedure, the frequent answer was "No, but I got one most of the time." Apparently, with some children the partial confirmation of a hypothesis was strong enough reinforcement for them to continue with an hypothesis which was not correct 100% of the time.

A conclusion that seems to follow from the above qualitative analysis is that average intelligence subjects have a different standard of adequacy than do subjects of high intelligence. For average intelligence subjects 100% reinforcement of an hypothesis is not necessary; high intelligence subjects, on the other hand, demand 100% reinforcement of an hypothesis. What is implied here is that some sort of perceived adequacy of a response may be operating. Klein (1960) noted that one must distinguish between the experienced confirmations of attainment from the fact of behavioral change alone. That is, individuals have different cognitive styles where adequacy or an acceptable "fit" are different for each individual. Klein goes on to note further:

> "... the _experienced_ attainment may be crucial in learning, i. e., in the "reinforcement" of behavior, ... that adequate results of activity are more likely to make sense to the learner than will simply a motor response or a perception. Now, if cognitive style contributes to such experiences of confirmation, it may also be expected to affect the course of learning (1960, p. 97)".

Several explanations of the behavior of the subjects in this investigation may now be proposed. Apparently, the ability to take in information and to transform such information is critical to efficient concept attainment. In addition, the subject must also take in information not relevant only to the hypothesis presently under consideration, and thus be able to shift from an unsupported hypothesis to another in order to solve the task.

Crucial in this process is the amount of reinforcement or non-reinforcement necessary for a given subject before he will shift to another hypothesis. What level of reinforcement does a given subject perceive as adequate support for his hypothesis? Apparently, for the subjects of average intelligence in this investigation partial reinforcement of a given hypothesis is acceptable and does not lead as promptly to an hypothesis change. Also, these subjects are not able to assimilate information relevant to alternative hypotheses as quickly as the high intelligence subjects and therefore do not change their hypotheses as quickly. Subjects of high intelligence, on the other hand, are not able to tolerate a lowered level of reinforcement and will shift their hypotheses after a relatively minimal number of non-reinforced trials, whereas the subjects of average intelligence will not. Perhaps high intelligence subjects did not perceive the task to be solved until they reached 100% reinforcement, whereas the subjects of average intelligence more often perceived the task as solved with less than 100% reinforcement.

From this discussion one can conclude that the process of concept attainment is not solely based on either hypothesis testing or the reinforcement contingencies operating at the time, but rather a combination of these two processes. These formulations of the processes involved in concept attainment require further substantiation and probably demand the refinement of experimental techniques in future research.

The following is an explanation for the failure of the verbalization group to perform in a significantly superior manner to the control group. It seems as though most of the subjects in this investigation were at a similar level of verbal sophistication for this task so as not to create any significant differences. Other investigators (Weir and Stevenson, 1959) obtained significant differences for subjects of the same age as those used in this study, but their task was a discrimination learning task which was not as complex as the one used in this investigation. Apparently, the subjects in this task who verbalized their responses did so without using their verbalizations as part of the task. With seven to eight year olds and complex information on a task such as the one used in this investigation, the effect of verbalization did not serve to hold the verbalized response for further selective evaluation. Rather, the subjects may have perceived the verbalization as separate from the task and did not make use of it in their solutions.

The lack of support for the hypothesis concerning the interaction between the disproportionality of different negative instances and intelligence bears consideration. The basis for this hypothesis came from Wolff's (1967a) explanation of his results. Wolff made use of Podell's (1958) explanation which hypothesized that a high variety of positive stimuli facilitates hypothesis testing learning (i.e., high intelligence subjects), while it hinders simple associative learning (i.e., average intelligence subjects). Wolff felt that Podell's conclusions were applicable to the negative stimuli of the task he used, and thus felt that the performance of the high intelligence subjects was hindered under the 75% one instance condition which Osler had used.

There are, however, several points of Podell's study which must be considered. Podell based her conclusions upon the variety of positive instances, and her reasoning may not extend to data dealing with negative instances. In addition, Podell's task was more of a classification or sorting task, and thus different from the tasks used in the present as well as in Wolff's investigation.

It is possible, however, that Podell's explanation may apply to negative as well as to positive instances and may also be valid for the type of concept attainment task used in this investigation. If this is the case, then the failure to support the hypothesis regarding disproportionality of different negative instances interacting with intelligence adds support to the previous contention that hypothesis testing behavior is not a process peculiar only to high intelligence subjects of the age used in this investigation. If hypothesis testing is more frequent among subjects of the age used by both Osler and Wolff, then the disproportionality of different negative instances may affect only the subjects of a higher age level than those used in this investigation.

There is no question that the disproportionality of different negative instances (76% one instance) made solution of the concept attainment task easier and more efficient. Several explanations for this data can be put forward. The first is that with the presence of "one instance" on 75% of the trials, a subject can easily and quickly eliminate one possibility of a response. That is, the "one instance" can be quickly eliminated because it is not reinforced on 75% of the trials and would have even greater effect over short blocks of trials. The subject is then free to work on eliminating the other negative instances. In addition, as cited before, the 75% one instance condition could also possibly lead to the formation of an alternate hypothesis such as "larger number." Such an hypothesis would only be correct 75% of the time and could be quickly tested andaltered to fit the incoming data. Under the equal proportion condition there is no way in which an hypothesis could be formed and tested as quickly and therefore altered.

Even though the 76% one instance condition was easier to solve, the average and high intelligence subjects did not perform at a similar level. Apparently under both conditions regarding the frequency of different negative intances the high intelligence subjects, because of their ability to shift from hypotheses which had proven to be incorrect, were still able to perform at a high level, higner than that of the subjects of average intelligence.

The results of this investigation indicate that with the presence of a set of stimuli which had "one instance" as the negative instance 75% of the time Osler used a simpler stimulus set. Why the high intelligence subjects in her study did not perform at the same high level as in this study under the object two set is not apparent at this time. However, it seems possible that since Osler's studies now appear to be the discrepant findings in this area of research, it is quite likely that there were other factors, unclear at this time, which contributed to the results she obtained. Furthermore, it is reasonable to view Osler's results in light of what is now two unsuccessful attempts to replicate and to conclude that her results may not be valid.

The general conclusions of this study may be stated as follows. Subjects of high intelligence because of their ability to shift hypotheses quickly following the non-reinforcement of a response perform better on concept attainment tasks than do subjects of average intelligence. Apparently, subjects of both high and average intelligence of seven to eight years of age make use of hypothesis testing in order to solve concept attainment problems. Children of high and average intelligence both have verbal labels for stimuli available, and this does not appear to be the critical variable in the superior performance of the high intelligence subjects. Complexity of stimulus materials does not differentially affect the performance of high and average intelligence subjects. Finally, when "one instance" is the negative instance on 75% of the trials, concept attainment is easier and more efficient.

Future research in this area should be primarily directed at tests of trying to more firmly and validly establish the process underlying concept attainment. Attempts to partial out effects due to memory and cognitive styles involving the scanning and articulating the various aspects of the stimulus field would likely tap some of the abilities of high intelligence subjects which allows them to function in a superior manner.

More searching methods of questioning subjects during a concept attainment task should be attempted, and would lead to valuable information regarding the process of concept attainment. Perhaps the method of having subjects justify their choices as the task progresses might be a useful method although Osler and Fivel (1961) claimed that it influenced their subjects' behavior.

REFERENCES

Archer, E. J., Bourne, L. E. Jr., & Brown, S. G. Concept investigation as a function of irrelevant information and instruction. Journal of Experimental Psychology, 1955, 49, 153-164.

Bourne, L. E. Jr., Effects of delay of information feedback and task complexity on the identification of concepts. Journal of Experimental Psychology, 1957, 54, 201-207.

Bourne, L. E. Jr. Human conceptual behavior. Boston: Allyn and Bacon, 1966.

Bourne, L. E. Jr., & Haygood, R. C. The role of stimulus redundancy in the identification of concepts. Journal of Experimental Psychology, 1959, 58, 232-238.

Bourne, L. E. Jr., & Haygood, R. C. Effect of redundant relevant information upon the identification of concepts. Journal of Experimental Psychology, 1961, 61, 259-260.

Bourne, L. E. Jr., & Restle, F. Mathematical theory of concept identification. Psychological Review, 1959, 66, 278-296.

Brown, F. G., & Archer, E. J. Concept identification as a function of task complexity and distribution of practice. Journal of Experimental Psychology, 1956, 52, 316-321.

Denny, J. P. Effects of anxiety and intelligence on concept formation. Journal of Experimental Psychology, 1966, 72, 596-602.

Eifermann, Rivka R. Response patterns and strategies in the dynamics of concept attainment behavior. British Journal of Psychology, 1965, 56, 217-222.

Kates, S. L., & Weiner, A. Concept attainment and learning strategies in different intelligence groups. Paper presented at Eastern Psychological Association, Boston, Massachusetts, April, 1967.

Kendler, Tracy S. Verbalization and optional reversal shifts among kindergarten children. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 428-436.

Kendler, Tracy S., & Kendler, H. H. Reversal and non-reversal shifts in kindergarten children. Journal of Experimental Psychology, 1959, 58, 56-60.

Klein, G. S. Cognitive control and motivation. in Lindzey, G. (Ed.) Assessment of human motives. New York: Grove, 1960.

Liublinskaya, A. A. The development of children's speech and thought. in Simon, B. (Ed.) Psychology in the soviet union. Stanford: Stanford Univ. Press, 1957.

Luria, A. A. The role of language in the formation of temporary connection. in Simon, B. (Ed.) Psychology in the soviet union. Stanford: Stanford Univ. Press, 1957.

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

Osler, Sonia F., & Fivel, Myrna W. Concept attainment; I The role of age and intelligence in concept attainment by induction. Journal of Experimental Psychology, 1961, 62, 1-8.

Osler, Sonia F., & Trautman, Grace, E. Concept attainment: II Effect of stimulus complexity upon concept attainment at two levels of intelligence. Journal of Experimental Psychology, 1961, 62, 9-13.

Osler, Sonia F., & Weiss, Sandra, R. Studies in concept attainment: III Effect of instructions at two levels of intelligence. Journal of Experimental Psychology, 1962, 63, 528-533.

Podell, Harriet A. Two processes of concept formation. Psychological Monographs, 1958, 72 (15 Whole No. 468).

Riley, D. A. Discrimination learning. Boston: Allyn and Bacon, 1968.

Simpson, W. H., & Bridges, C. C. Jr. A short form of the wechsler intelligence scale for children. Journal of Clinical Psychology, 1959, 15, 424.

Van de Geer, J. P., & Jaspars, J. M. F. Cognitive functions. Annual Review of Psychology, 1966, 17, 145-176.

Weir, M. W., & Stevenson, H. W. The effect of verbalization in children's learning as a function of chronological age. Child Development, 1959, 30, 143-149.

Wolff, J. L. Concept attainment, intelligence, and stimulus complexity: An attempt to replicate Osler and Trautman (1961). Journal of Experimental Psychology, 1967, 73, 488-490 (a).

Wolff, J. L. Effects of verbalization and pretraining on concept attainment by children in two mediation categories. Journal of Educational Psychology, 1967, 58, 19-26 (b).

Yudin, L. W. Formal thought in adolescence as a function of intelligence. Child Development. 1966, 37, 697-708.

Appendix 1

Means and Standard Deviations for Experimental Groups for Age and Hollingshead Index of Social Position

	Age (In Months)		Hollingshead Scale	
	M	SD	M	SD
High	93.56	3.58	2.48	1.18
Average	94.75	2.96	2.71	1.17
Simple	93.76	3.21	2.87	1.17
Complex	93.91	3.11	2.62	1.06
Object Two	94.21	3.40	2.28	1.29
Verbalization	94.07	3.51	2.65	1.15
Control	93.87	3.38	2.54	1.21
Set 1	94.89	3.08	2.92	1.11
Set 2	93.64	2.93	2.73	1.15

Appendix 2

Analysis of Variance Omitting the Data for the Complex Stimuli and Collapsed over Levels of Verbalization for Number of Errors on the Concept Attainment Task

	df	SS	MS	F	p <
Intellig. (A)	1	4306.64	4306.64	11.26	.005
Complexity (B)	1	1774.52	1774.52	4.64	.05
Freq. of Neg. (C)	1	2537.64	2537.64	6.35	.025
AB	1	199.54	199.54	1 <	ns
AC	1	11.39	11.39	1 <	ns
BC	1	1.26	1.26	1 <	ns
ABC	1	404.99	404.99	1.06	ns
S/ABC	57	21800.13	382.46		
Total	64	31036.11			

Appendix 3

Means and Standard Deviations Omitting the Data for Complex Stimuli and Collapsed over Levels of Verbalization for Number of Errors on the Concept Attainment Task

	M	SD
High	20.47	18.79
Average	36.87	21.95
Simple	23.41	22.01
Object Two	33.94	20.72
Set 1	22.37	20.62
Set 2	34.97	21.57
High		
Simple	13.44	15.85
Object Two	27.50	18.87
Average		
Simple	33.37	22.78
Object Two	40.37	20.50
High		
Set 1	13.75	21.12
Set 2	27.19	20.21
Average		
Set 1	31.00	22.21
Set 2	42.75	20.03

Appendix 4

Raw Scores, Age, Socio-Economic Classification for All Experimental Subjects

S Number	Errors	Age (In Months)	Socio-Economic	IQ Otis	IQ WISC
		High, Simple, Set 1, Verbalization			
1	7	95	4	119	120
2	2	91	3	116	121
3	10	99	3	119	117
4	2	82	4	122	118
		High, Simple, Set 1, Control			
5	1	91	4	121	120
6	15	97	4	116	119
7	38	99	3	117	121
8	0	99	3	116	121
		High, Simple, Set 2, Verbalization			
9	27	92	2	124	122
10	7	91	3	117	116
11	7	100	5	118	123
12	13	95	4	121	117
		High, Simple, Set 2, Control			
13	3	93	1	119	116
14	22	91	2	115	117
15	60	93	1	119	119
16	1	92	2	121	122
		High, Complex, Set 1, Verbalization			
17	0	92	2	119	117
18	15	94	3	116	121
19	1	96	5	124	120
20	27	95	2	116	121

Appendix 4 (cont'd)

S Number	Errors	Age (In Months)	Socio-Economic	IQ Otis	IQ WISC
		High, Complex, Set 1, Control			
21	34	96	1	120	118
22	24	91	4	125	120
23	28	93	2	115	118
24	6	92	3	115	120
		High, Complex, Set 2, Verbalization			
25	69	92	2	117	122
26	26	90	3	116	119
27	19	97	3	117	122
28	30	91	1	119	115
		High, Complex, Set 2, Control			
29	10	91	2	125	121
30	24	90	2	115	119
31	50	93	4	118	123
32	3	91	3	125	122
		High, Object Two, Set 1, Verbalization			
33	0	93	3	125	120
34	15	89	2	118	117
35	20	98	1	121	118
36	43	95	1	118	121
		High, Object Two, Set 1, Control			
37	31	94	1	121	118
38	2	91	5	118	117
39	1	93	2	117	121
40	33	98	2	121	119

Appendix 4 (cont'd)

S Number	Errors	Age (In Months)	Socio-Economic	IQ Otis	IQ WISC
High, Object Two, Set 2, Verbalization					
41	61	91	1	121	119
42	19	98	1	117	115
43	49	91	1	115	117
44	9	98	1	124	119
High, Object Two, Set 2, Control					
45	34	100	3	116	115
46	23	97	1	117	117
47	47	90	2	117	118
48	53	91	2	125	121
Average, Simple, Set 1, Verbalization					
49	48	94	5	96	98
50	6	97	3	96	99
51	1	94	3	100	104
52	39	95	2	105	101
Average, Simple, Set 1, Control					
53	34	92	3	103	100
54	4	94	2	103	99
55	27	95	2	105	102
56	42	91	4	103	100
Average, Simple, Set 2, Verbalization					
57	67	95	4	100	96
58	35	98	3	100	95
59	5	91	1	105	102
60	64	94	4	105	101

Appendix 4 (cont'd)

S Number	Errors	Age (In Months)	Socio-Economic	IQ Otis	IQ WISC
		Average, Simple, Set 2, Control			
61	0	97	4	103	100
62	56	94	2	102	98
63	55	97	1	104	99
64	51	92	1	103	98
		Average, Complex, Set 1, Verbalization			
65	1	93	3	99	95
66	18	95	2	103	99
67	51	97	4	97	101
68	21	91	3	100	100
		Average, Complex, Set 1, Control			
69	52	100	2	95	98
70	47	95	1	105	102
71	4	97	4	103	98
72	55	93	4	101	99
		Average, Complex, Set 2, Verbalization			
73	5	94	1	97	99
74	21	91	3	101	100
75	72	93	3	96	101
76	11	96	2	98	100
		Average, Complex, Set 2, Control			
77	54	93	3	96	98
78	42	103	4	100	101
79	29	99	1	100	102
80	45	97	2	104	100

Appendix 4 (cont'd)

S Number	Errors	Age (In Months)	Socio-Economic	IQ Otis	IQ WISC
Average, Object Two, Set 1, Verbalization					
81	2	92	3	100	96
82	76	97	2	96	97
83	1	92	2	103	99
84	55	97	5	102	100
Average, Object Two, Set 1, Control					
85	42	89	1	99	100
86	24	99	5	103	101
87	54	95	3	100	99
88	41	91	5	102	102
Average, Object Two, Set 2, Verbalization					
89	36	96	2	105	104
90	43	94	2	105	100
91	42	89	3	100	100
92	50	100	2	101	102
Average, Object Two, Set 2, Control					
93	11	93	3	103	101
94	53	98	1	97	98
95	59	97	2	98	95
96	57	92	3	100	96