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GRADUATE COLLEGE

A DEVELOPMENTAL INVESTIGATION OF VERBAL AND NONVERBAL METHODOLOGIES IN INCIDENTAL LEARNING

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

By

JENNY BOYER PETERSON

Norman, Oklahoma

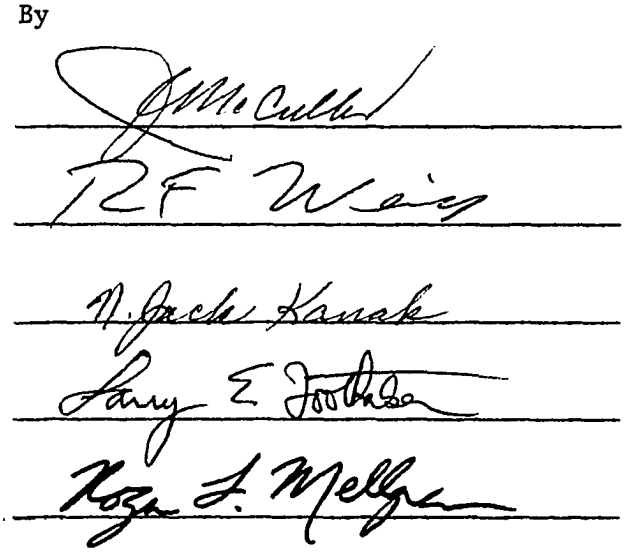
1974

A DEVELOPMENTAL INVESTIGATION OF VERBAL AND NONVERBAL METHODOLOGIES IN INCIDENTAL LEARNING

A DISSERTATION

APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

By



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Abstract

A decline in incidental learning around 11 or 12 years has been observed using nonverbal (memory) tasks but not using verbal (paired-associate) tasks. Three experiments investigated certain methodological variables within these tasks (e.g. the relatedness of the incidental dependent measures and materials to the intentional task, amount of training, and memory load) in order to observe their effect across age. Subjects were 328 public school children from grades 3, 5, 7, and 9.

In the first experiment a paired-associate (PA) and a memory task were equated for materials, dependent measures and number of trials. Two incidental stimuli were designed to be relatively related (object) and unrelated (color) to the intentional PA task. Both were assumed to be relatively unrelated in the memory task. It was expected that the PA task would show much better incidental performance than the memory task because of the related nature of incidental and intentional materials and because of the differences between the tasks with respect

to the role of the learning process. It was also expected that object scores would be much better than color scores in the PA task. Results confirmed these expectations.

The second experiment, using the same PA task as the first experiment, investigated degree of opportunity (2, 4, and 6 trials) on the intentional task upon incidental performance. Incidental performance increased with intentional training. A decline at grade 7 in incidental performance on color but not object scores was observed at 2 trials of intentional practice. At greater levels of intentional practice, trends were similar to those observed in traditional verbal learning studies.

The third experiment, using the same memory task as the first experiment, investigated the relationship of intentional task difficulty (arrays of 4 and 6 cards) upon incidental performance. Incidental performance was better for the easier memory task (array of 4) than for the more difficult one (array of 6). A slight decline at grade 7 was replicated for the array of 6.

Although these data do not show the reasons for the age decline, they do indicate some of the conditions under which it typically occurs. The conditions are minimal learning, relatively related incidental and intentional dependent variables, and moderate task difficulty for the 11- or 12-year old.

A Developmental Investigation of Verbal and Nonverbal Methodologies in Incidental Learning

Jenny Boyer Peterson

University of Oklahoma

Studies using nonverbal tasks heavily dependent on memory (Druker & Hagen, 1969; Hagen & Sabo, 1967; Maccoby & Hagen, 1965) have shown that children between the ages of 10 and 13 years show an age-related improvement in performance on an intentional learning task but a decline or absence of improvement in incidental learning performance. The results of these studies have been interpreted as being due to a developmental improvement in the subject's ability to selectively attend to what is task relevant. Younger children's poorer performance in intentional learning but better performance in incidental learning relative to that of children 10 to 13 years of age, has been attributed to their "labeling and making note of everything at once" (Maccoby & Hagen, 1965), i.e., their inability to distinguish between the relevant and irrelevant aspects of the task.

Studies using paired-associate (PA) tasks have reported that intentional (S-R) learning improves with age through the middle childhood years while incidental performance (recall of R-S associations) is invariant over the same age span (Kausler & Gotway, 1969; Cole &

Kanak, 1972). Cole & Kanak (1972) suggested that the invariant relationship for R-S learning across grade levels, as opposed to the curvilinear relationship across grade levels for incidental learning in nonverbal tasks, argues against R-S learning being a form of incidental learning in children.

Meaningful comparisons of incidental learning performance in studies using verbal and nonverbal methodologies are hampered by difference in stimulus materials, learning opportunities, and dependent measures. Three experiments are reported bearing on this general issue. The first study makes a comparison of incidental performance in the "memory" and PA tasks under conditions of a common methodological base. The aim of this first study was to help to resolve whether differences in developmental trends observed using these two tasks are partially due to methodological differences between the tasks.

A second problem concerns the relationship of the degree of mastery in the PA task to incidental performance. Previous research has examined incidental performance at criterion level of intentional performance (e.g., Cole & Kanak, 1972). A second study will attempt to see whether invariance in incidental performance across age with paired-associate tasks is peculiar to a criterion level of intentional performance.

A third study focuses on the relationship of the degree of difficulty of the memory task to incidental performance. Previous investigations have presented subjects of varying age the same intentional

(memory) task and a constant number of trials (e.g., Hagen, 1967). The question to be answered is whether observed developmental trends in incidental learning may be affected by the degree of difficulty (memory load) of the task.

Experiment I

In nonverbal tasks which depend heavily on memory factors, a decline in incidental performance around age 11 or 12 typically is found (e.g., Maccoby & Hagen, 1965; Hagen & Sabo, 1967; Druker & Hagen, 1969). In verbal tasks which involve the learning process, the decline usually is not found (Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972). The discrepancy between findings with verbal and nonverbal tasks may simply reflect that these two tasks tap different processes.

The memory task typically requires subjects to remember the locations of a series of related intentional stimuli for a few seconds. Exposure to incidental stimuli is simultaneous with that of intentional stimuli. Remembering the incidental stimuli not only is unnecessary to intentional performance but may even interfere with it. In the memory task the serial locations are new on each trial, and their correct identification requires a similar memory effort on each trial. Thus, the opportunity to perceive and learn incidental material probably depends more on the memory-load difficulty (number of stimuli in the series) of the intentional task than on amount of training on the intentional task. On the other hand, the paired-associate (PA) task involves the gradual mastery of a series of paired stimuli. Because

the pairs of stimuli remain constant over trials, intentional learning improves over trials. As trials progress, the opportunity to acquire incidental material increases. Also, the subject must at least recognize the incidental stimuli (S items) in order to perform the intentional task. Thus, with the PA task, the acquisition of incidental material does not usually interfere and may even facilitate intentional learning. A more detailed description of these tasks will be presented in the method section. In addition, these two tasks differ on a wide range of methodological points, e.g., stimulus materials, learning opportunities, relatedness of the incidental material to the intentional task, etc. Thus, it is possible that observed discrepancies between the PA and memory tasks may simply reflect differences in methodology.

The aim of the first study was to examine incidental learning in the PA and memory tasks under conditions of comparable methodology. The most common nonverbal task, serial-location memory (e.g., Hagen, 1967) was compared with the most common verbal task, paired associates, (e.g., Kausler & Gotway, 1969) with equivalent numbers of trials, stimulus materials, and dependent measures. The learning materials were constructed to provide incidental stimuli both relatively related and relatively unrelated to the intentional PA task. In the intentional portion of the paired-associate task, subjects were instructed to associate pairs of objects (S items) with animals (R items), presented on cards having different background colors. The subsequent (incidental) recognition of the color of the card was assumed to be more extrinsic than the

recognition of the object.

It was expected that incidental performance would be better in the PA task as compared to the memory task, at least on recognition of the related dependent measure (object). This prediction was based on the premise that subjects may use incidental stimuli in the performance of the intentional PA task. Similarly, it was predicted that the relatively related incidental dependent measure (object) would be greater than the relatively unrelated incidental measure (color) for the PA task.

For the memory task, no difference between incidental dependent measures was expected since both measures were assumed to be relatively unrelated to the intentional task. This attempt to equate the PA and memory tasks methodogically may work to eliminate performance differences between the tasks. Otherwise, invariance in incidental performance over grades 3, 5, 7, and 9 should be found in the PA task, based upon the results of previous studies (e.g., Cole & Kanak, 1972). A decline in incidental performance at grade 7 and possibly grade 9 should occur in the memory task since the task stimuli and amount of training would be similar to those of previous studies which showed the decline (Maccoby & Hagen, 1965; Hagen, Meacham, & Mesibov, 1970).

Method

Subjects and Design.--The subjects were 128 public school children (64 of each sex). There were 32 subjects (16 males and 16 females) at each of grades 3, 5, 7, and 9 of Norman (Oklahoma) Public Schools. A 2 (type of task) X 2 (orders of testing color and object)

X 4 (grade levels) factorial design was employed with 4 males and 4 females per cell. Sex thus formed a fourth factor in the design.

Stimuli and test materials.--The stimuli were a series of eight cards, each containing black line drawings of an animal and a household object printed on colored paper. The drawings were selected from the Peabody Picture Vocabulary Test and the Stanford Binet Intelligence Test and were essentially the same as those used by Hagen, Meacham, and Mesibov (1970). The eight objects and eight animals were paired in the following manner: telephone-fish, lamp-cat, chair-horse, television-camel, book-monkey, cup-bear, table-dog, clock-deer. The background colors were pink, red, orange, yellow, white, blue, green, and brown, respectively. The drawings were approximately 1½ in. in the longest dimension and centered 2 in. apart and 1 in. from the sides of 4 x 6 in. plastic cards.

Three 8½ x 11 in. boards were used for subsequent testing for incidental learning. One board contained line drawings of the eight animals on a white sheet of paper. Another had line drawings of the eight household objects on a white sheet of paper. The third had eight squares of the background colors on a white sheet of paper. The animal board was used as the cue for the recall of the serial location of the animal in the memory task as well as for naming the animals for the intentional portion of memory and PA tasks. The household object and color boards were used as cues for the incidental recognition test. Additional cards with individual drawings of each of the eight animals on white paper were also used as cues for the incidental recognition test.

Procedure.--The subjects participated individually in a mobile laboratory trailer. The experimenter and subject sat side by side at a table.

The Memory Task

Subjects were given instructions (see Appendix C) and asked to name the animals as the experimenter pointed to them on the animal board. Then the subjects were presented the series of eight cards, one at a time. Presentation proceeded from the subject's left to his right. The experimenter held each card in view for approximately 2 sec., and then placed it face down. When all cards had been presented, E then indicated, by pointing to one of the animals on the animal board, which animal was to be found on that trial. On each trial, the subject was asked to find a different animal. After the subject indicated his choice, the experimenter picked each card up, exposing it for approximately 2 sec. to the subject. Four orders of presenting the eight cards were used. The orders were constructed so that no card maintained the same ordinal position or followed the same card in any of the four orders. Training on the intentional portion of the memory and PA tasks was equated by means of a yoking procedure. Each memory-task subject was randomly yoked in terms of number of trials to a subject who had reached a criterion of one perfect trial on the PA task.

The Paired-Associate Task

Subjects were given instructions (see Appendix C) and asked to name the animals as the experimenter pointed to them on the animal board.

Presentation of the eight cards was by the anticipation method using a Hunter Card Master (Model 360). The list was presented at a 2:2 sec. rate with a 2-sec. intertrial interval. The same four orders of presentation were used to minimize serial learning that were used in the memory task. Subjects were taken to a criterion of one perfect (errorless) trial or to a maximum of 16 trials.

Incidental Learning

Immediately after the intentional task (either PA or memory) subjects were tested for both object and color recognition. Half of the subjects were individually tested for object recognition first, and half for color recognition first. The incidental test (see Appendix C for instructions to the subject) included the presentation of the board of household objects (or colors) and the individual animal cards. The subject was asked to select the object (or color) from the board which had previously appeared with the animal being presented. There was no time limit.

Results and Discussion

Intentional PA learning (trials to criterion) generally improved across grade levels (Table 1); however, the fifth grade required slightly fewer trials to reach criterion than did the seventh grade ($\overline{X}$s = 6.56 and 7.81 respectively). Table 2 presents the means and standard deviations of the numbers of colors and objects correctly recognized for each task and grade level. An inspection of Table 2 reveals an obvious difference in incidental performance between PA and memory tasks. Even under conditions of equal numbers of training trials, performance in the PA

task was clearly superior to that in the memory task. No change over age is evident in the PA task; however, a slight decline in means occurs at grades 7 and 9 in the memory task. Some differences between means for color and object measures are slightly greater within the PA task than within the memory task with object (O) scores being better in the PA task and color (C) scores being better in the memory task. ($\overline{X}_C = 6.13$; $\overline{X}_O = 7.28$; $\overline{X}_C = 3.13$; $\overline{X}_O = 2.74$, respectively.)

A 2 (Tasks) X 4 (Grades) X 2 (Orders of testing for color and object) X 2 (Sexes) X 2 (Stimuli: color and object) factorial analysis of variance was performed on the incidental recognition data. The Stimuli factor was analyzed as a within-Ss factor and the others as between-Ss factors. The Task effect, $F(1,96) = 215.14$, $p < .001$, and the Stimuli effect, $F(1,96) = 6.14$, $p < .001$ were both highly significant.

The main effect of Order of testing for color and object was not significant, $F < 1.00$. However Order did interact with Task and Stimuli. Table 3 gives the means for color and object scores within the two orders (object first and color first) for the PA and memory tasks. The analysis of variance revealed a significant Task X Order X Stimuli interaction, $F(1,96) = 5.28$, $p < .02$. The Task X Stimuli interaction was also significant, $F(1,96) = 22.39$, $p < .001$. In the PA task, as may be seen in Table 3, object scores were generally better than color scores, but order of testing did not make much difference. In the memory task, on the other hand, there was not much overall difference between color and object scores. Under these conditions, the subjects

showed better incidental recall of the first items, whether color or object, but with color scores being more affected by order than object scores. Tukey's pairwise comparison between color scores for each order of testing was significant ($q = 3.828$, $p < .01$) for the memory task data but nonsignificant for the PA data.

The absence of a Grade effect is consistent with earlier studies of incidental learning using PA tasks (Cole & Kanak, 1972; Kausler & Gotway, 1969). The mean differences in the memory task over age may have been masked by the invariance over age in the PA task. The large difference in incidental performance between the PA and memory tasks indicates the effect of the intentional task itself upon incidental learning.

The PA data and the memory data were analyzed separately by means of two 4 (Grades) X 2 (Orders of testing for color and object) X 2 (Sexes) X 2 (Stimuli: color and object) analyses of variance. For the PA data, only the Stimuli main effect was significant, $F(1,48) = 37.21$, $p < .001$, with object scores being higher than color scores. For the memory data, none of the main effects were significant. Only the Order X Stimuli interaction was significant, $F(1,48) = 5.77$, $p < .01$, confirming that performance was better in the memory task on the measure first tested, with the color scores most affected. See Table 3 for the mean color and object scores according to testing order. Thus, the significant interaction between Order and Task in the initial analysis was primarily due to the memory data. The absence of a Grade effect

for the PA task, $F < 1.00$, is consistent with the findings of previous research (e.g., Cole & Kanak, 1972). Also, as may be seen in Table 1, a decline in incidental performance at grades 7 and 9 may be seen in the means of the color and object scores in the memory task. The decline is primarily due to color scores. In the analysis of the memory data the Grade main effect was also nonsignificant, $F < 1.00$. The seventh grade had more intentional training than the fifth and ninth graders due to the yoking procedure. Additional intentional training may have tended to cancel the decline expected at the seventh grade.

Correlations between intentional and incidental performance for both the PA and memory tasks were nonsignificant. The absence of such correlations is consistent with previous research for both tasks (e.g., Druker & Hagen, 1969; Kausler & Gotway, 1969).

Experiment II

Studies using the PA task typically have tested for R-S (incidental) learning after subjects reached criterion performance on the intentional S-R task (e.g., Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972). Increments in degree of mastery on an intentional task (serial learning) has been shown to produce increments in incidental performance with adults (e.g., Bahrick, 1957). Further, Bahrick (1957) has shown that the rate of incidental learning is faster in the early and late stages of training on the intentional task.

This study investigated the developmental relationship between degree of mastery on the intentional task and subsequent incidental

learning performance. The PA task with the same materials and dependent measures as the first study was used. Three levels of training (2, 4, and 6 trials) were examined over the age span including grades 3, 5, 7, and 9. The chief aim of this study was to see if the degree of mastery on the intentional task is related to incidental performance in general and specifically to the decline which is typically observed at adolescence with nonverbal tasks. It was expected that a decline in incidental performance might be observed at grades 7 or 9 at low levels of training (2 trials), especially for the less relevant color scores. This prediction was based on a possible similarity between the memory task and the PA task at low levels of training. That is, given the minimal opportunity for learning and the general unrelatedness of incidental and intentional stimuli in the memory task, it was expected that the PA task at low levels of intentional S-R acquisition should yield incidental performance more like that found with the memory task, particularly if the incidental material were relatively unrelated to the intentional task. More specifically, a decline in incidental learning was expected with the relatively unrelated color scores. With more related incidental stimuli and increasing levels of intentional practice, the greater should be the tendency toward age invariance typically found in verbal learning studies.

Method

Subject and Design.--The subjects were 120 public school children (60 of each sex) selected from grades 3, 5, 7, and 9 of the Noble (Oklahoma)

Public Schools. A 3 (Numbers of Trials) X 4 (Grades) factorial design was employed with 5 males and 5 females per cell. Sex thus formed a third factor in the design.

Materials and Procedure.--The instructions, materials, and general procedure were the same as those for the PA task in Experiment I except one third of the subjects at each grade level received either 2, 4, or 6 trials of intentional practice before the test for incidental learning was given.

Results and Discussion

The means and standard deviations of correct numbers of responses for the intentional task are presented in Table 4. Inspection of the means shows improved performance over age for 4 and 6 trials. At 2 trials improvement is not as clear. The means and standard deviations of numbers of correct recognitions of colors and objects are presently separately for each grade and level of training in Table 5. As may be seen, the means for incidental color and object scores improved at each grade level with increased amount of training. An inspection of the means (Table 5) for total incidental performance (combined color and object scores) at two trials at grade 7 showed a decline in comparison with performance at grades 5 and 9. Since the object scores at two trials tended to increase across grades, the decline in Total scores was primarily due to color scores. These data support the idea that unrelated incidental measures and low levels of learning may be partly responsible for the decline typically found in developmental studies using nonverbal learning and memory tasks. As expected, the decline was less evident at four and six trials, and more nearly like the PA data at a criterion of one perfect trial.

A 3 (numbers of Trials) X 4 (Grades) X 2 (Sexes) X 2 (Stimuli: color and object) factorial analysis of variance was performed on the data. As in Experiment I the Stimuli factor was analyzed as a within-S variable and the others as between-S effects. The Trials effect, $F(2,96) = 28.87$, $p < .001$, Sex effect, $F(1,96) = 5.94$, $p < .001$, and Stimuli effect, $F(1,96) = 43.57$, $p < .001$ were significant. These findings confirm that amounts of training on the intentional task were associated with improved incidental performance. Considerable opportunity was given to subjects in the memory task in the first experiment ($\bar{X}$ number of trials = 7.22); however, incidental performance was relatively poor. Apparently it is not simply the amount of opportunity but also the requirements (e.g., memory load) of the intentional task that is important to the acquisition of incidental material. The significant Stimulus effect supports the idea that object (S item) learning was greater because of its interrelatedness with the requirements of the intentional task. The significant Sex effect was due to the superior performance of males (overall $\bar{X}$s = 3.175 for males and 2.625 for females).

A 4 (Grades) X 2 (Sexes) X 2 (Stimuli: color and object) analysis of variance was performed on the two-trial data (where grade changes were most evident). The Grade effect was only marginally significant, $F(3,32) = 2.41$, $p < .08$. The Stimuli effect, $F(1,32) = 15.26$, $p < .001$ and Stimuli X Grade interaction, $F(3,32) = 5.03$, $p < .005$ were significant. Tukey's pairwise comparison on color scores between grades 5 and 7 was highly significant ($q = 2.89$, $p < .01$). Other comparisons between color

scores by grade were nonsignificant. Comparisons between object scores by grade were nonsignficant except between grades 3 and 9, $q = 3.61$, $p < .05$, confirming an upward trend in object scores over grade levels.

Experiment III

Previous studies using the memory task have typically used a common number of items (usually 6 cards) for subjects ranging from grade 3 to grade 7. It is apparent that this procedure results in differential task difficulty at widely separated ages. The third study attempted to determine the extent to which task difficulty (memory load) affects incidental performance in the age range for which the decline has been observed. In contrast to Experiment I, which employed an array of 8 cards, this third study investigated two less demanding levels of difficulty (arrays of 4 and 6 cards).

Greater incidental learning was expected with an array of 4 than with an array of 6 cards. A decline in incidental performance at grade 7 or 9 was predicted for the array of 6 but not for the array of 4. This prediction was based on the assumption that subjects from grades 7 and 9 should be able to perform the relatively easy intentional task (array of 4) and also acquire the incidental material. Thus, no decline in incidental performance at grades 7 and 9 was predicted for the easier task (array of 4).

Method

Subjects and Design.--Subjects were 80 public school children from grades 3, 5, 7, and 9 of Norman Public Schools, Norman, Oklahoma.

A 2 (Arrays) X 4 (Grades) factorial design was employed with 5 males and 5 females per cell. Sex was included as a third factor within the design.

Stimuli and Test Materials.--These were the same as for the memory task in the first study except that a set of four cards (chair-horse, cup-bear, television-camel, table-dog) and a set of six cards (the 4-card array plus telephone-fish and clock-deer) were taken from the original set of eight cards to form the arrays. The boards of animals, household objects and colors, were reduced to the same four or six stimuli, dpending upon the length of the array.

Procedure.--The procedure was the same as for the memory task in the first study. Three orders were used for the presentation of the cards. Within the orders, no stimulus card maintained the same ordinal position or followed the same card. All subjects received eight trials.

Results and Discussion

Means and standard deviations for correct numbers of responses for the intentional task are presented in Table 6. As maybe seen, performance for both arrays improved over age. The percentages correct for color and object scores for an array of 4 and an array of 6 for each grade level are presented in Table 7. The difference in percentages correct for an array of 4 as compared to an array of 6 was greater at grades 7 and 9 than at grade 3. At grade 5 the percentage correct was greater for an array of 6 than for an array of 4, but the difference was minimal. Generally for all grade levels the total percentage correct for incidental performance for an array of 4 was 64% as compared to 54% for an array of 6. Table 8 contains means and standard deviations of absolute color, object, and

total scores for each grade level for arrays of 4 and 6 cards. Inspection of the total scores reveals a curvilinear trend for the array of 6. The slight decline occurred at grade 7 and a subsequent increase in incidental performance occurred at grade 9. The means for color and object were not different for either array.

A 2 (Arrays) X 4 (Grades) X 2 (Sexes) X 2 (Stimuli: color and object) analysis of variance was performed on absolute color and object scores. The Stimuli factor was analyzed as a within variable and the others as between variables. Only the main effect for Array was significant, $F(1,64) = 4.97$, $p < .03$, indicating that as opportunity increased, absolute incidental performance also increased. More specifically, absolute performance was greater for an array of 6 than for an array of 4. A 2 (Arrays) X 4 (Grades) X 2 (Sexes) X 2 (Stimuli: color and object) analysis of variance was performed on the proportion of correct color and object recognitions. None of the effects were significant, although the main effect for Array was marginally significant, $F(L,64) = 2.78$, $p < .10$. Thus, there was a slightly greater proportion of correct incidental recognitions for an array of 4 as compared to an array of 6.

An inspection of the means for the array of 8 from Experiment I (Table 2) and the array of 6 (Table 8) indicates that absolute incidental performance is not much greater for the array of 8 than for the array of 6. The more difficult intentional task (array of 8) did not result in improved incidental performance. An inspection of the means for the

array of 4 (Table 8) show that incidental performance is less than for the arrays of 6 and 8 then for the array of 4. Opportunity for incidental performance made a difference when the intentional task was relatively easy.

The slight curvilinear trend in incidental performance, found with the array of 6, is consistent with previous research (e.g., Maccoby & Hagen, 1965). In addition, the relatively easy intentional task (array of 4) tended to eliminate the decline at grade 7 and improve performance at grade 9. The greater total proportions correct for incidental performance in an easier task as compared to a more difficult task suggests that incidental performance was related to the difficulty of the intentional task. When the intentional memory load became lighter, incidental performance improved because more attention could be devoted to incidental material.

General Conclusions

The decline in incidental performance around 11 or 12 years appears to be related to several factors. One of the most important of these concerns the nature of the intentional task. Incidental learning is greater in a learning (PA) task where intentional performance gradually improves over trials, making the intentional task progressively easier and the incidental material more likely to be learned. Another factor contributing to incidental performance is the relatedness of the incidental and intentional dependent measures. Apparently, the more related the intentional and incidental measures are, the more incidental

learning that occurs. Within a task where intentional learning improves over trials and the intentional and incidental measures are highly related greater amounts of training on the intentional task were found to facilitate incidental performance (i.e., the PA data in Experiment I). Within the memory task, where constant intentional effort is required on each trial and where incidental and intentional measures are relatively unrelated, the demand characteristics of the intentional task appear to partially determine the extent of incidental learning (i.e., the memory data in Experiment III). That is, with easier tasks there may be no age differences or even increments in incidental performance across age. As the intentional task becomes more difficult, the older subjects (age 11 or 12 years and older) selectively attend to what appears to be relevant to the intentional task at expense of reduced incidental learning.

The reason for the decline at 11 or 12 years has not been provided in the present data. From a strictly methodological point of view, it appears that the conditions which are most likely to generate the decline are those of minimal learning (e.g., memory task or low levels training in a PA task), relatively unrelated intentional and incidental dependent measures, and a moderately difficult or demanding intentional task for the 11- or 12-year old. It is not so much whether an intentional task is verbal learning or nonverbal memory as whether it possesses certain characteristics. A learning task could be made to show the decline (as shown by the PA two-trial data in Experiment II), given minimal

learning. A memory task could be made to eliminate the decline (as shown by the memory data in Experiment III), given a relatively easy intentional task. Thus, the decline is eliminated by criterion levels of learning, especially where the relationship between incidental and intentional learning is great. The decline also seems to be eliminated with a very easy intentional memory task.

Theoretical explanations for the decline are still not definitive, but the typical explanation of the 11- or 12-year-old ignoring incidental information because he is focusing on intentional material remains viable. Relatively unimportant material, given certain methodological conditions, is ignored by the 11- or 12-year old, and a decline in incidental performance is reliably observed.

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Table 1

Experiment I

Mean Numbers of Trials Required to Reach Criterion[a] and Standard Deviations for the PA Task

		$\overline{X}$	S.D.
GRADES	3	8.50	4.21
	5	6.56	3.22
	7	7.81	3.43
	9	5.88	2.66

a Because of the yoking procedure, these figures also represent the mean number of training trials given on the memory task at each of the four grade levels.

Table 2

Experiment I

Means and Standard Deviations of Number of Correct

Recognitions of Colors and Objects

	Grade Level											
	3			5			7			9		
	Color	Object	Total	Color	Object	Total	Color	Object	Total	Color	Object	Total
						PA TASK						
$\bar{X}$	5.88	7.31	13.19	5.81	7.38	13.19	6.50	6.81	13.31	6.13	7.81	13.94
S.D.	1.93	1.14	2.56	1.52	1.02	2.17	1.46	1.68	2.80	1.67	.54	1.81
						MEMORY TASK						
$\bar{X}$	3.38	2.94	6.31	3.06	3.13	6.19	2.88	2.88	5.75	3.19	2.00	5.19
S.D.	1.78	1.69	2.77	2.38	2.50	4.62	2.28	1.50	2.41	2.29	1.41	3.15

Table 3

Experiment I

Means Numbers of Correct Recognitions

of Colors and Objects for each Order of Testing

PA TASK

Order of Testing	Color	Object
Object First	6.25	7.38
Color First	5.90	7.28

MEMORY TASK

Order of Testing	Color	Object
Object First	2.53	2.81
Color First	3.71	2.66

TABLE 4

EXPERIMENT II

Means and Standard Deviations for Correct Numbers of Response in the Paired-Associate Task for 2, 4, and 6 Trials

		TRIALS		
		2	4	6
3rd Grade	$\bar{X}$	1.40	3.00	5.40
	S.D.	.84	2.00	2.22
5th Grade	$\bar{X}$	2.40	4.60	5.60
	S.D.	1.17	1.51	1.78
7th Grade	$\bar{X}$	1.70	4.50	6.50
	S.D.	1.06	1.51	1.65
9th Grade	$\bar{X}$	2.50	4.70	6.20
	S.D.	1.78	1.42	1.81

Table 5

Experiment II

Means and Standard Deviations of Numbers of Correct

Recognitions of Colors and Objects

Number of Trials		Grade Level 3			5			7			9		
		Color	Object	Total	Color	Object	Total	Color	Object	Total	Color	Object	Total
2	$\bar{X}$	2.1	2.9	5.0	3.7	3.7	7.4	1.0	3.6	4.6	2.0	4.8	6.8
	S.D.	1.45	1.45	1.83	1.95	2.11	3.27	1.15	1.84	2.41	1.56	1.03	2.04
4	$\bar{X}$	3.6	3.9	7.5	3.1	5.7	8.8	4.8	5.0	9.8	3.9	5.0	8.9
	S.D.	1.51	2.33	3.24	1.66	1.83	3.22	1.81	2.26	2.39	2.23	2.67	3.70
	$\bar{X}$	5.3	5.5	10.8	5.2	6.5	11.7	4.5	7.2	11.7	5.3	6.7	12.0
	S.D.	2.63	2.92	5.37	2.15	2.17	4.11	1.27	.92	2.06	2.83	2.26	4.32

TABLE 6

EXPERIMENT III

Means and Standard Deviations for Correct Numbers of Responses in the Memory Task for Arrays of 4 and 6

		Arrays	
		4	6
3rd Grade	$\bar{X}$	5.10	4.10
	S.D.	1.20	1.37
5th Grade	$\bar{X}$	5.90	3.80
	S.D.	.99	2.25
7th Grade	$\bar{X}$	7.30	4.30
	S.D.	.82	2.31
9th Grade	$\bar{X}$	6.60	5.90
	S.D.	1.07	1.60

Table 7

Experiment III

Mean Percentages of Correct Recognitions

of Colors and Objects

		Array of 4			Array of 6		
		Color	Object	Total	Color	Object	Total
GRADES	3	.600	.500	.550	.433	.551	.492
	5	.525	.475	.500	.584	.565	.575
	7	.825	.675	.750	.549	.449	.499
	9	.775	.775	.775	.699	.517	.608

Table 8

Experiment III

Means and Standard Devisions of Numbers of Correct

Recognitions of Colors and Objects

Grade Level		3		5		7		9	
Arrays		4	6	4	6	4	6	4	6
Color	$\bar{X}$	2.4	2.6	2.1	3.5	3.3	3.3	3.1	4.2
	S.D.	1.17	1.15	1.60	2.01	.95	2.16	1.52	1.99
Object	$\bar{X}$	2.0	3.3	1.9	3.4	2.7	2.7	3.1	3.1
	S.D.	1.83	2.11	1.66	1.65	1.42	2.11	1.20	1.97
Total	$\bar{X}$	4.4	5.9	4.0	6.9	6.0	6.0	6.2	7.3
	S.D.	2.59	2.96	2.71	2.64	1.56	3.56	1.40	3.43

APPENDIX A

LITERATURE REVIEW

INCIDENTAL LEARNING: DEVELOPMENTAL TRENDS

A current interest in incidental learning appears to stem from the rather surprising finding that while intentional learning generally improves with age, incidental learning does not, and may even decline in some instances. This curious decline in incidental learning performance which occurs around age 11 or 12 years, may be specific to a particular methodology, especially since it is not found with verbal learning methodologies. The present purpose is to provide a comprehensive review of research, specifically pertaining to developmental changes in incidental learning as they have been observed in traditional laboratory tasks. This review will attempt to identify methodological issues within the literature as they pertain to developmental changes in incidental learning. It is hoped that the review and its implications for research will help to resolve whether developmental changes in incidental learning are due to actual developmental (subject) differences or to methodological artifacts of task.

Incidental learning is learning that occurs in the absence of instructions to learn. As such, it is a pervasive and important form of learning because it represents the means by which many human attitudes and behaviors are acquired. Although beyond the scope of this paper, it is apparent that much social learning (observational

learning) is acquired incidentally (Wilson, 1958; Bandura & Huston, 1961; Bandura, Ross & Ross, 1963; Mussen & Parker, 1965; Ross, 1966; Hartup & Coates, 1967). Most sex and social role behaivors, attitudes, values, and personality characteristics can be at least partially attributed to incidental learning.

Formal education's acceptance of the importance of incidental learning can be easily illustrated. The child is surrounded with aesthetic objects on the assumption that his developing tastes will be turned in desirable directions. Posters are assumed to influence health and safety habits. Teachers are selected who will serve as "good" examples to children in general conduct. It is also clear that there are enough "bad" examples present for children to learn lying, cheating, gossiping, swearing, etc. incidentally as well.

Human conditioning studies provide additional instances of incidental learning in that subjects are typically focused on a central intentional task (usually deceptive) while being conditioned incidentally or unconsciously. This is true in both classical and in instrumental paradigms. "Learning without awareness" (Rock, 1957) is also of an incidental nature. Many practice effects (warm-up, learning to learn, set) are acquired incidentally. Attention and perception also have many incidental components since subjects often attend to or perceive aspects of a task that were not emphasized by instructions. The "latent learning" research provides another example of incidental learning. Even "unconscious" processes within clinical settings represent additional illustrations of incidental learning. Although this review

will be concerned with incidental learning as it has been defined and studied in the laboratory, the previous examples illustrate the general pervasiveness of this type of learning process.

INCIDENTAL LEARNING RESEARCH

DEFINITION

What an individual is instructed to learn is typically referred to as "intentional" learning, and all other learning is referred to as "incidental." Two types of incidental learning situations have been identified and studied (cf. Kausler & Trapp, 1960; Mechanic, 1962a; Postman, Adams, & Bohm, 1956; Postman & Senders, 1946; Postman, 1964). In the first (Type I), the subject is not given instructions to learn but is subsequently tested on the materials to which he was exposed. In the second (Type II), the subject is exposed to two sets of materials, instructed to learn only one of the sets, and is later tested on the materials which he was not instructed to learn. Most recent studies of incidental learning have focused on the second type of incidental learning situation. There are several recent reviews of incidental learning, some of which include developmental and child research (McLaughlin, 1965; Postman, 1964; Esterbrook, 1959; Stevenson, 1972; Stevenson, 1970; Kausler & Trapp, 1960; Bruner, Matter, & Papanek, 1955; Botwinick, 1970). These reviews will be cited mainly as they pertain to the developmental focus of this paper.

EARLY RESEARCH

Methodological Considerations

The earliest investigations of incidental learning were not labeled as such, rather, they were investigations into "conscious" and "unconscious" processes. These early investigations were often merely demonstrations that learning can occur incidentally, i.e., without conscious awareness (e.g. Brown, 1915).

Many of the early studies were also comparisons of the relative efficiency of learning by incidental versus intentional means (Boswell & Foster, 1916; Barr & Park, 1932; Kirkpatrick, 1914). Boswell and Foster (1916) asked four adults to learn pairs of Chinese words and their English equivalents. There were two series, differing only in instructions -- one for permanent retention, one for "temporary" retention. The authors assumed that learning under instructions to retain temporarily was incidental. Actual differences, not surprisingly, were slight. However, this study raised the question of whether long-term memory storage is related in part to intentional effort. Barr and Park (1932) also compared intentional learning (memorization) and incidental learning with artificial alphabets. In the incidental method, subjects were instructed to concentrate on the translation of meaningful material, the content of which they were to be tested over later. In the direct method subjects were instructed to concentrate on the memorization of the symbols. Direct learning was found to be about 57% more efficient than incidental learning.

Kirkpatrick (1914) also investigated the efficiency of incidental practice and memorization but with children (fifth and sixth graders) as subjects. Kirkpatrick had one group practice writing multiplications products without the knowledge that they were products; another group memorized products for five or six days and then wrote them. Apparently, Kirkpatrick believed that if children were not told the reason for writing the products they would not try to remember them but learn them incidentally. The "memorizers" were found to be better on the second day but poorer by the tenth day. After two weeks, "practicers" remembered more products than memorizers. In the second part of this study, the relative merits of practicing and of computing products were investigated with college age women as subjects. The computers did much better then the practicers. In the third part of this study children, as computers, were found to be superior to practicers. Kirkpatrick (1914) is the earliest study of incidental learning as such with children, that allows some developmental comparisons to be made. Since similar results were found for college age women in comparison to fifth and sixth graders for both intentional and incidental learning, Kirkpatrick's (1914) data suggest an absence of developmental change after the fifth grade.

Most of the early demonstrations of incidental learning in the laboratory were of the Type I variety. For example, Myers (1913) recorded performance on several naturalistic tasks (observation of a watch dial, dates of familiar events, rapid estimation of letters in a word, estimation of sizes and proportion of familiar objects). He

made no attempt to teach his subjects in the laboratory but assumed they had learned the naturalistic tasks incidentally in everyday experience. An exception to the naturalistic type of Type I paradigm was Myer's use of a "letter square" task, in which attention was directed to one component of the "letter square" (a complex stimulus) and recall of other components were subsequently tested.

Once the existence of incidental learning had been established, a major shift away from demonstration-type experiments to investigations of the determinants of incidental leanring occurred around 1930. For example, Willoughby (1929, 1930) investigated age as a factor in incidental learning; while, Haefner (1932) investigated length of time between exposure to incidental stimuli and subsequent testing. Along with this interest in the determinants of incidental learning performance also came a methodological shift to the Type II incidental learning situation. One reason for the shift was to gain increased experimental control.

Theoretical Interpretations

In the early literature few theoretical discussions of the mechanisms involved in incidental learning are to be found. Explanations involving "unconscious" factors (Ordahl, 1911; Kuhlmann, 1905), attentional influences (Ordahl, 1911), "intent" to learn (Boswell & Foster, 1916) and "strength of associations" (Brown, 1915) were offered in a general way. Ordahl (1911) cited several early experiments to show conscious and unconscious factors in the learning process and emphasized that learning can progress without consciousness "of the fact that one is learning." She also suggested that

"attention" results in better performance than inattention. Thus, incidental learning was not mentioned as such but a theoretical base for it in attentional processes was begun. Kuhlmann (1905) was another early investigator who noted that much important learning - "the use and functional activity of our own bodies" - occurs without consciousness, but again no specific reference to incidental learning was made. Boswell and Foster (1916) believed that the intent to remember permanently "actually brings about retention." Brown (1915) wrote that poor incidental memory was due to "weakness of association" just as with poor intentional learning. In general these explanations were offered to account for differences in incidental and intentional learning performance in adults rather than to account for developmental changes in incidental learning. However, as this paper progresses, some of these early ideas concerning incidental learning will be reexamined from a developmental perspective.

DEVELOPMENTAL STUDIES WITH NONVERBAL TASKS

The data on developmental trends in incidental learning are not consistent. For example, Willoughby (1929, 1930) found consistent improvement in incidental learning performance over a wide age range while, more recent investigators (e.g., Maccoby & Hagen, 1965; Druker & Hagen, 1967; Hagen & Sabo, 1969; Siegel & Stevenson, 1966) have reported improvement only through the middle childhood years and a subsequent decline around age 11 or 12. The focus of the review in this section will be on methodological differences and similaries of tasks, dependent measures, and materials, as well as on the developmental

trends in intentional and incidental learning. Developmental trends will generally refer to any changes in performance with age. Although studies using subjects ranging from preschool to old age will be considered, principal interest will be on those studies that have used subjects ranging from age 8 to 14 years. The focus upon this age range stems from an interest in the decline in incidental performance observed to occur around age 11 or 12.

Children

The virtual absence of developmental investigations of incidental learning is striking. For example, in reviewing nonverbal developmental investigations of incidental learning in children, an attempt was made to be exhaustive; nevertheless, only eighteen studies, published between 1929 and 1973, were found. Wenger and Williams (1935) reviewed experimental learning studies in children and specifically excluded "incidental observation." Although they did not give an explanation as to why they excluded incidental learning, it may have been due to the sparcity of experimental research at that time.

Within nonverbal developmental studies with children, a variety of tasks, dependent measures, and materials have shown similar developmental trends. These tasks range from strictly memory tasks to successive discrimination learning tasks. Subjects have been exposed to widely varying sets of instructions for these tasks and the incidental learning material usually has not been integral to the intentional task. It may be useful to examine these studies in some detail preliminary to later comparisons with those studies primarily involving verbal tasks

which do not show similar developmental trends.

Consideration of age and task. Most of the tasks in this section may be categorized into "learning" and "memory" tasks. Learning tasks are those in which the effects of each trial are cumulative and subjects show acquisition (improvement) of performance over trials. Memory tasks, on the other hand, do not show acquisition effects over trials. An individual can either manage the memory load of the task or he cannot. In the learning task, intentional learning typically becomes easier for the subject as trials progress such that he might have an increased opportunity to focus on incidental material without interfering with his performance on the intentional task. With the memory task, intentional learning typically does not become easier for the subject as trials progress. Each new presentation requires approximately the same effort. The ability to memorize may be enhanced somewhat through practice. However, relatively difficult memory tasks may not allow the subject as much opportunity to learn incidental material as learning tasks. When learning and memory tasks show similar developmental trends, as they often do in the nonverbal studies, a distinction between learning and memory tasks may be unnecessary. The studies reviewed in this section use subjects ranging from three years to college age. Findings with adult subjects who are included in some of the studies with children are considered primarily in the section concerning adults.

Studies using learning tasks. Willoughby (1929, 1930) represents the beginning of truly developmental studies of incidental

learning. His intentional task, similar to the Digit Symbol substitution subtest of the Wechsler Intelligence Scale was administered to subjects ranging from 6 to 68 years of age. Subjects were required to write symbols to given numbers. After the subjects completed the intentional task, he asked them to recall the associations between number and symbol. Recalling the associations was a surprise task since subjects had not been previously asked to memorize them but simply to write them. He found that incidental performance improved until age 17 and then gradually declined through adulthood. This improvement in incidental performance well into adolescence is discrepant with more recent studies using both learning and memory tasks. These later studies consistently report a decline in incidental performance around age 11 or 12 (Maccoby & Hagen, 1965; Siegel & Stevenson, 1966). The discrepancy of Willoughby's findings may possibly have been due to the integral relationship between the intentional and incidental dependent measures. This possibility will be discussed more fully later under the subsection "Consideration of Materials and Dependent Measures," page 54.

Using a learning task, Norton (1958) in an unpublished dissertation found that incidental and central performance improved from fifth grade to college. Although she investigated the effect of age, hunger, and forgetting upon incidental learning, only age and task will be considered here. Subjects were presented an orienting task in which they were required to make color associations to a series of words. Intentional learners were instructed to remember the words as

well. Intentional learning of the words was found to be superior to incidental learning, and the performance of college students generally surpassed that of fifth graders. However, at the fifth grade level the difference between incidental and intentional performance was significantly smaller than it was at the college level. This finding suggests a sharper upward developmental trend for intentional learning than for incidental learning. In addition, since Norton ran only fifth grade and college subjects, it is possible that she would have found other developmental trends (e.g. a decline) if she had tested subjects in the years between.

There are only two developmental investigations of incidental learning which have included preschoolers as subjects (Stevenson, 1954; Hale & Morgan, 1973). Stevenson (1954) found improvement with age with a learning task. He had children aged 3, 4, 5, and 6 years, learn a V-shaped maze. Goal boxes were located at the end of each leg of the V. One goal box containing rewards was locked with a padlock, and the other goal box contained the key to open the padlock. The box with the key also contained irrelevant objects used in assessing incidental learning. Following six trials, subjects were shown the irrelevant, incidental objects and asked to find them. Going to the appropriate goal box indicated successful incidental performance. Stevenson found that incidental performance generally improved with age. He also reported that older children followed the intentional task instructions much better and performed more quickly than did younger subjects.

Also using a learning task, Hale and Morgan (1973) found a decrement in incidental performance in the age range from four to eight years in their investigation of developmental trends in "component selection" and incidental learning. This is discrepant with Stevenson's (1954) increment in performance from three to six years. An important characteristic of the component selection task is that it allows the subject a free choice of the means by which to discriminate among stimuli. Hale and Morgan's (1973) component selection task was composed of a learning phase and a posttest. In the initial phase, the subject learned the spatial position of several stimuli that differed on two dimensions, shape and color. These components were redundant in that a given shape was the same color throughout the task. In the posttest, attributes of each dimension were presented -- for example, a colorless triangle or a blue card -- and the subject was asked to identify the spatial position associated with each attribute. The number correct for each of the two components comprised the data. The incidental task was parallel to the component task except the subject was told to remember the shapes but later was tested for memory of color (incidental measure). Incidental learning declined slightly from four-year-olds to eight-year-olds. The age trend discrepancy between Stevenson (1954) and Hale and Morgan (1973) might be due to gross task differences. Although both tasks were learning tasks, as opposed to memory tasks, one required a gross motor skill while the other required visual discrimination.

Using a successive discrimination learning task, Siegel and Stevenson (1966) found a significant increase in incidental learning between ages 7-8 and 11-12 and a significant decrease between ages 11-12 and 13-14. Their experiment was divided into three parts. Children between ages 7 and 14 and a group of adults were initially taken to a criterion of eight correct responses on a three-choice successive discrimination task. Intentional performance improved with age on this initial discrimination. The discrimination task was followed by 12 trials in which each discriminative stimulus was presented in a stimulus complex with three additional objects. A response button that was correct for the first series of trials was also correct for the second series of trials. On a third series of trials, each of the 12 stimuli was presented separately. Incidental learning was measured by the number of incidental objects (previously associated with discriminative stimuli) to which the subject could respond correctly. In this study, subjects could perform the intentional task without learning the incidental stimuli.

Siegel (1968) found no increment in incidental learning from age 8 to 14, and the decline found by Siegel & Stevenson (1966) was not shown. He presented 8-year-olds and 14-year-olds with the same learning task of Siegel and Stevenson (1966) except for a modification in the second series of trials. In the second series of trials, an attempt was made to determine whether opportunity to learn the incidental stimuli was an important factor in incidental learning. For this series, one group at each age level received four trials of each incidental

stimulus, and another group received 12 trials of each incidental stimulus. Neither the 8- nor the 14-year-olds showed differences in amount of incidental learning as a function of the level of training on the intentional task. Central learning performance improved with age for all groups. Incidental learning results replicated Siegel and Stevenson's (1966) finding that the incidental learning scores of 8- and 14-year-olds do not differ significantly in this task. If Siegel had tested 11- and 12-year-olds, he might have found the decline, since Siegel and Stevenson (1966) found the decline between ages 11-12 and 13-14 using the same task. Thus, there really may be no discrepancy between Siegel (1968) and Siegel and Stevenson (1966). The failure to find differences between 8-year-olds and 14-year-olds in the four-trial group was contrary to the Siegel's expectations. It indicates that opportunity on the intentional task does not necessarily affect incidental performance.

Siegel and Corsini (1969) also found incidental learning scores of 8- and 14-year-olds to be the same although they primarily investigated whether attention to peripheral stimuli is dependent upon organizational ability. The task was a 3-part successive discrimination: Original learning, presentation of peripheral stimuli, and a test of recall and recognition of the peripheral stimuli. In the original learning, subjects learned to press the correct button for each central stimulus. In phase 2, the same central stimuli were presented with peripheral (incidental) stimuli. Half of the subjects were instructed to learn the peripheral material (Intentional group),

and half were given no further instructions (Incidental group). For half of the subjects under each of these groups, the peripheral material was conceptually related (Concept group) or unrelated (No Concept group). In incidental performance, the 8-year-olds did not profit from the related nature of the peripheral stimuli (Concept group), but the 14-year-olds did. The 8-year-olds and 14-year-olds performed similarly when peripheral stimuli were unrelated. This study is consistent with Siegel and Stevenson (1966) and Siegel (1968) in showing that the incidental learning scores of 8- and 14-year-olds do not differ.

Using a stimultaneous discrimination task, Crane and Ross (1967) reported that 11-year-olds are more likely than 8-year-olds to ignore irrelevant material. The authors reasoned that if 11-year-olds are able to attend selectively to the intentional task, they should profit less from prior experience with irrelevant cues than 8-year-olds. Their study was divided into three phases. The first phase made use of a two-choice discrimination task in which subjects were taken to a criterion of 9 out of 10 consecutive correct responses. In the second phase, irrelevant cues were made redundant by being paired with relevant cues. In the final phase the effects of redundancy were assessed by means of a problem in which the irrelevant cues of the second phase were made relevant. Analysis of the data of the third phase indicated that during the second phase, younger children had attended to the previously irrelevant stimuli more than the older children. The results of this study were consistent with the findings of develop-

mental incidental learning studies using both learning and memory tasks (eg. Maccoby & Hagen, 1965; Siegel and Stevenson, 1966; Siegel & Corsini, 1969) in that older children were found more likely than younger children to ignore irrelevant material.

A study by Siegel and Van Cara (1971) also found the decline in incidental learning performance, although the primary purpose of their study was to determine the effects of different types of reinforcement on 5-, 7-, and 9-year-old children's incidental learning. Subjects were presented a three-part successive discrimination task: Original learning, presentation of incidental stimuli and a test on the incidental material. Stimuli for the intentional task were drawings of a truck and an airplane. During second task, the truck and airplane were each shown on a slide with three other objects (the incidental stimuli). In the third task the six incidental stimuli and six new stimuli were shown individually. Subjects were asked whether they had seen the stimulus and if so, with the truck or with the airplane. The main effect of age was not significant although the trend of incidental learning was curvilinear. From inspection of the means, the decline in incidental performance appeared to be between grades seven and nine. Performance on the intentional task improved with age.

Hale, Miller, and Stevenson (1968) found a decline in incidental learning, when subjects viewed a film as the intentional task. Since they omitted all instructions concerning the film, this study represented a Type I incidental learning situation. Incidental learning, as measured by frequency of correct responses to 30 questions concerning

details of the film, was found to increase between grades three and six and to decline at grade seven. Girls had higher scores than boys, but the developmental trend was present in both sexes. This study would seem to make the decline a more general phenomenon because the task is so different from memory and learning tasks.

Most of the studies thus far reviewed using learning tasks have found an absence of increment in incidental learning performance in early adolescence or an actual decline in performance. Vaughan (1968) is an exception to these findings. He found a positive linear relationship between age and incidental learning. He attempted to equate incidental and intentional performance through clustering. Children in the first, fourth, and seventh grades were shown pictures of common objects. The pictures included four categories of objects (e.g., animals, clothing). Pictures of the same category appeared in sequence (cluster) for half of the subjects and randomly for the other half of the subjects. All children were told to make up a sentence about each picture. Half of the children were also told they should try to remember as many of the pictures as possible because they would be tested later (intentional group). Recall of the pictures was the same for children who had been told to remember the pictures as for those who had not. Clustering had a significant effect in that a greater number of pictures was recalled when clustered for both the intentional and incidental groups. The increment in incidental learning over age was probably not due to task differences, given that the task was similar to those used by previously reviewed studies. The reason for the increment over age may

have been due to the integral relationship between the central and incidental dependent measures, and this is discussed further under the subsection "Consideration of Materials and Dependent Measures," page 54.

Most of the studies using learning tasks tend to show different developmental trends for intentional as compared to incidental performance, at least for some age ranges. The trends for preschoolers are discrepant (e.g., Stevenson, 1954; Hale & Morgan, 1973), such that it is not clear whether incidental and intentional learning trends are similar during the early childhood years. During the middle childhood years, incidental and intentional performance are similar, in that both improve with age (e.g., Siegel & Stevenson, 1966; Vaughn, 1968; Siegel & Van Cara, 1971). At around age 11 or 12, however, incidental and intentional performance show dissimilar trends, in that incidental performance declines while intentional performance continues to improve (e.g., Siegel & Stevenson, 1966; Siegel & Van Cara, 1971). Major exceptions to these findings include Willoughby (1929, 1930) and Vaughn (1968). A few exceptions (e.g., Norton, 1958; Siegel, 1968) may be the result of a failure to include the appropriate age range to show the decline in incidental learning.

Studies using memory tasks. Maccoby and Hagen (1965) were the first investigators to report a decline in incidental learning around age 11 or 12. They tested children in the first, third, fifth, and seventh grades. The children were shown cards (one at a time) on which there were pictures and distinctively colored backgrounds. After each card was exposed, it was then placed face down in a row with the

other cards before the subject. The intentional task was to remember where a particular color (background) was in the row of cards. The experimenter displayed a color chip as the cue and the subject attempted to locate the card in the series that matched the chip. This basic task, remembering where stimuli were placed in a display, will be referred to as the "memory" task throughout this review. The incidental task, which followed several trials on the intentional task, was to match the pictures with the colors with which they had been paired on the cards. It was found that recall of incidental material improved slightly, though not significantly, between the first grade and the fifth grade. It was also found that recall of incidental material declined significantly between the fifth and seventh grades.

Hagen (1967) replicated Maccoby & Hagen (1965) with a slightly different memory task. His subjects were children in the first, third, fifth, and seventh grades. The children were shown cards on which there were pictures of household objects and animals. The intentional task was to remember the location of the animals. A control group had only the animals on the cards (one picture per card). The incidental task was to match the household object with the animal with which it had appeared. The control task (one picture per card) was significantly easier than the two-picture-per-card group. In general, central performance improved over age. Half the children had been tested under a distraction condition (high notes on a piano), and a decline in incidental performance was found with distraction. Without distraction there was no decline. Although Maccoby & Hagen (1965) did not find that

distraction affected production of the decline, Hagen did. No immediate explanation seems to account for these differences.

Maccoby and Hagen (1965) and Hagen (1967) measured performance on the central task immediately after each stimulus presentation but measured incidental learning at the end of intentional training. Using the memory task, Hagen and Sabo (1967) investigated whether there was a possible differential memory factor between the central and incidental measures. They also tested whether set (instructions) was the cause of differential recall of intentional versus incidental stimuli. They found that central performance improved with age and that incidental performance declined around the ninth grade. They also found a significant effect of instructions even when the testing order for incidental learning was counterbalanced.

Hagen, Meacham, and Mesibov (1970) also provided supportive evidence for the decline in incidental learning although they primarily were interested in labeling effects in the central and incidental learning of children in the fourth, sixth, and eighth grades. Using the memory task, they reported that labeling of central stimuli had no effect on central or incidental learning. A significant decline was found at the eighth grade for the "label" condition but not for the "no label" condition. Inspection of graphs revealed that incidental learning declined slightly from the sixth grade to the eighth grade in the no label condition, however.

Druker and Hagen (1967) also replicated the decline in incidental performance at the eighth grade. Using the memory task,

they investigated the role of perceptual discrimination on the ability of fourth, sixth, and eighth graders to process information selectively. Both the central and incidental cues on the stimulus cards were spatially separated. Spatial separation had no effect on central recall but had a detrimental effect on incidental recall. Generally, central recall scores improved with age.

Wheeler and Dusek (1973) replicated Druker and Hagen (1967) with younger children (kindergarten, third, and fifth grades). They found an absence of increment in incidental performance with grade level while central learning did show an increment with grade level. They also found, as Druker and Hagen had, that spatial separation had a detrimental effect on incidental learning but no effect on central learning. Labeling of central stimuli had a facilitative effect on central learning and a detrimental effect on incidental learning. Thus study is discrepant with earlier studies (Maccoby & Hagen, 1965; Hagen, 1967), which found increments in incidental performance with grade level until around the seventh or eighth grade.

Odom (1972) also found evidence supportive of the decline although he was exploring the development of perceptual and cognitive processes in kindergarten, third, and sixth grade children by varying dimensional salience. Using the memory task, he found that incidental performance declined as salience value declined. Inspection of Odom's mean errors for incidental recall from third to sixth grades indicates a slight decline when the central task had the more salient dimension as the solution (6.58 errors, third grade; 7.05 errors,

sixth grade). When the central task had the less salient dimension as the solution, the mean errors show improved incidental performance from third to sixth grade (7.70 errors, third grade; 6.42 errors, sixth grade). Most incidental learning research has probably used a more salient dimension as the solution to the central task. It is possible that the decline is specific to a situation where the more salient dimension is central and the less salient dimension incidental. Inspection of Odom's mean errors for central recall indicate slight improvement from third to sixth grade for the more salient group (3.38, 2.70 mean errors, respectively) but no change for the less salient group (4.83, 4.80 mean errors, respectively).

Implications of the memory task. Given that many studies have used the memory task to investigate incidental learning, it is important to consider the problems that this task raises for various age subjects. The length of the array of cards which subjects are asked to remember determines task difficulty and this factor has not been adjusted for developmental differences between subjects (e.g. Maccoby & Hagen, 1965; Hagen, 1967). In short, the same task, usually an array of 6 items (e.g. Maccoby & Hagen, 1965) and occasionally an array of 8 (e.g. Hagen, Meacham, & Mesibov, 1970) is given to children varying in age from 8 to 14. An absence of correlation between incidental and intentional performance reported by most investigators using the memory task (Maccoby & Hagen, 1965; Druker & Hagen, 1969; Hagen, 1967; Hagen & Sabo, 1967) has been interpreted as evidence that incidental and intentional performance are independent processes (Stevenson,

1970). Since the differential difficulty of the memory task across ages may have interacted with the investigated age ranges, correlations between incidental and intentional learning might have been masked. If the memory task were more nearly equated for difficulty developmentally, the relationships, if any, between incidental and intentional performance should become more evident. In general, studies using memory tasks have shown that intentional performance improves with age, while incidental performance improves only until early adolescence and then declines (e.g. Maccoby & Hagen, 1965; Druker & Hagen, 1967; Hagen & Sabo, 1967; Odom, 1972; Hagen, Meacham, & Mesibov, 1970). The results of studies using memory tasks are then very similar to those shown by studies using learning tasks (e.g. Siegel & Stevenson, 1966; Siegel & Van Cara, 1971). The consistency of findings concerning developmental trends in incidental and intentional learning indicate that the task differences that exist within nonverbal tasks (both learning and memory) are probably not responsible for observed performance differences in incidental and intentional learning.

Consideration of Materials and Dependent Measures. The materials used for nonverbal learning and memory tasks with subjects from age 8 to 14 have included colors (e.g. Maccoby & Hagen, 1965), pictures (Hagen, 1967), shapes (Crane & Ross, 1967) and words (Norton, 1958). Results generally have shown a decline in incidental learning in early adolescence despite variability of materials (e.g. Maccoby & Hagen, 1965; Siegel & Stevenson, 1966). An exception is Norton, (1958)

but she failed to include the appropriate age range to show the decline. Other studies have provided supportive evidence for the decline (e.g. Crane & Ross, 1967). In addition, the correlation between incidental and intentional learning generally has been shown to be nonsignificant (e.g. Hetherington & Banta, 1962; Siegel & Stevenson, 1966; Druker & Hagen, 1967).

A study showing the importance of materials in replicating the decline and absence of correlation between intentional and incidental learning was reported by Hale and Piper (1973). Using the memory task, they assessed 8- and 12-year-old's incidental learning of stimuli whose components were separate pictures (as in typical nonverbal developmental studies of incidental learning) and geometric figures (whose central and incidental components were shape and color, respectively). Incidental learning improved across age only with the integrated components (the colored geometric figures). Central learning improved across age. The second experiment assessed the two original stimuli in addition to three others: Shape outlines on colored background, shapes adjacent to colored patches, and pictures adjacent to colored patches. Incidental learning again improved across age for the colored shapes ("integrated components"), but not for the other stimuli. Hale and Piper concluded that integrated components, such as colored shapes, are different than "spatially independent components." When pictures are integrated such that subjects are able to perceive the incidental stimulus in conjunction with the intentional stimulus, a correlation between intentional and incidental learning would seem

more likely to be found. The studies using nonverbal tasks have typically used dependent measures for incidental learning that are not integral to the intentional task (e.g. Siegel & Stevenson, 1966; Maccoby & Hagen, 1965). Siegel and Stevenson (1966) had subjects respond to incidental stimuli that had been paired with the correct discriminative stimuli. Their incidental stimuli were unnecessary to successful performance on the intentional task. Maccoby & Hagen (1965) had subjects remember incidental stimuli that had been paired with intentional stimuli. Again performance on the intentional task did not depend upon attention to the incidental stimuli.

A Type I developmental study that used subjects at early adolescence and a film as the stimulus material (Hale & Miller, 1968) also found the decline in early adolescence. The plot of the film was assumed to be more central than the details of the film which were used as the incidental material. Hale & Miller did not ask questions concerning the plot, but they did suggest that 11- or 12-year olds should do well on questions concerning the plot of the film. Willoughby (1929, 1930) found an improvement over age for both central and incidental learning, even through early adolescence. The discrepancy of Willoughby's findings with those of other studies using nonverbal tasks was possibly due to the nature of the incidental and intentional dependent measures. Willoughby's subjects were asked to write down repetitious associations which were usually available as the intentional task. They could rely upon either vision or memory to perform the task, but successful performance depended upon memory. Subjects asked to recall the associations

as incidental material might rely on the same associations required in the intentional task. Vaughn (1968) also found a positive linear relationship between age (first, fourth, and seventh grades) and incidental learning. He arranged pictures of the same category in a sequence (clustering) for some subjects but randomly for others. In this case, the central task required children to focus on and use the incidental stimuli.

Theoretical Interpretations. Maccoby and Hagen (1965) attributed the decline in incidental learning in early adolescence to the incomplete merging of two growth periods. The first growth period, characteristic of younger children, emphasizes labeling objects and making note of everything at once. The second period, characteristic of adults and adolescents, emphasizes elimination of irrelevant (incidental) material early in the task. A child of 11 or 12 is thought to be caught between the first and second growth periods. The incomplete merging produces a temporary decline in incidental performance because the child is concentrating on the intentional task to the exclusion of the incidental task. Incidental performance improves with age after the two growth periods merge possibly because the older adolescent and adult are adept at the intentional task, a situation which allows them the opportunity to also learn incidental material. If an adult were not able to perform the intentional task easily, incidental performance might still be low because of the required attention to the intentional task.

Druker and Hagen (1969) identified two strategies, "verbal labeling" and "focused visual scanning" which were better utilized by older children to learn central material. They suggest that labeling and focused scanning are particularly effective for the older subject. When instructions are clear, instructions to attend to a central task are not as effective with younger subjects because they have strategies which predispose them to retain everything (both the central and incidental material). When an older subject follows central instructions well by using focused visual scanning and labeling, it may contribute to a decline in incidental performance relative to earlier age groups.

A study by Siegel and Corsini, (1969) investigated an attentional explanation rather than simply assuming that attention is important. Siegel and Corsini attempted to identify the attentional differences in 8- and 14-year-olds. They found that 14-year-olds profited from related peripheral materials; whereas, 8-year-olds did not. When materials were unrelated, 14-year-olds and 8-year-olds performed the same. Siegel and Corsini concluded that the 8-year-old is unable to attend while, the 14-year-old fails to attend. One question pertinent to this review is what is the case with the 11- and 12-year-old? If he is caught somewhere between inability and failure to attend, Siegel & Corsini's explanation would be consistent with the conception of the incomplete merging of two growth periods (Maccoby and Hagen, 1965).

Hagen & Sabo (1967) note that there is little in the developmental literature which indicates a change in cognitive processing at age 11 or 12 with the exception of Piaget. They suggest that it would not be possible to enter formal operations unless the ability to separate irrelevant from relevant information is present. However, it seems that this rather vague explanation would apply to conscious, intentional activity rather than incidental learning.

The typical conception that older children ignore irrelevant material may be relevant to earlier conceptions of attention, intent to learn, and conscious awareness. Older children are better at following instructions and consciously attending to designated materials The idea of older children ignoring irrelevant material would explain the decline in incidental performance but not necessarily its subsequent improvement. The difficulty of the intentional task may be less for older adolescents and adults such that some attention could be given to incidental material without hampering intentional performance. This idea of easy mastery of the intentional task for the older adolescent and adult might account for the upward trend in incidental learning after the decline at age 11 or 12. Obviously if the intentional task were developmentally equated for early adolescents and adults, no improvement in incidental learning would be expected.

All of the previous explanations assume that developmental differences exist in incidental learning performance around age 11 or 12. Finding the decline with nonverbal studies or not finding it with verbal studies does not conclusively show that these developmental

trends are due to real subject differences in the nonverbal studies or that the trend is necessarily absent in verbal studies.

Adults

Developmental studies of incidental learning using nonverbal tasks with adults have consistently shown no change with age or very small decrements with age. The developmental trend for intentional learning is typically very similar to that of incidental learning. Given that results are relatively consistent, methodological differences between nonverbal studies with adults are probably not crucial in the determination of developmental trends in incidental and intentional learning. Willoughby (1929, 1930) and Bromley (1958) used similar tasks and dependent measures of incidental and intentional performance that were highly related, and both found decrements in incidental and intentional performance over age. Bromley (1958) administered the Wechsler-Belleue Test to subjects in their 20s, 40s, and 60s as the intentional task. The incidental test was the recall of the eleven subtests.

Hulicka (1965) used a task that was much different from that of Willoughby (1929, 1930) and Bromley (1958) as well as dependent measures of incidental and intentional learning which were relatively unrelated. He showed subjects (aged 30-39, 60-75, and 76-89) pictures of seven faces, each paired with a name and a city. The intentional task was to learn the face and name. The incidental test was for associations of faces and cities. He found no differences in incidental or intentional learning over age as compared to the decrements

reported by Bromley (1958) and Willoughby (1929, 1930).

A study by Wimer (1960) provides evidence that the developmental trends of incidental and intentional learning are dissimilar. His subjects, over 65 and under 30 years, read six words each of which was printed in a different color. All subjects were told they were participating in a speed reading experiment. Half of the subjects of each age group were also instructed to remember the color in which the words were printed. The other half of the subjects received no additional instructions. All subjects were subsequently tested for recognition of the word-color combinations. Scores of the older subjects were the same in the intentional and incidental conditions; whereas, younger subjects in the intentional condition were superior to younger subjects in the incidental condition. Younger and older subjects in the incidental condition did not differ from each other.

DEVELOPMENTAL STUDIES WITH VERBAL TASKS

Verbal learning studies of incidental learning have been prevalent in the literature for a long time (Postman & Senders, 1946; Postman & Page, 1947; Postman & Phillips, 1954; Postman & Riley, 1959; Postman & Phillips, 1961; Postman, Adams, & Phillips, 1955; Postman, Adams, & Bohm, 1956; Postman & Adams, 1960; Postman & Adams, 1956(a)(b), 1957, 1958; and Postman, 1962(a)(b).

Developmental studies of incidental learning with verbal tasks are comparatively more recent (e.g., Palermo, 1961; Kausler & Gotway, 1969; Kausler & Lair, 1965; Cole & Kanak, 1972; Deichmann, Speltz, & Kausler, 1971) and consistently show no increment in incidental learning

over age with child subjects. Thus, the decline in incidental around age 11 or 12 found in studies using nonverbal methodology is absent in studies using verbal methodology. The purpose of this section is to consider task and dependent variable differences between nonverbal methodologies in relation to observed developmental trends.

Children

The children who have been subjects for verbal learning tasks have ranged from kindergarten to eighth grade. Developmental findings have been generally consistent for children in this age range within a particular task. Two tasks have been used: paired-associate and verbal discrimination.

Verbal studies of incidental learning, using a paired-associate task and R-S recall as the incidental dependent measure, have typically found an invariant relationship across age as compared to the curvilinear relationship found in nonverbal studies (e.g., Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972). A study using a verbal discrimination task has shown an increment over age for incidental performance but no evidence for a decline around age 11 or 12 (Deichmann, Speltz, and Kausler, 1971). Central performance generally improves with age for both nonverbal and verbal tasks.

Consideration of age and task. A study by Palermo (1961) was one of the earliest designed to determine whether backward associations (R-S learning) occur in children's paired-associate learning and whether the strength of such associations varies with age. R-S learning is considered incidental in that subjects are not instructed to

learn backward associations. Fourth and sixth grade children learned a list of six picture paired associates followed by the learning of a second list of six picture paired associates. The second list contained associations learned in the first list, backward associations relative to the first list, and some new associations. No differences between grade levels on R-S associations were found. S-R associations on the first list improved with age.

Kausler and Gotway (1969) measured R-S learning in kindergarten, second fourth, and sixth grade children following the reaching of one perfect S-R trial on a paired-associate list (six pairs, with pictures as the stimulus and response items). S-R learning improved across age levels, but there was no change in R-S recall performance with age.

Colé and Kanak (1972) measured S-R and R-S recall across first, third, fifth, and seventh grade levels. Subjects learned a paired-associate list of seven pairs of familiar pictures to a criterion of one perfect trial, followed by modified free recall. Incidental (R-S) performance was found to be invariant across age levels; whereas, intentional (S-R) performance improved with age.

Deichmann, Speltz, and Kausler (1971) investigated developmental trends in both the intentional and incidental components of a verbal discrimination task. Immediately following attainment of the intentional criterion, fourth, sixth, and eighth grade children were tested for incidental recall of the right item (word) from the verbal discrimination list upon seeing the wrong item. There was a direct relationship between age and amount of incidental learning, but no evidence for a decrement after the sixth grade.

Adults

Kausler and Lair (1965) compared subjects of mean ages 35 and 56 on paired-associate learning performance. S-R learning did not differ with age but the younger group had significantly better R-S performance. This study is inconsistent with Wimer (1960) who found that his subjects under 30 did better on intentional performance but not on incidental performance. Still this study shows, as Wimer (1960) did, that the developmental trends in intentional and incidental learning differ in young adults.

OVERVIEW OF VERBAL AND NONVERBAL METHODOLIGICAL CONSIDERATIONS

Central learning performance has generally shown improvement over age for most verbal and nonverbal methodologies, while incidental learning has shown discrepancies between these methodologies. Specifically, incidental performance in memory studies generally improves with age until early adolescence and then declines or fails to improve (e.g., Maccoby & Hagen, 1965; Hagen, 1967; Druker & Hagen, 1969; Hagen & Sabo, 1967). Other studies with tasks such as successive discrimination have reported the trends found with memory tasks (e.g., Siegel and Stevenson, 1966). Incidental performance on paired-associate tasks is essentially invariant in the same age span (Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972). A study using a verbal discrimination task showed improvement with age in incidental learning (Deichmann, Speltz, & Kausler, 1971).

When correlations have been reported between intentional and incidental learning, they usually have not been significant, either

for verbal or nonverbal methodologies. This has prompted theoretical statement that incidental and intentional learning may be distinct processes (Stevenson, 1970).

Type of Task and Dependent Measure. The two tasks that seem to produce the most discrepant results are the meory and paired-associate tasks. In the memory task the subject is asked to remember a group of things for a short time. Specifically, the subject is ased to view a series of cards, one at a time, and remember where a particular instance of a category is. He is subsequently tested for memory for instances of other categories to which he was exposed but not initially asked to remember. Memory of the card's location does not require associations between the stimuli on the cards. Incidental performance might be relatively poor due to the extrinsic nature of the incidental dependent measure in relation to the intentional task. In addition, memory tasks usually do not show improvement over trials such that the intentional task would not become easier and consequently allow attention to be focused on incidental material. In the paired-associate task the subject is asked to learn a series of associations by anticipating them one at a time. He is subsequently tested for recall of R-S associations. The dependent measure (RS recall or recognition) is integral to the intentional task, at least in comparison to the memory task, because the subject must repeatedly focus on the incidental material in order to perform the intentional task. The paired-associate task shows improvement over trials, such that it becomes easier as trials progress. Thus, more attention can be focused on incidental material. In comparing memory and paired-associate tasks, one would expect better incidental perfor-

mance on the paired associates because of the intergral relation of incidental material to the intentional task.

The absence of increments in R-S learning with increasing age has been taken as evidence against an incidental learning interpretation of R-S phenomena (cf. Ekstrand, 1966). Goulet (1968) noted that if R-S recall is a variant of incidental learning, increments in incidental learning through the sixth grade should be found with R-S learning as have been obtained with nonverbal tasks. Within the nonverbal methodologies the integral incidental dependent measure (in relation to the intentional dependent measure) did not show the decline. The paired-associate task and verbal discrimination task also have integral incidental dependent variables. R-S associations are different from incidental dependent measures which showed the decline in that they are more likely to be learned in conjunction with mastery of intentional material. It has been suggested that R-S associations may even be formed during performance on the intentional S-R task (Asch & Ebenholtz, 1962). In the verbal discrimination task the incidental dependent measure is also integral to the intentional dependent measure. It is important to note that although dependent measures differ radically for verbal and nonverbal methodologies, materials do not. Specifically, verbal tasks used pictures as stimuli, and most nonverbal tasks also used pictures or colors. It may be that specific materials (e.g., colors) may be easier to acquire incidentally than other materials (e.g., objects); however, there is no evidence on this question at this time.

Degree of Opportunity in the paired-associate task and difficulty of the memory task. It should be noted that studies using memory tasks (e.g., Maccoby and Hagen, 1965; Hagen, 1967; Hagen and Sabo, 1967; Druker and Hagen, 1969) provided a constant number of trials on the same task to all subjects. Siegel and Stevenson (1966) imposed a criterion on the original discrimination but during the second phase gave a constant number of trials exposing the subject to incidental stimuli. Crane and Ross (1967) took subjects to criterion initially and then gave them a common number of trials with the irrelevant cue. Studies using paired-associate tasks (e.g., Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972) took subjects to a designated criterion. Thus, the point at which subjects are noramally tested in nonverbal methodology is after a designated number of exposures to the incidental material. The point of which subjects are tested in verbal methodology is following practice to a common criterion.

With verbal methodology the possibility exists that observed incidental performance is specific to the degree of mastery of the intentional task (criterion). In studies using paired-associate tasks (e.g., Palermo, 1961; Kausler & Gotway, 1969; Cole & Kanak, 1972), subjects were taken to a designated criterion on the intentional task and then tested for incidental performance. Although equivalent mastery of the intentional task was assumed, it may not have been attained due to differential subject abilities. Subjects at different ages vary in the times at which they reach criterion. There is

evidence to show that incidental performance varies with the degree of mastery of the intentional task with adult subjects (Bahrick, 1957; Saltzman & Atkinson, 1954; Brown, 1954). Bahrick (1957) found that most incidental learning occurs during the very early trials and during the trials devoted to overlearning. A plateau or slight decline in incidental learning was found when subjects were tested at criterion. Thus, Bahrick concluded that incidental and intentional learning are to some extent complementary, with incidental learning occurring primarily when the subject is either uncertain of, or less motivated in relation to, the task set by the experimenter.

With the nonverbal methodology (memory studies), the same central task is used for all age levels. It is therefore possible that difficulty of the memory task (e.g., length of array) affects incidental performance. If the central task were optimal for 11 or 12 years, one might expect good central performance but poor incidental performance. The subject would be unable to adequately learn both central and incidental material. If the central task were relatively easy for older subjects, one might expect both central and incidental performance to be high. Older subjects would be expected to perform the easy task and also learn incidental material. If the central task were relatively difficult for younger subjects, one might expect incidental performance to be low if the subject focused on the central material. If the subject failed to focus on the central task,

incidental performance would be expected to be relatively bettern than that of the 11- or 12-year-old who is learning the central material by excluding the incidental material.

CONCLUSIONS AND IMPLICATIONS FOR RESEARCH

It is not clear just how related incidental and central learning are, but their developmental trends are not necessarily parallel. Central learning generally improves with age. With nonverbal methodology incidental learning has shown an improvement over age until early adolescence, when it declines slightly. Incidental learning again improves in later adolescence and adulthood. With verbal methodology incidental learning has shown an invariant relationship over the middle childhood years. Studies with adults using various methodologies generally show invariance or a slight decline in late adulthood.

In general, theoretical interpretations of the decline in incidental performance at age 11 or 12 have been vague and strikingly similar to each other. The original explanation of the decline (Maccoby & Hagen, 1965) is still representative of most theoretical efforts. Typically, the child of 11 or 12 years is assumed to in the process of learning to effectively focus attention on intentional aspects of a task. Thus, incidental material is not as readily learned by the 11- or 12-year-old as is intentional material. A younger child is assumed to learn more incidental material than the 11- or 12-year-old because he attends to both incidental and intentional material. Presumably, an older child or adult is able to effectively learn both intentional

and incidental material, primarily because of his generally superior cognitive abilities.

A number of variables have been observed to contribute to incidental learning in children: the salience and spatial separation of stimulus materials, the labeling of intentional stimuli, and the related nature of the incidental materials and dependent measures to the intentional task. Other variables (the difficulty of the intentional task and the amount of training in the intentional task) which would seem important, but have not yet been investigated in children, will also be summarized.

Variables which make the intentional task more taxing generally interfere with incidental performance. For instance, highly salient incidental stimuli or labeling of intentional stimuli interfere with incidental performance (Odom, 1972; Wheeler & Dusek, 1973). Spatial separation interferes more with incidental performance than with intentional performance, but it doesn't improve intentional performance (Druker & Hagen, 1969). Although intentional memory load has not been systematically investigated, it is possible that a heavy memory load would also interfere with incidental performance.

Variables which make the intentional task more highly related to the incidental task generally facilitate incidental performance. "Integrated" materials (Hale & Piper, 1973) and highly related dependent measures, such as R-S recall (Kausler & Gotway, 1969), show better incidental performance than relatively unrelated materials (Hale & Piper, 1973) and dependent measures (Maccoby & Hagen, 1965).

An increased amount of training on the intentional task has been found with adult subjects to improve incidental performance (Bahrick, 1957). It is reasonable that this variable would also be important in children's incidental performance. Siegel (1968) found that amount of exposure to incidental stimuli was not crucial, but he was using incidental materials and dependent measures which were relatively unrelated to the intentional task. Perhaps if there were a greater relationship between incidental and intentional dependent measures and materials (e.g. R-S recall), amount of training would improve incidental performance.

All of these variables are important to incidental performance, but some of them seem important to the understanding of observed developmental trends, specifically the decline at age 11 or 12. The decline is typically found with materials and dependent measures which are relatively unrelated to the intentional task. It is also found with a moderately difficult intentional task (e.g. memory load) for 11- or 12-year-olds. The studies showing the decline typically have used the same intentional task for all subjects. This procedure results in a relatively more difficult task for younger subjects and a relatively less difficult one for older subjects. The decline is not observed in a paired-associate learning task at a criterion level of intentional performance.

A number of methodological differences obviously confound the interpretation of developmental findings in incidental learning. Results of verbal studies using a paired-associate task and R-S recall as the dependent measure show no similarity to nonverbal studies using a memory task and memory of associations between pictures as the dependent measure.

In addition, amount of intentional training may be a significant factor which has not been investigated with learning tasks (e.g., paired associates). Difficulty of task in memory studies has not been equated developmentally, such that results of incidental learning studies may be partially due to the relative difficulty of the task for various ages of children. In addition, type of materials (e.g., "integrated" versus extrinsic components) has been shown to affect incidental performance. Thus, it is not clear whether observed developmental differences are real or merely methodological artifacts. It is possible that developmental differences are real but tied to specific methodologies.

Given that task, materials, and dependent measures differ so in the memory and paired-associate tasks and that these discrepancies point to different developmental trends, it is proposed that a memory and paired-associate task be equated for materials and learning opportunity. The present comparisons of verbal and nonverbal methodologies leave many questions unanswered. If the memory and paired-associate tasks were more nearly equivalent methodologically, a more realistic appraisal of verbal and nonverbal developmental trends in incidental learning could be made.

Since opportunity for mastery of the intentional task has been shown to affect incidental performance, it is proposed that different numbers of trials (e.g., 2, 4, 6 trials) be given subjects in a paired-associate task. Subjects would be tested for incidental learning at the end of 2, 4, and 6 trials of intentional practice. It is also proposed that the memory task array of cards be varied (e.g., array of

4 and array of 6) for several ages. If difficulty of the memory task affects incidental performance, it should be readily apparent.

More specifically, the research to be accomplished as a consequence of this review will consist of three studies. The first study will compare incidental learning performance in a paired-associate and memory task under conditions of comparable methodology. An attempt will be made to equate paired-associate and memory tasks on stimulus materials, dependent measures, and learning opportunities (number of trials). Cards on which pictures of animals and objects appear on colored paper will be the stimuli for both the paired-associate and memory tasks. For paired associates, the intentional task will require the association of the objects (S-items) with the animals (R items). For the memory task, intentional learning will require the subjects to find the location of a specific animal in a series of cards that are first exposed and then placed face down. Incidental learning will be measured in terms of recognition matching of colors and objects with appropriate animals. These measures represent relatively unrelated and related measures of incidental learning for the paired associate task. Both measures would be unrelated in the memory task. All subjects will be tested on both colors and objects; and the order of testing for color and object (either first or second) will be counterbalanced. Four age levels, spanning the years before and after that in which the decline is typically observed, will be investigated: grades 3, 5, 7, and 9.

The second study will investigate the relationship between degree of mastery on the intentional task and incidental learning per-

formance. The paired-associate task with the same materials and dependent measures as in the first study will be used. Three levels of training (2, 4, and 6 trials) and four grade levels (3, 5, 7, and 9) will be examined in a factorial fashion. The chief aim of this study will be to see if the degree of mastery on the intentional task is related to incidental performance in general, and specifically to the decline that is typically observed at adolescence with nonverbal tasks.

The third study will attempt to determine the extent to which difficulty of the memory task (memory load) affects incidental performance in the age range for which the decline has been observed. The same memory task, materials, and dependent measures will be used as in the first study. Two levels of difficulty (arrays of 4 and 6 cards) and four grade levels (3, 5, 7, and 9) will be investigated.

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APPENDIX B

STATISTICAL TESTS

EXPERIMENT I

SUMMARY TABLE FOR 2 (TASKS) BY 4 (GRADES) X 2 (ORDER) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON THE NUMBER OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	6.778	255		
Between	11.212	127		
A TASK	911.285	1	215.1452	.0001
B GRADE	0.171	3	0.0403	.9886
C ORDER	1.410	1	0.3329	.5723
D SEX	5.941	1	1.4027	.2374
AB	2.931	3	0.6920	.5625
AC	8.629	1	2.0372	.1530
AD	0.035	1	0.0083	.9249
BC	1.931	3	0.4559	.7178
BD	3.983	3	0.9404	.5738
CD	0.473	1	0.1116	.7385
ABC	4.462	3	1.0535	.3734
ABD	2.681	3	0.6330	.5994
ACD	0.004	1	0.0009	.9744
BCD	3.243	3	0.7658	.5189
ABCD	10.421	3	2.4602	.0662
Error (b)	4.236	96		
Within	2.379	128		
E (Stimuli: Color & Object)	11.816	1	6.1442	.0142
AE	43.066	1	22.3934	.0001
BE	1.379	3	0.7170	.5474
CE	4.785	1	2.4883	.1140
DE	0.473	1	0.2458	.6271
ABE	4.483	3	2.3311	.0778
ACE	10.160	1	5.2830	.0223
ADE	5.348	1	2.7806	.0947
BCE	2.410	3	1.2532	.2942
BDE	1.077	3	0.5599	.6470
CDE	0.316	1	0.1645	.6888
ABCE	1.764	3	0.9174	.5624
ABDE	1.806	3	0.9391	.5732
ACDE	0.316	1	0.1645	.6888
BCDE	0.816	3	0.4245	.7396
ABCDE	0.796	3	0.4137	.7472
Error (w)	1.923	96		

EXPERIMENT I - PA TASK

SUMMARY TABLE FOR 4 (GRADES) X 2 (ORDER) X 2 (SEXES)

X 2 (STIMULI: COLOR AND OBJECT) ON THE NUMBER

OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	2.431	127		
Between	2.710	63		
A GRADE	1.031	3	0.3462	.7946
B ORDER	1.531	1	0.5140	.5163
C SEX	2.531	1	0.8497	.6359
AB	2.615	3	0.8776	.5383
AC	2.198	3	0.7378	.5376
BC	0.281	1	0.0944	.7579
ABC	1.948	3	0.6538	.5880
Error (b)	2.979	48		
Within	2.156	64		
D (Stimuli: Color & Object)	50.000	1	37.2093	.0001
AD	3.208	3	2.3876	.0794
BD	0.500	1	0.3721	.5517
CD	4.500	1	3.3488	.0700
ABD	1.208	3	0.8992	.5493
ACD	0.375	3	0.2791	.8416
BCD	0.0	1	0.0	1.0000
ABCD	1.375	3	1.0233	.3918
Error (w)	1.344	48		

EXPERIMENT I - MEMORY TASK

SUMMARY TABLE FOR 4 (GRADES) X 2 (ORDER) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON THE NUMBER OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	4.003	127		
Between	5.426	63		
A GRADE	2.070	3	0.3770	.7730
B ORDER	8.508	1	1.5491	.2170
C SEX	3.445	1	0.6273	.5620
AB	3.779	3	0.6880	.5671
AC	4.466	3	0.8132	.5044
BC	0.195	1	0.0356	.8454
ABC	11.716	3	2.1332	.1071
Error (b)	5.492	48		
Within	2.602	64		
D (Stimuli: Color & Object)	4.883	1	1.9511	.1655
AD	2.654	3	1.0604	.3755
BD	14.445	1	5.7721	.0191
CD	1.320	1	0.5276	.5221
ABD	2.966	3	1.1852	.3252
ACD	2.508	3	1.0021	.4013
BCD	0.633	1	0.2529	.6232
ABCD	0.237	3	0.0947	.9618
Error (w)				

EXPERIMENT II

SUMMARY TABLE FOR 3 (TRIALS) X 4 (GRADES) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON THE NUMBER OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	5.809	239		
Between	8.044	119		
A TRIALS	156.801	2	28.8702	.0001
B GRADE	7.528	3	1.3861	.2506
C SEX	32.266	1	5.9408	.0158
AB	3.778	6	0.6956	.6558
AC	3.217	2	0.5923	.5602
BC	9.268	3	1.7064	.1694
ABC	1.749	6	0.3221	.9236
Error (b)	5.431	96		
Within	3.592	120		
D (Stimuli: Color & Object)	106.668	1	43.5736	.0001
AD	1.317	2	0.5380	.5912
BD	6.245	3	2.5511	.0590
CD	6.018	1	2.4584	.1162
ABC	7.260	6	2.9657	.0107
ACD	1.116	2	0.4558	.6412
BCD	1.571	3	0.6419	.5937
ABCD	1.905	6	0.7783	.5905
Error (w)	2.448	96		

EXPERIMENT II - TWO-TRIAL DATA

SUMMARY TABLE FOR 4 (GRADES) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON COLOR AND OBJECT SCORES ON THE NUMBER OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	3.661	79		
Between	3.159	39		
A GRADE	6.800	3	2.4126	.0839
B SEX	6.050	1	2.1463	.1492
AB	2.183	3	0.7746	.5194
Error (b)	2.819	32		
Within	4.150	40		
C (Stimuli: Color & Object)	39.201	1	15.2607	.0007
AC	12.933	3	5.0348	.0059
BC	1.251	1	0.4869	.5029
ABC	1.516	3	0.5903	.6296
Error (w)	2.569	32		

EXPERIMENT III

SUMMARY TABLE FOR 2 (ARRAYS) X 4 (GRADES) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON THE NUMBER OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	3.031	159		
Between	3.904	79		
A ARRAY	18.906	1	4.9713	.0275
B GRADE	4.941	3	1.2991	.2817
C SEX	0.308	1	0.0809	.7739
AB	3.590	3	0.9440	.5735
AC	6.007	1	1.5795	.2109
BC	3.389	3	0.8913	.5471
ABC	1.355	3	0.3564	.7874
Error (b)	3.803	64		
Within	2.169	80		
D (Stimuli: Color & Object)	3.308	1	1.6776	.1971
AD	0.006	1	0.0031	.9546
BD	1.256	3	0.6370	.5977
CD	1.805	1	0.9156	.6559
ABD	2.022	3	1.0256	.3883
ACD	1.057	1	0.5361	.5265
BCD	4.489	3	2.2767	.0869
ABCD	5.940	3	3.0121	.0357
Error (w)	1.972	64		

EXPERIMENT III

SUMMARY TABLE FOR 2 (ARRAYS) X 4 (GRADES) X 2 (SEXES) X 2 (STIMULI: COLOR AND OBJECT) ON THE PROPORTION OF CORRECT RECOGNITIONS OF COLORS AND OBJECTS

Source	M.S.	df	F	p
Total	.121	159		
Between	.152	79		
A ARRAY	.403	1	2.7830	.0963
B GRADE	.253	3	1.7475	.1649
C SEX	.000	1	.0030	.9554
AB	.198	3	1.3683	.2595
AC	.238	1	1.6401	.2022
BC	.160	3	1.1061	.3536
ABC	.075	3	0.5201	.6742
Error (b)	.145	64		
Within	.091	80		
D (Stimuli: Color & Object)	.146	1	1.7306	.1900
AD	.008	1	0981	.7534
BD	.035	3	.4175	.7446
CD	.055	1	.6501	.5714
ABD	.067	3	.7977	.5025
ACD	.025	1	.2909	.5981
BCD	.188	3	2.2315	.0918
ABCD	.247	3	2.9240	.0397
Error (w)	.084	64		

APPENDIX C

INSTRUCTIONS

The instructions for the paired-associate task were as follows:

This is a task to see how well you remember. See these animals. I have these same animals on cards on this machine (Experimenter shows board of animals and points to the Card Master). On this side a little window will open up and you will see a drawing of an object (points to left aperture). A few seconds later the little window on this side (points to right aperture) will open and you will see a drawing of an animal. Your job is to guess which animal is going to appear before the second window opens. In the beginning you will make a lot of mistakes but as you learn how it goes, you won't make so many mistakes. Just guess the first few times until you can remember. Now, before we begin, let's see if you can name these animals for me (points to animals on board).

The instructions for the short term memory task were as follows:

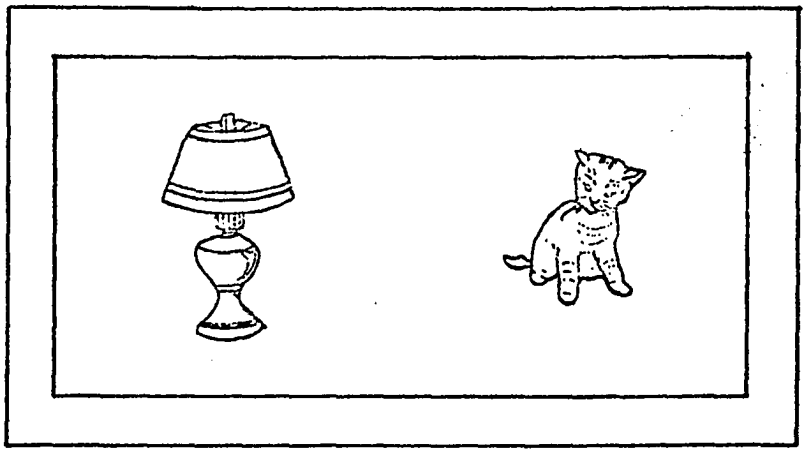
This is a task to see how well you remember. See these animals (Experimenter shows board of animals). I have these same animals on these cards (shows deck of eight cards). The way the task works is like this - I will show you one of the cards, and then I will lay the card down like this in a row (demonstrates by laying the eight cards face down one at a time in a row on the table). Then I will point to one of these animals (points to board of animals) and we will see if you remember where that animal is in the row. OK? Then I will pick up the cards and let you see again where each animal was. Now just before we begin, let's see if you can name these animals for me (points to animals on board).

Instructions for the Incidental Test

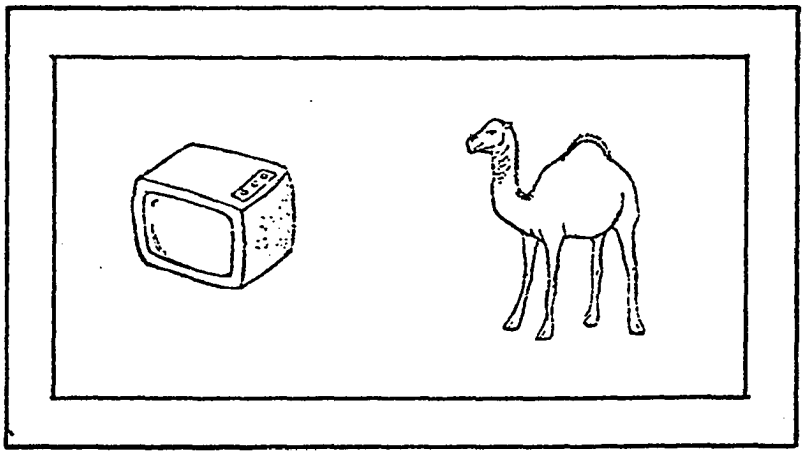
Ok, here are those other pictures (or colors depending on whether the subject was being tested for object or color first) that were on the cards (the experimenter holds up the second board with all the household objects), and here's one of the animals (points to a plain white card with a black line drawing of an animal). I want to see if you can remember which one of these objects (or colors) went with this animal.

APPENDIX D

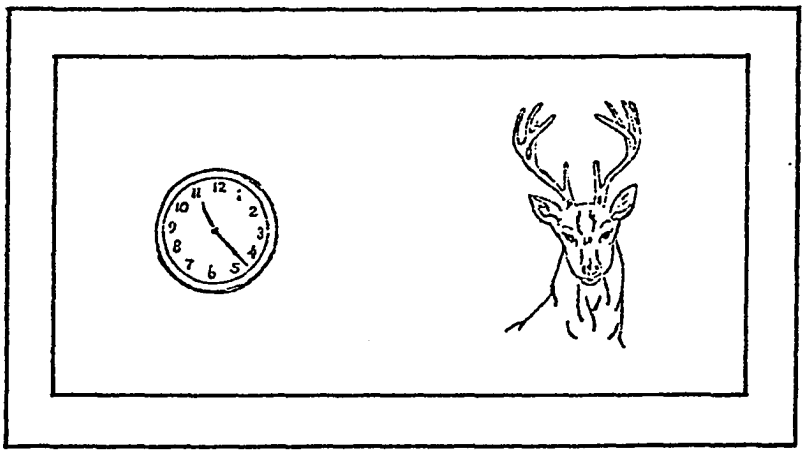
STIMULUS CARDS



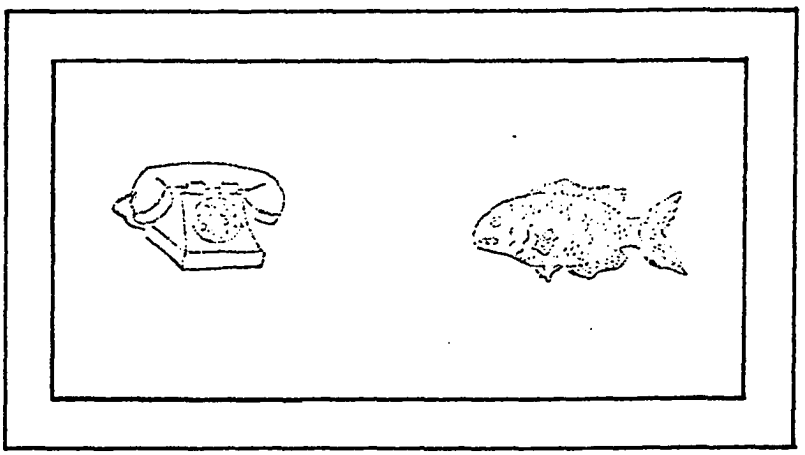
Card Color: RED



Card Color: YELLOW

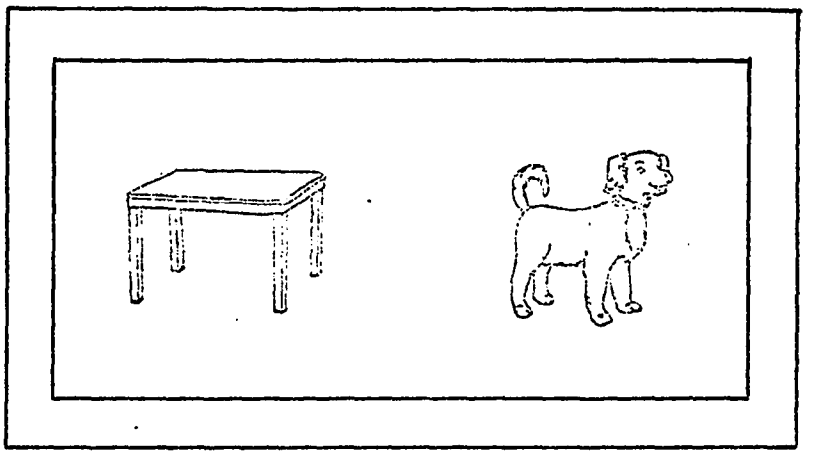


Card Color: BROWN

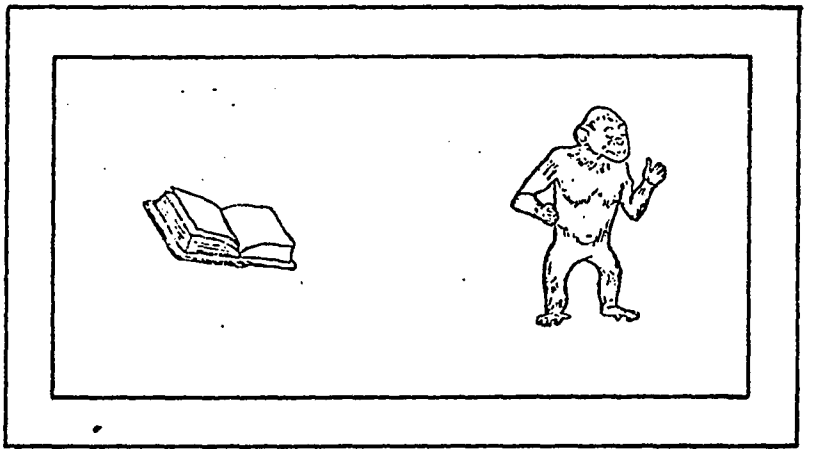


Card Color: PINK

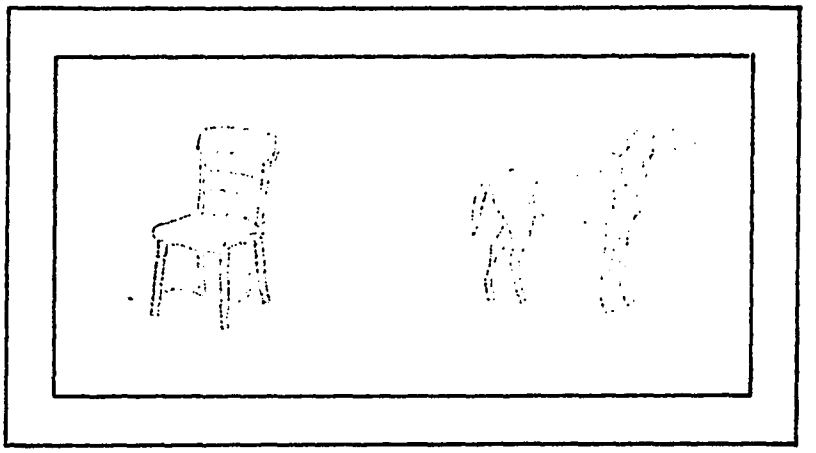
The cards, as depicted here, have been reduced one-third in size.



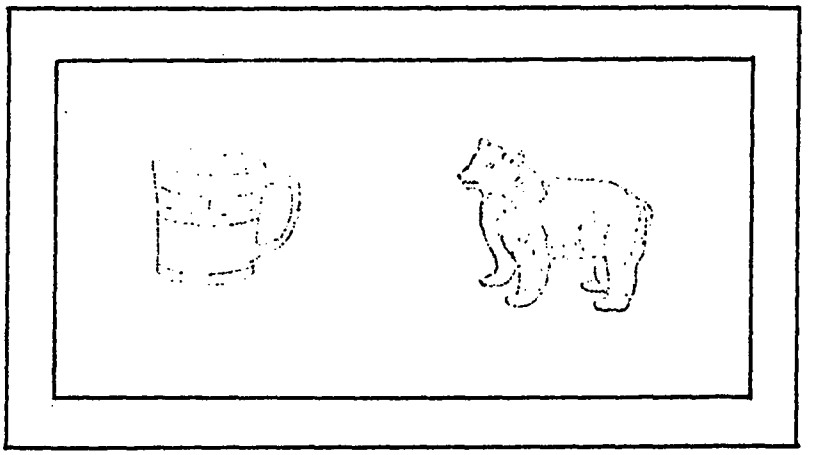
Card Color: GREEN



Card Color: WHITE



Card Color: ORANGE



Card Color: BLUE

The cards, as depicted here, have been reduced one-third in size.

APPENDIX E

RAW DATA

EXPERIMENT I

GRADE 3

	INTENTIONAL TRIALS	INCIDENTAL TRIALS		
		Object	Color	
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	Yoke to PA
M 1	4 5 7 7 8	X X X X X X X X	B X X X X X X X	
M 2	2 1 2 1 5 4 6 5 5 6 7 6 7 6 8	X X X X X X X X	R X X X X X X X	
M 3	4 5 6 7 8	X X X X X X X X	N X P Y X X X X	
M 4	3 3 3 4 5 4 8	X X X X X X X X	X X X X X X X X	
F 5	0 1 0 1 2 3 1 2 3 2 2 2 5 5 4 3	X X B R X P C X	B G W X X W X X	
F 6	2 1 3 4 4 5 5 6 6 6 7 7 7	X X X X X X X X	X X X Y X X X X	
F 7	3 3 7 7 8	X X X X X X X X	X X X X X X X X	
F 8	3 7 8	X X X X X X X X	X X X X X X X X	
M 9	2 2 5 3 4 7 7 7 8	X X X X X X X X	Y X G P X O N X	
M 10	2 2 2 4 4 6 6 8	X X X B X X P X	X X X X X W X X	
M 11	1 3 3 7 6 8	X X X X X X X X	X X X P X O X X	
M 12	3 3 4 7 7 8	X X X X X X X X	X X G Y X X N O	
F 13	4 5 6 4 7 8	X X X X X B V X	Y X N M X Y G X	
F 14	3 4 5 6 6 7 7 8	X X X X X B X X	X X X X X X X X	
F 15	2 2 5 4 6 7 7 6 8	X X C X X X X X	W X X X X X O X	
F 16	2 3 3 3 3 3 5 4 4 5 6 4 3 6 6 6	T X X X X X X X	N X O B X X Y O	
M 17	x - - - x - -	X X P B L L T R	Y X G B X X N M	4
M 18	x x - x - -	X M T L K X X R	N N N N N X N X	11
M 19	x x - x - -	X V L B P R T B	B P N X Y W R O	12
M 20	x x x	P X X T L P X X	B X N X X X X X	8
F 21	- x x - -	V X L C K T P R	N R X W G X X O	7
F 22	- x x x - - -	X X X V X L T B	M M G R P B N Y	14
F 23	- - x - x - x x - x x x x - -	V P L T X C K B	B X G Y X O P X	2
F 24	x - x - -	X X X X M X X X	N X M N X M Y X	1
M 25	x x x x - -	V X L X X B L B	Y X X G B X O X	13
M 26	x x - x - x - x -	X X X X V T V X	B X X X X X X X	9
M 27	x - x - - - - - - - - - - x x -	T L P L K X R C	Y X P B X G N X	16
M 28	x x - - - - x - -	P X V V X L X C	R X X G X X N X	15
F 29	x - - - - x - x - - x - - x x -	X P X T K X X K	O X X G X X W X	5
F 30	x x x x -	M X M V C P X R	B X P G X Y X X	3
F 31	x x x x - - x - x x x - -	V X T R C L X P	X X P Y X G B B	6
F 32	x x - x x x x -	X X T X X L V R	P O X W X Y N G	10

EXPERIMENT I

GRADE 5

	INTENTIONAL TRIALS	INCIDENTAL TRIALS		
		Object	Color	
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	Yoke to PA
M 1	3 8	X X T X R X X X	Y P X X X G W X	
M 2	4 6 7 8	X X X X X X X X	X X X P X O X X	
M 3	2 2 4 7 5 7 7 8	X X X X X X X X	W X X N X W X R	
M 4	5 8 8	X X X X X X X X	X X X X X X X X	
F 5	2 4 5 7 7 7 8	X X X X X X X X	X X X P X O X X	
F 6	3 5 5 6 8	X X X X X X X X	X X X X X Y P X	
F 7	1 1 3 1 3 5 6 7 8	X X T X X X X X	X X X X X X X X	
F 8	4 3 4 6 6 6 7 8	V P X X X B X X	B X P X X Y G X	
M 9	1 3 2 2 4 4 4 5 5 5 6 5 6 8	X X X X X X X X	X X M Y X X O X	
M 10	3 2 1 4 4 3 6 7 7 7 8	X X X X X X X X	X X X X X X X X	
M 11	2 2 5 5 6 7 6 6 8	X X T X R X X X	O X X P X G X X	
M 12	1 3 2 3 5 3 8	X X X X B X X R	B X X Y X X G X	
F 13	0 3 6 8	X X X X X X X X	N X X Y X X G Y	
F 14	2 4 7 6 8	X X X X X X X X	X X X X X X X X	
F 15	2 3 3 4 7 8	X X X X X X X X	B X X X X X N X	
F 16	6 7 8	X X X X X X X X	X X Y X X X B X	
M 17	- - - -	B T X C P L V T	B G O P Y R N X	13
M 18	- x - - x x x -	X X X K C X P B	W P N G X Y X O	8
M 19	- x x	T R M C B T K R	B N O W X B X P	16
M 20	x - - x x x x x	P X X C L B T P	R O N G Y W B R	7
F 21	- x - x - x x - - - - x x -	X X X X X X X X	X X X X X X X X	9
F 22	x x x - - - - - - x x x	X X T X R X X X	O X X X X X X X	10
F 23	x - x -	K B X X L T V C	N O P R B G X W	2
F 24	- x - - - - x	X X L X B T R V	X Y O B P R N W	12
M 25	x - x x - - x x -	X X X X X X X X	Y X X X X X G X	11
M 26	x x - x x	L V P R X K X C	R X X X P G N Y	6
M 27	- - - x x - -	L V P T L T V X	B R X N Y Y N X	5
M 28	x -	X X X B V L P T	N X B Y X G O R	1
F 29	x - x x x	L T K R C P V B	P Y N N X W O R	14
F 30	- x x x x -	X X V L B T P R	B X P X X X G X	15
F 31	x - -	V C X X L T X P	W X W X X N P X	4
F 32	- x - x - - - -	X X X V B T X X	Y X N B X X G X	3

EXPERIMENT I

GRADE 7

	INTENTIONAL TRIALS	INCIDENTAL TRIALS		
		Object	Color	
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	Yoke to PA
M 1	0 1 5 5 7 8	X X T L X X X P	B X G X X X X X	
M 2	4 7 7 8	X X X X X X X X	Y X X R X X X X	
M 3	3 6 6 7 7 8	X X X X X X X X	X X X X X X X X	
M 4	2 4 3 5 6 5 6 6 8	X X T B R X T X	O Y X P X W Y X	
F 5	3 4 3 4 4 6 8	X X T X X R X X	M X X X X G X X	
F 6	3 5 6 6 5 7 8	X X X X X X X X	B X G X X X X X	
F 7	4 5 7 8	X X X X X X X X	X X X X X X X X	
F 8	5 6 8	X X X X X X X X	X X X X X X X X	
M 9	2 2 4 5 5 7 7 8	X X X X X X X X	X X X Y X B X X	
M 10	2 4 5 5 5 8	X X X X X X X X	B X O R X X X X	
M 11	2 3 4 5 6 6 5 7 7 8	X X X L X X X R	B X G X X X X X	
M 12	2 1 2 3 6 5 7 6 7 8	X X X X X X X X	X X X X X X X X	
F 13	0 1 2 4 4 4 3 6 6 6 7 5 5 4 6 7	X X V R X M X P	X X M G X X B X	
F 14	2 4 3 4 5 5 5 6 7 8	X X X X X X X X	X X X X X X X X	
F 15	1 3 6 7 7 8	K C L X X C X X	Y X X X X X X X	
F 16	0 0 2 2 4 4 5 6 7 6 7 6 8	X X X X X X X X	X X X X X X X X	
M 17	x x x - - -	X X B X X X R X	P X O Y G B X X	1
M 18	x x - -	T X V T B R X X	P Y X X X G X X	2
M 19	x - - - - - - x	X X X V P L X P	N M W R G B X X	5
M 20	x x x - - x x - x	B X T X V T C X	N P O G B W P R	4
F 21	x x - - x - x - x x	T X X B V C X X	N Y O P G B W O	11
F 22	x x - - - - x x x x	X X X X L B V T	P G W Y X O G X	12
F 23	x - -	V X T R C L P X	B X G X X X G X	8
F 24	x - x - x - x x x x x x x x	X X B X X L T B	O R P B N Y N X	16
M 25	- x - x - x	M R V C B K M X	B N Y X X X G X	10
M 26	x - x - - -	V R X B M X M M	M X M P M M X M	3
M 27	x - - - - - - x	T X B V P R L C	X B O X X Y B X	6
M 28	- - x x	K R L X K T X R	B G O R P G N Y	7
F 29	x x - x x - x - - - x - x - x x	X X T X V L X R	W B Y G P R N X	13
F 30	- - - - - - x - -	X X T X C R X M	X X X X X X X X	9
F 31	- - - - - - - - - - x	B T X K V C P T	O X X Y X X G X	14
F 32	x - x - - x	L V P C X K P R	X X N X X Y B G	15

EXPERIMENT I

GRADE 9

	INTENTIONAL TRIALS	INCIDENTAL TRIALS		
		Object	Color	
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	Yoke to PA
M 1	1 1 3 5 4 6 5 5 6 7 6 8	X X X X X X X X	X X X B X X X X	
M 2	4 5 6 8	X X X X X X X X	P X X X X X X X	
M 3	2 5 4 4 5 5 7 8	X X X X X X K X	Y X X X X G P X	
M 4	4 7 8	X X X X X X X X	W O M M X G X X	
F 5	3 7 7 8	X X X X X X X X	X X X X X X X X	
F 6	2 2 4 5 4 6 8	X X X X X X X X	X P X X X X O X	
F 7	4 7 8	X X X X X X X X	O X X X X Y P X	
F 8	1 4 1 3 4 4 6 7 7 8	X X X X X X X X	X X X X X X X X	
M 9	7 8	X X X X X X X X	Y X O G X X B X	
M 10	3 2 6 7 8	X X X X X X X X	O X N P X X N X	
M 11	5 4 6 7 8	X X X X X X X X	X X X X X X X X	
M 12	2 4 5 5 7 7 7 8	X X X X V T X X	Y X X X X X N X	
F 13	1 1 4 7 7 8	X X X X X X X X	X X X X X X X X	
F 14	4 3 3 5 7 8	X X X X X X X X	B X X X X Y G X	
F 15	1 3 5 5 7 8	X X X X X X X X	X X X X X X X X	
F 16	1 4 6 6 8	X X X X X X X X	X X X X X Y P X	
M 17	x - x - - x x	V R P L X K P V	Y B O Y G X B O	6
M 18	x - x - -	B X X V C T P X	O X X R Y X O X	11
M 19	x x - x - x x x	K B T R V C P X	B X X X X G X X	12
M 20	x - x - x -	M M M X M M K C	M X X M M M M R	13
F 21	x x - x - x - - x x	B V K X L R T C	N R Y B O G W B	8
F 22	x -	V P X L B T K C	B G P G X Y W X	9
F 23	x x - x x x	K P L R B T V C	N R P X W G B Y	14
F 24	x - x - x - x x	X B L X X K V R	B P N X X G X X	3
M 25	- x - - - - x - x - - -	R C C T V T R P	M B Y X B X X X	1
M 26	x - - x	B X T R V P T X	B X G Y X X O X	2
M 27	x x - - - x	B X X X L X R C	X X X Y X X X X	15
M 28	x x x - x	K T C V R P X X	Y N N W Y G B X	16
F 29	x - x	P X C V X L K B	B X O X Y G W X	4
F 30	x - x -	M X T M M T X X	X X X X X X X X	5
F 31	x x -	K L B X X X R C	O X Y R P N B X	7
F 32	x - - - x	X L X X X X K B	X Y O X X G N P	10

EXPERIMENT II

GRADE 3

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	0 2	M X P L M X X T	R G O W P B X X
M 2	0 1	X X T B P C R R	X Y N G X B O P
M 3	0 1	V X T X B L C R	R X X G X Y O X
M 4	0 3	X X X T P X R X	X B P Y X W N O
M 5	0 2	X X T R P R X X	B X X X X O G X
F 6	0 0	R P V K C L M T	N X W N Y G N X
F 7	2 1	X V X K X B P X	N N W P X G B O
F 8	0 2	P X X C B L P V	W Y X P X N G O
F 9	0 1	C M T X C X R X	Y N M B X G N X
F 10	0 1	X X M B L X C X	R N Y B Y W P G
M 11	0 1 1 2	B X C X R X R T	N X N B X X G X
M 12	0 0 2 2	T X R C P K K T	B X P X X Y G X
M 13	1 3 4 7	X X X X X X X X	N X W X X W X X
M 14	0 3 2 2	R X P X X X X X	N X M Y X X G X
M 15	0 0 1 1	T P X T C L V X	R P Y B X B O X
F 16	0 1 2 2	T X C R L X X X	X X O B X X X X
F 17	0 3 2 3	T X X X B X X X	M M M M X O M X
F 18	0 5 4 6	X X T R X X X P	X X N X P Y B X
F 19	0 1 1 3	T X L X M R X M	X P M X X B W X
F 20	0 0 0 1	T C V R P X C K	B B N B X Y P Y
M 21	0 1 1 5 7 8	X X X X X X X X	X X X X X X O X
M 22	0 1 2 3 4 5	X X L X X X X X	X X X X X X X X
M 23	0 2 2 2 3 2	K V X X X B C X	B X N G X X W Y
M 24	0 2 2 6 7 7	X X X X X X X X	X X X X X X X X
M 25	0 0 1 2 3 5	X X X C X X X X	X X M B X X X X
F 26	0 2 6 7 6 8	X X X X X X X X	X X X X X X X X
F 27	0 0 1 3 2 2	X V K V X C R B	N X Y X B R G P
F 28	0 1 2 4 2 3	T P X C P B L V	X B W N X X X O
F 29	0 4 3 4 4 4	R X B M X X L M	W M O M X M N B
F 30	0 1 3 5 6 8	X X X X X X X X	X X X X X M M X

GRADE 5

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	0 4	R X C X X X X X	P X X G X O X X
M 2	0 3	X X T X X C X X	Y X M P X B O X
M 3	0 3	X X V X R T X X	X X Y X X X B X
M 4	0 2	X X T X R X T X	W N X Y O M X P
M 5	0 4	X T T K R X X X	B X P G X N O X
F 6	0 1	X V L K B R K X	N N M Y M G X O
F 7	0 1	X X T R P X X X	M X X X X X G X
F 8	0 2	B P L K L X C T	M Y W P O G R X
F 9	0 1	B T P R C X X X	X X X X X Y N B
F 10	1 0	L P K T R B C V	X X O Y X X M X
M 11	0 3 2 4	X X T R P X X X	M Y M X X O M X
M 12	0 3 1 3	V X X M R V X X	M G O W G X B X
M 13	0 5 4 7	X X X X X X X X	M X M X X M X X
M 14	0 4 5 5	X X X X X X X X	B X P P X X X X
M 15	0 0 2 4	L X V X X X X R	X P N B X W M X
F 16	1 5 4 6	X R K X X X X X	X N O W O X W R
F 17	0 1 2 5	X X T X X X X X	X X X M X X O X
F 18	1 3 4 6	X X X V X P X X	W M N M X M P X
F 19	0 0 2 2	R C P B X L K X	M N M M X O X M
F 20	1 2 2 4	X V X X X K X R	W N G Y X B P W
M 21	0 2 4 5 4 6	X X X X X X X X	P X X X X X X X
M 22	1 3 3 4 6 6	X X X X X X X X	X X X X X X X X
M 23	0 3 4 5 7 7	X X X X X X X X	B X G X X X O X
M 24	1 3 5 7 5 8	X X X X X X X X	X X X Y X Y X X
M 25	0 2 2 4 4 4	X X X V X P X X	R X P X X G X X
F 26	0 4 4 4 5 6	V X T X C R X X	P X X Y X G O X
F 27	0 1 1 1 2 2	K B P R X C V X	B G Y N X W P Y
F 28	0 0 1 1 1 4	X X V X X B R X	M G X X X B W X
F 29	0 3 3 4 6 7	X X X X X X X X	X X X Y X O B P
F 30	0 3 2 4 6 6	X X X X X X X X	X X X X X X X X

EXPERIMENT II

GRADE 7

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	0 1	P B X B X X K X	P O Y N P G O R
M 2	0 1	K L X V P T M V	M M N W G B P R
M 3	1 2	X X X M X M V X	W O N Y X X G B
M 4	0 3	X X X X L X X X	M M P X X G N X
M 5	0 3	X X T X K X B V	N N N N W O G B
F 6	0 3	T V X K X P L C	M Y X N X G O P
F 7	0 2	B K T X V L C K	P X G R P B N X
F 8	0 1	T L X V X K X X	W N N M W W N W
F 9	0 0	B X T X C X R X	Y P M B G R W X
F 10	0 1	B X X V X B P X	N N N N Y G B R
M 11	0 2 5 6	X X X X X L M X	M X X X X X N X
M 12	0 0 3 5	X M X T P L X K	X X X X X X X X
M 13	0 3 3 4	L X C X X L X K	M X X R Y X N O
M 14	0 2 6 7	X X X X X M X X	M X X P X Y M W
M 15	0 1 2 2	X R K X X X X X	O X G B X X X X
F 16	0 0 1 4	T T X K P X P V	X O X X X Y N X
F 17	0 1 3 4	X X T X R X X X	Y X M G X O P X
F 18	0 2 4 6	X K X X X X X X	X M X X X X X X
F 19	0 3 3 4	X X X X X X X X	M M M X X M M X
F 20	0 0 2 3	R X M X M M M X	M X M M X X X X
M 21	0 1 3 3 5 6	X V X X X R X X	M M X N X X O G
M 22	1 3 7 6 6 8	X X X X X X X X	X X X N X X O Y
M 23	0 1 3 7 3 3	X X V X X X X X	Y X G P X G O X
M 24	0 1 4 6 7 8	X X X X X X X X	Y X G B X X O X
M 25	1 6 5 5 5 8	X X X X X X X X	B X P X X X X X
F 26	0 1 2 1 2 3	X X L X X X X R	P X X P X Y B X
F 27	0 2 4 3 6 5	X X X X X X P X	Y X X P X G X X
F 28	0 3 4 5 6 8	X X X X X X X X	B X G X X X W X
F 29	0 1 1 4 2 5	X X X X B X V X	M X M M X G M X
F 30	0 1 4 5 6 4	X X X X X X X X	X X X Y X X O X

GRADE 9

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	2 5	X V T X R X X X	M M N X X W X X
M 2	0 3	B X X X X T L R	B X G P X W R X
M 3	1 4	X X X X X B V X	N N N N X B W B
M 4	0 2	R X T B R X X K	P X R Y B O W N
M 5	0 2	R M X X X C X X	W B P Y O R G W
F 6	0 0	X X V X L B R X	R N W G B X O Y
F 7	0 2	X X T X R X X X	Y X X N X X O G
F 8	0 2	X X X X X X L C	P O N R P W O X
F 9	0 5	R X T X X X P X	O X P G X M X X
F 10	0 0	X V L K X B X X	M N O G X M W B
M 11	0 4 4 5	X X X X X X X X	M X N X X G B Y
M 12	0 4 5 6	X X X X X X X X	M Y M B X X W X
M 13	1 4 2 4	X X X X X X X X	B X X X X X X X
M 14	0 1 1 4	R X P R P T X C	R X X R X B G X
M 15	0 0 2 1	V C B X V R T X	N N N N W W N X
F 16	0 1 5 5	V X X X X C X X	X X X Y X N B X
F 17	1 3 3 6	X X T B R X P X	Y X X X X X O X
F 18	0 3 2 2	P X T K L M X P	M X N Y X X G X
F 19	1 3 6 6	X X X V X P X X	M B N W [illegible] O G R
F 20	0 3 3 6	T X X X C M X X	X X X X X X N Y
M 21	0 5 5 7 7 8	X X X X X X X X	X X X X X X X X
M 22	0 3 8 8 8 8	X X X X X X X X	X X X X X X X X
M 23	0 4 7 5 6 7	X X X X X X X X	N Y X R G O W P
M 24	0 3 2 3 5 3	T X X X L X X X	N X P M O Y N M
M 25	0 1 3 5 6 7	X X M X X X X X	X X X P X B X X
F 26	0 4 7 7 7 8	X X X X X X X X	X X X X X X X X
F 27	0 2 2 2 5 4	T X T X L X X X	B X G X X G X X
F 28	0 2 4 5 3 4	X X X X X X X X	W X N G X X X X
F 29	1 1 2 2 1 4	T R C K B X L P	X Y N B X X O W
F 30	1 4 5 6 4 7	X X X X X X X X	X X X M X X X X

EXPERIMENT III

GRADE 3

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	x x x x x - x x	X T V R	Y O X B
M 2	x x x - x - - x	X X X X	B G X X
M 3	- x x - x x - x	V T C R	B G X G
M 4	x x x x x - x x	X X X X	O X G X
M 5	x x - x x x - -	X X X X	X X X X
F 6	- - x x - x x -	V V R C	O X G X
F 7	- x x - - x - x	V T R T	O X G X
F 8	- x x x x - x x	T X V C	X X X X
F 9	x x - x - x - x	X X X X	X X X X
F 10	- - x x - x - x	X V X C	Y X X G
M 11	x - x - x x - x	X X T X R X	N X M Y O X
M 12	- x - - x x x x	K T C X V R	X G M G X X
M 13	- - x - - x - -	X T X K P X	O Y B X G X
M 14	x - - x x - x -	X X V X R T	X X Y X N O
M 15	x x - x x x - -	K R C T P X	B G P Y O X
F 16	x - - x x x x -	X X X X X X	X X X X X X
F 17	- - - - - x x x	V P T C R K	P Y X B G X
F 18	- - - x x - x x	X X X X M X	P X G Y O X
F 19	- x x x x x - x	X X X T P X	P X X O X X
F 20	- - - - x x - -	X X X X X X	N M P M G X

GRADE 5

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	- x x x x x x x	X X V T	O G Y B
M 2	- x x x x x x x	X X X X	X X X X
M 3	- x x x - x x x	X X X X	B X X X
M 4	- x x x - x x -	R C V T	X X Y O
M 5	x x x x x x x -	X X X X	X X X X
F 6	x - x - - - x x	X X V T	B G Y O
F 7	x x x - - x - x	T M R X	X O Y B
F 8	x - x - x x x x	T V R C	B O G X
F 9	x - x x x x x -	V X X C	Y X X G
F 10	x x x - - x x x	V T C R	X X X X
M 11	- x - - x - - -	X X V X R M	N X X X X X
M 12	- - - - - - - -	X X X X X X	O Y G B P X
M 13	x - x x x x x x	X T K X R X	X Y B X O X
M 14	- x - - - x - x	X X P M R T	X N X B X P
M 15	- x x - - x - -	X X V X R T	X X X X X X
F 16	- - - - - - x x -	X X T V P C	Y G B O P X
F 17	- x x x x x x x	X X X X X X	X M X X X X
F 18	x - - x x x x -	X M X X X X	O X G X X X
F 19	x x x x - x - -	K P V C X X	X X X X X X
F 20	x - - x x x - -	V X C X R T	O P G Y B X

EXPERIMENT III

GRADE 7

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	- x x x x x x x	X X X X	X X X X
M 2	x x x x x x x x	X V R T	X X X X
M 3	x x - x x x x x	X X X X	X X Y O
M 4	x x x x x x x x	T C R X	X X X X
M 5	x x - - x x x x	V X C T	Y X X X
F 6	- x - x x x x x	X X X X	X X Y O
F 7	x x x x x x x x	X T R V	Y X X G
F 8	x x x x x x - x	X X X X	X X X X
F 9	x x x x x x x x	R C X X	X X X X
F 10	x x x x x x x x	X X X X	X X X X
M 11	- - - - x - x -	V R P K C T	X N Y X B O
M 12	x x x x x - x x	X V T X K R	B X X X X X
M 13	- - x - - x - x	X X X X V T	X X X X X X
M 14	- - x - x - x x	T X V X C R	X X X X X X
M 15	- - x - x - - -	V P T M K C	B N M X O Y
F 16	- x x x x x x x	X X X X X X	X X X X X X
F 17	- - - - x - - -	V C X K X P	Y X P G O X
F 18	x x - x x x x x	X T P R K X	B N O X X G
F 19	- x x - x - x -	X X P V X R	B Y N X G O
F 20	- x x x x x - x	X X X X X X	X O B X N Y

GRADE 9

	INTENTIONAL TRIALS	INCIDENTAL TRIALS	
		Object	Color
	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
M 1	x x x x x x x x	T X C X	X X X X
M 2	- - x x x - x x	X T V R	X X X X
M 3	x x x x x x x x	X X X X	B G X X
M 4	x x x x - x x x	X X X X	X X X X
M 5	- x x - x x x x	R C X X	X X X X
F 6	x - x x x - - x	X X X X	X X X X
F 7	x - x x x x x x	X X V T	X X X X
F 8	- - x x x x x x	X X X X	O M M M
F 9	- x x x x x x x	X X X X	O G B X
F 10	x x x x - x x x	X X X X	X X X X
M 11	x x x - x - x x	R X V C X P	X X X X X X
M 12	x - x x x x x x	X X T V P R	B P X Y G X
M 13	x - x x - - - -	X X X X X X	X X X X X X
M 14	- x - - x x x x	X X P R X V	N X Y X O X
M 15	x x x x x x x x	X R K X X X	B O G B X X
F 16	x - x x x - x -	X T M K M M	B G X Y P X
F 17	x x x x x x x x	T X C X R X	X X X X X X
F 18	x - x x x x x x	X X X X X X	X X X X X X
F 19	x - x x x - - x	R X T C V P	B G X X X X
F 20	x x - - x x x -	X X T X V X	X X X X X X