DOCUMENT RESUME

ED 101 317 CS 001 613

AUTHOR	Yussen, Steven R.; And Others
TITLE	Semantic Versus Physical Processing in Children's Recall and Clustering of Pictures. Technical Report No. 312.
INSTITUTION	Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
REPORT NO	WRDCCL-TR-312
PUB DATE	Aug 74
CONTRACT	NE-C-00-3-0065
NOTE	15p.; Report from the Project on Children's Learning and Development
EDRS PRICE	MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS	*Cognitive Processes; *Educational Research; Elementary School Students; Memory; Pictorial Stimuli; Primary Education; *Recall (Psychological); *Semantics; *Visual Stimuli

ABSTRACT

This study was conducted to determine whether the recent semantic-physical processing distinction that Jenkins and his associates have invoked to account for differences in subjects' recall and clustering of verbal materials could be extended to include pictorial materials as well. In the first experiment, second-grade children were exposed to 15 line drawings cross-classified to represent four taxonomic categories and four shape categories, with four instances per category. In the second experiment, first graders freely sorted the pictures and were classified as semantic or physical processors based on their predominant bases of sorting. Following exposure (experiment 1) or sorting (experiment 2), the subjects were asked to recall the picture names. Results of both experiments showed that semantic activity yields greater recall than physical activity. The second experiment also showed that semantic activity yields greater semantic clustering in recall and that physical activity yields greater physical clustering. (Author/RB)

Technical Report No. 312

SEMANTIC VERSUS PHYSICAL PROCESSING IN CHILDREN'S RECALL AND CLUSTERING OF PICTURES

by

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Report from the Project on
Children's Learning and Development

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin

August 1974

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the National Institute of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the National Institute of Education and no official endorsement by that agency should be inferred.

Center Contract No. NE-C-00-3-0065

Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

Acknowledgments

We are grateful to the staff and students of Our Lady Queen of Peace and of Blessed Sacrament schools in Madison, Wisconsin for their cooperation during data collection.

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Abstract

The present study was conducted to determine whether the recent semantic-physical processing distinction that Jenkins and his associates have invoked to account for differences in subjects' recall and clustering of verbal materials could be extended to include pictorial materials as well. In Experiment I, second-grade children were exposed to 16 line drawings cross-classified to represent four taxonomic categories and four shape categories, with four instances per category. Control subjects simply looked at pictures, Semantic subjects identified each picture's taxonomic category, and Physical subjects identified each picture's shape. In Experiment II, first graders freely sorted the pictures and were classified as Semantic or Physical processors based on their predominant bases for sorting. Following exposure (Experiment I) or sorting (Experiment II), all subjects were asked to recall the picture names. Results of both experiments show that semantic activity yields greater recall than physical activity. Experiment II also shows that semantic activity yields greater semantic clustering in recall and that physical activity yields greater physical clustering.

I
Introduction

In a recent series of experiments, Jenkins and his associates (Hyde & Jenkins, 1969, 1973; Johnston & Jenkins, 1971; Till & Jenkins, 1973; Walsh & Jenkins, 1973) have shown that efficient learning is not so much a function of intention to learn as it is a function of the nature of the cognitive processes activated during stimulus presentation. Thus, if a subject's task is to evaluate the meanings of stimuli (a semantic-processing activity), he recalls more of the stimuli, and organizes his recall more by available semantic relationships, than if his task is to examine one or more physical properties of the stimuli (physical processing), such as whether or not a particular stimulus contains the letter "e." Moreover, in the former case, the level of subjects' incidental recall approximates that of subjects given intentional learning instructions. Bobrow and Bower (1969) have arrived at similar conclusions concerning the difference between semantic and physical processing in the recall of sentences.

The purpose of the present study was to determine whether this phenomenon would generalize to contexts in which subjects are presented with pictorial rather than verbal stimuli. That is, would semantic processing of pictures be more effective than physical processing of them? There is available evidence to suggest that subjects are capable of organizing their recall of pictures along physical dimensions such as shapes, as well as along semantic dimensions such as taxonomic categories (see, for example, Frost, 1972). However, whether physical processing of pictures results in a level of recall comparable to that produced by semantic processing of pictures, has yet to be determined.

In the two experiments reported here, children attended to either the semantic or physical similarities among a number of pictures. The children's subsequent incidental recall and clustering of the pictures enable us to make inferences concerning the respective contributions of semantic and physical processing.

II
Experiment I

Method

Subjects

The Ss were 42 second-grade children (equal numbers of males and females) drawn from four classrooms in a predominantly white, middle-class, parochial school in the Midwest. All Ss were tested in the spring semester of the school year.

Design and Materials

The stimuli consisted of 16 black-and-white line drawings approximately 2 1/2" x 3 1/2" in size, centered on an 8 1/2" x 11" white background. The pictures represented common objects that young children could easily name (verified through pilot testing). The pictures were selected so that they could be cross-classified according to one of four semantic categories (toys, foods, body parts, and clothing) and one of four physical shape categories (round, square, curved, and V-shaped), with one instance for each of the 16 resulting combinations (a round body part, a V-shaped toy, etc.). Each picture was drawn with its predominant shape accentuated so that Ss would be able to distinguish the predominant shape from other less predominant physical characteristics (see Figure 1).

The Ss were randomly assigned in equal numbers to three experimental conditions. In the Control condition, Ss were instructed to look carefully at the pictures that would be presented one at a time. The Ss in two other conditions, in addition to being asked to look carefully at the pictures, were required to perform different types of processing activities. In the Semantic condition, Ss were asked to identify the conceptual category associated with each presented picture by pointing to one of four words ("Toys," "Food," "Body," "Clothes"). Each word was printed on a white 5" x 8" card, and the cards were placed in a 2 x 2 array on the table in front of the S. In the Physical condition, Ss were asked asked to identify the perceptual category associated with each presented picture by pointing to one of four shapes (○ □ ◡ ∨). The shapes were constructed and placed on the table as in the Semantic condition.

Procedure

For all conditions, E held up a picture in front of S for five seconds and then placed it face down in a pile on the table. In the two processing conditions, S was required to point to the appropriate category card during the five-second interval (which all Ss could do easily). Following the presentation of the last picture, S was unexpectedly asked to name as many of the pictures as he could remember. Recall was self-paced, with prompting provided by E ("Can you think of any more?") each of the first two times that S exhibited a long pause.

Results and Discussion

In addition to the recall data, two clustering scores were computed for each S, one based on the semantic categories and the other on the physical categories (S and P clustering, respectively). The clustering index is one adopted by Frost (1971), namely R/N-C, where R = the number of same-category repetitions among the items recalled; N = the total number of items recalled; and C = the number of different categories recalled. (See Frost, 1971, for details about scoring procedures.) This particular index was selected since it appears to distinguish between degrees of organization that are intuitively different while at the same time possessing the desirable characteristic of being uncorrelated with total recall. (Here,

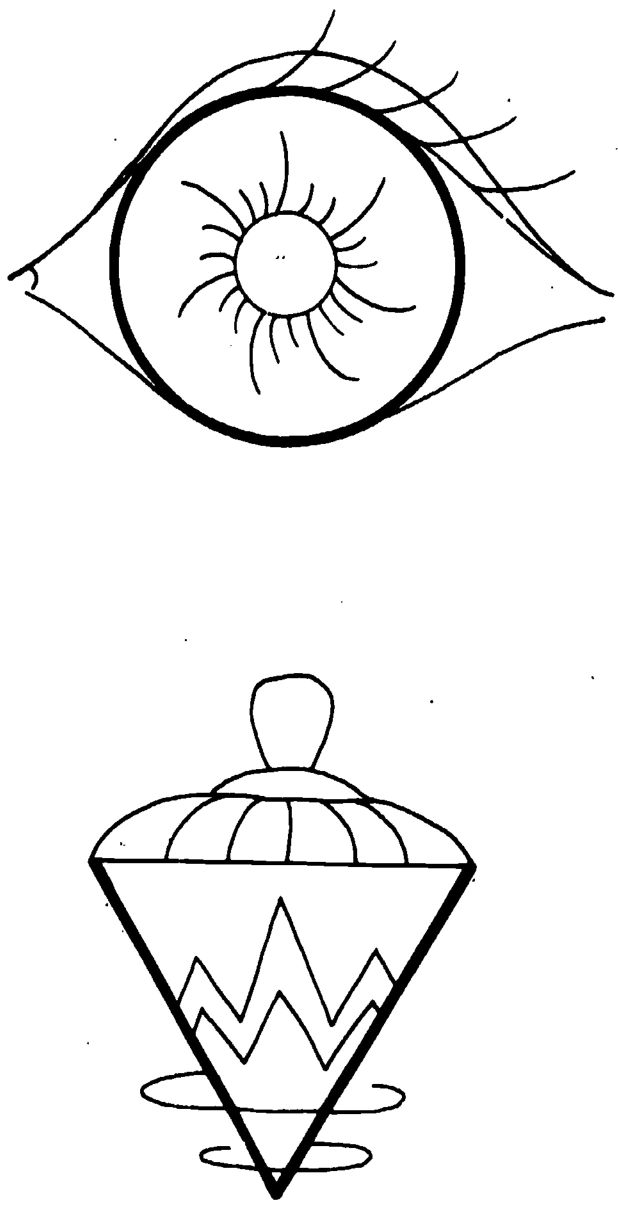

Figure 1. Examples of the stimuli employed in the present experiments.

the obtained correlation between recall and the S-clustering index was .10 and that between recall and the P-clustering index was .06.)

Mean performance on the three measures, by experimental condition, is reported in Table 1. In order to keep the familywise error rate for each measure approximately equal to .05 while making the most efficient use of the data, three directional pairwise comparisons were performed on each measure utilizing the mean square error and $\alpha = .02$.

According to this procedure, it was found that the Semantic condition produced a higher mean level of recall than that of either the Physical or Control condition, t's $(39) = 2.25$ and 2.15 respectively, both p's $< .02$. In contrast, the performances of Physical and Control Ss were comparable, $|t| < 1$. Although it appears from Table 1 that Semantic Ss exhibited more S clustering than did Physical Ss while the reverse was true for P clustering, none of the comparisons involving the clustering measures was statistically significant (all p's $> .05$).

Thus, it is possible to extrapolate the results of the Jenkins group to the incidental picture recall of children: semantic processing of the materials produces a higher level of recall than does physical processing. On the other hand, the clustering data do not differentiate among experimental conditions. Before it is concluded that the clustering data and/or the selected clustering index are not sensitive to the processing activity engaged in by S, let us consider the results of a second experiment conducted to maximize the possibility of obtaining the desired effects.

TABLE 1

MEAN PERFORMANCE IN THE THREE EXPERIMENTAL CONDITIONS (EXPERIMENT I)

Measure	Condition		
	Control	Semantic	Physical
Recall	5.00	6.50	4.93
S Clustering	.39	.38	.33
P Clustering	.26	.33	.49

III
Experiment II

In Experiment I, Ss in the Semantic and Physical conditions were required to attend to a stimulus and then point to a card representing a particular semantic or physical category. The procedure adopted in Experiment II differed from this in two ways: (1) the Ss actually sorted the stimuli into piles, and (2) the basis for sorting was determined from Ss' own spontaneous (uninstructed) semantic, physical, or idiosyncratic classifications. In allowing Ss to place the stimuli that were perceived as similar into observable piles, we hoped to provide a more explicit basis for Ss' organization of recall than was provided in Experiment I, which should in turn be evidenced in Ss' subsequent clustering patterns. (Note that the explicit basis for organization provided by the sorting task is somewhat analogous to a "blocked" presentation procedure which has been employed previously [see Jensen & Rohwer, 1970].) And in allowing Ss to perform these sorts spontaneously, we hoped to answer the question: Do children who spontaneously choose to process pictures semantically exhibit a higher level of recall than do those who choose to process them physically (thereby complementing the result of Experiment I, where Ss were "forced" by E to adopt these alternative processing modes)?

Method

Subjects

The Ss were 58 first-grade children (38 males, 20 females) from two parochial schools in the Midwest. Children a year younger than those of Experiment I were selected since we wished to obtain an adequate number of Ss who would spontaneously process the pictures on the basis of physical features, and the results of previous research suggested that it would be advisable to include children younger than second graders (e.g., Bruner, Olver, & Greenfield, 1966; Ingison & Levin, in press). As before, Ss were predominantly white and middle class, and they were all tested in the spring.

Design and Materials

Each S participated in the incidental free-recall task with the same set of pictures as before. In this experiment, the pictures were mounted on reduced-size backgrounds (3" x 4") so that S could easily glance at all 16 pictures and move them around. The recall task followed an incidental game in which S freely sorted the pictures into as many groups as he wished. All Ss were given the same instructions for sorting pictures, so there were no experimentally-defined treatment groups.

Procedure

The S was seated between two tables, each of which was easily accessible. The E indicated that S was to play a game in which he would take pictures from an array on one table and place them into groups on the second table. Children were instructed to form groups by putting pictures into piles according to which ones they thought belonged together. No limit on the number of pictures per group or on the number of groups was imposed, but once the child had sorted a picture he was not allowed to change his grouping. The sorting task began with the 16 pictures arranged in the outline of a square (five pictures per side), with the position of pictures within the starting configuration systematically rotated from one S to the next. The Ss averaged about three minutes to complete the task. The E recorded which pictures were placed into each pile as well as the spatial relationships of the piles. When S finished, he was instructed to close his eyes while E gathered up all of the pictures and put them out of signt. Then S was asked to recall as many of the pictures as possible. As in Experiment I, recall was self-paced and prompts were given following the first two S pauses.

Results and Discussion

On the basis of their picture groupings, Ss were classified as either spontaneous Semantic or Physical sorters. In so doing, both a lenient and a strict classification system was applied. In the lenient system, S was classified as a Semantic sorter if he exhibited relatively more semantic sorting than physical sorting (based on the a priori categories of Experiment I) and as a Physical sorter if he exhibited relatively more physical sorting. Twenty-eight Semantic sorters and 23 Physical sorters (and seven others who did not exhibit a predominance of one over the other) were identified using this system. In order for S to be classified as a Semantic (Physical) sorter in the strict system, no evidence of physical (semantic) sorting could be present. Thus, while it would be possible for Semantic (Physical) Ss to exhibit occasional idiosyncratic sorts, they could not exhibit any physical (semantic) sorts. Fourteen Semantic sorters and seventeen physical sorters were identified using this system. Since the results were comparable under the two classification systems, only those based on the strict system (where relatively "pure" Semantic and Physical sorters were identified) will be discussed here.

A comparison of the mean performance of Semantic and Physical sorters may be found in Table 2 where, on all three measures, statistical differences in the expected direction were obtained, t's $(29) = 2.26$, 3.38, and 5.92 for recall, S clustering, and P clustering respectively, all p's $< .02$.

Thus, in allowing Ss to classify pictorial stimuli according to their own spontaneous groupings, we find that those who do so on the basis of the semantic similarities among items remember more and organize their recall more in terms of the associated semantic categories, whereas those who do so on the basis of physical similarities among items organize their (less efficient) recall more in terms of the associated physical categories.

TABLE 2

MEAN PERFORMANCE OF SEMANTIC AND PHYSICAL SORTERS BASED ON THE STRICT CLASSIFICATION SYSTEM (EXPERIMENT II)

Measure	Classification	
	Semantic	Physical
Recall	8.29	6.35
S Clustering	.63	.25
P Clustering	.17	[illegible]

IV
General Discussion

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In both experiments, we found that in young elementary school children semantic processing of pictures leads to a higher level of recall than physical processing of them. With respect to clustering, however, dramatic differences were obtained only in Experiment II. This may have resulted from one or more procedural differences between the two experiments. The Ss in Experiment I were forced to comply with an E-imposed strategy, one-at-a-time processing of the pictures (presented in a random order), with only a total of 1 1/3 minutes to examine the stimuli, which were presented in limited five-second intervals. The Ss in Experiment II, on the other hand, were able to use their own strategies for sorting the pictures, could view several same-category pictures simultaneously (in spatially separated groups), and were inclined to spend about three minutes in performing their task. In this regard, note that the recall of Experiment II Ss was relatively more efficient (Table 2) than the recall of Experiment I Ss (Table 1).

At the same time, since the results in Experiment II are based on a comparison of self-selected samples, alternative explanations of the results are possible. That is, whereas Experiment I Ss were randomly assigned to semantic and physical conditions, in Experiment II the semantic-physical variable was defined in terms of how Ss themselves chose to sort the stimuli. With this kind of nonrandom-assignment design, it may be that variables other than (and perhaps correlated with) the one under consideration account for the results. However, at least for four variables that immediately come to mind and for which data could be gathered, there appears to be little relationship with performance. The sex distributions of semantic and physical sorters are virtually identical (each consisting of about 75% males). Considering age and ability information (which was available for about half of the Ss), the correlation between age and recall is -.15 and that between ability (as reflected by Metropolitan readiness scores) and recall is .28, both nonsignificant with $\alpha = .05$. Finally, Mandler's (1967) data suggest that the number of categories formed by Ss during study is highly related to recall; however, when considering the number of categories (actually the number of piles formed), there is little difference between the mean number formed by Semantic (4.57) and Physical (5.29) sorters, $t(29) = 1.30$, $p > .10$. Within this restricted age and ability range, then, there is no support for the claim that such subject variables are primarily responsible for the findings. Rather, it is possible that a subject's preference for semantic or physical sorting may be likened more to a cognitive-style variable than to a cognitive-ability variable (see, for example, Kogan, 1971).

Future research might be aimed at determining the extent to which a preference for semantic as opposed to physical processing of stimuli constitutes a stable individual difference characteristic among children of this age. If reliable differences in such children can be discovered, then these differences should be taken into consideration when various instructional and/or training decisions are made. It is also important to determine the extent to which the difference between the two processing strategies generalizes to learning tasks other than those demanding free verbal recall. Some interesting work by Davies (1972) illustrates that different processing activities may produce reversed performance differences on different tasks. Would, for example, physical processors be better than their semantic counterparts in a task requiring recognition of previously shown pictures (i.e., a visual inspection decision) rather than recall of them (where the semantic processing may induce verbal-associative activity)? Indeed, it even seems possible to bias the original Jenkins paradigm along similar lines in order to enhance the performance of adult physical processors as well.

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GPO 807-407-2