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ABSTRACT

To assess the importance of visual attributes relative to acoustic and semantic attributes in children's encoding, a 64-item recognition test was administered to first- and sixth-grade children. Recognition items were linedrawings of simple objects accompanied by aural labels. By manipulating the picture, label, and referent in various combinations, distractor items were formed to gauge the relative dominance of the visual, acoustic, and semantic attributes. False recognition data suggest the importance of the acoustic attributes for younger subjects but not older ones, the visual attribute for both ages, and the semantic attribute for older subjects and first-grade girls. (Author)

THE ROLE OF VISUAL, ACOUSTIC, AND SEMANTIC ATTRIBUTES IN CHILDREN'S ENCODING

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To assess the importance of visual attributes relative to acoustic and semantic attributes in children's encoding, a 64-item recognition test was administered to first- and sixth-grade children. Recognition items were linedrawings of simple objects accompanied by aural labels. By manipulating the picture, label, and referent in various combinations, distractor items were formed to gauge the relative dominance of the visual, acoustic, and semantic attributes. False recognition data suggest the importance of the acoustic attribute for younger subjects but not older ones, the visual attribute for both ages, and the semantic attribute for older subjects and first-grade girls.

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Any full account of children's learning must confront the questions of what features of a stimulus input are most prominent in a child's encoding and whether these features change with age. Impetus for investigation of these issues was supplied by Underwood's (1969) conception of memory as a grouping of attributes (such as temporal, frequency, and verbal associative attributes) and his suggestion that the particular attribute or attributes dominant in memory may shift with development.

Previous research on developmental trends in attribute dominance has focused on the roles of acoustic and semantic attributes and has generally shown that while the acoustic attribute plays a large role in the encoding of young children, its importance diminishes with age as various semantic components become more prominent. Using a false recognition paradigm, Bach and Underwood (1970) found that second-graders are more likely to judge as "old" a word that sounds like one they have seen before (acoustic distractor) than one that is a verbal associate of the old word (associative distractor). Sixth-graders, on the other hand, make more false recognition responses to verbal associates of old words than to acoustic distractors. Similarly, Ghatala (1970), using the same paradigm to test the effects of acoustic, associative, and conceptual (category superordinate) distractors with second-, fourth-, and sixth-graders, found that the importance of acoustic attributes decreases with age while that of conceptual attributes appears to increase. In contrast to the finding of Bach and Underwood, the associative attribute's importance did not increase with age. Felzen and Anisfeld (1970) administered a continuous recognition test to third- and sixth-grade subjects. Acoustic distractors elicited a significant number of false recognition responses at both age levels, but the semantic distractors (synonyms and antonyms) appeared to increase in potency with age. Using a free recall paradigm, Hasher and Clifton (1974) found that second-graders recalled more of the words that could be clustered according to acoustic similarity than of those that could be clustered according to semantic similarity. In contrast, sixth-graders recalled more of the semantically clusterable words.

Despite the relative consistency of outcomes indicating an age-related increase in the importance of semantic features relative to acoustic ones, the understanding of developmental changes in encoding patterns that can be generated from the evidence is limited since the relevant research has dealt only with verbal materials and has not assessed the developmental course of the importance of visual-imaginal attributes in children's encoding. This gap is emphasized by the importance attached to visual features and imagery in theories such as those of Bruner (1964) and Paivio (1971).

Bruner's hypothesis of developmental shifts from enactive (motor) to ikonic (visual) and finally symbolic (verbal) representation has developmental implications concerning the relative importance of visual-imaginal attributes compared to semantic ones. If indeed a major shift occurs around the age of 7 from primary dependence on visual representation to reliance on symbolic representation, one would expect visual attributes to dominate in encoding during the early elementary school years and the semantic attributes to dominate in the later years. In contrast, Paivio's emphasis on the continuing importance of imagery in memory leads to the prediction that visual attributes will have significant effects throughout development. Thus, an appraisal of the relative importance of visual features, conducted by means of methods associated with an attribute dominance framework, promised not only to fill an obvious gap in empirical information but to test the utility of theoretical positions as well. Such an assessment was the major goal of the present study.

Testing the relative importance of the visual attribute requires the use of pictorial as well as verbal materials, and verbal-pictorial materials can quite easily be fitted into the false recognition paradigm used in most previous developmental attribute dominance studies. Moreover, employing a combination of pictorial and verbal materials allows for the separate manipulation of visual, acoustic, and semantic input, making possible the formation of distractors which are the same as the target with respect to one attribute but quite different with regard to the other two. This procedure removes the problem of interpretation presented by previous studies where distractors were similar, rather than identical, to the target with respect to the relevant attribute and hence could be rejected by a subject either because he had not encoded the relevant attribute or because he had encoded and retained it perfectly. The procedure also ameliorates the problem of equating various types of distractors with regard to their similarity to the original word.

METHOD

Subjects

A total of 72 subjects, 36 each from the first and sixth grades, were tested. At the time of testing, the mean age of the first-graders was 6 years, 11 months, with a range from 5 years, 4 months to 8 years. Sixth-graders ranged in age from 11 years, 5 months to 13 years, 6 months with a mean age of 12 years. The subjects were drawn from a public elementary school in a high-SES, predominantly white, suburban area.

Sampling was random, except with regard to sex. The sixth-grade sample was chosen to include 18 boys and 18 girls. Equal numbers of boys and girls were not available for the first-grade sample; that sample contained 12 boys and 24 girls with a 1:2 ratio of boys to girls in each experimental condition.

Procedure

The recognition test was individually administered to each subject. Initially, the subject was informed that he would be seeing slides of various objects and hearing their names. He was instructed to watch and listen carefully and to try to remember the items.

The 70-item study list was then administered at a rate of 2 seconds per item. The slides were presented by a Kodak carousel slide projector synchronized with a Wollensak cassette recorder used to present verbal labels for the slides.

After a subject had been shown the study list, he was informed that he would now be seeing and hearing an additional set of items, some of which would be repetitions of those he had already been shown. If an item consisted of a picture and label he had been given together before, the subject was instructed to respond "old." If the picture, the label, or both were ones that had not been given previously, the subject was told to respond "new." After the subject indicated that he understood the instructions, the first six items of the test list were administered as unpaced practice items. For the practice items, the subject was given feedback concerning the correctness of his responses. If the subject made an error on one of the distractor practice items, the experimenter explained to him the way in which the distractor differed from the original target item and informed him that in such instances the proper response was "new." The time interval between the termination of the study list and the beginning of the test trial depended upon the subject's performance on the practice items, but averaged around 1-1/2 minutes.

After the subject completed the practice items and indicated that he understood the procedure and instructions, he was told that he would be asked to respond to the rest of the test items without feedback. The subject was instructed to respond to every item, even if unsure of his answer. The test list was administered with a 4-second interitem interval. Each slide was shown for 2 seconds, followed by a 2-second period during which the screen was blank and the subject gave his recognition response. The subject's oral responses were recorded by the experimenter.

Materials

Stimulus materials were linedrawings of common objects on 35 mm transparencies accompanied by orally presented verbal labels. The study list contained 6 initial practice items and 64 regular items, comprising 24 target, 12 control, and 28 filler items. Like the study list, the test list was 70 items long, consisting of 12 repeated target items, 12 distractor items (one for each of the unrepeated targets), 12 control items repeated from the study list, 12 new control items, 16 fillers (half of which were repetitions from the study list), and 6 initial practice items. The composition of the test list provided for a 50:50 ratio of old to new items.

Thus, half of the target items on a given study list reappeared at test. The repeated targets were exact repetitions of critical items on the study list. Those targets not repeated on the test list were replaced by distractor items. The distractor items were related to the original target items in one of three ways: Acoustic distractors were items with labels that were homophonous with one of the target items. Visual distractors consisted of a picture identical to that used for one of the targets with a new label that gave it a completely different referent. A semantic distractor was composed of a label synonymous with that of a target presented with a new linedrawing. Semantic distractors were drawn to be as visually dissimilar as possible to the semantic targets. Examples of target-distractor pairs of the three types are shown in Figure 1. Table 1 displays a list of all the target-distractor pairs.

Insert Figure 1

Insert Table 1

It should be noted that across the three types of target-distractor relationships there is a systematic variation of the acoustic, visual, and semantic attributes. For acoustic pairs, the aural input is the same for the target and the distractor but the linedrawings (visual input) and referents (semantic content) differ. For visual pairs, the linedrawings are identical, but the labels (acoustic input) and referents differ. The surface input in both modes (acoustic and visual) differs within semantic pairs but the underlying meaning, the referent class, is the same.

A new item, unrelated to any of the target items and designated as a new control item, appeared either before or after each distractor item on the recognition test. For each distractor type, half of the control items appeared immediately before distractors and half immediately after.

Another set of items served as controls for the target items which were repeated on the test list. A control item repeated from the study list and unrelated to any of the target items, appeared immediately before or after each repeated target on the test list.

Finally, a number of items were used simply to fill out the study and test lists. Twenty-eight fillers appeared on the study list; 8 of these and 8 new fillers were included in the test list. The only difference between "filler" and "control" items was that the list position and word frequency count of control items was equated with that of target repetitions and distractors so that responses to the control items could provide an adequate baseline from which to measure experimental effects.

Six practice items appeared at the beginning of both the study and test lists. Included among the practice test items was a distractor item of each type formed from one of the practice study items.

Word frequency was controlled across critical item types and for control items. The mean frequency count (Carroll, Davies, & Richman, 1971) was 203 for the acoustic target items, 202 for the visual items, and 202 or 203 for the semantic items on a given study list. Mean word frequency was 202 for both new and repeated control items.

The distribution of the three critical item types within the study list was controlled so that the same average presentation position was maintained for each type. The number of items intervening between the appearance of a target item on the study list and the appearance of its repetition or the corresponding distractor on the test list (and likewise between the appearance of a control item on the study list and its repetition at test) was also controlled. A mean interval of 76 items with a range from 68 to 82 was maintained for the three critical item types and for repeated controls. Finally, twelve study-test lists were formed to balance list position and item effects across factors of interest.

Design

In the analysis design, grade and sex served as the principal between-subjects factors. The factor of list was included only for consistency with the procedure of subject assignment. Because of the different sex distributions at the two grade levels, sex was treated as being nested within grade.

The within-subjects factor was critical item type (acoustic, visual, or semantic). False recognitions to distractor items of each type were taken as a measure of the potency of the relevant attribute. A subject's incorrect judgment of an acoustic distractor as "old" was interpreted as an indication that the acoustic attribute, on which the target and distractor were identical, was sufficiently dominant in the subject's memory to trigger a recognition response on an item that differed from the original in its visual and semantic properties. A false recognition response to a visual distractor would indicate that the visual attribute was of sufficient weight to override any conflicting information about the acoustic and semantic attributes (on which the distractor differed from the target). Similarly, false alarms for semantic distractors were interpreted as evidence that the meaning of an item is encoded and remembered to such an extent that it is difficult for the subject to discriminate between old items and items identical to them in meaning even when the surface features vary.

RESULTS

The principal results, as measured by proportion of possible errors committed for each item type, are displayed in Table 2. All statistical tests were performed at $\alpha = .05$.

Insert Table 2

The results of major theoretical interest are the false recognition rates for the three critical item types. It was decided to assess whether each individual distractor type was a significant factor in the subject's encoding as well as to compare the three distractor types to obtain a pattern of attribute dominance. Therefore the results for the distractor types were evaluated in two ways: (1) by testing the differences between the number of false recognitions made for each distractor type and the number made for new control items to ascertain whether each distractor type was more alluring than were unrelated new items, and (2) by making a set of pairwise comparisons of the number of false recognitions for the three distractor types. Thus six variables were created by testing each of the three distractor types against the baseline established for new control items and by making the three possible pairwise comparisons of distractor types.

Looking first at the differences between false recognition rates for each distractor type and the mean false recognition rate for new control items, all three distractor types produced significant false alarm levels, Fs $(1,24) =$ 7.36, 75.24, and 52.83, for acoustic, visual, and semantic distractors, respectively. There were no grade effects for acoustic, visual, or semantic distractors, all Fs < 2.35. However, within the first-grade sample there were sex differences in the potency of the visual and semantic distractor effects, with first-grade girls making more false recognition responses to visual, $F\ (1,24) = 6.03$, and semantic, F (1,24) = 7.79, distractor items than did first-grade boys.

Since there were sex effects, the pattern of attribute dominance was assessed separately for each sex within a grade level. The results of this analysis indicated that for first-grade boys, the acoustic and visual distractors produced significant false alarm rates, Fs (1,24) = 6.40 and 6.35, while the semantic distractors did not, F (1,24) = 3.00. Pairwise comparisons revealed that the visual and acoustic false recognition rates did not differ from each other, F < 1. It appears, then, that for first-grade boys, the acoustic and visual attributes are important while the underlying meaning of stimulus materials plays a lesser role in recognition decisions.

In contrast, for first-grade girls all three attributes play a role in recognition memory. The semantic factor was significant, F (1,24) = 60.17, as were the acoustic and visual factors, Fs (1,24) = 7.20 and 65.92. The visual and semantic effects did not differ from each other, F < 1, but each was greater than the acoustic effect, Fs (1,24) = 23.08 and 10.87. The size of this difference varied significantly across the twelve lists, but inspection of the difference for each list revealed no consistent item or item position factors that could explain the list effect.

While the pattern of results differed between the sexes for first-graders, a common pattern was found for both sexes in the sixth grade. Among these older subjects, the visual and semantic effects were significant, Fs (1,24) = 15.11 and 14.22 for boys, and Fs (1,24) = 10.25 and 4.50 for girls, while the acoustic distractor effect was not, Fs < 1.67. For both sexes the semantic distractor effect did not differ from the visual, Fs < 1.50. In summary, whereas the acoustic attribute figures in the performance of first-graders, it plays no significant role among sixth-graders, for whom the semantic and visual attributes have equal importance.

One might argue that the false recognition results for the various types of distractors reveal less about the importance of the corresponding attributes in encoding than about the differential ease with which the original targets are encoded and remembered. Subjects might make more false alarms to distractor items than to the control items simply because for some reason the original target items were more difficult than other study items to encode and remember. If this hypothesis were valid, one would expect to find a higher "miss" rate for repeated target items than for repeated controls. This was not the case. Where miss rates for repeated targets did vary from that for controls, the difference was in favor of the controls, indicating that the target items were, if anything, easier than the control items to encode and remember. Likewise, if differential difficulty in encoding the three target types was responsible for the subsequent differences in false recognitions to the corresponding distractor types, one would expect to find differences in miss rates for the three target types. Again, the data do not support such an alternative hypothesis. Pairwise comparisons of the miss rates for the three target types yielded no significant differences, all $Fs < 1.13$.

Several measures of overall performance were made. Total number of errors varied with grade, $F(1,24) = 7.25$, with sixth-graders making fewer errors. This grade effect in total errors can be attributed to a difference in miss rates, $F(1,24) = 6.13$, rather than false recognition rates, $F < 1$.

DISCUSSION

Previous developmental studies of attribute dominance (Bach & Underwood, 1970; Felzen & Anisfeld, 1970; Ghatala, 1970; Hasher & Clifton, 1974) have generally shown the acoustic attribute to be more potent than the semantic for young subjects, with the semantic attribute dominant for older subjects. The findings of the present study are consistent with these previous results with the exception of the data from the first-grade girls, who showed the more "mature" pattern of attribute dominance with the semantic attribute stronger than the acoustic. In the early elementary school years, girls often appear to develop cognitively more rapidly than boys, especially in areas of verbal skill (Maccoby, 1966). While the sex difference itself is therefore not too surprising, the difference in performance between the first-grade girls in this study and children one and two years older tested in previous studies still requires explanation. Since the use of pictorial materials in addition to verbal labels was the major innovation of the present investigation, it would seem reasonable to consider this factor as a possible cause of the mature encoding pattern of the first-grade girls. Perhaps pictures in some way encourage semantic encoding and thus lead children to employ a developmentally advanced encoding pattern at an age several years younger than that at which the same encoding pattern appears for purely verbal materials. Although consistent with the results of picture-word comparisons in other tasks (Bird & Bennett, 1974; Calhoun, 1974), in which pictures produced superior learning for children, this hypothesis requires direct empirical verification in a paradigm like the present one.

A second major finding of the study was the importance of the visual attribute at both ages tested. There was no indication from the data that with age the visual attribute was becoming less important relative to the semantic; the two were of equal importance for the sixth-graders. While consistent with Paivio's position, this finding contrasts with the kind of prediction one would make from Bruner's theory, which asserts that symbolic representation supercedes visual at about age 7.

Another interesting finding was the overall effectiveness of the semantic distractors. These results are inconsistent with the view that learning is based primarily on the formal, surface properties of stimuli. While the acoustic and visual distractors were both physically identical to their targets on one modality dimension, the semantic distractors were physically different along both dimensions. If encoding were based only upon the physical stimulus features, these semantic distractors would have been no more alluring than unrelated control items. However, the semantic distractors were quite effective, attaining significance for all groups except the first-grade boys (for whom they approached significance, < .10).

It has often been suggested that a developmental shift occurs between the ages of 5 and 7 from learning based on external, physical qualities of stimuli to learning based upon "deeper" encodings or mediating representations (Kendler & Kendler, 1967; White, 1965). The results of the present study are not inconsistent with the hypothesis in demonstrating the presence of a significant amount of semantic encoding by the first grade.

However, the hypothesis predicts not only the onset of semantic encoding but a weakening of the importance of surface features as determinants of learning as well. While the results for acoustic distractors (which were effective for younger children but not older ones) are consistent with this portion of the hypothesis, the visual distractor results are not. The hypothesis thus appears tenable for one set of surface features (i.e., acoustic) but not for visual surface features of a pictorial character, which appear to have a strong influence throughout childhood.

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Table 1: Acoustic, Visual, and Semantic Target-Distractor Pairs

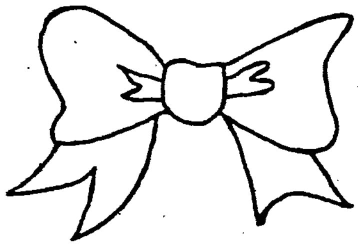
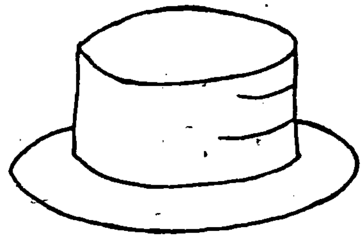
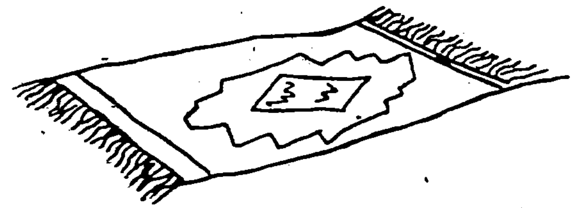
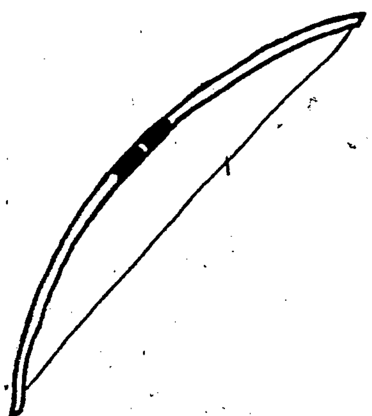
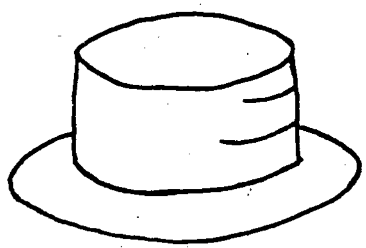
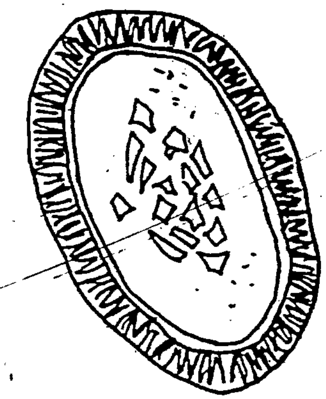
Acoustic	Visual	Semantic
Bow (archery)[a]-Bow (tie)	Hat-Cake	Dish-Plate
Bat (baseball)-Bat (rodent)	Sandwich-Ruler	Wood-Lumber
Nail (carpentry)-Nail (finger)	Bell-Broom	Jacket-Coat
Cone (pine)-Cone (ice cream)	Yarn-Wheel	Hen-Chicken
Pipe (smoking)-Pipe (plumbing)	Banana-Canoe	Pan-Skillet
Straw (sipping)-Straw (hay)	Leaf-Feather	Bucket-Pail
Pen (writing tool)-Pen (fence)	Brick-Butter	Buggy-Carriage
Horn (trumpet)-Horn (cow's)	Chain-Worm	Rug-Carpet

[a]Words in parentheses are provided here to clarify the referent class of each homograph; they were not included in the experimental input.

Table 2: Mean Proportion of Possible Errors Committed, by Item Type, Grade, and Sex

	First Grade			Sixth Grade			Combined
	Boys	Girls	Total	Boys	Girls	Total	
False Alarms							
Acoustic Distractors	.25	.16	.19	.19	.15	.17	.18
Visual Distractors	.27	.46	.40	.36	.32	.34	.37
Semantic Distractors	.21	.43	.35	.35	.25	.30	.33
New Controls	.11	.08	.09	.13	.12	.13	.11
Other Fillers	.11	.07	.09	.05	.04	.05	.07
Total False Alarms	.16	.18	.17	.18	.14	.16	.17
Misses							
Acoustic Targets	.42	.35	.37	.25	.24	.24	.31
Visual Targets	.38	.33	.35	.35	.18	.27	.31
Semantic Targets	.35	.31	.33	.36	.32	.34	.33
Old Controls	.48	.43	.44	.33	.28	.31	.38
Other Fillers	.47	.38	.41	.35	.42	.39	.40
Total Misses	.44	.38	.40	.33	.30	.32	.36
Total Errors	.30	.28	.29	.25	.22	.24	.27

Figure 1 - Examples of target-distractor pairs.

Acoustic	Visual	Semantic
		
bow	hat	carpet
		
bow	cake	rug