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Recommended Citation

Lindberg, M. A. (1989). The development of attribute dominance in the knowledge base. *The Journal of Genetic Psychology*, 150(3), 269-280.

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The Development of Attribute Dominance in the Knowledge Base

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ABSTRACT. Two cuing, free-recall studies were conducted to test Bach and Underwood's (1970) hypothesis that acoustic encoding is dominant among second graders and semantic encoding is dominant among sixth graders. When retrieval cues were presented with to-be-remembered items at both input and output (Experiment 1), and when cues were presented only at output (Experiment 2), semantic cues were more efficient in elevating recall than were acoustic cues for both second and sixth graders. When these and other results generally found using recognition, sorting, incidental learning, and free-recall experimental designs are compared, it seems plausible that item presentation and memory-testing formats interact with age, and that these factors account for the different patterns of attribute dominance found in the literature. The knowledge base cannot be understood by focusing on either subject or task analyses, but only by focusing on interactions between subject and task variables as they change over time. The educational implications for young grade-school children are discussed.

DEVELOPMENTAL CHANGE IN THE KNOWLEDGE BASE (e.g., Bjorklund, 1987) has been the dominant explanation of memory development during the 1980s. To study the importance of the knowledge base, most investigators have taken the approach of varying expertise with age (Chi & Koeske, 1983; Lindberg, 1980) and have found that age differences in memory performance are largely due to differences in knowledge of the items to be remembered. If younger children have more experience than older children with items used in a memory task, they show better recall of those familiar items than do the older children.

What this approach lacks is a theoretical or empirical description of the major theoretical construct—the knowledge base. So far, most knowledgebase theorists have not carefully specified its nature throughout development, preferring instead to treat it as an intervening variable. When such specifications have been offered (Chi & Koeske, 1983), they have been applied to very restricted domains and therefore do not allow for much generalizability (not unlike the Skinnerian situation a few years ago when all variability was reduced by using either only one subject or one experimental situation). In the literature on the knowledge base,

researchers have reduced variability by concentrating on only one or a few domains of knowledge. Although this kind of research is essential in generating micro models for these restricted domains, it is also important to test the boundary conditions of these knowledge base theories by comparing results across different paradigms (e.g., cued recall, incidental learning, sorting, recognition) and types of items.

To gain a more generalizable and powerful understanding of the knowledge base, researchers should treat it as a hypothetical construct and attempt to specify its structures and functions across development so that more powerful predictions and explanations can be offered. Brown, Bransford, Ferrara, and Campione (1983) stressed the importance of remembering that “. . . the criterion task is in large part responsible for the attribution of a certain kind of knowledge to a certain kind of knower” (p. 98). That is, the nature of the task may determine the kind of attribute that is dominant, and this in turn may interact with the knowledge bases and strategy characteristics of different developmental levels. (See Jenkins, 1979, and Bransford, 1979, for similar arguments.)

This conception of knowledge is not new. It can be seen in Piaget’s reassertion of the Kantian notion that knowledge acquisition can only be understood in terms of subject-environment interactions. If this view is to have scientific value, then researchers of memory development must specify subject and task variables and their interactions in a meaningful empirical fashion. Attribute dominance must be considered not only in terms of developmental level but also in terms of task demands. The knowledge base cannot be defined in terms of fixed tasks or attributes, only in terms of interactions between subject semantic memory characteristics and task demands.

These notions of the knowledge base also should be connected to older data generated from multicomponent theories of the memory trace, which were popular in the late 1960s and early 1970s (e.g., Morton, 1970; Norman & Rumelhart, 1970; Wickens, 1970; and Underwood, 1969). According to this verbal-learning tradition, the encoded representation of an item depends on the features activated in the semantic memory system during trace encoding. (Today developmental theorists tend to call the semantic memory system the knowledge base.)

Working within this tradition, Bach and Underwood (1970) stated that “. . . the memory for a word for younger subjects is more likely to be dominated by the acoustic attribute than is the memory for a word by older subjects” (p. 295). Support for this hypothesis was obtained from a

recognition Study in which second and sixth graders were presented with a 40-item list. The words were presented visually and were read aloud by both the experimenter and the subjects. A multiple-choice recognition test consisted of one of the correct words from the list, a semantic associate to the correct word, a rhyming acoustic associate to the correct word, and a neutral word having no obvious relation to the correct word. Attribute dominance was inferred from the types of errors made on the recognition tests. Bach and Underwood found that second graders made more errors on the acoustic foils, whereas sixth graders made more errors on the associative foils. These results and conclusions have been supported by other studies using similar recognition tasks (e.g., Bisanz, Pellegrino, Kail, & Siegel, 1978; Felzen & Anisfeld, 1970; and Freund & Johnson, 1972), though some variations were found when pictures were used as stimuli (e.g. Means & Rohwer, 1976). The present studies were designed to test the generalizability of these standard findings on the development of attribute dominance in semantic memory (the knowledge base).

The type of test given could limit the generalizability of results showing acoustic dominance in younger children. Different memory tasks and stimulus presentation formats may inflate or deflate the significance of the acoustic attribute; this in turn may interact with age differences in encoding patterns. For example, Underwood's (1969) work with college students showed that the importance or dominance of attributes is different in free-recall and recognition tasks. Leonard and Whitten (1983) showed that control processes of college subjects come into play in further differentiating performance in these tasks.

Even when free-recall tasks are used, attributes may change in dominance because of various methodological variations. For example, Bruce and Crowley (1970) found that the relative dominance of the acoustic attribute in free recall depends on the nature of the list. They found that college students used acoustic relatedness to enhance recall when rhyming words were presented together in the list, but not when they were separated. These results indicate that acoustic relatedness is not used as a retrieval cue unless words that bear such relationships are presented contiguously (cf. Wood, 1972). Thus, presentation and test formats can affect the importance of attributes, and age variables may interact with these task demands. In summary, it is not clear whether Bach and Underwood's (1970) claim of acoustic attribute dominance in young children refers to a general processing tendency or to a task-specific processing tendency.

Cuing designs offer an alternative to recognition studies as methods for assessing attribute

dominance. A cue word is used to facilitate recall of the list item (Tulving & Thomson, 1973), based on the assumption that information about cues, list words, and their relations are stored in memory at the same time (Tulving & Osler, 1968). Thus, comparisons of different types of cues can also be used to assess attribute dominance across developmental levels.

A few researchers have used cued-recall procedures to measure attribute dominance in children of different ages, but they found conflicting results. Naron (1978) found that second graders' cued recall after sorting tasks improved more with acoustic cues than with semantic cues and that sixth graders' recall improved more with semantic cues than with acoustic cues. Thus, these results converge upon the results found with recognition procedures. In contrast, Ghatala and Hurlbut (1973) found that both second and sixth graders benefited more from semantic cues than from acoustic cues. These results do not converge upon those from recognition studies.

Why would one cued-recall study show semantic attribute dominance among second graders and another show acoustic attribute dominance? At least two explanations can be offered. First, the discrepancy may have arisen from methodological differences. Naron (1978) related the list items both acoustically and semantically and instructed the children to sort the items. Ghatala and Hurlbut (1973) used lists of unrelated items and did not have the children sort them. If young children are more likely to notice acoustic relations between to-be-remembered items during encoding, but do not encode the acoustic attribute as dominant when rhyming between items is not present, then one could conclude that the discrepant results are due to methodological differences in design and materials.

A second interpretation focuses on some of the methodological problems in the Ghatala and Hurlbut (1973) study. They suggested that their "discrepant" result (semantic dominance among second graders) may have been due to the children's failure to understand the instructions in the acoustic-cue condition. For example, some children produced non-words during cue recall. Ghatala and Hurlbut suggested that giving cues at input would yield greater cuing effects, thus paralleling the results of recognition studies, which suggest that the acoustic attribute is dominant for second graders.

Two experiments were designed to test this possibility. The first, in line with Ghatala and Hurlbut's (1973) suggestion, involved presenting the cues along with the to-be-remembered test items. In the second experiment, cues were presented only during the retrieval phase. In these

experiments, as in the Ghatda and Hurlbut (1973) study, the list items were unrelated, but for comparability, they were taken from Bach and Underwood (1970).

Experiment 1

Method

Subjects. Second and sixth graders ($N = 80$) from a middle-class elementary school in a small town in the midwestern United States were the subjects. Sex of subject was balanced between conditions.

Procedure. The 40 to-be-remembered words, as well as the semantic and acoustic associates, were taken from Bach and Underwood's (1970) list. Children were tested individually. They were told that they would hear pairs of words on a tape recorder and see these word pairs on flash cards shown by the experimenter. The cue word was printed in lower-case letters; the target word was printed in upper-case letters and was underlined. Children were instructed to try to remember the second word of each pair, which would be printed in capital letters on the cards and would be louder on the tape. Each word took an average of 2 s to be presented by a male voice and were 5 s apart on the tape. The flash cards were held up about 1 m in front of the children and were presented for the full 5 s.

Half of the children heard the to-be-remembered words with acoustically related associates; the other half heard them with semantically related associates. After the lists were presented, children were asked to remember as many of the target words as possible. There was no time limit.

Upon completion of the free-recall task, children were given a cued-recall task with either semantic or acoustic cues, as appropriate. The cues were typed on flash cards, and the experimenter-pronounced each cue word. Children were asked to respond with the word from the list that the cue reminded them of. There was no time limit, and children were encouraged to respond to each cue.

Results

The results were analyzed with a 2 x 2 x 2 (Age x Cue x Type of Recall) analysis of variance (ANOVA). There were significant effects for age, $F(1, 76) = 5.837, p < .025, MSe = 18.375,$

showing that sixth graders recalled more items than second graders. Children in the semantic condition recalled more items than children in the acoustic condition, $F(1, 76) = 23.526, p < .01$. There was no interaction between age and type of cue, $F(1, 76) = .15, p > .05$.

The effects of cuing were significant, $F(1, 76) = 814.192, p < .01$, but cuing did not interact with age, $F(1, 76) = .01, MSe = 9.646, p > .05$. Cuing did interact with type of recall, $F(1, 76) = 31.645, p < .01$. In the semantic condition, recall was better with cues than without them. Sixth graders seemed to benefit proportionately more under semantic cuing, but this trend did not reach statistical significance, $F(1, 76) = 3.841, p < .06$. The means of the groups can be seen in Table 1.

Discussion

These results did not converge with those obtained from recognition studies or from studies in which subjects were instructed to sort the items and in which acoustic relations were present at input. As in Ghatala and Hurlbut's (1973) study

TABLE 1
Mean Recall Level as a Function of Grade and Condition in Experiments 1 and 2

Cue	Experiment 1		Experiment 2		Guessing ^a
	Free recall	Cued recall	Free recall	Cued recall	
<i>Second graders</i>					
Acoustic	3.00	15.25	5.444	9.833	6.777
Semantic	4.75	20.60	6.333	11.277	6.611
<i>Sixth graders</i>					
Acoustic	5.90	16.15	7.722	8.777	8.444
Semantic	5.20	22.90	8.444	14.722	12.500

^aBased on a separate sample (n = 32) that received acoustic or semantic cues only and were asked to guess words that rhymed or were similar in meaning as appropriate.

second graders' recall was facilitated more by semantic cues than by acoustic cues. There are several reasons why this could have happened.

First, if one assumes that a cue that activates a dominant encoding system will be more effective than a cue that activates a less dominant encoding system, then the present data suggest that second graders' dominant encoding attributes are semantic rather than acoustic for recall tasks in which list items do not share acoustic relations at input. This interpretation suggests that

the discrepancy between Ghatala and Hurlbut's (1973) findings and Naron's (1978) findings was produced by methodological differences. That is, when children were required to sort items and the items shared acoustic relatedness at input (as was done by Naron), the acoustic attribute was more important for the second graders, who used it as the dominant encoding attribute. When items were not acoustically related at input and were not sorted by the children, the semantic attribute was dominant (as was found in the present study). In addition, because recognition and sorting tasks require less semantic processing (Underwood, 1969), and because younger children's semantic networks are less elaborate to start with (Lindberg, 1980), the acoustic attribute may be relatively more dominant for younger children than for older children in these kinds of tasks.

This is not the only interpretation that can be offered, however. It could also be reasoned that presenting the cue with the to-be-remembered item led to encoding specificity, so that all children in the semantic cuing conditions were induced to encode the words semantically and children in the acoustic cuing condition were induced to encode the words acoustically. The provision of semantic cues at input may have overcome the younger children's production deficiency (Flavell, 1970) in the semantic conditions. Their recall may have improved because the semantic cues induced them to code the items more deeply or semantically than they normally would in typical recognition and recall tasks in which items are presented individually.

Experiment 2

A second experiment was performed to test the production-deficiency interpretation and to assess the reliability of the results of the first experiment. Cues were presented only at the cued-recall phase on the assumption that the cue most similar to the encoded trace would be most effective in activating that trace for recall (Thuving & Osier, 1968; Underwood, 1969).

Experiment 2 also involved two other changes. First, guessing control groups were added to insure that the differential benefits of cuing were not due to guessing alone. The Ghatala and Hurlbut (1973) and Naron (1978) studies and Experiment 1 did not include such controls, and therefore the discrepant results may have reflected differential guessing strategies in cued recall. Second, the list was shortened to 30 items because children in the first experiment felt overwhelmed by the long list.

Method

Subjects. The 72 second and sixth graders were from a middle-class elementary school in a small town in the Midwestern United States.

Procedure. The 30 to-be-remembered words, along with their semantic and acoustic associates, were taken from Bach and Underwood's (1970) list. The 30 items were presented to each child individually at the rate of 1 item every 5 s. At the same time that children heard each word on a tape recording, the experimenter showed them the same word typed in lower-case letters on a 10 cm X 15 cm flash card. The children were instructed to repeat the word after hearing and seeing it. Immediately following presentation of the list, children were given a free-recall test, with standard instructions. There was no time limit.

Upon completion of the free-recall test, children were given one of two cued-recall tests. Half the children in each grade were given the 30 semantic- associate cues for the correct words, and the other half, the 30 acoustic- associate cues. The cues were presented on flash cards, and the experimenter pronounced each cue word as he presented it. Children were instructed to say the word from the list that the cue reminded them of. There was no time limit, and children were encouraged to respond to each cue. This resulted in a 2 x 2 x 2 factorial design, with grade and type of cue as between-subjects variables and type of recall as a within-subjects variable.

To insure that semantic cues did not elicit more correct guesses than acoustic cues, a guessing experiment was also performed. Thirty-two additional children from Grades 2 and 6 were presented with the 30 acoustic associates and were specifically asked to make up a rhyme for each. They were also given the 30 semantic associates and asked to generate a semantic associate for each. The order of semantic and acoustic guessing was counterbalanced.

Results

The results, which may be seen in Table 1, were analyzed with a 2 x 2 x 2 (Grade x Type of Cue x Type of Recall) ANOVA. There were main effects for grade, $F(1, 68) = 7.288, p < .05$, $MSe = 14.183$, type of recall, $F(1, 68) = 52.412, p < .05$, $MSe = 11.92$, and type of cue, $F(1, 68) = 12.150, p < .05$, $MSe = 14.183$. There was a significant interaction between type of recall and type of cue: Semantic cuing produced a larger increase in free recall than did acoustic cuing, $F(1, 68) = 6.299, p < .05$. Finally, there was a significant interaction between grade, type of recall, and

type of cue, $F(1, 68) = 4.109, p < .05$, which showed that semantic cuing was better than acoustic cuing for sixth graders relative to second graders.

The data from the guessing experiment also can be seen in Table 1. They were analyzed in two ways. First, a 2×2 (Grade x Guessing: semantic vs. acoustic) ANOVA was performed, with grade as a between-subjects variable and guessing as a within-subjects variable. There were significant differences between grades, $F(1, 32) = 7.208, p < .05$, showing that sixth graders guessed more correct words from the word list than did second graders. Semantic cues elicited more correct guesses than acoustic cues $F(1,32) = 5.82, p < .05$. Cuing interacted with grade, however, $F(1, 32) = 12.0p < .01$: Although second graders produced more correct guesses with acoustic cues, sixth graders produced more correct responses with semantic cues. No other variables were significant.

The second analysis sought to test the possibility that the cuing results were due to guessing. Therefore, a $2 \times 2 \times 2$ (Grade x Cue x Task: experimental vs. guessing) ANOVA was performed. Because there was no reason to assume that semantic guesses on the semantic task affected acoustic guesses on the acoustic task, and because the preceding analysis showed no significant effects for task order, semantic and acoustic guessing responses were both treated as between-subjects variables (Winer, 1962). A further index of independence is offered by the fact that all children produced rhymes in the acoustic guessing condition and produced semantically related words (but no rhymes) in the semantic guessing condition. The only reason children in the guessing experiment performed both tasks was because of the small sample size available.

There were significant main effects for grade, $F(1, 136) = 13.173, p < .01$, $MSe = 16.891$ (sixth graders produced more correct responses than second graders), type of cuing, $F(1, 136) = 16.942, p < .01$ (semantic cues produced more correct responses than acoustic cues), and task, $F(1, 136) = 14.071, p < .01$ (children in the experimental group produced more correct responses than did children in the guessing group). There was also a significant Grade x Cue interaction, showing that semantic cues were proportionately better than acoustic cues for sixth graders relative to second graders. No other effects were significant.

Discussion

These data, in line with those of Ghatala and Hurlbut (1973), suggest that under free-recall instructions, and with lists that do not share acoustic relations at input, the dominant attribute in free-recall studies is semantic, even for second graders. Furthermore, the cuing data from

Experiment 2 suggest that the semantic attribute becomes more dominant with age (Bach & Underwood, 1970; Lindberg, 1980). Because the cues were present only at output in Experiment 2 and in the Ghatala and Hurlbut study, a production-deficiency account cannot explain the results very well. As with data from recognition studies (which show consistent acoustic attribute dominance over different lists, testing formats, and laboratories), cued-recall data from experiments in which there is no acoustic similarity between to-be-remembered items at input are equally consistent in showing semantic attribute dominance over different lists, testing formats, and laboratories. The present cued-recall results could not be explained by guessing, a criticism which can be applied to most other studies employing cued-recall procedures.

Other data suggest that the presence or absence of acoustic relatedness of to-be-remembered items at input in free-recall experiments is of crucial importance in determining whether or not young children encode the acoustic attribute as dominant. Hasher and Clifton (1974) visually presented to second graders, sixth graders, and college students lists of items for free recall. Embedded in the lists were items that were either semantically or phonemically related and were either massed or distributed in the list. Second graders receded more phonemically related words than semantically related words, whereas sixth graders recalled more semantically related items than phonemically related items. College students did not show any differences. In this design, where subjects had to read the items and the list items shared phonemic relations at input, second graders showed acoustic dominance.

Attribute dominance has also been studied with incidental learning tasks. Owings and Baumeister (1979) presented unrelated items with incidental and intentional instructions. The incidental instructions were to generate a rhyme (acoustic), indicate whether the item was presented in upper- or lower-case letters (physical), and to answer questions about what the item was (semantic). The intentional instructions merely told subjects to learn the list because recall was going to be tested. If young children naturally encode the acoustic attribute as dominant when they intentionally encode information for recall, then recall in the intentional conditions ought to be most similar to recall in the incidental acoustic conditions. If their dominant encoding dimension is semantic, however, their recall and recognition performance in the intentional condition ought to be most similar to their performance in the incidental semantic condition. Owings and Baumeister found that performance in the acoustic condition for Grades 2, 4, and 6 was lower than performance in the semantic and incidental conditions. The latter two

conditions did not differ significantly. Therefore, because even second graders' free-recall performance was more similar to recall under semantic orienting conditions than under acoustic orienting conditions, it is appropriate to conclude that their dominant encoding attributes were semantic rather than acoustic. This logic is correlational, but it does indicate that the interpretation of the present experiments may have generality across different kinds of tasks.

It could also be reasoned that the present results were due to differential retrieval cue effectiveness (see Moscovitch & Craik, 1976). That is, although young children's dominant encoding is acoustic, semantic cues may be superior to perceptual cues even when the initial encoding was not primarily semantic (Melkman, Tversky, & Baratz, 1981). If only retrieval processes are involved, however, then one would not be likely to find some studies showing acoustic attribute dominance and others, semantic attribute dominance. Thus, although retrieval factors may help determine which attributes will be most effective in various memory tasks, they cannot be the only factor involved.

To summarize, the apparently contradictory data on the development of attribute dominance make most sense if methodological and developmental variations are taken into account. If items share acoustic relatedness and must be read, or if subjects must sort or recognize items, then young children seem to use primarily acoustic attributes in memory. If the input items do not share acoustic relatedness and the subjects' task is to recall the items, then young children use primarily semantic attributes. Thus, to understand the development of attribute dominance more completely, researchers must explore the subject's semantic memory system in relation to the various methods for investigating memory; these designs tap different feature networks in subjects of different ages. More careful specification of the knowledge base in terms of interactions between feature structure and task design may also foster the development of better specification of subject strategy variables as they relate to the notion of mental-effort differences in development.

These conclusions and approach may have more practical implications than did either the older semantic-memory or more recent knowledge-base approaches, which define the major theoretical construct in terms of feature structures alone. For example, to design readers, instructions, pamphlets, movies, and so forth with the primary intent of getting young children to pay close attention to the meaning of the message, one should not use material that rhymes. If the goal is to teach young children the sounds of different words sound or spelling-to-sound

relationships, then materials that rhyme are appropriate. These educational implications should be tested in rigorous, straightforward designs that seek greater ecological and pragmatic utility.

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