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The Development of Memory Structure as Reflected by Semantic-Priming Effects

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This study was designed to investigate the development of knowledge about categorical and associative relationships as reflected by the presence or absence of semantic priming effects. Kindergarteners and second-graders were shown pairs of pictures, one picture at a time, and asked to name each picture as rapidly and accurately as possible. Picture pairs were of four types which reflected the factorial combination of associative relatedness (high and low) with categorial relatedness (high and low). An analysis of naming times revealed a significant main effect of associative relatedness, i.e., second pictures or "target" pictures in high-associative pairs were named faster than those in low-associative pairs. This reduction in naming latency, or priming effect, was independent of developmental level. However, the effects of category relatedness varied with developmental level, i.e., target pictures in high-categorical pairs were named significantly faster than those in low pairs by second-graders, but not by kindergarteners. These findings are discussed in terms of previous estimates of children's semantic competence.

Recent studies have focused on the development of memory structures and retrieval processes for semantic and conceptual information (e.g., McFarland & Kellas, 1975; Schaeffer, Lewis, &Van Decar, 1971). While there is reason to believe that early conceptual structures emerge from dynamic, action-based relationships (e.g., Nelson, 1974), relatively little is known about the subsequent development of superordinate and associative relationships which are thought to predominate in adult memory structure (Collins & Quillian, 1972; Smith, Shoben, & Rips, 1974).

According to one view (Collins & Loftus, 1975), memory structure develops in the form of a conceptual network. Pathways between concepts are not simply undifferentiated links, but are of various "types" which specify the nature of the connection. One important assumption of this model is that the activation of any concept in the network triggers a spreading of activation from that concept along the pathways connecting it to related concepts. These related concepts are thus activated or

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"primed," and their accessibility is increased for a brief time relative to that of unprimed concepts.

Several developmental studies have investigated children's processing of related concepts under conditions in which semantic priming would be expected to occur (e.g., Rosinski, Golinkoff, & Kukish, 1975; Willows, Note 1). In one experiment, McFarland and Kellas (1975) presented fourth-, sixth-, and eighth-grade students with pairs of semantic category names followed by a probe word. The subjects' task was to indicate whether or not the probe was a member of either of the semantic categories. On half the trials, the two semantic categories were similar, e.g., "fruit" and "vegetable," and on the remaining trials they were dissimilar, e.g., "bird" and "weapon." The results indicated that, consistent with the semantic-priming interpretation, response decisions about the probe word were faster with similar than with dissimilar categories for all subjects.

The purpose of the present experiment was to further examine the development of knowledge about semantic relationships as reflected by the presence or absence of priming effects. In order to assess priming developmentally, a procedure was developed in which responses are relatively "automatic" and not dependent on reading skills. The data obtained were therefore expected to closely mirror young children's semantic competence. In the experiment, kindergarteners and second-graders were shown pairs of pictures, one picture at a time. The children's task was simply to name each picture as rapidly as possible. If semantic priming is operative under these conditions, then naming time to the second picture in each pair (target picture) should very inversely with the degree of relatedness between the two pictures, i.e., naming latency to target pictures should be faster when preceded by a highly related than by a relatively unrelated picture.

Picture pairs were of four types (as determined by subjects' ratings described below) which reflected the 2 × 2 factorial combination of associative relatedness (high or low) with categorical relatedness (high or low). High associative–high categorical (HA–HC) pairs contained pictures such as "cat" and "dog," which are highly associated and also highly related categorically. High associative–low categorical (HA–LC) pairs were items such as "bone" and "dog," which were rated high in association value but low in categorical relatedness. The third type of pair, LA–HC, were items such as "lion" and "dog," which are not highly associated, but which are high in categorical relatedness. Finally, LA–LC pairs were items which shared only a minimal associative or categorical relationship, such as "airplane" and "dog."

Spread of activation in the semantic network should not be specific to a particular kind of relationship. Therefore, the extent to which activation of categorically and/or associatively related concepts occurs at the two developmental levels should provide evidence as to the sophistication of the semantic network. While priming based on associative relationships might be expected at both levels (i.e., naming times should be faster in HA than in LA pairs), it is not clear at what age subordinate–superordinate connections become well established. Data obtained by Schaeffer *et al.* (1971) indicate that by the second grade, children are reasonably good at solving semantic oddity problems based on superordinate relationships similar to those used in the present study. This suggests that at least some priming should also occur at the second-grade level as a function of categorical relatedness but does not eliminate the possibility of categorical priming for kindergarteners.

One further variable was manipulated between subjects in an attempt to somewhat more empirically establish the "automaticity" (Posner & Warren, 1972) of semantic priming under present task conditions. Half of the subjects at each developmental level saw the pictures in each pair 1 sec apart, and half saw the pictures 3 sec apart. Other research suggests that any priming obtained at the 1-sec interval should also be obtained following the unfilled 3-sec interval (e.g., Loftus, 1973). However, if developmental changes in semantic priming are obtained which really reflect an increasing sophistication in the use of subject-controlled strategies, the priming effect should actually be enhanced for older subjects at the 3-sec delay, since more time would be available to them for strategy utilization.

In summary, kindergarteners and second-graders were asked to name pictures presented in pairs which varied in degree of associative and categorical relatedness. The delay between pictures comprising a given pair was 1 sec for half the subjects and 3 sec for the remaining subjects. Naming times were expected to provide evidence of the development of associative- and category-based memory structures.

METHOD

Subjects. Eighteen kindergarteners and 18 second-graders who were randomly selected from classes at a local private school participated in the picture-naming task. The children were all upper middle class and approximately equal in numbers of males and females at each grade level. Kindergarteners had a mean age of 6.3 years (range of 5.5 to 6.6) and second-graders had a mean age of 8.2 years (range of 7.5 to 8.7).

Materials. A pool of stimuli, pictures of black and white line drawings, was initially established based on the appropriateness of the pictures for use with young children. Since naming time to the second picture in each to-be-constructed pair was to constitute the dependent measure, a set of these potential target pictures was selected from the stimulus pool. The selection criterion was that each target picture could be paired intuitively with other pictures to form the set of desired relationships, i.e., HA–HC,

TABLE 1

TEST PAIRS WITH THEIR MEAN CATEGORICAL AND ASSOCIATIVE RATINGS, RESPECIVELY (9-POINT SCALE)

Associative relatedness	Categorical relatedness					
	High	C	A	Low	C	A
High	cat–dog[a]	8.5	7.8	bone–dog	3.9	7.6
	foot–hand[a]	8.2	7.1	ring–hand	4.6	7.5
	cow–horse	8.2	6.2	saddle–horse[a]	5.1	8.2
	pants–shirt[a]	8.2	8.1	iron–shirt	3.7	6.0
	apple–banana[a]	8.3	6.0	monkey–banana	3.2	7.8
	truck–car[a]	8.1	7.5	tire–car	5.3	7.5
	nurse–doctor	8.2	8.2	needle–doctor[a]	5.1	6.3
	refrigerator–stove	8.1	7.8	pan–stove[a]	5.1	6.8
	peas–carrots	8.2	8.0	rabbit–carrots[a]	4.3	6.9
	fireman–policeman[a]	7.6	6.6	jail–policeman	5.3	7.5
	hammer–saw[a]	8.2	7.5	board–saw	4.1	6.5
	cake–pie[a]	8.5	7.3	apple–pie	5.7	7.8
	butterfly–bee	7.3	6.0	flower–bee[a]	4.5	7.2
	cat–mouse	6.7	8.3	cheese–mouse[a]	3.3	7.0
	coat–hat	7.7	7.6	head–hat[a]	4.3	7.6
	knife–gun	7.9	6.6	bullet–gun[a]	6.7	7.8
Low	lion–dog[a]	7.2	4.3	airplane–dog	1.7	1.0
	ear–hand[a]	7.1	5.1	cake–hand	3.3	1.3
	lion–horse	6.8	3.5	onions–horse[a]	1.3	1.0
	shoes–shirt[a]	7.6	6.5	ice cream cone–shirt	1.3	1.0
	cherry–banana[a]	8.2	5.0	screwdriver–banana	1.7	1.0
	airplane–car[a]	7.1	5.2	ear–car	1.7	1.0
	mailman–doctor	6.3	3.7	toaster–doctor[a]	1.3	1.0
	toaster–stove	7.0	5.2	cow–stove[a]	1.3	1.7
	onions–carrots	8.1	6.8	mailman–carrots[a]	1.3	1.0
	doctor–policeman[a]	6.3	3.5	cherry–policeman	1.7	1.0
	screwdriver–saw[a]	7.7	5.9	pants–saw	3.0	1.0
	ice cream cone–pie[a]	6.8	4.8	truck–pie	2.3	1.7
	spider–bee	7.0	4.3	nurse–bee[a]	1.3	1.0
	dog–mouse	5.7	3.2	arrow–mouse[a]	1.0	1.0
	shoes–hat	7.4	5.4	butterfly–hat[a]	1.0	1.0
	arrow–gun	7.4	5.6	spider–gun[a]	1.0	1.0

[a] Set A pairs. Other pairs were in Set B.

HA–LC, LA–HC, or LA–LC. Ratings from the Battig and Montague (1969) and Palermo and Jenkins (1964) norms were used to guide the pairing procedure whenever possible. Eighty pairs, 20 of each type, were constructed in the above manner from 20 target pictures. Care was taken to ensure that pictures of items from the same category were as visually dissimilar as possible.

The 80 pairs were listed randomly on rating sheets, with each pair followed by a 9-point scale. Twenty college students unaware of the purpose of the experiment were recruited to rate the pairs. Half of these students were instructed to rate the pairs according to associative strength, that is: "To what degree does the first item in each pair tend to bring to mind the second?" The remaining college students were instructed to rate the items according to their "categoriness" or the degree to which the words belonged to the same category.

The mean category and association ratings were tabulated for each pair. The pairs formed from four of the targets pictures were dropped, since our intuitions about their categorical and/or associative relatedness were not confirmed by subjects' ratings. The pairs formed from the remaining target pictures were selected as the test stimuli. The final list of test pairs is presented in Table 1. Mean categorical and associative ratings, respectively, for each of the four types of pairs were as follows: HC–HA—8.0, 7.3; LC–HA—4.6, 7.2; HC–LA—7.1, 4.9; LC–LA—1.6, 1.1; with 9.0 being maximum.

Apparatus. The apparatus consisted of two Kodak Carousel (Model C) slide projectors equipped with tachistoscopic lenses for presenting pictures, a voice operated relay wired to a Hunter Model 120-C Klockounter for recording naming latencies, and supportive programming equipment including a timer to control the interval between pictures in a given pair. The Klockounter was interfaced with the voice operated relay and tachistoscopic lenses such that the onset of the second picture in each pair started the timing cycle, and the subject's naming response stopped the cycle. Naming latencies were recorded to the nearest millisecond.

Design and procedure. Children at each developmental level were randomly assigned to either a 1- or 3-sec delay condition. Delay refers here to the interval between the subject's response to the first picture in each pair and the onset of the second picture.

Subjects were tested individually. At the beginning of the session, each subject was shown all of the pictures and asked to identify them. The pictures were presented individually and in a random order. Any naming errors were corrected by the experimenter (no more than one for any given subject). Following identification, the subject was given 15 practice trials on the picture-naming task with all pairs being of the LA–LC type. Pairs used during practice were as devoid of semantic relationships as possible so that any "set" or response bias which might be established would work against obtaining the predicted semantic effects. Subjects were instructed simply to name each picture as quickly as possible, without making errors. The interval between pictures during practice for a given subject was set in accordance with his treatment condition, either 1 sec or 3 sec. The intertrial interval was 10 sec for all subjects.

After the practice trials and the subject's assurance that he understood the task, the test sequence was initiated. Instructions were the same as

TABLE 2

MEAN NAMING LATENCIES (IN MSEC) FOR TARGET PICTURES AS A FUNCTION OF DEVELOPMENTAL LEVEL, DELAY, CATEGORICAL RELATEDNESS, AND ASSOCIATIVE RELATEDNESS

		1-second delay		3-second delay	
Grade	Categorical relatedness	Low-associative	High-associative	Low-associative	High-associative
K	Low	991	1012	1043	1010
	High	1076	981	1070	1007
2	Low	885	865	1018	966
	High	861	814	948	937

those during practice, and no mention was ever made about potential relationships between pictures. All subjects received 32 test trials composed of equal numbers of HA–HC, HA–LC, LA–HC, and LA–LC pairs. The 64 pairs shown in Table 1 were divided into two sets (A and B) of 32 pairs so that each target picture appeared only twice in a given set. Half of the subjects received Set A and half Set B, counterbalanced across developmental level and delay. Across subjects, each target picture therefore appeared equally often in all conditions, to control for item differences.

RESULTS AND DISCUSSION

The mean naming times for target pictures presented in Table 2 were analyzed in a mixed analysis of variance. Between-subjects factors were Developmental Level (K or 2) and Delay (1 or 3 sec), while all subjects saw picture pairs which varied in Associative Relatedness (high or low) and Categorical Relatedness (high or low). (Medians were also tabulated and analyzed, with results confirming those presented below for the means.) A preliminary analysis had indicated that subjects' naming times did not differ as a function of stimulus subset (A or B). This factor was therefore not included in the main analysis.

As expected, second graders were faster, in general, than kindergarteners in naming pictures, $F(1,32) = 7.90, p < .01$. Mean times were 1024 and 916 msec for kindergarteners and second-graders, respectively. No effects involving the Delay variable were significant, tentatively supporting the assumption that responses in this task are relatively automatic and not dependent on use of a naming "strategy." While this suggestion is based on a failure to reject the null hypothesis, none of the interactions which would support the strategy interpretation even approached significance (all p's $> .25$).

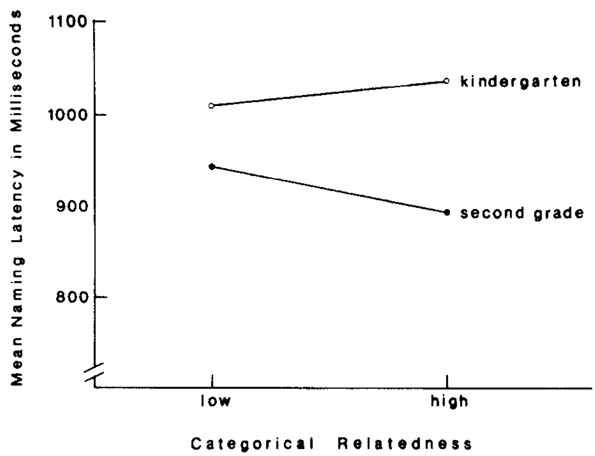

FIG. 1. Mean naming latencies to target pictures for kindergarteners and second-graders as a function of categorical relatedness.

It was previously suggested that activation or priming in the semantic system should lead to significant effects of either the associative or categorical variable, or both. The analysis revealed a significant main effect of Associative Relatedness, $F(1,32) = 9.24, p < .01$; target pictures in high associative pairs were named faster than those in low pairs (949 versus 990 msec). This 41 msec priming effect was clearly independent of developmental level ($F < 1.0$), with the mean difference in naming times for target pictures in high versus low associative pairs being 43 msec for kindergarteners and 39 msec for second-graders. The other effect obtained in the analysis was the interaction of Category Relatedness and Developmental Level, $F(1,32) = 4.74$, $p < .05$, shown graphically in Figure 1. Tukey B multiple comparisons indicated that target pictures in high categorical pairs were named significantly faster (52 msec) than those in low categorical pairs, by second-graders ($p < .05$) but not by kindergarteners.

The obtained effect of semantic relationships on picture naming per se provides at least suggestive support for an assumption implicit in the present methodology—pictorial and semantic representations of a concept are stored in the same memory system (see Barron & Urquhart, Note 2). In addition, the present data, in conjunction with results from other experiments (Rosinski *et al.*, 1975; Schaeffer *et al.*, 1971), suggest that both associative and categorical relationships have become an integral part of this memory system by the second grade. Alternatively, only associative relationships appear to be functionally established by the kindergarten level.

The similarity between developmental levels in the magnitude of the associative-priming effect suggests that the acquisition of superordinate–

subordinate relationships does not qualitatively change the child's existing associative structures. It should be noted that, as in other cases, it is somewhat tenuous here to assume similarity of process from response times alone. However, the implication of the present data is that response differences between kindergarteners and second-graders on other tasks, such as free association (e.g., Ervin, 1961), probably result from the addition of new structures rather than from an age-related reorganization of semantic memory. Further, as McFarland and Kellas (1975) have argued, it is likely that assessments of the semantic system from recall and clustering data have resulted in underestimates of the child's knowledge. While McFarland and Kellas' arguments were based on a demonstration of "automatic" semantic processes in fourth graders, the present data suggest that such processes are operative even earlier in development.

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