DOCUMENT RESUME

ED 209 663 CS 206 606

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TITLE Aging and Semantic Activation.
PUB DATE Aug 81
NOTE 12p.: Paper presented at the Annual Meeting of the American Psychological Association (89th, Los Angeles, CA, August 1981).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Age Differences; *Aging (Individuals); *Cognitive Processes; College Students; *Language Processing; *Language Research; *Long Term Memory; Older Adults; Recall (Psychology); Semantics; Word Recognition

ABSTRACT

Three studies tested the theory that long term memory consists of a semantically organized network of concept nodes interconnected by leveled associations or relations, and that when a stimulus is processed, the corresponding concept node is assumed to be temporarily activated and this activation spreads to nearby semantically related nodes. In the first study investigating semantic interference, it was found that both elderly subjects and college students took longer to call out the ink color when the printed word was semantically related to designated words held in memory than when it was not related. In the second study, elderly subjects showed at least as much semantic priming as younger subjects, that is, pairs of letter strings were identified as words more rapidly if the words were semantically related than when they were unrelated. In both studies the stimuli were highly associated with each other, so a third study was conducted, varying the degree of association, to see whether age differences in priming would appear for less highly associated pairs. Participants were asked to state whether pairs of letter strings printed one above the other were words, with the response time recorded. The results showed that the magnitude of the priming effect did not vary with age or with associativity of word pairs, thus indicating that automatic processes do not change during aging. (HTH)

Paper presented as part of a symposium entitled "Studies of Semantic Memory in Aging" at the annual meetings of the American Psychological Association, Los Angeles, August 1981.

AGING AND SEMANTIC ACTIVATION*

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Several contemporary theories (e.g., Anderson, 1976; Collins & Loftus, 1975) assume that long-term memory consists of a semantically organized network of concept nodes interconnected by labeled associations or relations. When a stimulus is processed, the corresponding concept node is assumed to be temporarily activated (i.e., rendered more accessible) and this activation spreads to nearby semantically related nodes, rendering them more accessible as well. Several years ago we began investigating semantic activation across the adult lifespan. Today I will summarize our earlier findings and then describe some new data from an experiment we have just completed.

We began this series of studies for two reasons. First, semantic activation appears to play an important role in language comprehension, memory search, and problem solving, so it is important to know whether it declines in the later years of life. Second, studies of aging and semantic activation should help to clarify the influential processing-deficit theory proposed by Eysenck (1974) and others. Processing-deficit theory states that elderly adults are less able than young to process stimuli to deep semantic levels. Viewed from the perspective of network theories, then, it suggests that with old age there is a decline in the spread of semantic activation. We have investigated this possibility by examining patterns of semantic interference and semantic priming throughout adulthood.

In our first study (Howard, Lasaga, & McAndrews, 1980) we examined semantic interference in a modified Stroop procedure that Warren (1972, 1974) has used with college students. People were asked to hold a set of three related words in memory for a few seconds. During this brief retention interval they attempted to call out the color of ink in which a base word was printed, while ignoring the base word itself. Warren had found that college students take longer to call out the ink color when the base item is semantically related to the words in the memory set than when it is not. According to network theories, this semantic interference indicates that activation has spread from the nodes corresponding to the memory set words to the nearby node for the base word. This makes the base word more accessible, and therefore more difficult to ignore during color naming. When we presented this task to adults ranging in age from 20 through 80, we found that this semantic interference was just as pronounced in the elderly participants as in the young. This age constancy in semantic interference suggested, then, that there is no decline in old age in the semantic activation that occurs when words are held in working memory.

It seemed possible that this age constancy only occurs when people hold several related words in memory for a few seconds, but that elderly individuals might show less semantic activation than the young if they were asked to make simple speeded decisions about words. Therefore, in our next experiment (Howard, McAndrews, & Lasaga, in press) we adopted the lexical decision task introduced by Meyer and Schvaneveldt (1971). Participants were shown pairs of letter strings and asked to respond "yes" only if both strings were words. Meyer and Schvaneveldt had shown that students reveal semantic priming in this task. That is, affirmative decisions are made more rapidly for pairs of semantically related words (e.g., CAT-FUR) than for pairs of unrelated words (e.g., CAT-NET). According to network theories, this semantic priming occurs because looking up the concept node for CAT results in activation spreading to the related node for FUR, thereby facilitating its processing. When we compared young and elderly adults, we found that the elderly individuals showed at least as much semantic priming as the young. Furthermore, this age constancy occurred regardless of whether the related pairs were category member associates (e.g., RAIN-SNOW) or descriptive-property associates (e.g. RAIN-WET), suggesting that the patterns of semantic activation are similar across the adult years.

In both studies I've described so far, the related trials always contained stimuli which were very high associates of each other, so network theory would assume that their nodes are located very close together in long-term memory and that, consequently, activation need not spread very far in order to yield priming. If related items were less highly associated, however, activation would need to spread further in the network in order for priming to occur. Therefore, despite the age constancy in priming and interference we've observed with highly associated items, it is still possible that activation does not spread as far in the aged, and that age differences in priming would appear for less highly associated pairs.

Therefore, in the experiment we have just completed we varied the degree of associativity of the words within related pairs in a lexical decision task. Each trial consisted of a fixation point, followed by a pair of letter strings printed one above the other. This array remained on the screen until the person pressed a button labeled either "yes" if both strings were words, or a button labeled "no" otherwise. Response time was recorded from onset of the letter strings.

Each participant responded to seven different kinds of trials, examples of which are shown in Table 1. Note that for four of these trial types the correct response is "yes" and for three it is "no". The "yes" trials are most important for present purposes, so we will only consider those. Notice that the word pairs always consisted of a category name above a category exemplar. On related trials the category name and exemplar were from the same category, whereas on unrelated trials they were from different categories. We varied associativity by presenting two levels of category dominance. On high dominance trials the category exemplar was among the most frequently named exemplars of a category (e.g., BIRD-DUCK), whereas on low dominance trials it was a less frequently named category exemplar (e.g., BIRD-ROBIN). The related pairs were chosen using the Battig and Montague (1969) norms and the category norms we had collected earlier from other adults ranging in age from 20 through 80 (Howard 1980a, 1980b).

In order to insure that the degree of semantic priming does indeed vary with degree of associativity as we defined it here, we conducted a pilot study in which we tested 20 college students using the task and stimuli I've just described. Their mean response times for the four "yes" trial types are shown in Table 2. The most important column is the one labeled "prime effect" which was obtained by subtracting response time on related trials from that on unrelated trials. Notice that as predicted, there is a significant prime effect for both high and low dominance pairs, and that the magnitude of this effect is significantly greater for high dominance pairs (194 msec) than for low (113 msec).

Having established that the dominance variable influences magnitude of priming among college students, we then conducted our primary experiment in which we tested 20 young and 20 elderly adults, none of whom were full-time students. The characteristics of our participants are displayed in Table 3, and their mean response times for "yes" trials and their prime effect are shown in Table 4. The most important characteristic of these findings is that the magnitude of the prime effect does not vary significantly with either age or with dominance. Both age groups reveal significant and equivalent priming for both high and low dominance pairs. Indeed, the overall correlation between magnitude of the prime effect and age is a nonsignificant -.14. In light of our college student data, it is somewhat surprising that dominance did not influence the degree of priming for either of these nonstudent groups, even though it did influence their overall response time.

The skeptics among you might be suspecting that we have simply tested a superior group of elderly individuals who would not show a deficit even on traditional episodic memory tasks. In order to investigate this possibility, following the lexical decision task we also tested each participant for incidental free recall and then forced-choice-recognition of the words they had seen during the lexical decision task. We found significant age differences favoring the young adults in both tasks as indicated in Tables 5 and 6. Thus, even though both age groups revealed equivalent priming for these words, the younger participants both recognized and recalled them more accurately than the old.

In closing, then, our research to date suggests three general conclusions. First, semantic activation as assessed through semantic interference and/or semantic priming appears to remain remarkably stable throughout the years from 20 through 80. This similarity holds across different tasks, different kinds of semantic relations, and different degrees of relatedness. Indeed, the work of Elisabeth Clark (1981) indicates that it holds even for elderly adults with moderate memory difficulties.

Second, this similarity in semantic activation places constraints on the nature of any processing-deficit that can be called upon to explain the elderly person's difficulties with episodic memory and with some of the inferential aspects of language comprehension. Our results do not rule out the possibility that the elderly person is less likely to engage in some forms of semantic elaboration. However, they do indicate that the aged are not deficient in the semantic activation that occurs when words are perceived or held in working memory. In this sense at least, they are just as likely as young adults to engage in semantic encoding, even when it is not necessary to complete the task at hand.

Third, to the extent that the spreading semantic activation we have studied is an automatic process, our findings are consistent with Hasher and Zacks' (1979) hypothesis that automatic processes do not change during aging. In fact, our current research is concerned with separating the automatic from the effortful components of semantic activation.

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*This research was supported by Grant 1R23AG00713 from the National Institute on Aging. A technical report containing a more detailed presentation of these findings can be obtained from the author at the Department of Psychology, Georgetown University, Washington, D. C. 20057.

Howard, D. V Aging and Semantic Activation. Paper presented as part of a symposium entitled "Studies of Semantic Memory in Aging" at the meetings of the American Psychological Association, Los Angeles, August 1981.

TABLE 1

EXAMPLES OF THE CONDITIONS FOR THE LEXICAL DECISION TASK

Trial Type	Correct Response	Dominance High		Dominance Low	
Related	yes	BIRD ROBIN	(9)*	BIRD DUCK	(9)
Unrelated	yes	BIRD LINEN	(9)	BIRD KNIT	(9)
Nonword-Nonword	no	BATZLE TAVE	(12)		
Word-Nonword	no	CANDY ZORK	(12)		
Nonword-Word	no	FETROL MEAT	(12)		

*Numbers in parentheses indicate the number of trials per subject

Note: Each participant saw each word or nonword only once, but across participants a given word occurred equally often in the four "yes" conditions, so each word served as its own control.
High and low dominance category exemplars were balanced for overall frequency in the English language, using the Thorndike-Lorge (1944) norms.
Nonwords were created by replacing one letter in a high frequency English word, producing a pronounceable nonword.

TABLE 2

MEAN RESPONSE TIME (MSEC) FOR THE PILOT STUDY
COLLEGE STUDENT SUBJECTS

	Trial Type Unrelated	Related	Prime Effect*
High Dominance	998 (314)	804 (237)	194
Low Dominance	978 (316)	865 (297)	113
Mean	988	835	153

*Prime Effect=Response time on Unrelated trials minus response time on Related trials

Values in parentheses indicate the standard deviation.

MAJOR FINDINGS:
1. Significant priming for both high and low dominance, Trial Type $F(1,19)=38.02$, $p < .001$
2. Significantly greater prime effect for high dominance than for low, Dominance x Trial Type $F(1,19)=5.93$, $p < .025$

TABLE 3

SUBJECT CHARACTERISTICS - AGING STUDY

Group*	n	Age Range	Age Mean	Age SD	Years of Education Mean	Years of Education SD	Ammons' QT Score Mean	Ammons' QT Score SD
Young	20	22-42	31.1	6.4	16.5	1.7	137.8	5.6
Old	20	64-78	69.5	4.3	16.5	3 0	141.2	4.6

*Each age group contained 7 men and 13 women.

TABLE 4

MEAN RESPONSE TIME (MSEC) FOR THE AGING STUDY

	Young Group			Old Group		
	Unrelated	Related	Prime Effect*	Unrelated	Related	Prime Effect*
High Dominance	1359 (612)	1204 (522)	155	1436 (411)	1349 (377)	87
Low Dominance	1433 (656)	1308 (583)	125	1540 (415)	1435 (422)	105
Mean	1396	1256	140	1488	1392	96

*Prime Effect=Response time on Unrelated trials minus response time on Related trials

Values in parentheses indicate the standard deviation.

MAJOR FINDINGS:

1. Significant priming for both high and low dominance, Type $F(1,38)=53.82$, $p < .0001$
2. Significantly faster response times for high dominance than for low dominance, Dominance $F(1,38)=35.13$, $p < .0001$
3. Priming not significantly greater for high dominance than for low, Type x Dominance $F(1,38)=2.37$, $p > .10$
4. No main effects or interactions with Age approach significance
5. Correlation between Age and Prime Effect is -.14, n=40, $p > .10$

TABLE 5

MEAN NUMBER OF LEXICAL DECISION WORDS FREE RECALLED*

Young	Old
7.80 (5.03)	5.00 (3.16)

*Of a possible 96 words.

Values in parentheses indicate the standard deviation.

$t(38)=2.06$, $p < .05$

TABLE 6

MEAN PERCENT CORRECT RECOGNITION OF WORDS FROM "YES" TRIALS*

Young	Old
69.04 (17.99)	58.62 (22.09)

*Chance=25%

Values in parentheses indicate the standard deviation

$F(1,38)=4.70$, $p < .05$