Effect of Generating a Semantic Prime: The Impact of Age and Cognitive Impairment

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Studies of both semantic priming and the generation effect (GE) have implicated spreading activation in semantic memory and have provided evidence for a semantic memory access disorder in patients with dementia. Fifteen subjects consisting of young, elderly, and demented patients participated in a semantic priming/GE task to determine whether the act of generating a semantic prime enhanced activation and reduced reaction times to related items. Reaction times were recorded for semantically related and unrelated targets presented after either read or generated word pair cues. From the results it was suggested that generating a prime provided little benefit for young subjects or subjects with dementia; elderly subjects benefited more from generating information than from reading it. Implications for theories of dementia and normal aging are discussed.

One of the most often cited language problems present in dementia is word-retrieval difficulty (Flicker, Ferris, Crook, & Bartus, 1987). Many explanations for this word-retrieval deficit have focused on an information processing breakdown, particularly regarding semantic memory (Chertkow & Bub, 1990a; Grober, Buschke, Kawas, & Field, 1985). Although some researchers have suggested that dementia results in a *loss* of actual conceptual knowledge (Chertkow & Bub, 1990a), a majority of studies have found evidence for a semantic memory *access* disorder, presumably due to disruptions in the associations between concepts or to decreased activation of concepts (Abeysinghe, Bayles, & Trosset, 1990; Grober et al., 1985; Salmon, Shimamura, Butters, & Smith, 1988).

Studies of semantic priming effects support the possibility of an access disorder in dementia. No semantic priming effects have been found in some subjects with dementia (Albert & Milberg, 1989; Salmon et al., 1988), which is consistent with an access impairment caused by insufficient activation of concepts and associations. On the other hand, "hyperpriming" has been found in some subjects with dementia (Chertkow & Bub, 1990b); this has also been attributed to weakened links between associations in semantic memory and decreased activation of concepts.

Further evidence of a semantic memory breakdown in patients with dementia comes from studies of the generation effect (GE). The GE refers to a phenomenon whereby a word generated by a person will be better remembered than one that is simply read (Slamecka & Graf, 1978). In studies of subjects with dementia, little or no GE has been evident. It has been hypothesized that this may be due to a semantic processing deficit that leads to decreased activation of concepts in semantic memory and decreased memorability of generated items (Dick, Kean, & Sands, 1989; Mitchell & Schmitt, 1986).

Because it has been theorized that semantic priming is caused in part by spreading activation (Chertkow & Bub, 1990b; Nebes, Martin, & Horn, 1984), and because theories of the GE include spreading activation (Mitchell & Schmitt, 1986), it is of interest to examine the relationship between priming and the GE. In the present study, an attempt was made to determine whether the act of generating an item enhanced activation of that item in semantic memory, thereby reducing reaction times to related targets in a priming task. The purpose of this study was to explore further the possible semantic memory breakdown in subjects with dementia by comparing them to subjects matched in age and education and without cognitive impairments on a unique task that combined GE and semantic priming. To document any changes that might be attributed to normal aging, and not to dementia, a group of young subjects with no known neurological impairments was also tested. It was postulated that, if the lack of a GE in patients with dementia is associated with an access disorder from insufficient activation in semantic memory, the act of generating an item would not decrease reaction times to semantically related items in a priming task.

Method

Subjects

Fifteen subjects, divided into three groups, participated in this study. Group 1 consisted of five young subjects (M age = 20.8, M education = 13.0 years) with no known neurological impairment. Group 2 consisted of five elderly subjects (M age = 79.4, M education = 12.6 years) with no known neurological impairment. Group 3 consisted of five subjects with dementia, as diagnosed by a physician (M age = 82.6, M education = 10.4 years). Presence of dementia and its severity were verified using the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975). Subjects with dementia had an average MMS score of 16.6 and a mean severity of moderate impairment.

Materials

Stimuli consisted of 120 stimulus-response triads, each including a rhyme pair and a third target word. The second word of each rhyme pair served as the semantic prime for the semantically related or unrelated target (third stimulus in each triad).

Stimuli were arranged into four conditions, with a total of 30 trials per condition (see Figure 1). In the *read* conditions (RR & RU), the entire prime

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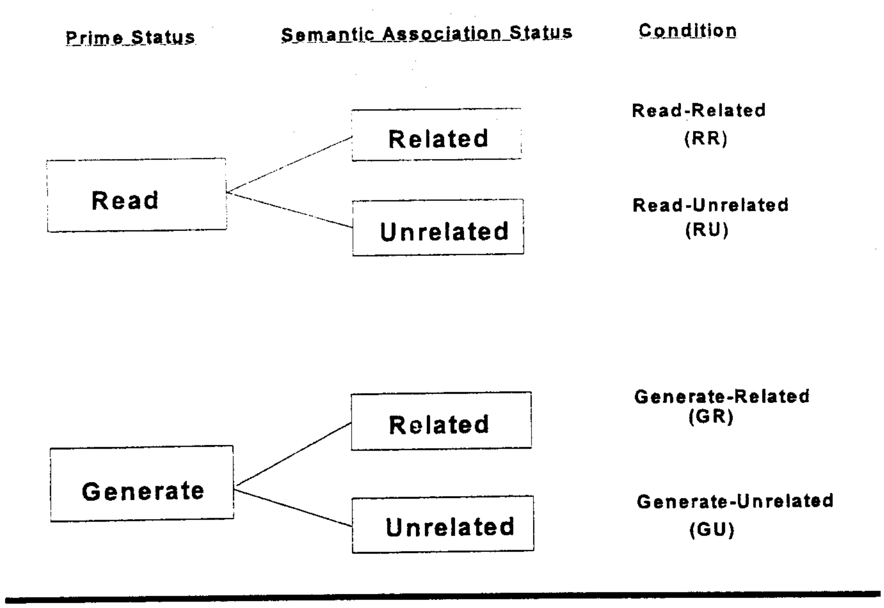
FIGURE 1. Summary of the four experimental conditions including prime type and association status.



was read aloud by the subject (boy-toy). In the *generate* conditions (GR & GU), the subject was required to self-generate a prime that rhymed with the first word of the pair based on letter cues (boy-t__). Primes had the following characteristics: word length ranged from 3–7 characters ($M = 4.48$) and frequency of occurrence ranged from 66 to 2110 per million ($M =$ 231.7 per million) (Francis & Kucera, 1982). For both conditions, a semantically related (RR & GR) or unrelated (RU & GU) word that the subject read aloud followed the rhyme pair. Semantically related words were selected based on word association norms (Balota & Lorch, 1986). Examples of related stimulus-response triads are as follows: *look-book/read, poor-door/window, heat-seat/chair*, and *say-day/night*. Examples of unrelated triads include: *vote-note/bug, air-chair/apple, wire-fire/drink*.

Procedure

For the experimental task, subjects completed 2 blocks of 60 trials. Each block contained equal numbers of either read (RR & RU) or generate (GR & GU) items. Related and unrelated stimuli were randomized within each block. Presentation order of the blocks was randomized by subject. Rhyme pair stimuli appeared for 3,500 ms, immediately followed by targets that were presented for 2,000 ms. Subjects read the target aloud as soon as it appeared. Reaction times (RTs) were collected using a voice-activated relay switch. Subjects were informed of the rhyming nature of the task and were instructed to read the first two words aloud, generating a rhyme if the entire word was not presented. They were then told to read the single word that appeared next to the rhyme pair as soon as it appeared. To ensure that subjects understood the tasks, practice trials were given before experimental stimuli were presented.

Statistical analyses consisted of planned contrasts carried out using paired *t*-tests. Analyzed data included only correct responses. To determine practical significance, the effect size indicator eta-squared (η^2) was calculated for all *t*-tests. The following effect size levels were used for comparison: large = .14, medium = .06, small = .01 (Cohen, 1977). Following Bonferroni adjustment of *p*-values, an alpha level of .08 was adopted for the multiple *t*-tests.

Results

Within-Group RT Comparisons

Group RT data by condition are presented in Table 1. For each comparison, individual RT data closely reflected group data.

Although statistical significance was not reached for any comparison, trends emerged, based on effect size indicators, that are addressed below.

Read-Related versus Read-Unrelated. In comparing RR and RU, statistically significant priming effects were not found for any group. However, a degree of priming was evident for young [$t(4) = 1.94, p > .08, \eta^2 = .32$] and demented subjects [$t(4) = .88, p > .08. \eta^2 = .16$] and large effect sizes favored related stimuli. Large effect sizes for the elderly group indicated trends favoring unrelated over related targets, $t(4) = 2.19, p > .08, \eta^2 = .54$.

Generate-Related versus Generate-Unrelated. For the GR versus GU comparison, both elderly and demented subjects demonstrated faster average RTs to related stimuli than unrelated stimuli and large effect sizes indicated relationships favoring priming in these groups [Group 2: $t(4) = 3.09, p > .08, \eta^2 = .70$; Group 3: $t(4) = 1.27, p > .08, \eta^2 = .28$]. Young subjects, on the other hand, showed significantly faster RTs to unrelated stimuli [$t(4) = 3.43, p = .08, \eta^2 = .75$], and large effect sizes support this relationship.

Generate-Related versus Read-Related. Statistical significance was not reached in any group for the comparison of GR and RR. However, effect size indicators reflected emergent trends. Elderly normals demonstrated large effect sizes in favor of

TABLE 1. Means, standard deviation, and ranges for RTs (in milliseconds) for each condition by group.

Condition		Young	Elderly	Demented
Read-Related	*M*	714.47	856.77	904.46
	SD	103.82	99.14	136.04
	Range	(619.30–921.96)	(689.00–981.46)	(712.90–1061.68)
Read-Unrelated	*M*	724.54	781.74	974.43
	SD	108.22	104.06	248.11
	Range	(644.81–929.68)	(631.43–928.71)	(800.03–1411.84)
Generate-Related	*M*	735.32	807.89	956.16
	SD	105.62	95.45	152.80
	Range	(653.28–841.31)	(708.32–879.95)	(806.11–1169.84)
Generate-Unrelated	*M*	708.74	841.71	987.69
	SD	104.68	91.68	136.96
	Range	(642.10–803.93)	(718.63–946.33)	(863.18–1147.95)

the GR condition, $t(4) = 1.81$, $p > .08$, $\eta^2 = .45$. Young normals and subjects with dementia showed large effect sizes favoring RR over GR [$t(4) = -.80$, $p > .08$, $\eta^2 = .14$; $t(4) = 1.53$, $p > .08$, $\eta^2 = .37$, respectively].

Between-Group RT Comparisons

Although statistically nonsignificant for most comparisons, descriptive comparisons of RTs to each condition among groups yielded expected results. Young normals reacted more quickly in all conditions than elderly subjects who, in turn, reacted more quickly than subjects with dementia. Following Bonferroni adjustment of p values, only the comparison of the younger group to the group with dementia yielded significant results [$t(8) = 4.10$, $p < .08$, $\eta^2 = .68$]. Results of t-tests and effect size calculations can be found in Table 2.

Error Analysis

Normal subjects responded to rhyming tasks with 100% accuracy. Subjects with dementia did make errors on the rhyming tasks, although data regarding specific error types were not available for analysis. However, for the subjects with dementia, mean errors (semantic or off-target) were 1.6 for RR, 0.4 for RU, 4.6 for GR, and 2.0 for GU.

TABLE 2. *T*-test results for between-group RT comparisons including degrees of freedom (df), *t* value, *p* value, and eta squared (η^2).

	df	t	p[a]	η^2
Group 1 vs. 2				
Condition I (RR)	8	1.94	.71	.31
Condition II (RU)	8	.81	3.52	.14
Condition III (GR)	8	1.69	1.04	.26
Condition IV (GU)	8	2.82	.18	.17
Group 2 vs. 3				
Condition I (RR)	8	.61	4.48	.04
Condition II (RU)	8	1.60	1.33	.24
Condition III (GR)	8	1.99	.78	.33
Condition IV (GU)	8	2.05	.66	.34
Group 1 vs. 3				
Condition I (RR)	8	2.33	.384	.4
Condition II (RU)	8	2.03	.72	.34
Condition III (GR)	8	2.94	.224	.52
Condition IV (GU)	8	4.10	.056	.68

[a]p values reflect Bonferroni adjustment.

Discussion

Within-Group Comparisons

Read-Related versus Read-Unrelated. Based on effect sizes, a degree of semantic priming was found for both young subjects and subjects with dementia for this comparison. However, elderly subjects reacted faster to RU targets, demonstrating negative priming. In a study conducted by Bowles (1989), elderly subjects were inhibited by a related prime in a word retrieval task. Bowles suggested that these subjects made a decision regarding the correctness of the prime, which added an extra processing step and served to increase reaction times to related stimuli. It is possible that, in this study, elderly subjects reacted similarly to Bowles' subjects. The subjects may have unconsciously attempted to make a decision about related primes because of the inherent relationship between the stimuli, which does not exist in the unrelated condition. This decision-making step may have been employed by elderly subjects, but not young subjects, because of expected declines in word-finding abilities associated with aging. On the other hand, subjects with dementia may not have completed the decision-making step because of attentional and processing differences expected with dementia.

Generate-Related versus Generate-Unrelated. For this comparison, both elderly normal subjects and subjects with dementia demonstrated faster RTs to related than to unrelated stimuli, indicating that priming occurred, to some degree, and effect sizes favored this relationship. It may be that a larger sample size would have allowed significance to emerge. Young subjects, on the other hand, showed faster RTs to GU stimuli. These subjects may have attempted to determine any relationship between the presented items, which may have had more of an impact in the generate condition than the read condition. If it is assumed that generation causes increased activation in semantic memory, then any attempt to figure out the relationship between items would possibly interrupt activation, or distract attention from the task, causing slower reactions once the target was presented.

Generate-Related versus Read-Related. As mentioned earlier, it was thought that, if generating an item had an impact on the activation level of that item in semantic memory, then RTs to GR items should reflect this and be faster than RTs to RR items. As indicated, results were not significant between these conditions for any group. For elderly normal subjects, however, effect size indicators favoring GR stimuli supported the expected result of faster RTs for generating. On the other hand, both young subjects and subjects with dementia showed effect sizes favoring the RR condition over GR. This was not unexpected for the group with dementia, suggesting that they do not benefit more from generating an item than from reading it. It is also possible that generating a word requires effortful access to semantic memory, which is more difficult for individuals with dementia (Nebes et al., 1984) and may account for the slower RTs in the GR condition. However, slower performance in the GR condition was not expected in young normal subjects. Perhaps young subjects completed the rhyme phase of the task more quickly, which allowed time for decay of activation to occur prior to the presentation of the target. It is possible that the GE requires a higher level of activation for items to become memorable. If this is true, then any activation decay could more profoundly impact generated items, leading to slower RTs for the GR condition.

The presence of a degree of semantic priming, based on effect sizes in subjects with dementia, suggests that activation occurs in this group. The problem may again lie in the degree of activation required for the GE. Due to the neurological damage associated with dementia, generated items may not reach a high enough level of activation to become memorable. This may explain why generated primes did not produce faster RTs than read primes in the related conditions, and may suggest an access disorder in subjects with dementia characterized by decreased concept activation. It is also possible that the demented subjects' attentional resources were diverted or depleted during task completion, which would have had the effect of reducing priming effects, particularly in the generated conditions.

Between-Group Comparisons

Results of RT comparisons for each stimulus condition between groups are consistent with the notion that normal aging results in longer RTs in a priming task. Dementia also appears to further increase RTs for priming. However, drawing definitive conclusions regarding the impact of generating an item in normal aging or dementia is premature in light of the contradictory results from within-group comparisons. Based on results of the comparison between the young normal subjects and subjects with dementia, however, it may be that normal aging is not sufficient to cause significant differences in priming with generated items. Neurological damage, such as that associated with dementia, may be the factor, in conjunction with aging, that causes priming differences. It should be noted that, for many of the comparisons, the existence of large effect sizes without statistical significance reflects a lack of power and makes conclusions difficult to generalize.

It became apparent during the course of this investigation that rhyming was a particularly difficult task for demented patients. Many potential subjects with dementia had to be excluded from this study because of rhyming difficulties. However, the five subjects used were able to adequately rhyme words for this task. Rhyming difficulties were not specific to any dementia severity level, nor related to any obvious language characteristics; rather, the occurrence of this difficulty appeared to be random. It would be of interest to explore this aspect of the language of demented patients to determine patterns of rhyming breakdown and how they may be related to other declines in language efficiency.

Whether an alternative method of examining the influences of the GE in dementia is needed, rather than a semantic priming paradigm, remains unclear. Nonetheless, continued refinement of the procedures outlined herein may prove worthwhile. More specific controls in experimental design, including emphasizing response speed for subjects, collecting RT data for the actual rhyming task, establishing baseline RTs for stimuli, and manipulating stimuli association strength and task instructions to minimize or examine the influence of subjects' strategy development on RTs, would be beneficial for future studies. The potential information that could result holds promise for further understanding the nature of lexical breakdown in dementia.

References

Abeysinghe, S. C., Bayles, K. A., & Trosset, M. W. (1990). Semantic memory deterioration in Alzheimer subjects: Evidence from word association, definition, and associative ranking tasks. *Journal of Speech and Hearing Research, 33*, 574–582.

Albert, M., & Milberg, W. (1989). Semantic processing in patients with Alzheimer's disease. *Brain and Language, 37*, 163–171.

Balota, D. A., & Lorch, R. F., Jr. (1986). Depth of automatic spreading activation: Mediated priming effects in pronunciation but not in lexical decision. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 336–345.

Bowles, N. L. (1989). Age and semantic inhibition in word retrieval. *Journal of Gerontology, 44*, 88–90.

Chertkow, H., & Bub, D. (1990a). Semantic memory loss in Alzheimer type dementia. In M. Schwartz (Ed.), *Modular deficits in Alzheimer type dementia* (pp. 207–244). Cambridge, MA: MIT Press.

Chertkow, H., & Bub, D. (1990b). Semantic memory loss in dementia of the Alzheimer type: What do various measures measure? *Brain, 113*, 397–417.

Cohen, J. (1977). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum.

Dick, M. B., Kean, M. L., & Sands, D. (1989). Memory for internally generated words in Alzheimer type dementia: Breakdown in encoding and semantic memory. *Brain and Cognition, 9*, 88–108.

Flicker, C., Ferris, S. H., Crook, T., & Bartus, R. T. (1987). Implications of memory and language dysfunction in the naming deficit of senile dementia. *Brain and Language, 31*,187–200.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini–Mental State": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198.

Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar.* Boston: Houghton Mifflin.

Grober, E., Buschke, H., Kawas, C., & Field, P. (1985). Impaired ranking of semantic attributes in dementia. *Brain and Language, 26*, 276–286.

Mitchell, R., & Schmitt, F. (1986). The generation effect and reality monitoring: Evidence from dementia and normal aging. *Journal of Gerontology, 44*, 79–84.

Nebes, R. D., Martin, D. C., & Horn, L. C. (1984). Sparing of semantic memory in Alzheimer's disease. *Journal of Abnormal Psychology, 93*, 321–330.

Salmon, D. P., Shimamura, A. P., Butters, N., & Smith, S. (1988). Lexical and semantic priming deficits in Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology, 10*, 477–494.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory, 4*, 592–604

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