

Age-Related Slowing in the Retrieval of Information from Long-Term Memory¹

David J. Madden²

The present experiment investigated adult age differences in the retrieval of information from long-term memory. Each trial required a decision regarding the synonymy of two visually presented words. On the yes-response trials, the two words were either identical, differed only in case, or were synonyms that differed in case. Age differences in absolute decision time were greater for the synonyms than for the other word pairs, but the proportional slowing of decision time exhibited by the older adults was constant across word-pair type. A generalized age-related slowing in the speed of information processing can currently account for age differences in the retrieval of letter-identity and semantic information from long-term memory.

Key Words: Reaction time, Aging, Visual classification, Semantic judgment, Cognitive performance

THE concept of an age-related slowing in the speed of information processing has been used to account for age differences in several aspects of cognitive function (Cerella et al., 1980; Di Lollo et al., 1982; Mueller et al., 1980; Salthouse, 1980). Petros et al. (1983), however, have reported data suggesting that adult age differences in the retrieval of information from long-term memory cannot be adequately characterized as a nonspecific slowing of processing speed. On each trial in the Petros et al. experiment, a pair of words was presented visually and participants made one of three judgments: whether or not the words were physically identical, had the same name (but differed in case), or were members of the same semantic category. Older adults' decisions regarding category membership were 42% slower than those of the young adults, whereas the older adults' name and identity judgments were 35% and 26% slower, respectively.

One limitation of the paradigm employed by Petros et al. (1983) is that the type of judgment performed, as well as the type of information retrieved from memory, varied across experimental conditions. Consequently, the qualitative changes in age differences that were associated with the semantic category judgments may represent comparison and decision processes rather than memory retrieval per se. In the present experiment, participants made the

same type of judgment, a decision regarding the synonymy of a pair of visually presented words, on each trial. For those trials that required a "yes" response, the word pairs either were identical, were different only in case, or were synonyms that differed in case. Estimates of the time required to retrieve letter identity and semantic information could thus be obtained while the type of judgment was held constant.

METHOD

Thirty-two individuals, 16 young and 16 older adults, participated in the present experiment. There were eight men and eight women in each age group. The young adults were Duke University undergraduates ranging from 18 to 20 years of age ($M = 18.6$). The older adults were relatively healthy, community-dwelling individuals between 58 and 72 years of age ($M = 67.5$), who were equivalent to the young participants in their performance on the Vocabulary subtest of the Weschsler Adult Intelligence Scale.

The presentation of the stimuli and the collection of reaction time (RT) on each trial were controlled by an Apple II-plus microcomputer. On each trial two words were presented simultaneously on the video monitor, and the participant responded yes or no to the implicit question "Do these two words mean approximately the same thing?". The two words presented on each trial were arranged one above the other (separated by one character line), left-justified, in the center of the monitor screen. Participants rested the index and middle fingers of their dominant hand on two adjacent response keys

¹This research was supported by research grant R23 AG03072 from the National Institute on Aging. I am grateful to G. Kay Bishop and Audrey Norman for invaluable technical assistance. The Memory Search Study System (MS3) microcomputer software was designed by Mark Lumsden, Martha Weinberg, and John Eisenmenger.

²Center for the Study of Aging and Human Development, Box 2980, Duke University Medical Center, Durham, NC 27710.

throughout the experiment and pressed one of the keys when the word-pair appeared on the screen.

The test trial sequence contained 150 trials, presented in five blocks of 30 trials. Within each block, 18 trials required a yes response and 12 required a no response. The yes-response trials within each block were composed of six pairs containing two identical words (e.g., BUTTON/BUTTON), six pairs containing the same word presented in two different cases (e.g., COPY/copy), and six synonym pairs (e.g., target/GOAL). The same-case identical word pairs were always presented in uppercase, and the synonym pairs always contained one uppercase and one lowercase word. The no-response trials in each block contained four trials on which the two words were both uppercase (e.g., TRAIN/CAKE) and eight trials on which the two words differed in case (e.g., plate/OAK). Two completely separate lists of 150 trials each were constructed. All words were between three and seven letters in length. The mean Standard Frequency Index (Carroll et al., 1971) for the words in each combination of list and word-pair type ranged from 54.7 to 58.7. The synonym pairs were drawn from the Whitten et al. (1979) norms and possessed a mean synonymy rating of 5.8 on a 7-point scale (range = 4.4 to 6.3).

Each trial began with the appearance of a 2-sec warning signal (the cursor from the Apple II editor) in the center of the viewing screen, which was followed by the presentation of the word pair for that trial. The participant's keypress response erased the word pair and brought the cursor back to the screen. Each participant performed two blocks of practice trials and five blocks of test trials; each block contained a random sequence of yes- and no-response trials. The two stimulus lists were counterbalanced across subjects within each age group. At the beginning of each participant's session, the microcomputer selected a random sequence for the order of the five test-trial blocks and randomly assigned the yes and no responses to the two response keys.

RESULTS

Split-plot analyses of variance were performed on participants' mean correct RT and error rate that included age as a between-subjects variable and word-pair type as a within-subjects variable. Yes- and no-response trials were analyzed separately. Preliminary analyses revealed no main effect or interaction associated with stimulus list. Effects that were significant at the .05 alpha level, and their

associated utility index (*UI*) values (Gaebelein & Soderquist, 1978) are reported.

Yes-response trials. — The analysis of RT on the yes-response trials yielded significant main effects of age, $F(1, 30) = 29.57$, $UI = .24$, and word-pair type, $F(2, 60) = 271.38$, $UI = .56$. The Age \times Word-Pair Type interaction was also significant, $F(2, 60) = 6.90$, $UI = .01$, because the age difference in absolute RT increased with the amount of time required for a decision. This interaction is consistent with the findings of Petros et al. (1983). The young participants' mean RT was 557 msec for the same-case identical word pairs, 633 msec for the pairs differing only in case, and 892 msec for the synonym word pairs. The corresponding values for the older adults were 763, 875, and 1227 msec. The Age \times Word-Pair Type interaction was significant when the word-pair type variable included only the same-case and different-case identical words, $F(1, 30) = 5.06$, $UI = .004$, and when this variable included only the different-case identical words and synonyms, $F(1, 30) = 5.26$, $UI = .01$. An estimate of the amount of time required for the retrieval of letter information can be obtained by subtracting the mean RT for the same-case identical words from the mean RT for the different-case identical words. This value was 76 msec for the young adults and 112 msec for the older adults. Similarly, subtracting mean RT for the different-case identical words from RT for the synonym words provides an estimate of semantic retrieval time. This latter estimate was 259 msec for the young adults and 352 msec for the older individuals.

In contrast to the findings of Petros et al. (1983), the proportional increase in RT for the older adults in the present experiment was constant across word-pair type. For the yes-response trials, the proportional slowing exhibited by the older adults, relative to the young, was 37% for the same-case identical words, 38% for the different-case identical words, and 37% for the synonym words. The constant proportionality of age differences across word-pair type was confirmed by an analysis of log-transformed RT, a transformation that treats equal ratios as equal intervals. The Age \times Word-Pair Type interaction in this analysis was not significant ($F < 1.0$).

In the analysis of the error rates on the yes-response trials, only the main effect of word-pair type $F(2, 60) = 43.28$, $UI = .47$, was significant, as a consequence of the higher error rate associated with the synonym pairs (7.60%) relative to the

different-case identical pairs (1.04%) and same-case identical pairs (0.41%).

No-response trials. — In the analysis of RT on the no-response trials, only the main effect of age, $F(1, 30) = 20.31$, $UI = .37$, was significant, which represented a 312 msec age difference in RT. The age main effect, $F(1, 30) = 4.21$, $UI = .06$, was also the only significant effect in the analysis of the error rates on the no-response trials. The mean error rates were 1.01% for the young adults and 2.65% for the older adults.

DISCUSSION

In the present experiment, each trial required the same type of judgment regarding a pair of words, but the type of long-term memory information that was sufficient for performing this judgment was varied. Although age differences in absolute RT were larger in magnitude for the synonym pairs than for the identical and different-case pairs, the proportional increase in RT exhibited by the older adults was constant across word-pair type. The present results suggest that age differences in the retrieval of long-term memory information reflect a generalized age-related slowing in the speed of information processing. Comparison and decision processes, however, are also important factors in choice-RT tasks. For example, a task that requires naming a single word rather than comparing two words may eliminate age differences in retrieval

time altogether (Cerella & Fozard, 1984). The particular interaction between comparison and retrieval processes that may lead to a disproportionate slowing of older adults' performance (Petros et al., 1983) deserves further investigation.

REFERENCES

- Carroll, J. B., Davies, P., & Richman, B. (1971). *The American Heritage word frequency book*. American Heritage, New York.
- Cerella, J., & Fozard, J. L. (1984). Lexical access and age. *Developmental Psychology*, 20, 235–243.
- Cerella, J., Poon, L. W., & Williams, D. M. (1980). Age and the complexity hypothesis. In L. W. Poon (Ed.), *Aging in the 1980s: Psychological issues*. American Psychological Association, Washington, DC.
- Di Lollo, V., Arnett, J. L., & Kruk, R. V. (1982). Age-related changes in rate of visual information processing. *Journal of Experimental Psychology: Human Perception and Performance*, 8, 225–237.
- Gaebelein, J. W., & Soderquist, D. R. (1978). The utility of within-subjects variables: Estimates of strength. *Educational and Psychological Measurement*, 38, 351–360.
- Mueller, J. H., Kausler, D. H., & Faherty, A. (1980). Age and access time for different memory codes. *Experimental Aging Research*, 6, 445–449.
- Petros, T. V., Zehr, H. D., & Chabot, R. J. (1983). Adult age differences in accessing and retrieving information from long-term memory. *Journal of Gerontology*, 38, 589–592.
- Salthouse, T. (1980). Age and memory: Strategies for localizing the loss. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), *New directions in memory and aging: Proceedings of the George A. Talland Memorial Conference*. Erlbaum, Hillsdale, NJ.
- Whitten, W. B., Suter, H. W. N., & Frank, M. L. (1979). Bidirectional synonym ratings of 464 noun pairs. *Journal of Verbal Learning and Verbal Behavior*, 18, 109–127.