

Saying Versus Touching: Age Differences in Short-Term Memory Are Affected by the Type of Response

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We examined whether the type of response used to report items recalled from short-term memory affects the age difference in verbal and spatial memory spans. Younger and older adults viewed either a series of letters or a series of locations in a grid, and then they reported their memory for the items either vocally or by using a touch screen. Overall, age differences were larger for spatial memory spans than for verbal memory spans, replicating previous results. Changing the response modality affected only older adults' verbal spans, which were approximately one item higher with a vocal response than with a manual response. This resulted in a smaller age difference for verbal items reported vocally than for any other condition. The results can best be explained by age-related difficulties in both spatial processing and in dealing with stimulus-response incongruity.

ALTHOUGH adult age differences in short-term memory are well established (Bopp & Verhaeghen, 2005; Verhaeghen, Marcoen, & Goossens, 1993), the suggestion that age differences are larger for spatial than verbal spans (Jenkins, Myerson, Joerding, & Hale, 2000; Myerson, Hale, Rhee, & Jenkins, 1999) remains controversial. Some studies report equivalent age differences in the two domains (Salthouse, 1995; Salthouse, Kausler, & Sauls, 1988), but others report an Age \times Domain interaction (Jenkins et al.; Myerson et al.). Moreover, Spatial Span subtest scores on the Wechsler Memory Scales (WMS-III) decrease more rapidly with age than do Digit Span subtest scores (Myerson, Emery, White, & Hale, 2003).

Interpretation of these findings is problematic because standardized verbal and spatial memory tests typically require different types of responses: vocal for verbal memory, manual for spatial memory. To avoid this confound, experimenters sometimes require manual (e.g., keyboard) responses on both types of task (e.g., Salthouse, 1995). Doing so, however, may make the reporting of verbal items especially difficult for older adults, because manual responses tend to have a spatial component (Hale, Myerson, Rhee, Weiss, & Abrams, 1996; Lawrence, Myerson, Oonk, & Abrams, 2001), and visuospatial processing appears to be particularly age sensitive (e.g., Jenkins et al., 2000; Verhaeghen et al., 2002). In addition, manual responses show greater slowing than vocal responses when stimulus-response congruence is low (Doose & Feyereisen, 2004). Thus, the low stimulus-response congruence of verbal memory items paired with manual responses may also disadvantage older adults.

Our goal in the current study was to investigate the role of response modality in age differences in verbal and spatial short-term memory by crossing the domain of the memory material (letters vs locations) with the type of response (vocal vs manual). Knowing how the type of response affects memory span is potentially important from both theoretical and practical perspectives. First, such knowledge may shed light on whether aging differentially affects spatial and verbal working memory. Second, knowing the conditions under which specific responses interfere with recall is important in its own right, with implications for the

modularity of the working memory system (e.g., Hale et al., 1996; Lawrence et al., 2001). Finally, the kinds of information to be remembered and the types of response used to report this information are “mixed and matched” in the world outside the laboratory, and this study is the first to our knowledge to address how these permutations affect older adults' memory performance.

METHODS

Participants

Participants were 24 undergraduates at Washington University (age = 17–21 years; $M = 19.2$ years) and 24 older adults recruited from the Washington University Older Adult Subject Pool (age = 66–79 years; $M = 72.9$ years). We screened all participants for history of neurological disorder, serious illness, or visual problems that would prevent them from reading standard-sized text.

Materials

Software, written in Visual Basic, presented stimuli and recorded participant responses on a touch screen (Model 1727, MicroTouch Corporation and LG Electronics Inc., Seoul, Korea) and keyboard input from the experimenter. We tape-recorded and transcribed all vocal responses.

Letter Span Task

We pseudorandomly constructed lists of 1–12 items, with two lists at each series length, from a pool of 16 letters (B, C, F, G, H, J, K, L, M, N, P, Q, R, S, T, and X). Each letter appeared on the computer screen for 2,250 ms, with a 750-ms pause between letters. After each series, the computer presented a 4 \times 4 grid containing all 16 possible letters in alphabetical order.

In the manual recall condition, the experimenter instructed participants to touch the letters they had just seen in the order of presentation. When they were done, participants touched an asterisk on the lower right-hand corner of the screen, and the software recorded and checked their responses. In the vocal

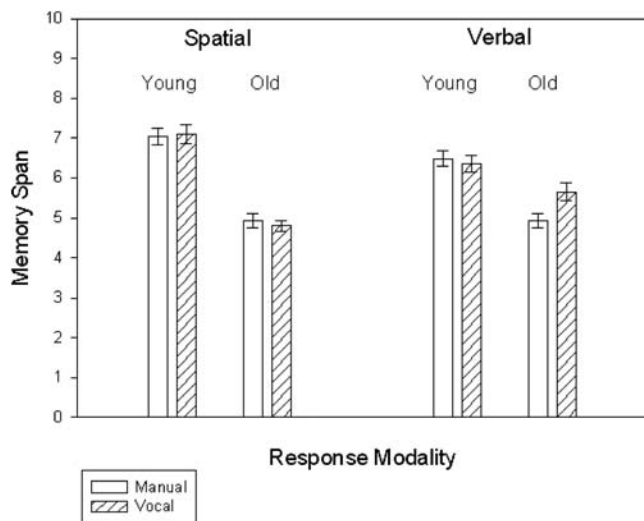


Figure 1. Mean memory span as a function of age group, domain, and response modality.

recall condition, the experimenter instructed participants to say the letters aloud in the order of presentation. The experimenter checked the accuracy of the responses and initiated the next trial when the participant was ready.

Location Span Task

We pseudorandomly constructed lists of 1–12 locations, two at each series length, with each location indicated by an X appearing in one cell of a 4×4 grid. Each X was presented for 2,250 ms, with a 750-ms pause between Xs. After each series, the computer presented a grid containing the same 16 letters as in the Letter Span task. For the Location Span task, the computer arranged the letters in a different order on each trial to prevent participants from using verbal strategies to remember locations.

In the manual recall condition, the experimenter instructed participants to “touch the locations on the grid where you saw the Xs.” In the vocal recall condition, participants were instructed to “say the letters that occupy a space where you saw the Xs.” Accuracy checks and initiation of the next trial were the same as for the Letter Span task, except that, as in previous studies (e.g., Myerson et al., 1999), accuracy did not depend on order of recall.

Procedure

We counterbalanced the order of the two domains (verbal vs spatial) within each age group. Within each domain, the manual recall condition was always first for half of the participants in each age group, and the vocal recall condition was first for the other half. For each task, the experimenter gave the participants four practice trials.

Our test administration was similar to that of the Digit and Spatial Span subtests of the WMS-III (Psychological Corporation, 1997). The first pair of trials involved lists of one item, and list length increased by one item until the participant missed two trials of the same length.

RESULTS

A 2 (age: young vs old) \times 2 (domain: verbal vs spatial) \times 2 (response modality: vocal vs manual) analysis of variance

revealed a main effect of age, $F(1, 46) = 48.96, p < .001$, an Age \times Domain interaction, $F(1, 46) = 9.62, p < .01$, and an Age \times Domain \times Response Modality interaction, $F(1, 46) = 3.12, p < .05$. No other effects were significant (all $ps > .10$).

The main effect of age indicates that young adults outperformed older adults overall (young, $M = 6.74$; old, $M = 5.07$). Indeed, young adults outperformed older adults in each condition (Figure 1). However, the effect size was much smaller for verbal items reported vocally, $t(46) = 2.20, p < .05, d = 0.63$, than for the other three conditions: spatial-vocal, $t(46) = 6.23, p < .001, d = 1.80$; spatial-manual, $t(46) = 5.68, p < .001, d = 1.64$; verbal-manual, $t(46) = 4.96, p < .001, d = 1.43$.

The Age \times Domain interaction reflects the fact that, overall, there was a larger age difference in spatial spans (young, $M = 7.07$; old, $M = 4.85$) than in verbal spans (young, $M = 6.42$; old, $M = 5.29$). However, this two-way interaction was qualified by a three-way interaction with response modality, reflecting an effect of modality on older adults' verbal memory spans. Older adults had higher verbal spans with a vocal response ($M = 5.64$) than with a manual response ($M = 4.94$), $t(23) = 3.98, p = .001$, but they had equivalent spatial spans regardless of response modality, ($M = 4.92$ for manual responses, $M = 4.79$ for vocal responses), $t(23) < 1.0$. In contrast, young adults had equivalent memory spans regardless of response modality in both domains; both $ts < 1.0$. Finally, there was an Age \times Domain interaction for vocal responses, $F(1, 46) = 14.99, p < .001$, but not manual responses, $F(1, 46) = 1.74, p > .10$, and for domain-congruent responses (spatial-manual, verbal-vocal), $F(1, 46) = 10.66, p < .001$, but not domain-incongruent responses (spatial-vocal, verbal-manual), $F(1, 46) = 2.77, p > .10$.

DISCUSSION

In the current study, spatial memory spans showed a larger age difference than did verbal memory spans. This replicates results from previous studies in which spatial spans were reported manually and verbal spans were reported vocally (e.g., Myerson et al., 1999; Myerson et al., 2003). Changing the response modality affected memory spans in only one case: Older adults' letter spans were approximately one item lower with manual than with vocal recall. This resulted in smaller age differences for verbal items reported vocally than for any other combination of domain and modality.

We designed the present study to determine whether response modality affects age differences in performance on short-term memory tasks, not to test hypotheses regarding the mechanism(s) underlying such effects. We would note, however, that older adults' difficulties with stimulus-response incongruities and with the processing of spatial material could play a role. Previous research has shown that older adults' manual responses are slowed when stimulus-response congruity is low (Dooze & Feyereisen, 2004), as in the case of visually guided manual responses to verbal memory items. Older adults are also differentially slowed when they are processing spatial material (Hale & Myerson, 1996). Such slowing could cause difficulty in recall as a result of both passive decay and active interference from processes involved in responding (Cowan et al., 1992; Doshier & Ma, 1998).

Neither an age-related spatial processing deficit nor a stimulus-response incongruity deficit alone, however, can account

for the present results, because neither can explain why response modality affected only older adults' verbal spans. A multiple-deficit perspective that assumes both spatial and incongruity deficits, however, can account for the observed pattern. Assume, for example, that older adults have trouble with spatial processing (which can operate during encoding or responding) and dealing with stimulus-response incongruity. The condition involving vocal reporting of verbal items did not require either of these impaired functions, whereas the other conditions each depended on two uses of these functions. Reporting verbal items manually involves spatial responding and stimulus-response incongruity; reporting spatial items manually involves spatial encoding and responding but no incongruity; and reporting spatial items vocally involves spatial encoding plus stimulus-response incongruity. This could explain why the age difference was smallest for verbal items reported vocally, and it would be consistent with the pattern of Age \times Domain interactions that we observed when we analyzed manual, vocal, congruent, and incongruent response conditions separately.

Although the two memory tasks in the present study were similar in many respects, only the verbal task required recalling items in order. This asymmetry parallels many real-world situations requiring verbal and spatial recall, and it follows the traditional experimental approach to visuospatial short-term memory (Logie, Zucco, & Baddeley, 1990). As long as verbal items are reported vocally and spatial items manually, verbal and spatial laboratory tasks show a pattern of age differences similar to psychometric short-term memory tests, even though psychometric spatial tests often involve memory for order (Myerson et al., 2003). Moreover, a post hoc analysis of transposition errors from the last two series attempted in the vocal and manual report conditions of the Letter Span task revealed no effects of age or response modality and no Age \times Modality interaction. Thus, there is no evidence that differences in memory for order created a confound in the present study. Nevertheless, a replication using ordered spatial recall might strengthen the case that our findings generalize to psychometric test performance.

Although further research is needed to clarify the theoretical mechanisms underlying the current results, their measurement and practical implications seem clear. With respect to measurement, manual recalling decreased the performance of older, but not younger, adults on the Verbal Span task. Because the execution of specific behavioral responses can interfere with recall but cannot lead to recall of otherwise unretrievable items, we conclude that memory spans measured by means of vocal responses provide a more accurate measure of older adults' verbal memory span. Moreover, the larger age differences in verbal span with manual responses may explain the lack of an Age \times Domain interaction in some previous studies using such responses (Salthouse, 1995; Salthouse et al., 1988; cf. Jenkins et al., 2000).

From a practical perspective, technological advances such as the computer mouse and automated teller machines have increased the number of situations in which verbal memory items must be reported manually. Such devices may selectively disadvantage older adults, highlighting the need for human factors research directed at preventing such problems (Fisk, Rogers, Charness, Czaja, & Sharit, 2004). Finally, although the use of computerized tasks has made laboratory data collection

more efficient for researchers, we caution that such methods may result in an exaggeration of age differences.

ACKNOWLEDGMENTS

This research was supported by a Sigma Xi Grant-in-Aid of Research award to Lisa Emery and by the National Institute on Aging (Training Grant AG00030 and Grant R01-AG22448).

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REFERENCES

- Bopp, K. L., & Verhaeghen, P. (2005). Aging and verbal memory span: A meta-analysis. *Journal of Gerontology: Psychological Sciences, 60B*, P223–P233.
- Cowan, N., Day, L., Saults, J. S., Keller, T. A., Johnson, T., & Flores, L. (1992). The role of verbal output time in the effects of word length on immediate memory. *Journal of Memory and Language, 31*, 1–17.
- Doose, G., & Feyereisen, P. (2004). Stimulus-response translation in manual and vocal modality: Is age-related slowing influenced by changes in working memory functioning? *European Journal of Cognitive Psychology, 16*, 597–624.
- Dosher, B. A., & Ma, J. (1998). Output loss or rehearsal loop? Output-time versus pronunciation time limits in immediate recall for forgetting-matched materials. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 316–335.
- Fisk, A. D., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2004). *Designing for older adults: Principles and creative human factors approaches*. Boca Raton, FL: CRC Press.
- Hale, S., & Myerson, J. (1996). Experimental evidence for differential slowing in the lexical and nonlexical domains. *Aging, Neuropsychology, and Cognition, 3*, 154–165.
- Hale, S., Myerson, J., Rhee, S. H., Weiss, C. S., & Abrams, R. A. (1996). Selective interference with the maintenance of location information in working memory. *Neuropsychology, 10*, 228–240.
- Jenkins, L., Myerson, J., Joerding, J. A., & Hale, S. (2000). Converging evidence that visuospatial cognition is more age-sensitive than verbal cognition. *Psychology and Aging, 15*, 157–175.
- Lawrence, B. M., Myerson, J., Oonk, H. M., & Abrams, R. A. (2001). The effects of eye and limb movements on working memory. *Memory, 9* (4–6), 433–444.
- Logie, R. H., Zucco, G. M., & Baddeley, A. (1990). Interference with visual short-term memory. *Acta Psychologica, 75*, 55–74.
- Myerson, J., Emery, L., White, D. A., & Hale, S. (2003). Effects of age, domain, and processing demands on memory span: Evidence for a differential decline. *Aging, Neuropsychology, and Cognition, 10*, 20–27.
- Myerson, J., Hale, S., Rhee, S. H., & Jenkins, L. (1999). Selective interference with verbal and spatial working memory in young and older adults. *Journal of Gerontology: Psychological Sciences, 54B*, P161–P164.
- Psychological Corporation. (1997). *WMS-III administration and scoring manual*. San Antonio, TX: Harcourt Brace.
- Salthouse, T. A. (1995). Differential age-related influences on memory for verbal-symbolic information and visual-spatial information? *Journal of Gerontology: Psychological Sciences, 50B*, P193–P201.
- Salthouse, T. A., Kausler, D., & Saults, J. S. (1988). Investigation of student status, background variables, and feasibility of standard tasks in cognitive aging research. *Psychology and Aging, 3*, 29–37.
- Verhaeghen, P., Cerella, J., Semenc, S. C., Leo, M. A., Bopp, K. L., & Steitz, D. W. (2002). Cognitive efficiency models in old age: Performance on sequential and coordinative verbal and visual spatial tasks. *Psychology and Aging, 17*, 558–570.
- Verhaeghen, P., Marcoen, A., & Goossens, L. (1993). Facts and fiction about memory aging: A quantitative integration of research findings. *Journal of Gerontology: Psychological Sciences, 48*, P157–P171.

Received August 22, 2005

Accepted May 5, 2006

Decision Editor: William Hoyer, PhD