Neuropsychology
2010, Vol. 24, No. 6, 804–807

0894-4105/10/$12.00 DOI: 10.1037/a0020244

BRIEF REPORTS

Interference, Aging, and Visuospatial Working Memory: The Role of Similarity

Gillian Rowe
University of Toronto

Lynn Hasher
University of Toronto and Rotman Research Institute of Baycrest Centre

Josée Turcotte
Laurentian University

Objective: Older adults' performance on working memory (WM) span tasks is known to be negatively affected by the buildup of proactive interference (PI) across trials. PI has been reduced in verbal tasks and performance increased by presenting distinctive items across trials. In addition, reversing the order of trial presentation (i.e., starting with the longest sets first) has been shown to reduce PI in both verbal and visuospatial WM span tasks. We considered whether making each trial visually distinct would improve older adults' visuospatial WM performance, and whether combining the 2 PI-reducing manipulations, distinct trials and reversed order of presentation, would prove additive, thus providing even greater benefit. ***Method:*** Forty-eight healthy older adults (age range = 60–77 years) completed 1 of 3 versions of a computerized Corsi block test. For 2 versions of the task, trials were either all visually similar or all visually distinct, and were presented in the standard ascending format (shortest set size first). In the third version, visually distinct trials were presented in a reverse order of presentation (longest set size first). ***Results:*** Span scores were reliably higher in the ascending version for visually distinct compared with visually similar trials, $F(1, 30) = 4.96$, $p = .03$, $\eta^2 = .14$. However, combining distinct trials and a descending format proved no more beneficial than administering the descending format alone. ***Conclusions:*** Our findings suggest that a more accurate measurement of the visuospatial WM span scores of older adults (and possibly neuropsychological patients) might be obtained by reducing within-test interference.

Keywords: visuospatial working memory, aging, proactive interference, distinctiveness, Corsi block task

Older adults are more vulnerable than younger adults to the disruptive effects of distraction from a number of sources, including the recent past (Hasher, Lustig, & Zacks, 2007). This latter effect, descriptively called *proactive interference* (PI), occurs when previously presented but no longer relevant materials disrupt the ability to recall the most recently presented information. PI differentially lowers the performance of older adults on a number of memory tasks (e.g., Hasher, Chung, May, & Foong, 2002; Kausler, 1990; Winocur & Moscovitch, 1983), including those measuring verbal working memory (WM) span (May, Hasher, & Kane, 1999; Lustig, May, & Hasher, 2001). These latter studies manipulated the buildup of PI by reversing the conventional order of presentation (starting with the longest instead of shortest set size), thus increasing older adults' span scores compared with scores on the standard, ascending format. More recently, a similar manipulation found comparable effects in the Corsi block version of a visuospatial working memory (VSWM) task (Rowe, Hasher, & Turcotte, 2008).

Although reversing the presentation of set sizes reduces the amount of PI in WM span tasks and enhances older adults' performance, it is unlikely that this manipulation addresses all potential sources of interference. In particular, another source of older adults' poor performance in the standard format of the visuospatial span task may be the similarity between trials; as is common in the literature on VSWM, the stimuli in the Rowe et al. (2008) study were visually identical across all trials. Evidence from verbal paradigms (e.g., Nairne, 2002; Wickens, 1972) suggests that when multiple trials of to-be-remembered items are similar, forgetting can be exacerbated because of difficulty discriminating current items from those presented in earlier trials or difficulty maintaining suppression of prior trial information in the face of highly similar items. Thus, similarity of material may play a critical role in forgetting by contributing to the buildup of PI,

Gillian Rowe, Department of Psychology, University of Toronto; Lynn Hasher, Department of Psychology, University of Toronto and Rotman Research Institute of Baycrest Centre; Josée Turcotte, Department of Psychology, Laurentian University.

This research was supported by National Institute on Aging Grant NIA R37 AGO 4306 awarded to Lynn Hasher and by a fellowship from the National Sciences and Engineering Research Council to Gillian Rowe. Some data in this article (that of the control group in the visually similar ascending condition) were presented at the 10th Cognitive Aging Conference, April 2004, Atlanta, GA, and is reported in Rowe et al. (2008).

Correspondence concerning this article should be addressed to Gillian Rowe, Department of Psychology, University of Toronto, 100 St. George Street, Toronto, ON M5S 3G3, Canada. E-mail: gillian@psych.utoronto.ca

with more errors for high-compared with low-similarity items, an effect that becomes greater as the number of trials increases (Duffy, 1971).

There is evidence that when trial stimuli are more distinct, the negative effect of PI is decreased, and in some cases even eliminated. For example, a classic study by Wickens (1972) found that increasing the distinctiveness of to-be-remembered material between trials dramatically improved recall on a short-term verbal memory task. More recently, the buildup and release of PI has been demonstrated in a number of verbal WM span tasks (e.g., Bunting, 2006; Hasher et al., 2002; Nairne, Whiteman, & Kelley, 1999). Of particular relevance to the current study, May et al. (1999) considered the additive effect of two simultaneous PI-reducing manipulations by introducing unique tasks between each trial in both the ascending and descending format of their reading span study. In this way, they changed the context of the task between trials, a manipulation known to provide release from PI. Similar to the benefit seen in the PI-reducing descending span task, older adults' performance improved dramatically when contextual changes were inserted in the ascending format. However, combining the two PI-reducing manipulations (reversed format and contextual changes between trials) did not improve span estimates relative to the descending format alone. Taken together, results of release from PI paradigms provide compelling evidence that verbal memory improves whenever current targets can be easily discriminated from those of prior trials.

Here, we consider how material similarity influences older adults' VSWM span using a version of the Corsi block task (CBT; Corsi, 1972). We do this by comparing previously published performance on a standard (ascending format) span task (Rowe et al., 2008), in which the patterns indicating locations on each trial are visually the same, with performance on a task identical in all respects except that patterns on the locations are different on each trial. The critical question here is whether making each trial visually distinct would improve older adults' performance on the interference-laden ascending format. To address the possibility that a combination of the two PI-reducing manipulations would prove additive, thus providing an even greater benefit, we also included a condition in which visually distinct trials were presented in the descending format, which we had previously shown differentially benefits older adults. May et al. (1999) found no such extra benefit in their sentence span task; nevertheless, we considered that a similar combination in a visuospatial task could conceivably show a different result. Given prior findings that the detrimental influence of PI is reduced when trials are conceptually distinct (e.g., Bunting, 2006; Hasher et al., 2002; Nairne et al., 1999; Wickens, 1972), we anticipated that a reduction in between-trials similarity would improve older adults' span scores by reducing the amount of PI in the task.

Method

Older adults participated in one of three conditions of a VSWM span task. For two versions, trials were presented in the standard format (starting with the shortest set size), in which locations on all trials were either visually similar or locations on all trials were visually distinct. In the third version, visually distinct trials were presented in the PI-reducing descending format.

Participants

Thirty-two older adults (*M* age = 68.26 years, *SD* = 5.37; range = 60–77 years) were randomly assigned to either the ascending (*n* = 16) or descending (*n* = 16) format of the CBT in which all trials were visually distinct. Their performance was compared with that of 16 older adults (*M* age = 67.00 years, *SD* = 4.65; range = 60–75 years) who had previously been tested on the visually similar ascending version of the CBT (data published in Rowe et al., 2008). All participants were volunteers registered with the University of Toronto's older adult participant pool, and received remuneration based on $10 for each hour of participation. Data were discarded if participants failed to meet criterion on visual acuity (minimum 30/40 on the Rosenbaum acuity test), years of education (minimum = high school diploma), or showed evidence of cognitive impairment screening (more than 6 on the Short Blessed Test; Pfeiffer, 1975). The three groups did not differ in mean age, education, vocabulary test scores (Shipley, 1946), Short Blessed Test scores (see Table 1), or health.

Materials

The experimental span task was programmed using E-Prime software (Psychology Software Tools, Inc., Sharpsburg, PA). We used a computerized version of the CBT, with the nine potential target locations presented as two-dimensional squares of equal size (3 cm^2) against a white background and arranged in the randomized display of Corsi's (1972) original task. For each of the 12 trials in the visually distinct conditions, a different black and white abstract pattern was chosen from stimuli in the Self-Ordered Pointing Task (Petrides & Milner, 1982; see Figure 1), with trial patterns identical on the ascending and descending formats. This contrasted with the visually similar condition, in which squares in all trials were the same color, gray. Stimuli were presented on a touch screen monitor with a display area of 38.10 cm. Target sequences were chosen based on those used in the spatial span task of the Wechsler Memory Scale—Third Edition (Wechsler, 1997).

Procedure

All participants were tested before 11 a.m. This time was chosen given findings that performance on many cognitive tasks is affected by circadian arousal patterns, with older adults' peak time, in general, being in the morning (Hasher, Zacks, & May, 1999).

Subsequent to reading the task instructions, participants were given one practice trial with a two-location sequence, after which

Table 1
Means (and Standard Deviations) for Age, Years of Education, Vocabulary Scores, and Short Blessed Test (SBT) Scores for the Three Task Conditions

Variable	Visually similar ascending	Visually distinct ascending	Visually distinct descending
Age	67.00 (4.65)	69.21 (4.77)	67.23 (5.96)
Education	16.13 (3.61)	17.06 (2.86)	15.45 (2.58)
Vocabulary[a]	34.10 (5.58)	34.79 (5.03)	36.69 (3.15)
SBT	0.55 (0.73)	0.71 (0.91)	0.53 (1.19)

[a] Shipley vocabulary task (Shipley, 1946).

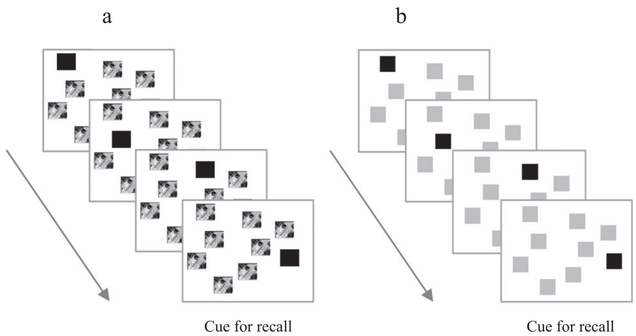

Figure 1. Examples of a four-location visually distinct trial (a) and a four-location visually similar trial (b).

sequences were presented in either an ascending (starting with set size 4 and progressing to set size 7) order of difficulty, or in a PI-reducing, descending (from seven to four locations) order of difficulty. In all conditions (including the visually similar ascending condition from Rowe et al., 2008), three trials at each of the four set sizes were presented, for a total of 12 trials. All three trials of a set size were presented before continuing to the next set size. Except for the ascending versus descending order of test administration, the same spatial sequences were used for all participants.

Each trial began when the participant pressed the keyboard's spacebar, following which the display of nine squares on a white background was presented for 1,200 ms. A pattern of the required number of target locations was then presented with each target location identified by becoming black for 1,500 ms. Immediately after presentation of the to-be-remembered sequence, a thin black frame appeared around the entire display as a prompt to begin recall. Participants recalled target items by touching the relevant squares in the order of presentation. Responses were automatically recorded.

Results and Discussion

We measured span as the percentage of trials that were correctly recalled in the order presented. Because we considered two questions, the comparison between visually distinct and visually similar trials in the ascending format and the possibility that combining the two PI-reducing manipulations (distinct trials and a descending format) would have an additive effect, we analyzed the data accordingly and present the findings separately.

Visually Distinct Versus Visually Similar Trials in the Ascending Format

A one-way analysis of variance (ANOVA) on these scores showed an effect of condition, $F(1, 30) = 4.96$, $p = .03$, partial $\eta^2 = .14$, power $= .6$, with span scores for participants in the PI-reducing visually distinct version of the task ($M = 45.24$, $SD = 17.52$) reliably higher than those in the interference-laden, visually similar condition ($M = 33.33$, $SD = 13.91$).

Ascending Versus Descending Visually Distinct Trials

As shown by a one-way ANOVA, $F(1, 30) < 1$, $p = .81$, there was no significant difference between performance when visually distinct trials were presented in the ascending ($M = 45.24$, $SD = 17.52$) relative to the descending ($M = 43.75$, $SD = 18.73$) format. Thus, the combination of two PI-reducing manipulations did not further improve span score performance of older adults.

There is now a substantial body of work in the verbal domain (e.g., Lustig et al., 2001; May et al., 1999) showing that typical WM span tasks are vulnerable to the negative effects of proactive interference, and that this effect is exacerbated when current information is similar in meaning to previous information (e.g., Bunting, 2006). The present study speaks to the contribution of similarity in determining spatial span scores for older adults. Our findings are clear: Memory is better when materials on each trial are distinctive. With the Rowe et al. (2008) findings, the present results strongly suggest that at least a portion of what is being measured by spatial span scores is the ability to handle PI. The current findings join those of previous work (e.g., May et al., 1999; Rowe et al., 2008) in showing that even modest reductions in PI (i.e., distinct trials or a descending format) can improve older adults' performance dramatically. However, combining PI reductions provides no additional benefit in either verbal or visuospatial span tasks. May et al. (1999) speculate that this apparent limit to older adults' improvement suggests that older adults' susceptibility to PI cannot entirely account for age-related declines in WM span, and other factors may also be involved.

Our study included only healthy older adults; however, susceptibility to interference is known to negatively affect the cognitive performance of clinical populations, including individuals with Alzheimer's disease (Duchek, Balota, & Thessing, 1998) and with frontal lobe lesions (Hamilton & Martin, 2007). The current findings are important because the CBT is used extensively in clinical (and experimental) studies as a nonverbal task (Berch, Krikorian, & Huha, 1998). Its inclusion in neuropsychological batteries contributes to the assessment of a diverse range of populations, including stroke patients (e.g., Kessels, Kappelle, de Haan, & Postma, 2002) and individuals with Korsakoff's syndrome (e.g., Joyce & Robbins, 1991), Alzheimer's disease (e.g., Carlesimo, Fadda, Lorusso, & Caltagirone, 1994), and Williams syndrome (e.g., Sampaio, Sousa, Férnandez, Henriques, & Gonçalves, 2008). However, little attention has been paid to possible influential factors within the tasks themselves when assessing spatial memory. Our findings suggest that the performance of older adults, and possibly of neuropsychological patients, may well be influenced not just by spatial difficulties alone, but by susceptibility to interference effects from prior, highly similar trials.

References

Berch, D. B., Krikorian, R., & Huha, E. M. (1998). The Corsi block-tapping task: Methodological and theoretical implication. *Brain and Cognition, 38,* 317–338.

Bunting, M. (2006). Proactive interference and item similarity in working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 183–196.

Carlesimo, G. A., Fadda, L., Lorusso, S., & Caltagirone, C. (1994). Verbal and spatial memory spans in Alzheimer's and multi-infarct dementia. *Acta Neurologica Scandinavica, 89,* 132–138.

Corsi, P. M. (1972). Human memory and the medial temporal region of the brain. *Dissertation Abstracts International: Section B. Sciences and Engineering, 34*(02), 819. (University Microfilms No. AA105-77717)

Duchek, J. M., Balota, D. A., & Thessing, V. C. (1998). Inhibition of visual and conceptual information during reading in healthy aging and Alzheimer's disease. *Aging, Neuropsychology, and Cognition, 5,* 169–181.

Duffy, T. M. (1971). Mnemonics and intra-list interference in paired-associate learning. *Canadian Journal of Psychology, 25,* 33–41.

Hamilton, A. C., & Martin, R. C. (2007). Proactive interference in a semantic short-term memory deficit: Role of semantic and phonological relatedness. *Cortex, 43,* 112–123.

Hasher, L., Chung, C., May, C. P., & Foong, N. (2002). Age, time of testing, and proactive interference. *Canadian Journal of Experimental Psychology, 56,* 200–207.

Hasher, L., Lustig, C., & Zacks, R. T. (2007). Inhibitory mechanisms and the control of attention. In A. Conway, C. Jarrold, M. Kane, A. Miyake, & J. Towse (Eds.), *Variation in working memory* (pp. 227–249). New York: Oxford University Press.

Hasher, L., Zacks, R. T., & May, C. P. (1999). Inhibitory control, circadian arousal, and age. In D. Gopher & A. Koriat (Eds.), *Attention & Performance, XVII, Cognitive Regulation of Performance: Interaction of theory and application* (pp. 653–675). Cambridge, MA: MIT Press.

Joyce, E. M., & Robbins, T. W. (1991). Frontal lobe function in Korsakoff and non-Korsakoff alcoholics: Planning and spatial working memory. *Neuropsychologia, 29,* 709–723.

Kausler, D. H. (1990). *Experimental psychology, cognition, and human aging* (2nd ed.). New York: Springer-Verlag.

Kessels, R. P. C., Kappelle, L. J., de Haan, E. H. F., & Postma, A. (2002). Lateralization of spatial-memory processes: Evidence on spatial span, maze learning, and memory for object locations. *Neuropsychology, 40,* 1465–1473.

Lustig, C., May, C., & Hasher, L. (2001). Working memory span and the role of proactive interference. *Journal of Experimental Psychology: General, 130,* 199–207.

May, C. P., Hasher, L., & Kane, M. J. (1999). The role of interference in memory span. *Memory & Cognition, 27,* 759–767.

Nairne, J. S. (2002). Remembering over the short-term: The case against the standard model. *Annual Review of Psychology, 53,* 53–81.

Nairne, J. S., Whiteman, H. L., & Kelley, M. R. (1999). Short-term forgetting of order under conditions of reduced interference. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 52*(A), 241–251.

Petrides, M., & Milner, B. (1982). Deficits on subject-ordered tasks after frontal- and temporal-lobe lesions in man. *Neuropsychologia, 20,* 249–262.

Pfeiffer, E. (1975). A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *Journal of the American Geriatric Society, 23,* 433–441.

Rowe, G., Hasher, L., & Turcotte, J. (2008). Age differences in visuospatial working memory. *Psychology and Aging, 23,* 79–84.

Sampaio, A., Sousa, N., Férnandez, M., Henriques, M., & Gonçalves, O. F. (2008). Memory abilities in Williams syndrome: Dissociation or developmental delay hypothesis? *Brain and Cognition, 66,* 290–297.

Shipley, W. C. (1946). *Institute of Living Scale.* Los Angeles: Western Psychological Services.

Wechsler, D. (1997). *Wechsler Memory Scale—Third Edition.* New York: Psychological Corporation.

Wickens, D. (1972). Encoding categories of words: An empirical approach to meaning. *Psychological Review, 77,* 1–15.

Winocur, G., & Moscovitch, M. (1983). Paired associate learning in institutionalized and non-institutionalized old people. *Journal of Gerontology, 38,* 455–464.

Received September 15, 2009
Revision received September 21, 2009
Accepted September 25, 2009 ■