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

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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
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 elimi-
nated. For example, a classic study by Wickens (1972) found that
increasing the distinctiveness of to-be-remembered material be-
tween 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, combin-
ing the two PI-reducing manipulations (reversed format and con-
textual 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 discrimi-
nated 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
rules 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 pre-
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 consid-
ered that a similar combination in a visuospatial task could con-
ceivably 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 reduc-
ing 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 cm²) against a white background and arranged in the ran-
monized 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 af-
ected 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Visually similar ascending</th>
<th>Visually distinct ascending</th>
<th>Visually distinct descending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>67.00 (4.65)</td>
<td>69.21 (4.77)</td>
<td>67.23 (5.96)</td>
</tr>
<tr>
<td>Education</td>
<td>16.13 (3.61)</td>
<td>17.06 (2.86)</td>
<td>15.45 (2.58)</td>
</tr>
<tr>
<td>Vocabularya</td>
<td>34.10 (5.58)</td>
<td>34.79 (5.03)</td>
<td>36.69 (3.15)</td>
</tr>
<tr>
<td>SBT</td>
<td>0.55 (0.73)</td>
<td>0.71 (0.91)</td>
<td>0.53 (1.19)</td>
</tr>
</tbody>
</table>

a Shipley vocabulary task (Shipley, 1946).
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 (Bench, Krikorian, & Hua, 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, Fernandez, Henriques, & Goncalves, 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


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