Selective Interference With Verbal and Spatial Working Memory in Young and Older Adults

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It is well established that healthy older adults perform more poorly than young adults on tests of working memory function (for a review, see Craik & Jennings, 1992). It is also well established that working memory has separate verbal and visuospatial components (Baddeley, 1986; Hale, Myerson, Rhee, Weiss, & Abrams, 1996; Logie, Zucco, & Baddeley, 1990; for a review, see Logie, 1995), but no studies have compared age differences in memory spans for verbal and visuospatial information. Further, no studies have compared age differences in the susceptibility of verbal and visuospatial working memory to interference by secondary tasks.

One of the reasons why these issues have not been examined previously may be that it is very difficult to interpret a difference in the size of the age deficits on two tasks, unless those tasks are equivalent in difficulty (Chapman & Chapman, 1973). Accordingly, the present experiment compared young and older adults’ verbal and spatial working memory using a visual digit span task and a location memory span task known to be equally difficult for young adults (Hale et al., 1996, Experiment 1). Digit and location span tasks, as well as a combined span task (in which participants had to recall both the locations and identities of digits in a matrix), were administered both alone and in conjunction with verbal and spatial secondary tasks.

The secondary task procedures were chosen carefully so as to interfere with the maintenance, rather than the encoding, of memory items (Hale et al., 1996). The verbal secondary task required naming the color in which memory items were presented, and the spatial secondary task required pointing to a matching color. The automatic encoding of the identity of a stimulus during color discrimination is well known from studies of the Stroop task (for a review, see MacLeod, 1991), and it has been shown that an object’s location is automatically attended to when its color or shape is discriminated (Tsai & Lavie, 1988; 1993). Thus, successful execution of the secondary tasks, which required reporting the color of the memory items, is unlikely to have interfered with the encoding of these items, and may even be taken as evidence that they were encoded.

When these secondary tasks were interleaved with presentation of memory items for the primary span tasks, the procedure was formally analogous to the reading span task of Daneman and Carpenter (1980), a paradigmatic working memory measure (for a recent review, see Daneman & Merkle, 1996). In the reading span task participants read a series of unrelated sentences, and at the end of the series they attempt to recall the last word of each. Each sentence may be thought of as a stimulus with multiple attributes (e.g., the individual words making up the sentence), which must be discriminated, although only one attribute (i.e., the final word) is relevant to the primary memory task. Similarly, the present procedures present a stimulus with multiple attributes (e.g., the color, identity, and location of the item), at least two of which must be discriminated, but only one of which (i.e., either the identity or the location of the item) is relevant to the memory task. In both cases, a series of stimuli are followed by a recall test on which only the relevant attributes are to be reported, and the number of stimuli in the series is increased until the maximum number of items that can be maintained in memory under these conditions (i.e., working memory span) is determined.

Hale and associates (1996) showed that the interference produced by their secondary tasks (i.e., color naming and matching) was highly selective (i.e., domain specific) in younger adults. Although performance on the combined span task was disrupted by both verbal and spatial secondary tasks, performance on the digit span task was disrupted only by the verbal secondary task (i.e., color naming), and performance on the location span task was disrupted only by the spatial secondary task (i.e., pointing to a matching color). Of interest in the present study was whether older adults would show a pattern of selective interference by secondary tasks similar to that observed in young adults.

METHOD

Subjects

The participants were 20 young adults (M age = 20.4 years, SD = 1.1, range = 18–22) and 20 community-dwelling older adults (M age = 67.0 years, SD = 2.0, range = 63–69). There were 13 women and 7 men in each age group. All participants
reported that they had good corrected visual acuity, normal color vision, and were in good to excellent health.

**Apparatus**

Stimuli were presented on a NEC MultiSynch 2A color monitor (NEC Technologies, Inc., Itasca, IL) controlled by a CompuAdd 286 computer (CompuAdd Computer Group, Bristol, UK). Participants pressed a button to initiate the presentation of each series of stimuli.

**Stimuli**

All stimuli were identical to those used in Experiment 1 of Hale and colleagues (1996). For all tasks, the information to be remembered was presented one item at a time. For the digit span task, each digit was presented in a box located in the center of the left half of the monitor screen. For the location and combined span tasks, each X or digit was presented in the center of one of the 16 cells of a 4 X 4 matrix located in the center of the left half of the screen. A palette, consisting of six circles arranged in a ring, was presented in the center of the right half of the screen.

In all conditions, digits and Xs were presented in one of six colors (blue, brown, gray, green, pink, or red) against a dark gray background. In the spatial secondary task conditions, each inner circle of the palette was filled with one of these six colors. In all other conditions, these circles were filled with the dark gray background color. The signal to recall was either an empty white box (digit span task) or an empty white grid (location and combined span tasks), presented in the same location used during presentation of the digits or Xs.

For the digit span task, digits (1–9) were selected randomly with the constraints that all digits occurred with similar frequency and that no digit was repeated within a series. For the combined span tasks, each digit was presented in a box located in the center of the left half of the monitor screen. For the location and combined span tasks respectively, each X or digit was presented in the center of one of the 16 cells of a 4 X 4 matrix located in the center of the left half of the screen. A palette, consisting of six circles arranged in a ring, was presented in the center of the right half of the screen.

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with no secondary task (both $p < .05$). A post hoc Neuman-Keuls test revealed no significant additional decrease in span, relative to pointing alone, when subjects both said the color name and pointed to a match.

Although the preceding analyses provide no evidence of age-related differences in the absolute size of interference effects, the size of such effects relative to baseline span values may also be of interest. Accordingly, each subject’s memory spans in conditions with a secondary task were divided by his or her span in the digit span-no secondary task condition alone. Consistent with the previous analysis of the raw data, there was no significant difference between the effects of the spatial and the verbal plus spatial secondary tasks.

**Figure 1.** Mean spans and standard errors for the digit and location span tasks (upper panel) and for the combined span task (lower panel). The labels SAY and POINT refer to the verbal and spatial secondary task conditions, respectively, and the label SAY + POINT refers to the verbal plus spatial secondary task condition (combined span task only).

**Discussion**

The present results demonstrate that the age-related decline in spatial working memory is much greater than that in verbal working memory. Although older adults performed more poorly than young adults in all conditions, the age difference was particularly pronounced in conditions where the primary task was to remember locations (location span task) or locations and digits (combined span task) as compared with conditions in which the primary task was to remember digits alone (digit span task). The present finding of a greater age-related decline in spatial than verbal working memory is consistent with results for immediate recall of supraspan lists of words and designs (Tubi & Calev, 1989), and is reminiscent of the greater degree of age-related slowing observed on visuospatial tasks (as compared with verbal) response time tasks (Hale & Myerson, 1996; Lawrence, Myerson, & Hale, 1998).

Regardless of whether the primary memory task involved verbal or spatial information, no age differences were observed in the present study with respect to either the magnitude or pattern of effects of secondary tasks on working memory span. The pattern of domain-specific interference observed in the present study replicates and extends Hale and colleagues’ (1996) findings in young adults, and is consistent with Baddeley’s (1986) hypothesis of separate verbal and visuospatial subsystems in working memory. The fact that both young and older adults showed similar patterns of selective interference strongly suggests that, at least in healthy older individuals, the two subsystems remain functionally distinct.

The finding of no age difference in interference by secondary tasks is difficult to reconcile with the inhibition deficit hypothesis as currently formulated (Connelly & Hasher, 1993; Hasher & Zacks, 1988). Part of the problem in reconciling this finding with the inhibition deficit hypothesis is obviously that, contrary to the present results, the hypothesis appears to imply a greater sensitivity to interference on the part of older adults. Another part of the problem is more general, however, and applies to other theoretical frameworks as well. That is, the mechanism by which secondary tasks interfere with working memory is poorly understood, and without such understanding, it is difficult to interpret the present results (or other findings regarding interference effects) in any theoretical context. Although it is often assumed that interference occurs when secondary tasks prevent rehearsal, some researchers have questioned the role of rehearsal in working memory (e.g., Brown & Hulme, 1995), particularly in the case of memory for visuospatial information (e.g., Hale et al., 1996; Washburn & Astur, 1998; for a review, see Logie, 1995).

Future research in cognitive psychology in general, and in cognitive aging in particular, would benefit greatly from more
clearly specified models of working memory. One potential benefit from such models is that they could provide a theoretical basis for deciding whether analyses should focus on the absolute or relative size of interference effects. In the absence of such guidance, we report the results of both types of analyses. None of these analyses provided any support for the hypothesis that older adults are more susceptible to interference with working memory than young adults. Like young adults, older adults were susceptible to interference only by secondary tasks from the same domain (i.e., verbal or spatial) as the memory items. Moreover, there were no age differences in the magnitude of interference produced by such secondary tasks, regardless of whether interference was measured in absolute terms or as a proportion of baseline values.

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