Does Strategic Memory Training Improve the Working Memory Performance of Younger and Older Adults?

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Abstract. The paper examines the effect of strategic training on the performance of younger and older adults in an immediate list-recall and a working memory task. The experimental groups of younger and older adults received three sessions of memory training, teaching the use of mental images to improve the memorization of word lists. In contrast, the control groups were not instructed to use any particular strategy, but they were requested to carry out the memory exercises. The results showed that strategic training improved performance of both the younger and older experimental groups in the immediate list recall and in the working memory task. Of particular interest, the improvement in working memory performance of the older experimental group was comparable to that of the younger experimental group.

Keywords: working memory, memory training, aging, imagery

Introduction

In the first formulation of the working memory model (Baddeley & Hitch, 1974), the characteristics of the working memory system and its relation to long-term memory were underspecified (Baddeley, 2000). Indeed, the majority of studies tried to analyze the possible role of this component in higher order cognition, e.g., reading comprehension (Daneman & Merikle, 1996; Ericsson & Kintsch, 1995).

The limited interest toward the role of long-term memory in working memory maintenance continued until Ericsson and Kintsch’s (1995) proposal. These two authors introduced the concept of a long-term working memory conceived of as a subset of long-term memory, which is directly accessible via cues in the short-term working memory. According to this view, therefore, the working memory capacity can rely on long-term memory resources. Thus, skilled memorizers are those people who are able to strategically encode information linking, for example, new information with previously learned information (see, for example, Ericsson & Delaney, 1999). This is supposed to happen through the cues strategically generated in working memory, which activate retrieval structures in long-term memory. In other words, using prior knowledge, for example, incoming information can be easily retrieved as it activates, through associations, elements encoded in long-term memory. An implication of this concept is that through teaching or improving the use of encoding strategies it is possible to increase the amount of information available in short-term memory or short-term working memory (Kintsch, 1994). Thus, according to McNamara and Kintsch (1996), the working memory limitations are bypassed because the experience within a particular domain leads to enriched knowledge structures, and to improved retrieval strategies.

Similarly to Ericsson and Kintsch (1995), other authors have proposed a continuity between working memory and long-term memory storage (see, for example, Cowan, 1995, and Engle, Kane, & Thuloseki, 1999). As Miyake and Shah (1999) pointed out, in several models of working memory the role of long-term knowledge and skills are actually considered to account for performance in working memory tasks, particularly in everyday tasks in which prior knowledge and skills make a more striking contribution. In some real-life situations people perform tasks in which they are highly skilled and well practiced, involving well-known knowledge domains. Skilled, expert performance provides many examples of such situations – playing chess or medical diagnosis, for instance. In fact, working memory, as related to new learning acquisition, is actually conceived of as enhancing the ability to use prior knowledge in order to improve performance: High span individuals, for example, benefit to a greater extent from preexisting domain knowledge compared to low span individuals (Hambrick & Engle, 2002). Furthermore, in the revision of
the original model, Baddeley (2000) included a component that handles the relation between working memory and long-term memory, i.e., the episodic buffer. According to Baddeley’s view, this component provides a temporary interface between the slave systems (the phonological loop and the visuospatial sketchpad) and long-term memory.

Most of the working memory models agree that working memory and long-term memory are in some ways related, nevertheless, the role and, thereby, the consequences of the use of long-term retrieval structures on the maintenance of information in working memory are clearly outlined only by Ericsson and Kintsch’s (1995) and Engle et al.’s (1999) models. Indeed, both the models, with some differences, state that a better use of strategies should extend working memory performance (Ericsson & Kintsch, 1995) or should make the task less attention-demanding, thus, increasing performance in a working memory task (Engle et al., 1999).

Surprisingly, although many studies have focused on demonstrating the capacity limitations of working memory, few have investigated how working memory performance is affected by practice and learning. However, in the past few years some evidence has emerged regarding how working memory performance may be enhanced. Another issue of interest is how training benefits may be generalized to other domains (transfer effects). Indeed, cognitive training may have an impact on other cognitive domains and, therefore, may offer interesting implications in the fields of both education and rehabilitation. In the literature on working memory training, it is possible to find two categories of studies: Those interested in understanding whether training based on mnemonic strategies can produce an improvement in working memory performance (see, for example, McNamara & Scott, 2001), and those aimed at understanding whether working memory training produces positive effects on cognitive functions conceptually related to working memory, such as fluid intelligence (see, for example, Klingberg et al., 2005; Klingberg, Forssberg, & Westerberg, 2002; Jäggi, Buschkühl, Blaser, & Perrig, 2006). Therefore, while the focus in the first category of studies is on the characteristics of working memory in relation to other memory systems, in the latter it is on clarifying the nature of working memory in higher order cognition.

The current paper is in line with the first category of studies. In one of the works on this topic, McNamara and Scott (2001) bring evidence in favor of the importance of strategic knowledge and its use for improving working memory performance. Across two experiments, but in particular in the second experiment, McNamara and Scott demonstrated that training focused on immediate list-recall produced gains in a working memory task (see Daneman & Carpenter, 1980; Turner & Engle, 1989). The working memory task used by McNamara and Scott required participants to read a set of sentences, each followed by an unrelated word, and then serially recall as many of the unrelated words as possible. Trained participants reached a higher working memory performance level relative to non-trained participants. The general positive effect of training found in strategic participants supports the notion of long-term working memory. This view is also partially confirmed by Turley-Ames and Whitfield’s study (2003). These authors showed that different training activities had a positive impact on working memory performance but only in the case of low span participants. In particular, when analyzing the efficacy of different kinds of strategies (rehearsal, imagery, semantic) they found that low working memory participants benefit more from rehearsal strategic training. In contrast, high span participants did not benefit from any kind of training instruction probably because they are more used to apply a strategy or strategies to perform the task even prior to strategy instructions (Turley-Ames & Whitfield, 2003). In fact, high span participants approach complex tasks using more controlled processing strategies, probably because they have greater attentional resources available than individuals with a low working memory capacity (Feldman-Barrett, Tugade, & Engle, 2004). Of particular interest, Turley-Ames and Whitfield (2003) showed that the correlation between working memory performance and reading comprehension increases when the use of strategies is controlled for.

Concerning the effect of memory training in the field of aging, there is a broad literature reporting the positive effect on elderly people’s performance. For example, Verhaeghen, Marcoen, and Goossens (1992), using a meta-analytic procedure, found that the elderly can benefit from memory training: The effect size obtained in the case of trained groups indicated the possibility of increasing performance from pre- to posttest by about 0.7 standard deviations. This was not the case when control or placebo groups were considered. Furthermore, Verhaeghen et al.’s meta-analysis revealed that the positive effect of memory training was not dependent on the kind of strategies taught. Indeed, the level of gains of the older participants was comparable both in the case of imagery, verbal, and semantic strategies. Nevertheless, it is worth noticing that in the studies included in the meta-analysis there was a prevalence of training based on imagery.

However this meta-analysis as well as other studies (see, for example, Derwinger et al., 2003; Rasmussen, Rebok, Blysm, & Brandt, 1999; Singer, Lindenberger, & Baltes, 2003) have considered the effect of training on episodic memory measures. In the case of the elderly, to our knowledge, only one study has made an attempt to test the effect of two different kinds of strategic training on working memory performance (Cavallini, Pagnin, & Vecchi, 2003). In their study, Cavallini et al. trained groups of young (20–35), young-old (60–70), and old-old (70–80) on two memory strategies focused either on learning the loci mnemonics technique or the use of several strategies to be used depending on the task requirements. During the training activities the two techniques were taught in an everyday context. The effect of training was assessed with five ecological tasks, three metamemory questionnaires, and four working memory tasks requiring
The categorization working memory task has been shown to be strongly correlated \( (r = .76) \) with fluid intelligence measures (Raven test) (e.g., Borella, Carretti, & Mammarella, 2006), and with other verbal \( (r = .63) \) and visuo-spatial working memory \( (r = .63) \) tasks (e.g., Borella, Carretti, & De Beni, 2006).

The categorization working memory task was modified with older adult participants (Verhaeghen et al., 1992) and in consideration of results found in the literature (e.g., Cornoldi & De Beni, 1995), which show the high impact of verbal imagery in memory training activities and their high applicability. Furthermore, the use of a different strategy with respect to the work by McNamara and Scott (2001) will allow us to generalize the previously obtained results.

Method

Participants

For this study, 30 younger adults and 30 older adults aged between 65–75 years participated; 15 younger (14 females and 1 male) and 15 older adults (12 females and 3 males) were randomly assigned to the training group. The remaining 15 younger (10 females and 5 males) and 15 older adults (10 females and 5 males) were assigned to the control group.

Participants were all native speakers of Italian and volunteered for the study. Older adults were selected on the basis of a physical and health questionnaire. All participants who fit the exclusion criteria proposed by Crook et al. (1986) (i.e., history of head trauma; any neurological or psychiatric illness; history of brain fever; dementia or any other state of consciousness alteration; use of benzodiazepines in the last 3 months; use of illicit drugs; visual, auditory, and/or motor impairment; any symptomatic cardiovascular condition, breathing problems or pathologies causing possible cognitive impairments) were excluded from the study.

Older participants were, therefore, healthy. They were recruited both from the University of the Third Age in Verona and in social clubs, and were active in the cultural and social activities of their neighborhood.

Materials and Procedure

Immediate List Recall Task

Two lists of 15 words comparable for word length and imagery value were prepared. Participants heard the list of words presented at a rate of 2 s per word. The lists of words were audio-taped. At the end of the presentation participants were required to recall as many items on the list as they could. No order constraint was set. Pretest and posttest word lists contained different words, and the lists were counterbalanced across testing sessions.

Categorization Working Memory Span Task (CWMS; De Beni et al., 1998)

This task is similar to the classical working memory tasks, with the unique difference that it requires processing lists of words instead of sentences, limiting the role of semantic processing. In previous studies, this latter modification of the task allowed us to study, in detail, the role of working memory in individual differences in reading comprehension (see, for example, Carretti, Cornoldi, De Beni, & Palladino, 2004). The materials consisted of eight sets of words. Each set is composed of 18 lists of words, which
are organized in series of words lists of different length (from three to six). Each list contains five words of high – medium frequency. Furthermore, lists contain zero, one, or two animal nouns, which can be presented in various locations, including the final position. An example of a list is the following: house, mother, dog, word, night.

Half of the sets (four) were used as a pretest task and the latter four as posttest. The two sets were counterbalanced across testing sessions.

Participants heard the lists of words presented at a rate of 1 s per word and were required to tap their hand on the table whenever they heard an animal word (processing phase). The interval between the two lists of words was 2 s. At the end of the series, participants recalled the last word of each list in serial order (maintenance phase). The presentation was, therefore, paced by the experimenter.

The total number of correctly recalled words was considered as being the measure of working memory capacity. The number of tapping errors was also measured to consider the level of accomplishment of the processing task. The number of intrusion errors (i.e., nonfinal words incorrectly recalled) was also computed. This measure is intended to measure the ability to control the permanence of information in working memory as a function of their relevance with the task aim (see, for example, De Beni et al., 1998).

**Strategic Memory Training Procedure**

Each participant of both the experimental and the control groups attended five individual sessions that were completed within a 2-week time frame with a fixed interval between sessions of 2 days. Control groups attended the same number of sessions as experimental groups, but they were not instructed to use any strategy. Each session took about 30–60 min. In planning the training we followed the procedure proposed by McNamara and Scott (2001), thus allowing us to observe whether the benefit obtained using their training strategy can be generalized to another kind of training.

The five sessions were organized as follows.

– In Session 1 (pretest session), participants were administered the CWMS pretest, the immediate list recall task pretest, and the vividness of visual imagery questionnaire (VVIQ).
– In Session 2, two training blocks consisting of 10 words each and two training blocks consisting of 15 words were administered.
– Session 3–4 each consisted of training with four lists containing 15 words each.
– In Session 5 (posttest session), participants were required to carry out the CWMS posttest and the immediate list recall task posttest. Across all lists, no target words were repeated.

Training included 12 word lists distributed across three sessions. The participants were advised to create an image for each word trying to interrelate the obtained images. In Session 2, the participants controlled the word-presentation rate raising their hand when the image was created. Then the experimenter read aloud the next word on the list. In Sessions 3 and 4, the experimenter controlled the presentation rate. Using a stopwatch, the experimenter allowed approximately 4 s per word (after being pronounced) in Session 3, and 2 s in Session 4. The actual use of mental images was monitored by asking participants to orally rate the quality of the images at the end of each training list. This rating was requested after the recall phase.

To limit the influence of sensory variables (hearing; see Lindenberger & Baltes, 1997) on test results, the auditory presentation, for the immediate recall list and the CWMS task, was adjusted to the participants’ hearing level, simply increasing, if necessary, the volume of the tape-recorder.

**Results**

The data were screened for outliers. Outliers were defined as cases more than 3 SD above or below the mean. The data of five participants (two females from the older experimental group; one female from the older control group; two females, respectively, from the younger experimental and the control groups) who met this criterion in both the list recall and working memory tasks during the pretest were excluded. The final sample used is presented in Table 1.

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2 As in working memory tasks, correct recall was considered if 85% of correct processing (tap the hand on the table whenever an animal word was heard) was done (see Conway et al., 2005).

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**Table 1. Demographic characteristics of the experimental and control groups of younger and older adults**

<table>
<thead>
<tr>
<th>Age</th>
<th>Education</th>
<th>VVIQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Younger adults</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>N = 14</td>
<td>M = 22.5</td>
</tr>
<tr>
<td>Control</td>
<td>N = 14</td>
<td>M = 22.93</td>
</tr>
<tr>
<td><strong>Older adults</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>N = 13</td>
<td>M = 68.92</td>
</tr>
<tr>
<td>Control</td>
<td>N = 14</td>
<td>M = 70.21</td>
</tr>
</tbody>
</table>

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Table 2. The effect of strategic training in immediate list recall and working memory recall by Condition (experimental vs. control group) and Age group (young vs old)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Condition</th>
<th>Test</th>
<th>Immediate list recall*</th>
<th>95% CI</th>
<th>Working memory recall**</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>SE</td>
<td>95% CI</td>
<td>M</td>
</tr>
<tr>
<td>Younger adults</td>
<td>Experimental</td>
<td>Pretest</td>
<td>8.49</td>
<td>0.54</td>
<td>7.41–9.58</td>
<td>57.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-test</td>
<td>11.11</td>
<td>0.70</td>
<td>9.70–12.51</td>
<td>62.75</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>Pretest</td>
<td>9.35</td>
<td>0.56</td>
<td>8.22–10.47</td>
<td>53.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>9.32</td>
<td>0.72</td>
<td>7.87–10.77</td>
<td>55.46</td>
</tr>
<tr>
<td>Older adults</td>
<td>Experimental</td>
<td>Pretest</td>
<td>5.12</td>
<td>0.47</td>
<td>4.19–6.06</td>
<td>39.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>6.33</td>
<td>0.60</td>
<td>5.12–7.54</td>
<td>46.20</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>Pretest</td>
<td>5.76</td>
<td>0.69</td>
<td>4.38–7.14</td>
<td>39.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>5.48</td>
<td>0.89</td>
<td>3.7–7.27</td>
<td>40.46</td>
</tr>
</tbody>
</table>

*Adjusted on the covariate “level of education”; **adjusted on the covariates “level of education” and “VVIQ score.”

The 2 × 2 ANOVA with Condition (experimental vs. control group) and Age group (young vs old) as between subject factors on years of education showed a main effects of Condition, F(1, 51) = 7.95, p < .01, MSE = 4.68, η² = .16, and Age group, F(1, 51) = 194.45, p < .001, MSE = 4.68, η² = .79. The experimental group had a level of education higher than the control group, and younger adults had an overall level of education higher than the older groups. The interaction Condition × Age group was also significant, F(1, 51) = 10.95, p < .01, MSE = 4.68, η² = .18. Posthoc comparisons with Tukey’s method showed that the older control group had a lower level of education with respect to all the other groups (p < .01).

Since the training focused on the use of imagery to improve memory performance, the VVIQ, devised by Marks (1973) and translated into Italian, was administered to be sure that the groups were able to mentally visualize objects or situations. The 2 × 2 ANOVA on the total score obtained in the VVIQ yielded only a main effect of Age group, F(1, 51) = 5.62, p < .05, MSE = 602.71, η² = .10, with the groups of older adults reaching an overall better performance than younger adults. Neither the main effect of Condition nor the interaction Condition × Age group were significant.

As significant differences emerged in the analyses of variance on the educational level and the total score on the VVIQ between younger and older adults, correlation analyses were conducted between these variables and pretest and posttest performance in the list recall and in the working memory tasks, respectively. The total number of words correctly recalled in the pretest and posttest in the list recall task correlated significantly with educational level (r = .66, p < .001, and r = .67, p < .001, respectively), but not with the score on the VVIQ. On the contrary, the number of correctly recalled words in working memory performance correlated significantly with both the educational level (pretest: r = .80, p < .001; posttest: r = .81; p < .001) and the VVIQ score (pretest: r = −.40, p < .01; posttest: r = −.40, p < .01). Therefore, ANCOVA analyses were conducted as follows.

Immediate List Recall Task

The number of correctly recalled words in the immediate list recall task was analyzed with a repeated measure 2 × 2 ANCOVA with Condition (experimental vs. control group) and Age group (young vs old) as between variables, Test (pretest vs. postest) as within variable, and educational level as covariate. The main effect of Age group was significant, F(1, 50) = 19.34, p < .001, MSE = 4.47, η² = .28; younger adults had an overall better performance than older ones. The effect of Condition, Test, and the covariate were not significant. The interaction Condition × Test was, however, significant, F(1, 50) = 18.97, p < .001, MSE = 1.33, η² = .27 (see Table 2). Posthoc comparisons with Tukey’s method, conducted on the means adjusted on the effect of the covariate, showed that the performance at the posttest for the experimental groups (M = 8.71, SE = .38), regardless of age, was higher than that of control groups (M = 7.4, SE = .38) (p < .01). Furthermore, the performance of the experimental groups increased significantly from the pretest (M = 6.81, SE = .29) to the posttest (M = 8.72, SE = .38) (p < .01), contrary to that of the control groups (pretest M = 7.55, SE = .29, posttest M = 7.4, SE = .38). In this case, too, it is worth noticing that the performance of the experimental groups at the pretest was lower with respect to that of control groups. No other interaction reached statistical significance.

Table 3. The values of effect size reported for the difference between pre- and posttest

<table>
<thead>
<tr>
<th>Age group</th>
<th>Condition</th>
<th>Immediate list recall difference pretest/posttest</th>
<th>Working memory recall difference pretest/posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>d</td>
</tr>
<tr>
<td>Younger adults</td>
<td>Experimental</td>
<td>1.30</td>
<td>.79</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.04</td>
<td>.20</td>
</tr>
<tr>
<td>Older adults</td>
<td>Experimental</td>
<td>.75</td>
<td>.58</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>.14</td>
<td>.18</td>
</tr>
</tbody>
</table>
Table 3 reports the value of d (Cohen, 1988), which expresses the effect size of the comparisons. For the comparisons of the improvement between pre- and posttest within each group, the values revealed a large effect size (above .80) in the case of the experimental groups, whereas in the case of control groups they indicated a small or even null effect size. The effect size of the comparisons between experimental and control groups in performance at posttest fluctuated from a medium (.50 – .70) to a large (above .80) effect size, respectively for the older (d = .57) and younger participants (d = .82).

**CWMS Task**

The number of correctly recalled words in the working memory task was analyzed with a repeated measure 2 × 2 × 2 ANCOVA with Condition (experimental vs. control group) and Age group (young vs. old) as between variables, Test (pretest vs. posttest) as the within variable, and educational level and VVIQ score as covariates.

Results indicated a main effect of Condition, F(1, 49) = 5.61, p < .05, MSE = 94.28, \( \eta^2 = .10 \), with a better performance of the two experimental groups than the control groups. The main effect of Age group was also significant, F(1, 49) = 16.7, p < .001, MSE = 94.28, \( \eta^2 = .25 \); the younger adults had an overall better performance than the older adults. The interaction Condition × Test was also significant, F(1, 49) = 4.73, p < .05, MSE = 24.31, \( \eta^2_p = .09 \) (see Table 2). Posthoc comparisons with Tukey’s method, conducted on the means adjusted on the effect of the two covariates, revealed that the performance at the posttest for the experimental groups (M = 54.47, SE = 1.51), regardless of age, was significantly higher than that of the control groups (M = 47.96, SE = 1.49; p < .01). Moreover, the performance of the experimental groups increased significantly from the pretest (M = 48.7, SE = 1.58) to the posttest (M = 54.47, SE = 1.51; p < .01), contrary to that of the control groups (pretest M = 46.48, SE = 1.57; post-test M = 47.96, SE = 1.49). In this case, too, it is worth noticing that the performance of the experimental and control groups at the pretest did not differ. No other effects or interactions were significant.

Table 3 reports the value of d (Cohen, 1988), which expresses the effect size of the comparisons. As for the comparisons of the gains from the pre- to the posttest within each group, the values revealed a fluctuation from a medium (.50 – .70) to a large (above .80) effect size, respectively, in the case of the older and younger experimental groups, whereas in the case of the control groups the values indicated a small effect size. The effect size of the comparisons between experimental and control groups in the performance at posttest showed a large effect size (above .80) both in younger (d = 1.27) and older adults (d = 1.23).

Concerning tapping errors and intrusion errors, since the two scores correlated significantly with educational level (tapping errors: pretest r = -.57, p < .001, post-test r = -.53, p < .001; intrusion errors: pretest r = -.58, p < .001, posttest r = -.45, p < .001) and the VVIQ (tapping errors: pretest r = .38, p < .01, posttest r = .26, p < .05; intrusion errors: pretest r = .29, p < .05, posttest r = .11 ns), ANCOVA analyses were conducted.

The ANCOVA on the tapping errors showed a main effect of Condition, F(1, 49) = 13.13, MSE = 37.91, p < .01, \( \eta^2 = .21 \), favoring the experimental groups, and of Age group, F(1, 49) = 4.58, p < .05, MSE = 37.91, \( \eta^2_p = .09 \), with younger adults committing a lower number of errors than older ones. The interaction Age group × Condition was also significant, F(1, 49) = 9.65, p < .01, MSE = 37.91, \( \eta^2_p = .16 \). Posthoc comparisons with Tukey’s method, conducted on the means adjusted on the effect of the two covariates, showed that the older adults control group made a significantly higher number of errors compared to other groups (p < .01). No other interaction reached statistical significance.

The ANCOVA on the number of intrusion errors did not reveal any significant effects or interactions.

**Benefit Due to the Training**

To better understand the effect of the training on the performance in the immediate list recall task and in the CWMS task, a measure expressing the benefit resulting from the training activities was calculated. The formula used was as follows [score Posttest – score Pretest]/score Pretest]. In our opinion, this measure should give a clear-cut picture of the gains obtained after training, since it allows for controlling for individual differences in the recall rates of older and younger adults.

The indexes obtained both for the immediate list recall and the working memory recall did not correlate with educational level and VVIQ score, therefore ANOVA analyses were run. Two separate ANOVA analyses were run, with Condition (experimental vs. control group), Age group (young vs. old) as between factors, on the benefit index for the gains in the immediate list recall task, and in the CWMS (recall performance). Results on the benefit index for the list recall indicated only the main effect of Condition, F(1, 51) = 22, p < .001, MSE = 2.61, \( \eta^2_p = .30 \), with the experimental groups having a larger benefit than the control ones. The same main effect of Condition emerged on the working memory benefit index, F(1, 51) = 5.51, p < .05, MSE = 46.85, \( \eta^2_p = .10 \), with a larger benefit for the experimental groups compared to the control ones.

With this formula, we also compared the performance of younger and older adults for the experimental groups in both the immediate list recall and CWMS tasks. We ran planned comparisons contrasting the gains of the younger and older adult experimental groups in the immediate list recall and CWMS tasks. The ANOVA with Age group (young vs. old) as a between variable on the indexes of benefit did not yield significant results, that is, no significant differences between the younger and older experimen-
tal groups both in the immediate list recall, $F(1, 25) = 3.27$, $p = .075$, and CWMS tasks, $F < 1$ (see Figure 1) emerged.

To document the magnitude of the training-related gains, all the participants were categorized into two groups as suggested by Singer et al., (2003): Individuals with (a) a gain of less than two words and (b) a gain of two or more words between the pre- and the posttest. In the case of the list recall task, the percentage of participants that improved their performance was 79% in the younger adults experimental group and 14% in the control group. When older adults are taken into account, 69% of participants in the experimental group increased their performance in contrast to the 21% in the control group. Similar results were obtained in the case of working memory performance. In the younger adults’ groups, 85% of participants in the experimental groups improved from the pre- to the posttest and 50% in the control group. In the older adults’ groups, 77% of participants in the experimental groups improved from the pre- to the posttest and only the 29% in the control group.

Discussion and Conclusions

In this research we examined the possibility of enhancing working memory performance with strategic training in younger and older adults. As discussed in the introduction, some approaches have indicated that higher performance in working memory tasks is associated with a skilled use of mnemonic strategies (Ericsson & Delaney, 1999; Ericsson & Kintsch, 1995). According to this proposal, skilled memorizers are able to encode relevant information into long-term memory (LTM) in such a manner that, through cues, the information can be efficiently retrieved from LTM whenever it is needed (see, for example, Ericsson & Charness, 1994).

According to skilled memory theory proposed by Chase and Ericsson (1981, 1982; Ericsson, 1985; Ericsson & Chase, 1982; Ericsson et al., 1980) three principles could explain exceptional memory performance in terms of acquired encoding skill. First, to attain exceptional memory performance individuals need to rely on prior knowledge and patterns to encode the presented items and store the items as encoded groups in LTM (encoding principle). Second, encoded information needs to be associated with retrieval cues during study that can later trigger retrieval from LTM (retrieval structure principle). Finally, with additional practice individuals become more proficient in their encoding and can store the same amount of presented information in less time (speed-up principle).

The same principles can be adopted in reference to how strategic training can act in improving working memory performance. Indeed, taking as an example the particular case of the current strategic training, the activities of the training should have allowed participants with practice to go beyond merely rehearsing information to encode and store information using more appropriate strategies, in this case the LTM imagery strategy.

The results of the current paper strongly confirmed the positive effect of strategic training for enhancing the performance in a working memory task and in immediate recall both for the younger and older experimental group. Indeed, the trained groups significantly improved their performance from the pre- to the posttest in comparison to the control groups. In our opinion, the relevant result concerns the benefit in working memory performance: Younger and older adults trained to use an imagery strategy in the context of LTM recall (an immediate recall list task) were able to transfer this new learned strategy in the context of recalling the target information in a working memory task. The magnitude of the effect was generally large as demonstrated by the values of the $d$ index (Cohen, 1988). The $d$ value was always higher in the case of younger adults than in older ones, especially in the case of the working memory task. Although this result may seem to contrast with the score obtained with the benefit index, it is crucial to consider how the two indexes are computed. The benefit index takes into account only the means of the groups, whereas the $d$ index is based on the standard deviations and on the group dimension (N). Thus, the lower value of the $d$ index for the group of older adults may depend on the higher...
variability inside the older adult groups (e.g., Nelson & Dannefer, 1992), especially when the working memory task is considered.

Nevertheless, the overall positive effects of the training suggest that the lower memory performance of older adults, resulting from their limited cognitive resources, can be compensated by strategic support that decreases the processing requirements of the memory task (Naveh-Benjamin, Craik, Guez, & Krueger, 2005). Naturally the gap between younger and older adults in memory performance remained significant. Nevertheless, to our view this latter result is not a point of weakness of our results, since our aim was to demonstrate that, in the case of working memory tasks, there is room for improvement even in the case of older adults.

The experimental groups, indeed, showed an increase in working memory performance compared to the control groups (see percentage of participants that improved their performance as the result of training). Both in the case of younger and older adults, the increase in performance is referred only to the maintenance aspect of the working memory task, whereas the performance in the secondary task remained stable from pre- to posttest. The facilitation occurred, presumably, because the use of an imagery-based strategy allows building cues that draw upon personal knowledge and do not require additional resources or mental effort to retrieve the target words, thus acting as an environmental support. In other words, the strategic training facilitated the use of the retrieval structure of long-term memory to improve working memory performance. It is worth noticing that the procedure of our working memory task was not self-paced, thus, processing times were constrained by the experimenter. Nonetheless, the increase in performance observed at posttest suggests that participants in the experimental groups were able to make use of a learned strategy during the execution of the working memory task. This observation contrasts with Lépine et al. (2005) who stated that strategy-knowledge does not have a role in working memory performance when working memory tasks are time-constrained. To reconcile Lépine et al.’s view with current results it is possible to hypothesize that learning a new memory strategy that allowed participants to rely upon long-term retrieval structures, facilitated the lowering of attentional demands of the working memory task and, therefore, the allocation of resources on task goals, in order to increase working memory performance.

Altogether these results are consistent with those reported by McNamara and Scott (2001) with younger adults, thus, they are in line with an expert-performance approach to working memory (Ericsson & Kintsch, 1995). Participants trained to use a strategy to better encode and retrieve information reached a higher level of performance in carrying out a working memory task in comparison to untrained participants. Nevertheless, the data can also be interpreted in light of Engle et al.’s (1999) framework in which training lessens the attentional demands of the task, thus, the relevant information is actively maintained despite interference, distraction, and/or attentional shifts (Kane & Engle, 2000). However, as noted before, these views do not contradict each other; they only place the focus on two different aspects of working memory functioning. Indeed, Ericsson and Kintsch seem to be more interested in the structure that maintains incoming information in working memory, while Kane and Engle’s view is focused on its main functions to explain individual differences.

Returning to the discussion of the results, of particular interest is the comparison between younger and older adults on the measure of benefit from training activities. This measure, which shows the increase in individual performance after training, allows for a direct comparison between younger and older adults’ rate of advantage. The results reveal that the gains of the younger and older experimental groups were comparable both in the immediate recall measure and in the working memory task. In agreement with previous research (see Verhaeghen et al., 1992), these results highlight that even in the case of elderly adults there is room for an increase in memory performance and, importantly, it shows that the improvement can be as great for the elderly as for the younger participants. This also happens when a demanding strategy is taught. These results, therefore, shed light on the nature of individual differences in working memory, since to a certain extent the variability between groups can be explained by a higher efficacy in managing items to be recalled for participants with a higher working memory.

In conclusion, our study demonstrates that memory training, using an on imagery-based-strategy, can enhance the performance of older and younger adults in a list recall task, and this improvement can be extended to working memory performance.

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References


