Research Article

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Strategy-adaptation memory training: predictors of older adults' training gains

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Abstract: Over the past decades, memory training interventions have been developed in an attempt to stabilize or enhance memory functioning in aging. Only recently has attention been paid to individual differences in training gains and consequently to predictors of such gains. The aim of the present study was to identify which specific cognitive mechanisms/processes or components of the intervention were responsible for the desired change and which individuals were more responsive to memory strategic training. Eighty-one older adults (aged 55 to 82) were involved in a four-session strategy-adaptation training based on a learner-oriented approach that has previously been found to be effective in improving memory performance in practiced and untrained tasks. Results showed that baseline performance in memory tasks predicted the gains in the practiced task. Baseline performance in memory tasks and other cognitive variables, such as working memory, processing speed, and verbal knowledge predicted transfer effects. Interestingly, we found that the magnitude of training gain on the associative memory practiced task predicted the gains in the transfer tasks, suggesting those who best implemented the targeted strategies during training realized greater transfer to other tasks. Our study shows that older adults with larger cognitive resources will benefit more from interventions focused on the generalization via active processes.

Keywords: individual differences, strategic intervention, learner-oriented approach, cognitive resources, transfer effects

Introduction

There is a general agreement that advancing age is accompanied by cognitive decline, which is observed in multiple cognitive domains. One of these domains is episodic memory (Park, Lautenschlager, Hedden, Davidson, Smith, & Smith, 2002). Since the involvement of memory occurs in all daily activities and given that it represents a central component of successful aging due to its role in maintaining autonomy (Baltes & Baltes, 1990), researchers are continually seeking ways to contrast the decline. A significant body of research has demonstrated the effectiveness of memory training in improving memory performance in

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healthy older adults (for a review see Gross et al., 2012). Many memory intervention studies have focused on how training gains might lead to performance improvements in untrained tasks. Hence, the extension of the newly acquired knowledge or abilities being put to use in new situations, that is to say the transfer effect, represents the ultimate goal of training research (Willis, 2001; Willis & Schaie, 2009). Finding the right way to generalize intervention gains to untrained tasks may help older adults use the new knowledge and abilities in their everyday life, improving the possibility to preserve independent living until a very old age. Unfortunately, some studies have failed to report the generalization of strategies or abilities acquired during training to new tasks. This lack of transfer effects has several explanations. One possibility is that, without extensive practice on particular materials, older adults will be unable to apply the new mnemonic or ability to those materials effectively. It may be that disuse or generalized cognitive decline undermines older adults' ability to perform a new task without practice. An alternative explanation is that older adults merely do not know that the newly learned mnemonic can (or should be) applied to learning non-practiced materials.

Notwithstanding the large number of studies on the effectiveness of memory interventions, a limited number of studies showed that, even if training is successful at the group level, individual differences in training-related performance gains are usually large (e.g., Bissing & Lusting, 2007; Hill, Yesavage, Sheikh, & Friedman, 1989; Langbaum, Rebok, Bandeen-Roche, & Carlson, 2009; Rosi et al., 2017; Sanberg, Rönnlund, Derwinger-Hallberg, & Stigsdotter Neely, 2016). Some individuals benefit more than others, despite being exposed to the same program and materials (e.g. Lövdén, Brehemer, Li, & Lindenberger, 2012). Therefore, the field of cognitive interventions has been slowly shifting from just testing whether training works to analyzing for whom it works. This methodological approach, based on analyzing individual differences, additionally allows researchers to investigate the mechanisms driving training-related changes in performance.

The variability in terms of gains is crucial both theoretically and practically. From a theoretical point of view, the study of individual differences permits researchers to study mechanisms or processes that may underlie the treatment effects. For instance, for strategic training, it is crucial to understand the link between cognitive functioning, strategy learning, and training gains. From a practical point of view, it is relevant to examine which among the alternative training interventions is best suited to a given older adult. This would allow trainers to differentiate the type or the level of a training and to suggest the correct intervention to each older adult.

The aim of the present study was thus to identify what specific cognitive mechanisms/processes or components of the intervention were responsible for the desired change and which individuals were more responsive to memory strategy training.

Studies on memory interventions are mainly concentrated on three different approaches: strategy training, multidomain training intervention, and processes-based intervention. Strategy-training programs usually show large and often long-lasting improvements on the training task, but limited transfer effects (Rebok, Carlson, & Langbaum, 2007; Verhaeghen, Marcoen, & Goossens, 1992). Multidomain training interventions engage multiple cognitive processes, but often report small transfer effects (e.g., Basak, Boot, Voss, & Kramer, 2008; Park, Gutchess, Meade, & Stine-Morrow, 2007). Process-based training protocols target more general processing capacities, such as the speed of processing or working memory, which tend to decline with advancing age, yet they are crucial because of their involvement in general cognitive functioning. Research on process-based training often finds transfer effects to new tasks highly similar to those practiced during the training (near transfer effects) but small transfer gains in untrained tasks (Karbach & Verhaeghen, 2014).

Given the general failure of training programs to achieve transfer, we have developed an innovative intervention aimed to help older adults actively transfer strategies to new materials (Bottiroli, Cavallini, Dunlosky, Vecchi, & Hertzog, 2013; Bottiroli, Cavallini, Dunlosky, Vecchi, & Hertzog, 2017; Cavallini, Dunlosky, Bottiroli, Hertzog, & Vecchi, 2010; Cavallini et al., 2015). We constructed this intervention (see Bottiroli et al., 2013; Cavallini et al., 2010) by taking into account one possible explanation for the lack of transfer effect. We supposed that the difficulties of older adults to transfer gains to new tasks were due to a knowledge deficit. We hypothesized that older adults merely do not realize that trained mnemonics can (or should be) applied to learning non-practiced materials (Hertzog & Dunlosky, 2012). Traditional strategy-training interventions do not inform older adults that the major goal of training is to use the trained strategies in new contexts (McDaniel & Bugg, 2012), nor are participants informed that using the newly trained strategies on different tasks could be beneficial. Hence, remaining silent about the importance of transfer effects, namely not to explicitly ask older adults to generalize strategies, may be advantageous for obtaining empirical evidence relevant to alternative theories of transfer processes (Barnett & Ceci, 2002; Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010), but it does not help older adults realize that they should also use the new strategies in their everyday life.

We created a training based on a learner-oriented approach in which older adults are treated as active partners in attempting to achieve the generalization of their behavior. The learner-oriented approach helps participants understand that the new strategies can be applied to a variety of materials across many contexts. This new training includes strategies learning, task analysis, and instructions on how to adapt and apply learnt strategies to new materials. We decided to teach more than one associative strategy with the idea that working on multiple strategies might lead to broader strategy adaptation and transfer because different materials may afford different strategies, leading to better options for strategy adaptation than learning of one specific technique (Verhaeghen, 2000). In our training intervention, older adults are trained to use both interactive imagery and sentence generation (as in Cavallini et al., 2010). Both strategies encourage learners to organize to-be-learned items with relational encoding (e.g., by developing an internal image where the referents of items are interacting or by developing a verbal story that links the referents together). These two strategies have been shown to be the most effective in mediating associative memory because they provide better integration of the two elements into a single associative trace (e.g. Hertzog & Dunlosky, 2006; Hertzog, Price, & Dunlosky, 2012; Hinault, Lemaire, & Touron, 2017). Furthermore, our intervention teaches older adults to do a simple task analysis of any new transfer task to help them adapt the trained strategies to meet the new task's processing demands. This task analysis is based on the self-regulated-learning theory that posits that effective strategy use requires analyzing the characteristics of a task and adapting strategies to match those features (Lemaire, 2010). In addition, older adults are invited to consider how to adapt strategies to new materials by considering specific questions about the new task context. Otherwise, older adults have difficulties in adapting their newly learned strategies to study different materials when merely instructed to do so (Cavallini et al., 2010). In one training study, Bailey, Dunlosky, and Hertzog (2014) trained organizational strategies for free recall (i.e., using verbal or imagistic means of relating words into new groups, such as imaging multiple objects in a scene). Training on this kind of relational organization then transferred to a working memory task – the former involves learning individual words while the latter also involves remembering words but while performing a secondary task. In this case, the organizational strategies used to encode words for a free recall task (e.g., link all the to-be-learned words together in a meaningful way) is similar to the task of trying to remember the to-be-learned words for the working memory task, which also requires freely recalling the individual words. However, training in this organizational strategy did not increase performance on another transfer task of associative recall (e.g., study "dog – spoon" with a test being "dog - ?"), probably because it is not obvious that the strategy of mentally organizing an entire list of words for free recall should be applied to studying pairs of words (i.e., "dog – spoon") that need to be associated as a separate unit. The failure to obtain transfer in this case suggests that a passive approach to training is not effective in making participants understand how to adapt the new strategies to a context where they may not be obviously applied.

Our approach focuses on the broader applicability of trained strategies by having older adults explicitly consider and practice strategy adaptation during the training itself. Given participants' active involvement in the requisite task analysis, we call the new training a *strategy-adaptation memory* intervention. It is interesting to note that this approach was effective in producing transfer gains in several tasks (Bottiroli et al., 2013), including those related more to older adults' everyday life (Bottiroli et al., 2017). Specifically, we used two subtests of the Everyday Cognition Battery (Allaire & Marsiske, 1999), measuring multiple basic cognitive abilities (i.e., inductive reasoning and working memory) as expressed in the context of important instrumental everyday tasks (i.e., medication use, financial planning, and food nutrition).

Moreover, this program was useful both when it was administered in groups guided by a trainer (Bottiroli et al., 2013) and when it was self-administered via a manual that older adults used at home (Bottiroli et al., 2013) or in a residential care center (Cavallini et al., 2015). For strategy-adaptation memory training, participants do not only practice using a particular strategy, they are explicitly trained how to adapt the strategy to new tasks (for details, see the Method section below). In brief, Bottiroli et al. (2013) trained older adults to use two effective strategies (i.e., interactive imagery and sentence generation), and they practiced using these strategies while studying paired associates (e.g., "dog – spoon"). They then discussed how they could adapt these strategies to new tasks. Importantly, they received pre-training and post-training tests on the practiced task (paired associates) as well as on new tasks (e.g., learning a list of groceries) that were not practiced or discussed during training. Another group were instructed to use the effective strategies (imagery and sentences) and practiced using them, but this standard strategy-training group received no adaptation training. As compared to this standard training group, those who had strategy-adaptation training demonstrated substantial gains from the pre-training to post-training tests for both the practiced tasks and for the transfer (unpracticed) tasks. Nevertheless, large individual differences were evident in the size of the training gains (i.e., pre- to post-training gains) made by those who received strategy-adaptation training. Thus, due to the success of the strategy-adaptation memory intervention in improving older adults' memory performance in several tasks, we became interested in examining the variables which were potentially responsible for the individual differences in training gains.

In the remainder of the introduction, we discuss models relevant to explaining who may benefit most from training and then describe variables that are expected to predict individual differences in training gains.

The association between variables that predict training gains can be captured by one of two models: the magnification model and the compensation model. The magnification model (Kliegl, Smith, & Baltes, 1990; Lövdén et al. 2012; Verhaeghen & Marcoen,1996) suggests that younger individuals benefit more from cognitive training, as they have the cognitive resources necessary for successfully performing the tasks. The compensation model postulates that older participants with lower initial cognitive status tend to benefit more from the intervention because it allows them to compensate for their difficulties. Participants with lower baseline performance and cognitive resources would have more room for improvement (see Lovden, Brehmer, Li, & Lindenberger, 2012).

Baseline performance indicates the individual's initial level of performance on a cognitive task without intervention or support. Baseline plasticity refers to the extended range of possible performance improvement when additional resources are provided. Sandberg et al. (2016) found that older adults with a higher initial performance in the memory target task were those who tended to benefit the most from mnemonic training compared to participants with a lower performance.

Moreover, Rosi at al. (2018), in their study on predictors of training based on teaching the use of different simple memory strategies, such as verbal and visual associations to be used according to different everyday situations, reported baseline performance as a predictor of training gains in practiced and transfer tasks. Fandakova and collaborators (Fandakova, Shing, & Lindenberger, 2012) found that low-performing older adults in associative memory performance benefited more from direct instruction of the strategy than from practice. High-performing older adults benefited from both direct instruction and practice of the strategy. It is interesting to note that in their study differences in baseline performance led to both compensation (for low-performing older adults) and magnification (for high-performing participants) of training gains. Hence, baseline performance should be taken into account in studies analyzing the predictors of training gains.

Other cognitive variables may be critical predictors of training gains. One variable that may play a role in memory training is working memory, given its relationship with episodic memory (Verhaeghen & Marcoen, 1996; Sandberg et al., 2016) and verbal learning (Rast, 2011). Individuals with greater working memory capacity are able to keep task relevant information active in memory while inhibiting irrelevant information, which could support the more effective use of relational encoding strategies. De Caro and colleagues (DeCaro, Thomas, & Beilock, 2008) found that higher working memory capacity predicts faster learning of rules based on categories for younger adults. In addition, Wahlheim, McDaniel, and Little (2016) found that older adults with a higher working memory reported better training gains during an intervention based on category learning strategies.

Vocabulary is an indicator of a general crystallized cognitive factor reflecting access to existing knowledge (Jones et al., 2005; Rast, 2011). Individuals high (vs. low) in verbal ability may be better able to use semantic knowledge to support creation of mediational strategies, such as sentence generation. Interestingly, Sandberg and colleagues (2016) found that vocabulary predicted short-term gains of strategy training and that it was the unique predictor of the long-term gains over a period of 8 months. Rosi and colleagues (2017) also reported vocabulary to be a predictor of short-term gains in the task practiced during training.

Processing speed may also be a variable influencing training benefit. It is related not only to episodic memory (Hedden, Lautenschlager, & Park, 2005) but is also predictive of gains from trainings. Kliegl et al. (Kliegl, Smith, & Baltes, 1989) and Singer and colleagues (Singer, Lindenberger, & Baltes, 2003) in their study on the method of Loci, found that the speed of processing is a factor accounting for memory plasticity. Salthouse (1996) argues that individuals higher in processing speed can overcome rate-based limitations on implementing cognitive processes; accordingly, they may be better able to generate new strategies given limited encoding time.

The effect of age on training gains has received the most attention. Several studies reported larger training gains in younger than in older adults (e.g., Bürki, Ludwig, Chicherio, & de Ribaupierre, 2014; Schmiedek, Lovden, & Lindenberger, 2010), and in young-old adults compared to old-old adults (e.g., Borella et al. 2014; Zinke, Zeintl, Rose, Putzmann, Pydde, & Kliegl, 2014). These results fit with the magnification model (Kliegl et al., 1990; Lövdén et al. 2012; Verhaeghen & Marcoen,1996). However, other studies did not find age-related differences in training benefit (e.g. Rosi et al., 2017), and others reported that older adults got more benefit from training than young adults (e.g., Bherer, Kramer, Peterson, Colcombe, Erickson, & Becic, 2008; Karbach & Kray 2009). The latter results are in line with the compensation model (see Lovden et al., 2012).

We believe that other variables, such as the activities adults engage in, should also be studied as potential predictors of training gains. Several studies have revealed a relationship between cognitive functioning and (a) lifetime occupations in leisure, (b) cognitively stimulating activities, and (c) physical and social activities. For instance, Ortiz and Fernandez (2018) found that the performance in episodic memory was higher in participants with high values in engagement with cognitively stimulating activities. Fratiglioni and colleagues (Fratiglioni, Paillard-Borg, & Winblad, 2004) and Hertzog and colleagues (Hertzog, Kramer, Wilson, & Lindenberger, 2008; Jopp & Hertzog, 2007) reported that older adults who engage in activities show a better quality of life and better cognitive functioning than those with lower levels of activity.

In general, we expected to confirm the beneficial effect of strategy-adaptation training in producing training gains on trained and transfer tasks (as in Bottiroli et al., 2013; Bottiroli et al., 2017; Cavallini et al., 2010; Cavallini et al., 2015). We also expected a role of baseline performance in positively predicting training gains in the practiced task, task with instructions, and non-practiced task in line with the amplification model (Verhaeghen & Marcoen, 1996) and as reported in a previous study on the use of strategies (Rosi et al., 2018). For cognitive functioning, we hypothesized that working memory, processing speed, and crystallized intelligence would positively predict training gains in task with instructions and in the non-practiced task. However, because the adaptation of strategies requires more cognitive resources (Lemaire, 2010) than following specific instructions, we expected to find that more cognitive variables would predict training gains for the transfer tasks (where strategy adaptation is needed) than the practice tasks. For engagement in activities, we expected it to positively predict training gains as well, given its positive relationship with cognitive resources (e.g. Hertzog et al., 2008; Jopp & Hertzog, 2007).

Method

Participants

Eighty-one community-dwelling volunteers (age range 55 to 82) were recruited through advertisements in a local newspaper. Background information is presented in Table 1. Participants were involved in a strategy-adaptation training, which mentioned that participants would be involved in a memory training program that took part in a classroom setting. The advertisement recruited volunteers who were 55 years of age or older and who had never participated in a memory-training intervention. Volunteers were not given any tangible incentives (e.g., money or gifts) to participate. Participants were invited to fill out a demographic questionnaire in order to exclude people with a diagnosis of dementia, history of psychiatric or neurological disorders, and substance abuse compromising cognition. None of the older participants reported any of these cases.

Table 1. Demographic characteristics, cognitive variables, and Engagement in leisure activities Scale

	Strategy-adaptation memory training participants n=81	
	M	**SEM**
Male (n)	25	
Age	68.1	0.66
Years of Education	10.3	0.42
Verbal knowledge	43.7	0.57
Working memory	4.4	0.16
Processing speed	38.2	1.9
Engagement in leisure activities	113.1	2.7

Note. M = mean; SEM = standard error of the means.
Note: Maximum vocabulary score = 50; maximum processing speed score = 100

Training testing materials

Three memory tasks were administered during the pre-training and post-training sessions, using two versions of each task, to test the gains of the training. We describe each task in detail below. The time limit differed across tasks so as to ensure that participants had enough time to study all the materials. The tasks differed with respect to how much they were practiced and discussed during training: practiced task (task in which participants applied the strategies), task with instructions (task in which a discussion on how to apply the strategies was provided), and non-practiced task (task neither practiced nor discussed during training).

Practiced task

Associative learning. Participants were presented with 25 paired associates. Pairs consisted of words chosen from Paivio, Yuille, and Madigan (1968) concreteness and imagery norms and from De Mauro, Mancini, Vedovelli, and Voghera (1993) word frequency norms. Each pair was printed on a 5 x 7 index card. The 25 cards were handed to participants, who were instructed to study the pairs for up to 10 minutes. After study, participants were asked to write down the corresponding response on a sheet reporting the stimuli. Performance was evaluated on the basis of the number of items correctly remembered (range 0-25).

Task with instructions

Name-face learning. Participants were presented with 16 black and white photographs of faces (2.75 x 4) paired with the last name printed below it. The 16 name-face cards were handed to participants, who were instructed to study the pairs for up to 15 minutes. After this name-face study, faces were presented on two sheets of paper, and participants were asked to write down the name that had been previously paired with it. Performance was evaluated on the basis of the number of names correctly associated to the corresponding faces (range 0-16).

Non-practiced task

Learning of activities planned for the week. A list composed of 18 appointments during a week was studied by participants for 15 minutes. Performance in an immediate written recall was evaluated on the basis of the number of events correctly remembered in the right order (range 0-18).

Cognitive predictors

Working memory. The Backward Digit Span test was used to assess working memory (Spinnler and Tognoni, 1987). Participants had to remember lists of single-digit numbers of increasing length and recall them in the opposite order. Performance was defined by the highest level of complexity at which participants correctly recalled at least two out of three sequences.

Processing speed. To assess the processing speed in the visual modality, the *Symbol Digit Modalities Test* was used (SDMT; Smith, 1982; Italian version (Nocentini, Giordano, Di Vincenzo, Panella, & Pasqualetti, 2006). At the top of the sheet of paper geometric symbols associated with the numbers 1 to 9 was shown. Participants were instructed to write the number, as quickly as possible, corresponding to each symbol into rows of empty boxes with symbols above them. Participants were given 90 s to complete as many empty boxes as possible. The score used for this task was obtained by considering the number of correct symbols completed within the allowed time (range 0-100).

Verbal knowledge test. A verbal knowledge task (drawn by Primary Mental Ability; Thurstone & Thurstone, 1963) was administered to assess crystallized ability. Participants were asked to identify the closet synonym of 50 words from five alternatives. Participants had 8 minutes to answer. Performance was measured by the number of items answered correctly (range 0-50).

Activities engagement predictor

Engagement in leisure activities Scale. This is a section (17 items) of the cognitive Reserve Questionnaire (Nucci, Mapelli, & Mondini, 2012). It refers to all of those cognitively stimulating activities that are normally carried out before or after work or school. The items included indicate the activity for which it is necessary to estimate the frequency within the given time interval.

This section is divided into four parts, to differentiate the frequency with which the activities are usually carried out – i.e., weekly (e.g., reading newspapers and weekly magazines, use of new technologies), monthly (e.g., cinema or theatre, voluntary work), annually (e.g., journeys lasting several days, exhibitions, concerts or conferences), or at a fixed frequency (e.g., caring for pets, children). For each section, participants had to choose between "Never/Rarely" (corresponding to a frequency less than or equal to 2 times per week, per month or per year, respectively) or "Often/Always" (corresponding to a frequency equal to or greater than 3 times per week, per month or per year, respectively). Only in cases in which participants state that an activity has been carried out "Often/Always" for at least 1 year, the number of years is counted. If the activity had been carried out intensively for less than 1 year or for several years but only "Rarely", then the number of years for which it has been carried out must not be counted. (*For example, for a person aged 70 who has used the computer "Often/Always" for 30 years, the "Often/Always" box will be ticked, stating a period of 30 years. If a person aged 70 used the computer for 30 years but only occasionally – i.e., less than twice a week – the "Never/Rarely" box should be ticked -as if the person had never used the computer- and the number of years is not recorded*).

Procedure

Participants took part in two 2-hr testing collective sessions and in four 2-hr training collective sessions in the following order: the pre-training test, four training sessions, and the post-training test. At the beginning of the pre-training session, participants first completed a demographic questionnaire.

Training sessions. Strategy training (for more details see Bottiroli et al., 2013) was conducted by a female trainer in classrooms of about fifteen older adults (minimum 13 – maximum 15 participants). The four training sessions took place over four successive weeks. During the training sessions, participants were first instructed on how to use two strategies - sentence creation and interactive imagery - on paired associates. In particular, they were instructed to use the two strategies to link the two (concrete or abstract) words in each pair, so that when they were later presented with each stimulus, they would be able to use the sentence or image to retrieve the response. Next, participants were invited to adapt the trained strategies (i.e., interactive imagery and sentence generation) to the new tasks by answering four questions: 1) What are you requested to do in this task?; 2) Does the memory task involve a cue, and if so, what is it?; 3) What is the nature of the materials to which you need to add meaning?; 4) How can you adapt sentences and imagery to help you meaningfully process the to-be-learned materials? The first three questions concern the task analysis, the fourth one regards the adaptation of the two strategies. Identifying the cues available at the test help participants integrate these cues to the to-be-learned materials. Identifying the kind of material allows participants to decide how to organize the to-be-learned information and elaborate items in a meaningful manner in order to adapt the two strategies. The four questions have to be answered every time the older adults approach a new task.

During the first session, the trainer explained the two strategies, then participants practiced them using lists of 3 – 5 – 10 concrete-concrete pairs, which included study and recall. The second session began with a brief review of the mnemonic strategies and with the explanation of transfer instructions and strategy adaptation for abstract-concrete pairs. Next, participants practiced 15 abstract-concrete pairs. After the practice, a new task – name-face association – was introduced and the trainer asked participants to answer the adaptation questions, writing them down. Participants were involved in discussion about strategy adaptation. During the third lesson, older adults practiced two lists, consisting of 5 and 10 abstract-concrete pairs. After practicing the strategies with pair associates, participants were presented with a new task: grocery list learning. In the first part of the fourth lesson, participants practiced strategies with a list of 25 abstract-concrete pairs. The second part of the lesson was focused on a new task: text learning. Participants answered questions about strategy adaptation and then discussed them with the trainer.

In general, the training was based on discussions and corrective positive feedback in order to make older adults realize that they should use the strategies in a flexible way and thus adapt them to other memory-demanding tasks. After practicing strategies with word pairs, participants were involved in a discussion on how they used the strategies. In order to guide the discussion the following protocol was used: "You learned to use these strategies on paired associates. Do you think the strategies were useful? Please give me some examples on how you used the strategies. What sentence and/or image did you create to link two words? Do you think it is possible to use the strategies on other material?". The trainer supplied participants with correct information about the applicability of the strategies, further explanation about the latter, and positive feedback emphasizing correct responses.

To work on transfer instructions and strategy adaptation, for each task, the trainer, after reading the task instructions, provided participants with a sheet of paper with the four questions. Next, participants were invited to present their answers and to discuss them as a group. As feedback, the trainer presented the correct answers for the current task, providing correct information and explanations about the use of the strategies. As noted above, the trainer discussed abstract-concrete pairs and face-name association during the second lesson, grocery list learning during the third session, and text learning during the fourth session.

In detail, for abstract-concrete word pairs, the trainer explained that (1) the task requires one to associate two pairs of words and then, when the highlighted word appeared, retrieve the associated word (2) the task involves a cue (i.e., the first word of each pair); (3) the task includes verbal materials, consisting of concrete and abstract words. Abstract words require the attribution of a meaning (e.g., victory could be winning a favorite game); and (4) it is possible to create sentences or images to link the words in each pair together in a meaningful manner. For this task only, participants were then provided with practice with lists of word pairs. For the name-face association task the trainer explained that (1) the task requires the participant to associate a name to a face reported in a picture so that when the face will be presented again, the name will be retrieved; (2) the task involves a cue (i.e., the face); (3) the task includes verbal material, consisting of a name and visual material, consisting of a face. The name requires the attribution of a meaning and the face needs to individuate its relevant and stable features (e.g., blue eyes, long face, etcetera); and (4) it is possible to create sentences or images to link the name to one of the characteristics of the face.

For the grocery list task, the trainer explained that (1) the task requires the participant to remember as many grocery items (in any order) as they can; (2) because this task does not provide an external cue, they would need to create an internal cue. For instance, they could remember the number of associations created, and, for each association, they could create a key word or image to be used as a retrieval cue; (3) the material is verbal and concrete; (4) it is possible to create sentences and interactive images to link the grocery items together.

For text learning, the answers were: (1) the task requires one to memorize and recall as much information as possible; (2) the task does not provide external cues but it is possible to use the structure (i.e., introduction, characters description, event, etcetera) of the text as cues; (3) the text has a structure and is verbal; (4) to use the strategies it is necessary to individuate, for each part of the structure, a cue (e.g., an individual word or image) and then to create a new sentence (or image) to link the internal cues.

Results

Training gains

For each task, we computed the percentage of correct responses. To measure the training gains, we ran a repeated measure analysis on each task. We also computed effect sizes (Cohen's *d*) by dividing the difference between pre-training and post-training scores for a given task by the standard deviation of the pre-training scores for that task.

Results (see Table 2) revealed significant improvement in performance on the practiced task ($d = 0.9$), $F(1, 80) = 122.60$, $p < .001$, partial $\eta^2 = .60$, on the task with instructions ($d = 0.6$), $F(1, 80) = 36.84$, $p < .001$, partial $\eta^2 = .31$, and on the non-practiced task ($d = 0.8$), $F(1, 80) = 91.28$, $p < .001$, partial $\eta^2 = .53$, .

Table 2. Pre-training and Post-training Scores for the three memory tasks (expressed in percentage of correct responses).

	Strategy-adaptation memory training participants	
	Pre-training	Post-training
	M (*SEM*)	*M* (*SEM*)
Practiced task	33.83 (2.3)	53.1 (2.9)
Task with instructions	51.9 (2.6)	66.4 (3.1)
Non-practiced task	51.2 (2.3)	69.3 (2.9)

Note. M = mean; SEM = standard error of the means.

Correlations between pre-training and post-training performances and between training testing materials and predictors

Performance at baseline in practiced task, task with instruction, and non-practiced task were positively correlated to those at post-training: $r = .81$, $r = .66$, and, $r = .72$, respectively (all significantly different from zero, $p < .001$).

All variables taken into account as possible predictors of training gains were positively associated with performance in the trained tasks. Only processing speed did not correlate with the practiced task. Age was negatively associated with all predictors (see Table 3).

Table 3. Correlations between training testing materials and predictors

	Practiced task (at pre-training)	Practiced task (at post-training)	Task with instructions (at pre- training)	Task with instructions (at post-training)	Non-practiced task (at pre- training)	Non-practiced task (at post-training)
Age	-.30**	-.27*	-.40***	-.42***	-.41***	-.43***
Working memory	.22*	.23*	.31**	.33**	.30**	.43***
Processing speed	.12	.13	.17	.35**	.20	.36**
Verbal knowledge	.55***	.48***	.37**	.44***	.43***	.55***
Engagement in leisure activities	.35**	.31**	.26*	.30**	.38***	.43***

*p<.05; **p<.01; ***p<001

Predictors of training gains

Next, to investigate which variables predicted the training gains, we ran separate hierarchical multiple regression analyses for the practiced Associative Learning task, the Name-Face Learning task with adaptation instructions, and the non-practiced Weekly Activities task, using the post-training score from each task as the dependent variable (see Table 4). We have decided to regress post-training scores on pre-training scores instead of analyzing differences between post-training scores and pre-training scores (gain scores), because the latter approach ignores the fact that the reliability of the difference scores can be low and approaches zero as the stability of individual differences approaches the maximum level possible given the reliability of the tests (Ragosa, Brandt, & Zimowski, 1982). However, considering predictors of post-training score, covarying on pre-training score, is functionally equivalent to studying individual differences in training gains (Kessler & Greenberg, 1981). For the practiced task, we ran a regression model with four hierarchical stages. The first step entered the pre-training score on memory task at the first step as a control variable. At the second step, we entered age. At the third step we entered working memory. At the fourth step we included vocabulary and engagement in leisure activities. For the task with instructions and the non-practiced task, we entered pre-training scores at the first step as a control variable. At the second step, we entered age. At the third step we entered working memory and processing speed. At the fourth step we included vocabulary and engagement in leisure activities. At the fifth step we entered the gains in the practiced task. Significant increments to R^2, controlling on baseline performance, would indicate that individual differences in training gains were predicted by the set of gains, with unique influences captured by significant regression coefficients for each variable.

For the practiced task, baseline performance predicted post-training performance. No other covariate predicted post- training performance, with non-significant hierarchical increments to R^2 at the remaining steps.

Performance on the task with instructions (face-name association) was also predicted by baseline performance. In this instance, however, adding cognitive predictors to the model reliably increased R^2. Vocabulary and processing speed predicted individual differences in training, above and beyond baseline performance. Individuals with a higher vocabulary and faster processing speed improved more, relative to baseline. Furthermore, the significant increment to R^2 showed that training gains on the practiced task predicted incremental variance, indicating that individuals who benefitted more from training showed greater transfer to name-face learning. The effect of a self-reported active life style was positive but not statistically reliable.

Performance on non-practiced Weekly Activities task was also reliably predicted by baseline performance. Adding abilities to the model significantly increased R^2. Post-training performance was predicted by the working memory, processing speed, and vocabulary abilities, with higher ability predicting greater training performance, controlling on initial pre-training (baseline). Once again, the final step resulted in a significant increment to R^2. Individuals who showed the greatest training effects on the practiced task performed better on the post- training, controlling for the pre-training and other ability predictors. In this instance, engagement in leisure activities had a weak effect on the post-training score that approached but did not achieve statistical significance on the .05 Type I error criterion.

Table 4. Hierarchical Multiple Regression analysis investigating predictors of post-training performance

		Practiced task			Task with instructions			Non-practiced task		
	Predictors	B	SE B	β	B	SE B	β	B	SE B	β
Step1	Baseline performance	1.03	.08	.81***	.79	.10	.65***	.92	.09	.75***
Step 2	Baseline performance	1.02	.09	.80***	.69	.11	.57***	.85	.10	.67***
	Age	-.14	.31	-.03	-.89	.43	-.19*	-.62	.35	-.14†
Step 3	Baseline performance	1.02	.09	.79***	.65	.11	.54***	.78	.09	.64***
	Age	-.09	.32	-.02	-.44	.45	-.09	-.16	.35	-.04
	Working memory	.85	1.29	.05	2.39	1.66	.12	3.72	1.30	.21**
	Processing speed	-	-	-	.32	.14	.20*	.29	.11	.19*
Step 4	Baseline performance	.98	.11	.77***	.56	.11	.47***	.62	.10	.51***
	Age	-.11	.33	-.02	-.44	.44	-.12	-.35	.34	-.08
	Working memory	.70	1.36	.04	1.53	1.67	.08	2.80	1.25	.15*
	Processing speed	-	-	-	.26	.14	.17*	.23	.10	.15*
	Verbal knowledge	.20	.43	.04	.96	.48	.18*	1.13	.37	.22**
	Engagement in leisure activities	.01	.08	.01	.08	.09	.07	.11	.07	.10
Step 5	Baseline performance	-	-	-	.48	.11	.40***	.52	.09	.43***
	Age	-	-	-	-.63	.42	-.13	-.44	.31	-.10
	Working memory	-	-	-	1.39	1.59	.07	2.61	1.15	.14*
	Processing speed	-	-	-	.24	.13	.16*	.21	.10	.14*
	Verbal knowledge	-	-	-	.99	.46	.18*	1.19	.34	.23**
	Engagement in leisure activities	-	-	-	.08	.09	.08	.12	.07	.12†
	Practiced task benefit	-	-	-	.42	.14	.24**	.37	.10	.23**
		R^2 = .66*** for Step 1 ΔR^2 = .001 for Step 2 ΔR^2 = .002 for Step 3 ΔR^2 = .001 for Step 4			R^2 = .42*** for Step 1 ΔR^2 = .03* for Step 2 ΔR^2 = .05* for Step 3 ΔR^2 = .03† for Step 4 ΔR^2 = .05** for Step 5			R^2 = .57*** for Step 1 ΔR^2 = .02† for Step 2 ΔR^2 = .07** for Step 3 ΔR^2 = .05** for Step 4 ΔR^2 = .05*** for Step 5		

†*p*<.09, **p*<.05; ***p*<.01; ****p*<001

Discussion

This study represents a shift from the investigation of training gains, using a classical research approach, to the analysis of predictors of such gains, adopting an individual-differences perspective. Investigating individual differences in the memory training field may help researchers account for the mixed findings in training improvement and in transfer effects. Training interventions are different in terms of cognitive demands requested to foster performance changes. Hence, even if people are apparently exposed to similar programs (e.g., strategy-training interventions), participants' training responses depend on the variables underlying those trainings.

The aim of the present research was to investigate possible predictors of training gains that occurred after strategy-adaptation training (Bottiroli et al., 2013, 2017; Cavallini et al., 2010, 2015). Put differently, our aim was to describe the profile of participants who benefited more (vs. less) from this intervention. With regard to the standard analyses on the efficacy of the strategy-adaptation intervention, we found significant training gains in both practiced and non-practiced tasks. These results are in line with our previous studies (Bottiroli et al., 2013, 2017; Cavallini et al., 2010, 2015). Here, we would like to highlight the present study did not include a comparison group, such as a waiting-list control group or a group who was trained to use strategies but not on how to adapt them (as in Bottiroli, 2013, see the Introduction for details). This is a limitation in that we cannot establish that strategy adaptation training in the current study would produce larger gains as compared to some other form (or to no) training. Nevertheless, the size of training gains (expressed also in terms of effect sizes) found in the current study are similar to those reported in previous studies adopting the same approach (e.g., Bottiroli et al. 2015, 2017; Cavallini et al., 2015). Specifically, in Cavallini and colleagues' study (2015) an active control group was involved in general cognitive stimulation activities, some of them including the elaboration of verbal materials, such as newspaper reading, crossword puzzles, and text writing. Interestingly, the active control group reported improvements similar to those obtained by the strategy-adaptation memory training in the text learning task. Nevertheless, the active control group participants did not increase in any other tasks. This appears to suggest that the mere practice produces improvements only in target tasks and is not responsible for transfer effects. With this in mind, however, we acknowledge that exploring individual differences (as was the main aim in the present research) would be informative using a design that involves a training group as well as some kind of control group. Doing so in future research would allow one to further replicate the differential gains for the training (over control) group and to evaluate whether any gains demonstrated by the groups are explained by the same (or different) set of predictor variables.

The most important results of the present study regard the relationship between possible predictors of training gains. We found that performance on the training task at pre-training was positively related to working memory and verbal knowledge. These results are in line with studies reporting a relationship between episodic memory and other cognitive resources, such as working memory and verbal knowledge (Hultsch, Hertzog, Dixon, & Small, 1998; Sandberg et al., 2016; Verhaeghen & Marcoen, 1996). However, we did not find any relation between episodic memory and processing speed. The lack of such an association was not surprising given ample time given to participants to study materials in the episodic memory tasks. However, we found correlations between processing speed and post-training performance, showing that the best use and adaptation of strategies require a higher speed of processing. In addition, we found negative relationships with age, confirming a decline in episodic memory across years (Park et al., 2002).

It is interesting to note the association between engagement in leisure activities and baseline performance in episodic memory. This result provides new evidence that carrying out stimulating activities can have advantages for cognitive functioning (e.g., Hertzog et al., 2008; Ortiz & Fernandez, 2018).

For predictors of training gains, it is noteworthy that we found a different pattern of results for practiced and non-practiced tasks. For the practiced task, we found that baseline performance predicted the training benefit. People who started with a higher performance tended to benefit more from the practice of the strategies. These results are consistent with those reported in previous studies on strategy-training intervention (Sandberg et al., 2016; Rosi et al., 2018). For the task receiving just instructions on how to adapt and use the strategies, older adults reporting a higher baseline performance, processing speed, and verbal knowledge demonstrated more improvement than those with lower performances. This suggests that although thinking about the relevance of task characteristics as a result of a few questions about task analysis creates transfer effects, it is a process more cognitively demanding than that involved in the practice of strategies. Interestingly, we also found that the magnitude of training gain on the associative memory practiced task predicted the post-training performance in the task with transfer instructions. The same result was found in the untrained task, participants who benefited most from practicing strategies were also those obtaining better post-training performance. For the untrained task, it is interesting to note that, above and beyond baseline performance, cognitive variables, such as working memory, processing speed, and verbal knowledge, emerged as predictors of gains. This result is new and shows that generalizing strategies requires the involvement of higher cognitive resources. For instance, a high processing speed appears to facilitate the use of strategies to encode and retrieve the to-be learned material. Furthermore, the engagement in leisure activities was a predictor of transfer gain, even if only marginally. People who are more active tend to be more flexible in adapting strategies to new tasks. This may be due to the fact that engagement in leisure activities are related to cognitive functioning (i.e. Hertzog et al., 2008; Jopp & Hertzog, 2007).

Given the positive association between the set of cognitive variables and post-training performances, our results fit with the amplification model (Verhaeghen & Marcoen, 1996), indeed, initial differences in baseline performance were amplified after the training. Who started with higher level of performance tented to reach higher lever after training.

As noted above, however, without a control group, we cannot determine how much that simple practice on the task is responsible for some of the performance gains and, in turn, individual differences in those gains (e.g., Ferrer et al., 2008). Future research would benefit from direct comparison of predictors of pretraining-posttraining improvements in both control and training groups. The limited evidence available at present suggests that predictors like age, education, and gender do not affect individual differences in practice effects within the control group, but have some relationships to training gains and transfer (e.g, McArdle & Prindle, 2008). Whether this pattern also holds for cognitive predictors like working memory or fluid intelligence remains an open question.

In general, then, our results show that strategy-adaptation training relies on higher cognitive resources than the application of the strategies. In our training, the transfer seems to be due to practice and abstraction. Indeed, the strategy are learned and practiced until they become automated. Practicing the strategies makes them increasingly flexible (Shiffrin & Schneider, 1977) and adaptable to new materials. However, the generalization of the strategies to new materials also involves a mindful and deep processing of information and the abstraction or decontextualization of cognitions about the strategies (Perkins & Salomon, 1989). As Salomon and Perkins (1989) reported, a mindful abstraction occurs when participants are able to abstract a learned principle and apply it to a range of new tasks and situations. Giving information on how to apply strategies should encourage an abstraction that provides a bridge to apply a strategy from one material to another. Further research would be needed to understand the role of these two processes and their relationships with cognitive variables.

Another avenue for future research would be to evaluate whether training gains vary as a function of the type and the intensity of interventions. In a recent paper on working memory training with adults, Küpera and Karbach (2014) reported that a short-term, single n-back training was more effective in promoting improvement than a more complex dual n-back training. It may be that older adults with lower cognitive resources benefit more from simpler training or training based on the practice of strategies with a variety of materials. A similar conclusion could be arrived at a study in which the strategy-adaptation training was adapted to the cognitive level of older adults living in residential care (Cavallini et al., 2015). We found training and transfer effects showing that a simpler version (less items to be learned) of the training in relation to the original one can produce gains on memory performance. Hence, future research should focus on a direct investigation of the efficacy of interventions, while varying in terms of different versions of the same training suggested according to the dissimilar grade of older adults' cognitive resources. This may allow researchers/trainers to adapt training interventions to populations with specific needs, such as individuals in the old-old age or in a clinical setting. It is conceivable that varying the manipulations of the training could produce the same improvement in participants with different cognitive resources. In addition, given that Fandakova et al. (2012) found that while low-performing older adults benefited from strategy instruction, only the high-performing older adults were able to benefit further from additional practice sessions, it would be interesting to evaluate the effect of practice in maximizing training and transfer effects.

Some limitations of our study should be acknowledged. First, we considered only adults from the age of 55 and above. It would be interesting to include other age groups to more thoroughly investigate the role of age on training effects. Second, this study did not have a follow-up phase; an important question for future research is, therefore, which among the cognitive variables best predict the maintenance of the training and transfer effects. For instance, Sandberg and colleagues (2016) found that although the magnitude of gains in recall from pre- to post-training assessments were predicted by baseline episodic memory, processing speed, and verbal knowledge, the latter variable was the only significant predictor of maintenance effects after eight months. Third, we included only one test for each variable, future research should take into account composite scores deriving by several measures of the same construct. Fourth, to be sure that a change in strategies use occurs after the intervention, future research should include a strategy report to administer at the pre-and post-training phases. And, as discussed above, including a matched control group would allow one to estimate the gains arising from the training intervention as well as to evaluate whether the same (or different) cognitive variables predict performance both in the trained and control groups.

In conclusion, our results support the view that some individuals benefit more than do others, despite being exposed to the same intervention and materials. Hence, our study sheds light on the interplay between the design of training programs and their implementation and reveals that older adults with stronger cognitive resources will benefit more from interventions focused on the generalization by active and mindful processes. Moreover, the present study helps us to better understand the abilities underlying the use and the adaptation of strategies.

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Appendix

Peer-reviewed studies on strategic training program developed by Cavallini and colleagues

Study	Sample	Effects on practiced tasks	Transfer effects to Tasks receiving instructions	Transfer effects to non-practiced tasks	Modality
Cavallini et al., 2010	N=62, age range 60-80 (M=68.3)	Associative learning-Yes List learning-Yes	Text learning-Yes Name-face learning-Yes	Grocery list learning-Yes Place learning-No	Classroom setting
Bottiroli et al., 2013	Exp. 1: N=107, age range 57-82 (M=66.6)	Associative learning-Yes List learning-Yes	Text learning-Yes Place learning-Yes	Grocery list learning-Yes Name-face learning-Yes	Classroom setting
	Exp. 2: N=62, age range 60-75 (M=66.0)	Associative learning-Yes	Name-face learning-Yes Place learning-Yes Grocery list learning-Yes	Planned activities learning-Yes Text learning-No	Self-guided training
Cavallini et al., 2015	N=32, age range 70-92 (M=85.1)	Associative learning-Yes Object list learning-Yes	Name-face learning-Yes Grocery list learning-Yes	Figure-word learning-Yes List learning-Yes Text learning-Yes Everyday problem test-Yes General and personal memory beliefs-Yes	Self-guided training
Bottiroli et al., 2017	N=61, age range 60-78 (M=66.5)	Associative learning-Yes	Name-face learning-Yes Everyday inductive reasoning-Yes	Everyday working memory-Yes	Self-guided training