Research Article

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Metacognitive-strategy training promotes decision-making ability in older adults

Abstract: Research on decision making and aging has shown that some decision-making skills decrease with age. Despite these age-related declines, no study has yet investigated the possibility of promoting improvements in decision-making skills in older adults. The present study was designed to address this gap in literature by examining the efficacy of a metacognitive-strategy decision-making training on practiced and non-practiced tasks. The training was based on the use of specific metacognitive principles and analytical strategies for promoting an analytical mode of thinking in the decision-making process. We examined 66 older adults (M_{age} = 67.52 years, *SD* = 5.38; age range 60-81) assigned to two training groups: a metacognitive-strategy decision-making training group and an active control group involved in a strategic memory intervention. Both training groups attended four 2-hour training sessions conducted once a week. Results showed that, after intervention, the decision-making training group improved their decision-making skills significantly more than the active control training group. Crucially, the positive effect of the training was evident in both practiced and non-practiced decision-making tasks. This is the first study investigating the efficacy of a decision-making training in older adults based on metacognitive and strategic principles.

Keywords: aging, metacognitive principles, decision-making training, generalization

Introduction

Decision making is a fundamental skill we use throughout our lifetime in order to make choices and maintain independent living (Mather, 2006). In recent years, there has been a growing interest in age-related changes in the decision-making ability associated with healthy aging. Most of this research has found that some decision-making skills decrease with age (Brand & Markowitsch, 2010; Bruine de Bruin, Parker, & Fischhoff, 2012; Denburg, Tranel, & Bechara, 2005; Queen & Hess, 2010), threatening older adults' decision outcomes and their independence in making everyday decisions. These studies revealed a decline in those decision-making tasks requiring cognitive abilities that decrease with aging, such as fluid abilities (Brand & Markowitsch, 2010; Bruine de Bruin et al., 2012; Henninger, Madden, & Huttel, 2010). For instance, older adults have more difficulty in correctly applying decision rules when they have to choose among alternatives than younger adults (Bruine de Bruin, Parker, & Fischhoff, 2007). This predicament in

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choosing the correct rule is explained by the age-related decline in reasoning (Bruine de Bruin et al., 2012), working memory, and verbal fluency (Del Missier et al., 2013; 2017; Rosi et al., 2017). Additionally, previous studies have found that older adults tend to use less analytical strategies and have difficulties in applying them in the correct way (Lemaire, Arnaud, & Lecacheur, 2004; Mata, Schooler & Rieskamp, 2007; Mata, von Helversen, & Rieskamp, 2009; for a meta-analysis see Mata & Nunes, 2010).

The age-related decline of these decision-making skills has also been explained taking into consideration the dual-process theory (Epstein, 1994; Evans, 2008; Kahneman, 2003; Stanovich & West, 2000) that posits the existence of *experiential* versus *analytical* modes of thought which underlie decisions. Decisions based on experiential modes of thinking (also referred to as affective system or System 1) are effortless, automatic, fast, and based on intuition and specific experiences. On the other hand, decisions based on analytical modes of thinking (also referred to as deliberative system or System 2) are slower, effortful and are based on reasoning and the analysis of information. There is a general consensus that older adults perform worse on decision-making tasks which require analytical processing (Queen & Hess, 2010; Strough, Mehta, McFall, & Schuller, 2008). They frequently rely on experiential-based thought in making decisions that often lead them to make mistakes (Peters & Bruine de Bruin, 2012; Peters, Diefenbach, Hess, & Västfjäll, 2008; Peters, Hess, Västfjäll, & Auman, 2007; Queen & Hess, 2010). Indeed, individuals who tend to make decisions based on the experiential mode are more susceptible to biases and heuristics compared with individuals using the analytical mode of thought (Besedeš, Deck, Sarangi, & Shor, 2012; Epstein, Pacini, Denes-Raj, & Heier, 1996; Klaczynski, Gordon, & Fauth, 1997).

To summarize, older adults' decision outcome is threated by: (a) the age-related difficulty in the correct application of decision strategies, and (b) the detrimental use of experiential processes in making a decision.

The age-related decline in the decision-making process, and its implication in the daily life of older adults, suggests a requirement for the development of new interventions which promote an improvement in decision-making skills. Although this is one of several cognitive functions which demonstrate a decline in aging, previous studies have demonstrated considerable plasticity in older adults' cognition (e.g., Greenwood, 2007) that can be enhanced through cognitive and/or metacognitive interventions providing training for specific skills, such as memory (e.g., Bottiroli, Cavallini, Dunlosky, Vecchi, & Hertzog, 2017; Cavallini, Dunlosky, Bottiroli, Hertzog, & Vecchi, 2010; Rosi et al., 2017), reasoning (e.g., Anand et al., 2011), as well as more complex abilities such as Theory of Mind (e.g., Cavallini et al., 2015; Lecce, Bottiroli, Bianco, Rosi, & Cavallini, 2015; Rosi, Cavallini, Bottiroli, Bianco, & Lecce, 2016). For example, previous studies have demonstrated the benefits of strategic training programs designed to enhance memory through the acquisition of useful strategies which help to encode and retrieve information (e.g., Cavallini et al., 2003a; Cavallini et al., 2003b; Rosi et al., 2017). In healthy older adults, these interventions are effective in improving memory skills in tasks repeatedly practiced during the training (i.e., practiced tasks; for a review see Rebok, Carlson, & Langbaum, 2007). This evidence led us to expect that decision-making skills can also be treated in aging. So far, intervention studies on decision-making skills have typically been conducted on adolescents, adults, or professional workers (e.g., Batha & Carrol, 2007; Donovan, Güss, & Naslund, 2015; Knight, Danserau, Becan, Rowan, & Flynn, 2015; Mecca et al., 2016; Morewedge et al., 2015; Nota & Soresi, 2004). Different kinds of approaches used to train decision-making skills have been applied. Morewedge and colleagues (2015) found that a debiasing training intervention in younger adults, focused on teaching participants to recognize biases (e.g., anchoring effect), their influence on judgment, and strategies to diminish adverse effects, was effective in reducing bias and improving decision making. Batha and Carrol (2007) evaluated the efficacy of a training based on a "metacognitive strategy instruction" (defined by Palingsar, 1990) in improving decision-making performance in younger adults. The "metacognitive strategy instruction" training consisted of explaining to participants how to implement a four-step procedure (i.e., translation, integration, solution planning, and solution execution) in order to monitor and plan the correct use of strategies in a decision-making task. They reported that the experimental group which used the metacognitive strategy instruction improved their decision-making performance to a greater extent compared to a control group. These results suggest that awareness, monitoring, and regulation of strategies lead individuals to have more efficiency in the decision-making process. Finally, Knight and colleagues (2015) examined the effectiveness of a theoretically-based judgment and decision making intervention

in adolescents based on the Integrated Judgment Decision-Making Model (IJDM; Danserau, Knight, & Flynn, 2013). This model postulates the existence of a metacognitive system that has a general role in monitoring and controlling information produced by the intersection of the experiential and analytical modes of thought (i.e., wisdom/expertise system; Dansereau et al., 2013). Implementing this model in the training, the authors found that adolescents in the experimental group improved more in the decision-making process compared to the control group, particularly in the area of self-awareness, thanks to the use of metacognitive strategies and the recognition of negative decisions. These findings suggest that the effort to learn metacognitive principles and analytical strategies, and practice them, can help individuals make better decisions. However, as of yet no study has investigated whether it is possible to improve older adults' decision-making abilities.

In the present study, we developed a new training in order to promote improvements in older adults' performance in decision-making tasks. Whilst designing this study, we focused on one of the main issues of cognitive intervention for older adults: the generalization. Indeed, older adults show difficulties in transfer skills or knowledge learnt during the training on new materials (Rebok et al., 2007). We created a training based on an approach previously used to maximize the generalization of memory strategies in aging: the learner-oriented approach (Bottiroli, Cavallini, Dunlosky, Vecchi, & Hertzog, 2013). The core method of this approach is to treat participants as active partners in attempting to achieve the generalization of their behavior. In addition, we based our new decision-making training on the intervention approach as suggested by the Integrated Judgment and Decision-Making Model (IJDM; Dansereau et al., 2013). This latter approach improves the decision-making ability by using specific metacognitive principles and analytical strategies for promoting a systematic and analytical mode of thinking. For instance, the authors suggest presenting participants with different hypothetical decision problems and teaching them to use analytically created structures (such as guide maps or checklists) to monitor and control their decision-making process through a series of questions that should be automatically activated in new situations.

In our training, older adults were involved in a transfer process by taking part in discussions on when and how to use strategies. During the training, participants practiced a decision-making task (the Everyday Decision Making Competence task) consisting of hypothetical real-life decision problems in which characters have to make a decision in daily, economic, and health care scenarios. In addition, participants were asked to think about their day-to-day life and to provide examples of decision-making situations therein. This helped them to realize that they could use newly acquired skills to perform everyday decision-making tasks. Crucially, our training was based on the active involvement of participants in the transfer process via the discussion of several questions (see Table 1) which triggered analytical decision task analysis, and when and how to apply decision strategies. These metacognitive-strategic questions helped participants to improve their metacognitive awareness and strategic behavior when dealing with a decision problem by identifying and analyzing information, exploring potential alternatives, considering different perspectives and outcomes, and thinking about the best strategy to apply in a specific situation. Hence, the main purpose of the present training was to teach older adults successful strategies for moving from an experiential mode of thought toward analytic thinking, relying on replacing intuition with analytic processes (Milkman, Chung, & Bazerman, 2008). To evaluate this issue, we used a decision-making task (i.e., the Everyday Decision Making Competence task) that examines the experiential and analytical mode of thought, being composed of both experiential and analytical-based problems. Moreover, given that experiential (System 1) and analytical mode of thought (System 2) play an important role in the majority of daily behaviors (Chen & Sun, 2003; Handley & Trippas, 2015; Hess, 2015; Johnson, 1990), the decision-making task used was structured in order to assess the ability to make decisions in some ecological contexts such as daily, economic, and health care.

In order to assess the specificity of our intervention, we compared the effects of the metacognitive-strategy decision-making training with those of an active control training. The active control training group received a strategic memory training (adapted from Cavallini et al., 2010) in which participants were involved in the practice of two strategies (sentence generation and interactive imagery creation) in order to elaborate memory information. In addition, participants received instructions (without practice) on how to apply strategies to other materials. This choice thereby gave us the possibility to investigate the specific

contribution of metacognitive principles and analytical strategies on the improvement of decision-making ability. In the present study, we were interested in evaluating improvements in decision-making abilities by using a target task that was practiced during the intervention (the Everyday Decision Making Competence task), and a non-practiced task (the Applying Decision Rules task; Bruine de Bruin et al., 2007) aimed to measure the generalization of participants' behavior to new material.

Given the success of the learner-oriented approach in improving older adults' memory performance (Bottiroli et al., 2013) and the efficacy of the activities suggested by the Integrated Judgment Decision-Making Model (Danserau et al., 2013; Knight et al., 2015) with adolescents, we expected that metacognitive-strategy decision-making training would be effective in promoting improvements in performance in both practiced (Everyday Decision Making Competence task) and untrained tasks (Applying Decision Rules task). In particular, for the practiced task, we expected that the metacognitive-strategy decision-making training would be effective in improving performance in daily, economic and health care scenario of both experiential and analytical-based problems.

Table 1. Metacognitive-strategic questions.

1. Did I understand the decision problem I have to face? *(If not, I review or reevaluate the decision problem until I fully understand the situation)*
2. What is the main information of the decision problem?
3. Do I have all the information necessary to make a decision? *(If not, what additional information do I need to make a decision?)*
4. Who will be affected by my decision?
5. Who can help me with this decision?
6. What are the possible choices for this decision problem? (*describe each choice*) For each choice, how will I feel 10 minutes after I make this choice?
7. Which strategies can I apply in order to decide?
8. What is the final decision?

Method

Participants

Participants were 66 older adults recruited through the local branch of the University of Third Age located in northern Italy. Participants were randomly assigned to one of the two groups: the decision-making training group ($n = 36$; age range 60 – 79; $n = 33$ female) or the active control training group ($n = 30$; age range 60 – 81; $n = 26$ female). Prior to testing, participants filled out a demographic questionnaire in order to exclude older adults with a diagnosis of dementia, a history of psychiatric or neurological disorders and/or substance abuse that may have compromised cognition. None of the participants was excluded on the basis of the aforementioned criteria. A vocabulary test (drawn by Primary Mental Abilities test; Thurstone & Thurstone, 1963) was included in the study as a control variable of crystallized intelligence. Participants of the active control training group were significantly older than participants in the decision-making training group, $F(1, 64) = 11.80$, $p = .001$, $\eta p2 = .16$. There were no significant differences regarding years of education, $F(1, 64) = 0.01$, $p = .915$, $\eta p2 = .01$, and vocabulary scores, $F(1, 64) = 1.54$, $p = .219$, $\eta p2 = .02$. Descriptive statistics on age, years of education, and vocabulary scores are reported in Table 2.

Table 2. Means value (deviation standard) of demographic characteristics as a function of group.

	Decision-making training group	Active control training group
	(*n* = 36)	(*n* = 30)
Age	65.25 (4.89)	69.80 (5.87)
Years of education	11.81 (3.29)	11.70 (4.67)
Vocabulary	46.17 (3.12)	45.70 (3.38)

Note: Maximum vocabulary score = 50; Scores in parentheses refer to Standard Deviation.

Measures

Practiced task

Everyday Decision-Making Competence (EDMC) task. To assess the decision-making ability of the participants with regard to daily life, we developed a new task specifically for this study. The task was developed on the basis of the inductive reasoning problems taken from Kokis, Macpherson, Toplak, West and Stanovich (2002) and Fong, Krantz and Nisbett (1986) studies. At both pre-test and post-test, participants were given 12 hypothetical real-life decision problems in which characters have to make a decision in daily (four problems; e.g., decide in which supermarket it is more convenient to buy grocery items), economic (four problems; e.g., decide which insurance policy to purchase for a car) and health care (four problems; e.g., decide which therapy is best to treat hypothyroidism) contexts.

Six of the problems required participants to use effortful analytical strategies based on mathematical calculations in order to make advantageous decisions (*analytical-based problems*). Participants have to think analytically and rely on effortful abilities using System 2 (Kahneman, 2003; Stanovich & West, 2000) to succeed in the solution of the problems. For example, (see Appendix A) Sarah started a new job and will have to use the intercity bus from Monday to Friday for all month. She has to decide whether to buy the weekly bus pass at the cost of 21 euro (option a and b) or the monthly bus pass at the cost of 77 euro (option c and d). To solve the problem, participants have to apply only analytical reasoning and mathematical calculation in order to identify the most advantageous choice. Given that there are at least 4 weeks in a month, the choice to buy the monthly bus pass is most advantageous (77 euro) compared to buying the weekly bus pass (21 euro x 4 = 84 euro). Each response was rated using a four-point scale (from 1 to 4), where the choice of option (c) or (d) (scored 3 and 4, respectively) indicated the advantageous decisions, while the choice of option (a) or (b) (scored 1 and 2, respectively) indicated the disadvantageous decisions. The other data reported in the problem, such as the cost of single journey ticket (3.85 euro) and of the one-day ticket (6.90 euro), were irrelevant information.

Conversely, the remaining other six problems (*experiential-based problems)* reported decisions consisting of two options based on conflicted sources of information: one source of information was base-rate evidence and the other one was based on a single case or personal experience. For example, (see Appendix A) Simon wants to give his friend a pack of golf balls. He has to decide whether to buy the "Star balls" recommended by a number of golf experts from a specialized magazine (option c and d) or to buy the "Mega balls" recommended by a couple of golfers in the sport shop (option a and b). Selection of "Star balls" indicates that participants are employing aggregate base-rate information in making decision, while the selection of "Mega balls" indicates that participants are using the experiential information coming from a single case experience of lower reliability. Each response was rated using a four-point scale (from 1 to 4), with lower scores reflecting more experiential responses (i.e., 1 and 2), and higher scores indicating more rational and analytic responses (i.e., 3 and 4). The other data reported in the problem, such as the "Star balls" are in a pack of six and cost 18 euro (hence 18 euro/6 = 3 euro each ball) and that the "Mega

balls" are in a pack of six or in a pack of twelve at a cost of 36 euro (hence 36 euro/12 = 3 euro each ball), reported exactly the same prices and were irrelevant information. Participants who are more prone and able to employ the base-rate information are more likely to override the intuitive and experiential response, activating System 2 (analytical processing; Handley & Trippas, 2015; Kahneman, 2003). People who tend to underweight base-rate evidences in favor of experiential information (base-rate neglect; Kahneman & Tversky, 1973) are more likely to activate System 1 (intuitive processing).

Hence, the difference between the two types of decision problems is that in the analytical-based problems participants have to use the System 2 in order to make the best decision. In the experiential-based problems participants can use heuristic/experiential responses, activating the System 1, or avoid these thinking biases and engage in cognitive effort opting for the base-rate information, System 2. For all decision problems, participants were required to read the story and answer the test questions. Participants were allowed to consult the text until a response was given so as to avoid memory loads. For the purpose of this study, we created two different kinds of scores: (a) one based on the scores of experiential-based problems and analytical-based problems, and (b) the other based on the three different total scores corresponding to the three different scenarios (daily, economic, and healthcare). To reduce the learning effect, at post-test we administered a parallel version of this task which was similar in length and complexity to the pre-test. We created similar parallel versions of the task by analyzing the scores collected from a previous study (Rosi, Cavallini & Russo, 2015), in order to ensure that the complexity of the pre- and post-test was the same. Examples of decision-making problems with scoring criteria are given in Appendix A.

Non-practiced task

Applying Decision Rules (ADR) task. At pre- and post-test, the Applying Decision Rules task (drawn by the Adult Decision Making Competence battery; Bruine de Bruin et al., 2007; Italian version by Del Missier, Mäntylä, & Bruine de Bruin, 2010) was administered to assess the ability to apply decision rules. The task has been validated in terms of psychometric properties and relationships with real-world decision outcomes (Bruine de Bruin et al., 2007). Participants were presented with 10 decision problems where different hypothetical consumers wanted to buy an electronic product. To reduce the learning effect, we created two parallel versions of this task for the pre-test and post-test, changing superficial aspects of the problems, such as the names of characters and the kind of electronic products (computers at the pre-test and televisions at the post-test) involved. Each decision problem involved five computers (or televisions) that differed in terms of the following features: picture quality, sound quality, programming options and the reliability of the brand. Participants were asked to select one or more computers (or televisions), by implementing the decision rule specified for each consumer. Participants had to correctly apply decision rules (e.g., equal weights, elimination by aspects, satisficing, and lexicographic rules) in order to succeed in the task. Performance was measured by the number of problems answered correctly. Therefore, possible scores ranged from 0 to 10.

Procedure

All participants took part in two 2-hour testing sessions and in four 2-hour training sessions (see Table 3) in the following order: pre-test, training sessions, and post-test. All testing and training sessions were conducted by two female trainers in classes made up of 15 participants. Each session was conducted in successive weeks, with one training session per week.

At pre-test, all participants completed the demographic questionnaire, the vocabulary test, the Applying Decision Rules task, and the Everyday Decision-Making Competence task. At post-test, all participants were tested on the parallel versions of the tasks used. With the exception of the vocabulary test, no task had a time limit, thus the experimenter waited until all participants had concluded a task before giving them the next one. The content of the decision-making training and of the activities carried out in the active control training group are detailed below and in Table 3.

Table 3. Description of training sessions by group

Session	Decision-making training group	Active control training group
Pre-test	Demographic questionnaire, vocabulary test, Applying Decision Rules task, Everyday Decision Making Competence task.	
Session 1	a) Introduction to the main content of the training b) Explanation of the *metacognitive-strategic questions* to use during the training to analyze decision problems c) Explanation of how to answer the *metacognitive-strategic questions* for a decision problem d) *Metacognitive-strategic questions* practice on two simple decision problems (based on analytic and experiential mode of thought)	a) Introduction to the main content of the training b) Explanation of the two memory strategies (sentence creation and interactive imagery) to use during the training c) Explanation of the application of the strategies on paired associated words d) Strategies practice on 3 paired associated words
Session 2	a) Brief summary of the previous explanations on the *Metacognitive-strategic questions* b) *Metacognitive-strategic questions* practice on two daily decision problems (based on analytic and experiential mode of thought) c) *Metacognitive-strategic questions* practice on a decision problem with emotional and social pressure.	a) Brief summary of the previous explanations on the two memory strategies b) Practice session with 5, 15 and 25 paired associated words c) Explanation of the application of the strategies on a list of words d) Practice session with 5 lists of words
Session 3	a) Brief summary of the previous explanations on the *Metacognitive-strategic questions* b) Explanation of the *decision strategies*: equal weight, elimination-by-aspects, satisficing, and lexicographic c) Decision strategies application on four short decision problems followed by a question about which strategies were appropriate to use in each specific decision situation d) *Metacognitive-strategic questions practice* on two economic decision problems (based on analytic and experiential mode of thought)	a) Brief summary of the previous explanations on the two memory strategies b) Practice session with 25 lists of words c) Explanation of the application of the strategies on name-face learning d) Practice session with 12 and 20 name-face associations e) Explanation of the application of the strategies on grocery list learning
Session 4	a) Brief summary of the previous explanations on the *Metacognitive-strategic questions* and on the decision strategies b) Decision strategies application on three short decision problems followed by a question about which strategies were appropriate to use in each specific decision situation c) *Metacognitive-strategic questions practice* on two healthcare decision problems (based on analytic and experiential mode of thought)	a) Brief summary of the previous explanations on the two memory strategies b) Practice session with 40 paired associated words c) Explanation of the application of the strategies on place learning d) Practice session with 40 lists of words e) Explanation of the application of the strategies on text learning
Post-test	Applying Decision Rules task, Everyday Decision Making Competence task.	

Metacognitive-strategy decision-making training

As previously anticipated, the framework of the decision-making training was developed by combining the intervention approach suggested by the Integrated Judgment and Decision-Making Model (Danserau et al., 2013) and by the learner-oriented approach developed by Bottiroli and colleagues (2013). All activities carried out in the training aimed to promote judgment and decision-making skills through the use of specific metacognitive principles and analytical strategies.

In the first training session, the trainer presented the aims of the decision-making training and participants were introduced to the decision-making process, focusing on different kinds of choices in real life, stressing the existence of an analytic and experiential mode of thought in such decision-making situations. Participants were also introduced to the *metacognitive-strategic questions* consisting of eight questions which had to be answered every time they approached a new decision problem (for the specific questions, see Table 1). The strategic-metacognitive questions serve to guide thinking and help participants internalize the key elements of a systematic decision-making process, focusing their attention on the importance of (a) analyzing the decision problem, (b) considering taking a multiple-perspective approach to the decision, (c) exploring the potential options and outcomes of making the decision, and (d) choosing and applying the correct decision strategy. The metacognitive-strategic questions were explained to participants through two simple decision-making problems: one based on analytical processing and one based on experiential processing.

From the second training session to the last one, the trainer presented decision-making problems similar to those of the Everyday Decision-Making Competence task (practiced task). For each problem, participants were asked to analyze the decision-making situation by answering the metacognitive-strategic questions. The trainer asked participants to write down their answers individually and then encouraged them to take part in a group conversation. Notably, the decision-making problems' scenario presented in the training sessions concerned situations in daily, economic and health care contexts, relying on and eliciting both analytical and experiential modes of thought.

Moreover, in the third and fourth training sessions, the trainer explained four different decision-making strategies consisting of: equal weight, elimination-by-aspects, satisficing, and lexicographic strategies (for a detailed description see Payne, Bettman, & Johnson, 1993). The 'equal weight' strategy involves choosing the option that has the highest overall perceived quality across alternatives. The 'elimination by aspects' strategy involves selecting the options that meet a minimum criterion set for the most important attribute, and selecting from those the alternative that meets a minimum criterion on the second most important attribute, and so on until only one option is left. The 'satisficing' strategy considers alternatives one at a time in the order they occur, and choosing the first option that has values that meet the predefined cutoffs. Finally, the 'lexicographic' strategy identifies the most important attribute and examines the value of all alternatives for that attribute, selecting the option with the best value on the most important attribute. Participants were provided with short decision-making problems in which they had to reflect on which strategy was the most appropriate to use in that specific decision-making situation. Participants then wrote down their answers individually, and were involved in a discussion with the trainer about the correct applicability of the strategies. Critically, during all sessions, participants were asked to think about decision-making situations in their day-to-day life and to reflect on how to implement the metacognitive-strategic questions in that situation. This led them to realize that they could not only generalize newly acquired skills but also apply them to their everyday decision-making tasks.

Active control training group

Participants in the active control training group took part in a strategic memory training for the same amount of time as the decision-making training group. The training program was adapted from Cavallini and colleagues (2010) and was based on teaching the use of two memory strategies. In the first training session, the trainer presented the aims of the strategic memory training and participants were introduced to the two memory strategies (sentence generation and interactive imagery; for a description of strategies see Cavallini et al., 2010). Training comprised of practicing the two memory strategies on a gradually increasing number of items across the four sessions on different kind of memory tasks, such as paired associated words, single words, and name-face learning. Moreover, during the third and fourth training sessions, participants received explanations on how to apply the two memory strategies to other memory tasks, i.e., grocery list learning, place learning, and text learning. Detailed information about training sessions are reported in Table 3. Of interest, we also evaluated the efficacy of the memory training on a memory task (i.e., paired

associated words task), and found that participants significantly increased their memory performance from pre-test to post-test, $F(1, 29) = 45.16$, $p < .001$ (Pre-test: $M = 4.95$; $DS = 4.04$; Post-test: $M = 10.62$; $DS = 5.91$).

Analytic strategy

For each decision-making task, we computed the percentage of correct responses at both pre-test and post-test (Table 4). To evaluate the effect of the training, a repeated-measures analysis of variance (ANOVA) was conducted on practiced (i.e., overall scores of experiential-based and analytical-based problems of the EDMC task; scores of daily, economic, and health care scenario of the EDMC task) and non-practiced decision-making tasks (i.e., ADR task), with time (pre-test vs. post-test) as the within-subjects factor and training groups (Decision-making training group vs. Control active training group) as the between-subjects factor. To test interactions, post hoc pairwise comparisons were performed with Bonferroni's correction for multiple comparison at p < .05.

Table 4. Mean and (standard error of the mean) of performance (expressed in percentage of correct responses) for practiced and non-practiced decision-making tasks as a function of group (decision-making training and active control training groups), and time (pre- and post-test).

	Decision-making training group		Active control training group	
	Pre-test	Post-test	Pre-test	Post-test
Practiced tasks				
EDMC task experiential-based problem	54.52	77.44	51.94	59.03
	(1.98)	(1.57)	(2.24)	(2.25)
EDMC task analytical-based problem	74.77	79.80	75.97	68.61
	(10.01)	(8.07)	(2.01)	(2.32)
EDMC task - daily	63.55	76.05	62.30	58.96
	(1.72)	(1.72)	(2.18)	(2.34)
EDMC task - economic	60.94	80.56	59.17	66.87
	(2.28)	(2.28)	(2.10)	(3.03)
EDMC task - health care	69.44	79.00	70.42	65.62
	(2.38)	(2.16)	(2.66)	(2.64)
Non-practiced task				
ADR task	47.50	64.17	37.67	39.00
	(3.44)	(3.32)	(3.98)	(3.34)

Note. EDMC = Everyday Decision Making Competence task; ADR = Applying Decision Rule task

Results

Decision-making practiced task

For the experiential-based problems of the EDMC task, results showed a significant main effect of time, $F(1, 64) = 58.67$, $p < .001$, $\eta p2 = .48$, and Time X Group interaction, $F(1, 64) = 16.34$, $p < .001$, $\eta p2 = .20$. Pairwise comparison showed significant improvements between pre-test and post-test in the decision-making training group, $p < .001$, 95% CI [-28.19, -17.64], and in the control active training group, $p = .017$, 95% CI [-12.86, -1.30]. Pairwise comparison also showed equivalent scores at pre-test between the two groups,

p = .319, 95% CI [-3.36, 8.50], but reliable differences at post-test, p < .001, 95% CI [13.05, 23.75], where the decision-making training group outperformed the control active training group.

Regarding the analytical-based problems of the EDMC task, the main effect of time was not significant, $F(1, 64) = 0.42$, $p = .521$, $\eta p2 = .01$. The Time X Group interaction was significant, $F(1, 64) = 11.72$, $p = .001$, $\eta p2 = .15$. Pairwise comparison showed a significant improvement between pre-test and post-test in the decision-making training group, $p = .043$, 95% CI [-9.90, -0.15], and a significant decrement in the control active training group, $p = .008$, 95% CI [2.02, 12.70]. Pairwise comparison also showed equivalent scores at pre-test, $p = .643$, 95% CI [-6.37, 3.96], and reliable differences at post-test between the two groups, $p < .001$, 95% CI [6.04, 16.33], where the decision-making training group outperformed the control active training group.

For the daily scenario of the EDMC task, analysis showed a significant main effect of time, $F(1, 64) = 7.05$, $p = .010$, $\eta p2 = .09$, and Time X Group interaction, $F(1, 64) = 21.04$, $p < .001$, $\eta p2 = .25$. Pairwise comparison showed a significant improvement between pre-test and post-test in the decision-making training group, $p < .001$, 95% CI [-17.15, -7.85], and no significant changes in the control active training group, $p = .196$, 95% CI [-1.76, 8.43]. Pairwise comparison also showed equivalent scores at pre-test, $p = .649$, 95% CI [-4.21, 6.71], and reliable differences at post-test between the two groups, $p < .001$, 95% CI [11.65, 22.52], where the decision-making training group outperformed the control active training group.

Regarding the economic scenario of the EDMC task, a significant main effect of time, $F(1, 64) = 39.59$, $p < .001$, $\eta p2 = .38$, and Time X Group interaction was found, $F(1, 64) = 7.52$, $p = .008$, $\eta p2 = .11$. Pairwise comparison showed significant improvements between pre-test and post-test in the decision-making training group, $p < .001$, 95% CI [-25.47, -13.77], and in the control active training group, $p = .019$, 95% CI [-14.12, -1.30]. Pairwise comparison also showed equivalent scores at pre-test, $p = .575$, 95% CI [-4.50, 8.04], and reliable differences at post-test between the two groups, $p < .001$, 95% CI [7.16, 20.20], where the decision-making training group outperformed the control training group.

For the health care scenario of the EDMC task, the main effect of time was not significant, $F(1, 64) = 0.96$, $p = .330$, $\eta p2 = .01$. The Time X Group interaction was significant, $F(1, 64) = 8.75$, $p = .004$, $\eta p2 = .12$. Pairwise comparison showed significant improvement between pre-test and post-test in the decision-making training group, $p = .005$, 95% CI [-16.09, -3.02], but not in the control active training group, $p = .186$, 95% CI [-2.36, 11.94]. Pairwise comparison also showed equivalent scores at pre-test, $p = .786$, 95% CI [-8.10, 6.16], but reliable differences at post-test, $p < .001$, 95% CI [6.62, 20.11], where the decision-making training group outperformed the control training group.

Given that there were age differences in the two training groups, all analyses were also controlled for age and the results did not change.

Decision-making non-practiced task

Regarding the Applying Decision Rule task, we found a significant main effect of time, $F(1, 64) = 21.28$, $p < .001$, $\eta p2 = .25$, and a significant Time X Group interaction, $F(1, 64) = 15.44$, $p < .001$, $\eta p2 = .19$. Pairwise comparison showed a significant improvement between pre-test and post-test in the decision-making training group, $p < .001$, 95% CI [-21.92, -11.41], but no changes in the control active training group, $p = .645$, 95% CI [-7.09, 4.42]. Pairwise comparison also showed equivalent scores at pre-test, $p = .064$, 95% CI [-0.61, 20.27], and reliable differences at post-test, $p < .001$, 95% CI [15.70, 34.64], where the decision-making training group outperformed the control training group.

Given that there were age differences in the two training groups, all analyses were also controlled for age and the results did not change.

Discussion

Given the decline of decision-making skills in aging (Hess, Strough, & Löckenhoff, 2015), the aim of this study was to evaluate the possibility of promoting changes through a specific training. In order to reach this goal, we developed a new training based on metacognitive principles in order to promote an analytical mode of thinking about decision-making problems and on the use of strategies. We compared the effects of the metacognitive-strategy decision-making training group with those of an active control training group, which took part in a strategic memory training. Comparing these two training groups allowed us to demonstrate that a specific training, based on a discussion on how to apply decision-making strategies, worked better than a training based on the practice of memory strategies with memory tasks. Moreover, in the present study we focused on the generalization effect. Indeed, the training was created in order to maximize the generalization of older adults' behavior.

Results of the present study showed that the metacognitive-strategy decision-making training group increased performance in decision-making tasks significantly more than the active control training group. Notably, this improvement was evident not only in the practiced task, but also in the non-practiced task.

In line with our expectation, the first noteworthy result concerns improvements in the performance of the decision-making training group in all problems (analytical and experiential-based problems) and scenarios (i.e., daily, economic, and health care) of the Everyday Decision Making Competence task (practiced task). The structure of this task was based on decision-making problems activating both analytical and experiential modes of thought. Our result suggests that teaching older adults an analytical and strategic way to analyze the decision-making problems allows them to increase the use of System 2 (analytical processing), not only in the analytical-based problems which require definitely the analysis of the problem structure and the use of effortful cognitive abilities (such as doing mathematical calculations), but also in the experiential-based problems. In the latter problems participants are simultaneously presented with conflicting heuristic/experiential response (that appear to be activated rapidly and automatically by System 1) and analytical response (that required to process base-rate information, activating System 2). The improvement in this kind of problems suggests that older adults became more able to override the intuitive and experiential response of System 1, moving from suboptimal experiential modes of decision toward improved analytical thinking of System 2 (Milkman et al., 2008).

The second key result of the present study is the generalization effect on the non-practiced task, which assessed the ability to apply decision rules (Bruine de Bruin et al., 2007). The application of decision rules in order to choose the best option from a set of alternatives according to specific goals (Payne et al., 1993) is a cognitive-demanding decision-making task in which older adults usually tend to experience a decline due to their limited cognitive resources (Bruine de Bruin et al., 2012; Del Missier et al., 2010, 2013; 2017; Rosi et al., 2017). Interestingly, in the present study, improving older adults' analytical approach and awareness in decision strategies led participants to generalize their behavior to a new task, and consequently to enhance their ability to apply a decision rule correctly. This generalization effect appears to additionally derive from the learner-oriented approach (Bottiroli et al., 2013; Cavallini et al., 2010) that we adopted in the present training. Indeed, in our training, older adults were involved in discussions on how and when strategies could be applied. This may have helped them to adapt strategies to the new task. Furthermore, it is important to highlight that despite both training groups being based on a strategic approach, only the decision-making training group reported an improvement in non-practiced task. This signifies that in order to promote an improvement in the applying decision rules ability, it is necessary to work on specific decision strategies involved in the decision process.

This is the first study showing that decision-making skills may be enhanced in healthy aging through an intervention using metacognitive principles and analytical strategies to promote an analytical mode of thinking. Moreover, this training can be considered to be a first step in testing the effectiveness of a metacognitive-strategy decision-making training in aging, as we have uncovered several important issues with which to drive future research. First, the number of older adults recruited was relatively small. A new study, aimed to replicate these results, should involve a larger number of participants. Second, given that we only had two measures of decision-making ability linked to the trained skills, the generalization

of our results on other decision-making skills should be considered with caution. In future studies, it would be important to include additional decision-making tasks and other measures which mimic daily decisions more scrupulously (i.e., naturalistic tasks). Indeed, the ultimate goal of an intervention should be the use of learnt skills in the everyday context. Third, future studies could compare different training approaches; it may be interesting to administer a training based on the improvement of cognitive abilities related to the decision-making process (Bruine de Bruin & Parker, 2017), such as working memory training. Moreover, given that the decision-making training adopted was based on both strategy and metacognitive components, we could not distinguish whether the efficacy of the training was attributable to only one of these components or to their combination. This issue should be investigated in future studies. Finally, further research is also needed in order to investigate whether the training produces training gains that are durable across time.

In conclusion, these findings add significantly to the existing literature on decision-making ability in aging by showing that a metacognitive-strategy training, based on eliciting older adults to use strategic decisions and an analytical mode of thinking, was effective in improving performance in decision-making tasks practiced and not practiced during the training. From a practical point of view, improving decision-making skills in older adults could have a beneficial effect not only in making better decisions, but also in maintaining independent living and achieving successful life outcomes (Mather, 2006; Salthouse, 2012).

Ethics statement: This study was carried out in accordance with the recommendations of the Italian Association of Psychology. The protocol was approved by the Ethical Committee of the University of Pavia/IUSS. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

Conflict of Interest: The authors have no conflict of interest with respect to this publication.

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Appendix A

Example of analytical-based and experience-based problems of daily scenarios from the Everyday Decision-Making Competence task.

Example of analytical-based problem
Sarah lives in a small provincial town. She started a new job in the nearby city and will have to use the intercity bus from Monday to Friday at 7:30 am and at 6:10 pm. The single journey ticket costs 3.85 euro, while the one-day ticket costs 6.90 euro. Sarah has discovered that there are two kinds of bus passes and must choose whether to buy the 5-day weekly pass, which costs 21 euro, or the 30-day monthly pass, at the cost of 77 euro.

QUESTION: Which bus pass is Sarah more likely to buy?
(a) Definitively the weekly pass – 1 point
(b) Probably the weekly pass – 2 point
(c) Probably the monthly pass – 3 point
(d) Definitively the monthly pass – 4 point

Example of experiential-based problem
Simon wants to give his friend a pack of golf balls as a Christmas gift. Golf experts writing for the magazine "All about Golf" recommended STAR balls. As soon as Simon arrives at the sports shop, he learns from a couple of golfers that the MEGA balls are better than the STAR balls. The STAR golf balls are in a pack of six at a cost of 18 euro, while the MEGA golf balls are in a pack of six at a cost of 18 euro, or in a pack of twelve at a cost of 36 euro.

QUESTION: Which brand of golf balls is Simon more likely to buy for his friend?
(a) Definitively the MEGA balls –1 point
(b) Probably the MEGA balls – 2 points
(c) Probably the STAR balls – 3 points
(d) Definitively the STAR balls – 4 points