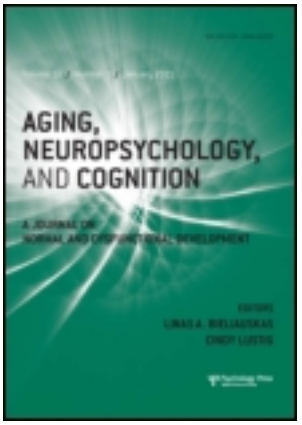

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Strategy selection and aging: Impact of item concreteness in paired-associate task

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Strategy selection and aging: Impact of item concreteness in paired-associate task

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ABSTRACT

The aim of this study was to examine the effect of aging on strategy selection in a paired-associate word task. Twenty-eight younger adults (mean age = 20.68 years) and 28 older adults (mean age = 68.46 years) studied 39 pairs of concrete, middle and abstract words. The concreteness level was manipulated in order to modify the benefit of imagery and sentence strategies in relation to task characteristics. The results showed an age difference in strategy selection in relation to concreteness level. Older adults showed less adaptive strategy selection for the imagery strategy but not for the sentence strategy. Change in strategy selection did not seem to be explained by better efficiency of sentence than imagery, so this study suggests a partial reduction of strategy adaptivity during aging.

Keywords: Age differences; Strategy selection; Paired associate learning; Words characteristics; Imagery; Sentence.

INTRODUCTION

Strategy adaptivity is necessary for good adaptation to a changing world. In the domain of aging, the study of cognitive strategies has become a major interest for researchers trying to understand cognitive decline and more particularly memory modification. A possible explanation is that a decrease with age in the use or effectiveness of encoding strategies could explain the decline in associative memory in older adults (Light, 1991; Verhaeghen & Marcoen, 1994). Two major concurrent hypotheses have been proposed: either older adults do not use effective strategies spontaneously or they fail to execute these strategies efficiently (Dunlosky, Hertzog, & Powell-Moman,

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2005; Light, 1991). In favour of the first explanation, research has shown that older adults seem less likely than younger individuals to initiate effective strategies spontaneously (Hulicka & Grossman, 1967), particularly for imagery (Dunlosky & Hertzog, 1998; Whitbourne & Slevin, 1978). However, in accordance with the second explanation, the benefit of strategy instruction is sometimes lesser in older than in younger participants (Dirkx & Craik, 1992). For example, older subjects did not attain the same level of performance as younger ones (Hulicka & Grossman, 1967), or they failed to increase their performance (Isingrini, Fontaine, Métras, & Bonneau, 1994; Mason & Smith, 1977). This decrease in effectiveness could be explained by other processes like difficulties in retrieving and decoding of constructed mediators in a paired-associated task (e.g., Dunlosky et al., 2005).The two hypotheses have been very frequently opposed in the literature, but it appears important to consider them together rather than as two dichotomous explanations. The decrease in memory performance with aging could be explained by the decline not only in the use but also in the effectiveness of encoding strategies (Naveh-Benjamin, Brav, & Levy, 2007). Moreover, when studying strategy adaptivity to changing success rates with a dynamic and complex air-traffic control task, Schunn and Reder (2001) noted that the best strategy might not be the same from one individual to another. A person could use a less efficient strategy because it is the best strategy for them, whereas a more efficient strategy would be too effortful. This conclusion obtained in the context of a complex task could be applied to less complex situations like paired-associated memory tasks. Studies about memory during aging provide evidence for this approach. A study by Verhaeghen and Marcoen (1994) suggested that age differences in strategy use can be explained by age differences in cognitive abilities. Indeed cognitive reduction associated with aging could reduce the ability of older adults to use effortful encoding strategies (Bryan, Luszcz, & Pointer, 1999; Salthouse, 1991; Taconnat et al., 2006). This shows the need to investigate simultaneously the efficiency and cost implementation of strategies. Hence, research into decision-making has proposed that strategy selection is the result of the cost and benefit of strategy implementation (Mata, Schooler, & Rieskamp, 2007). Benefits correspond to the efficiency and accuracy of strategies, whereas costs are seen in terms of the cognitive effort required to apply the strategy. For example, people might choose the best strategy for a given task in relation to conscious or unconscious anticipation of the cost–benefit of each strategy (Payne, Bettman, & Johnson, 1993). This estimation could be associated in part with previous experience (Payne et al., 1993) and reinforcement learning (Rieskamp & Otto, 2006). Consequently an efficient strategy for younger adults might not be so for older adults. Mata et al. (2007) showed that older adults tend to choose simpler strategies more often than do young adults, and that reduction of fluid intelligence explains this difference. Nevertheless,

their results suggest that older adults remain capable of adaptive selection of decision strategies. Siegler and Lemaire (1997) defined strategy adaptivity as the capacity to choose the best strategy according to task characteristics, strategy characteristics and self-competencies. Three other dimensions have been specified by these authors: the whole set of several strategies to accomplish tasks (repertory), the employment proportion of each strategy (frequency) and lastly the speed and accuracy of execution (efficiency).

In the domain of arithmetic problems, several studies have suggested that older adults are less efficient than young adults in choosing the best strategy in relation to problem characteristics (Duverne & Lemaire, 2004, 2005; Lemaire, Arnaud, & Lecacheur, 2004; Yagoubi, Lemaire, & Besson, 2003, 2005). Concerning memory tasks, Dunlosky and Hertzog (1998, 2001) have shown that both young and older adults possess the same strategy repertory, with several strategies for learning paired-associate words. In the paired-associate task, effective strategies may include a mediator for linked pair-words (Richardson, 1998), the mediator being an image associating the two words (imagery strategy) or a sentence including the two words (sentence strategy). Another less effective strategy is the rote repetition of words (repetition strategy). Finally, other strategies are sometimes used or individuals may use no strategy at all. Previous studies have suggested that image-generation ability declines with aging (Craik & Dirkx, 1992; Dror & Kosslyn, 1994; Kemps & Newson, 2005) and that older adults produce more general images and report more irrelevant details about them (Palladino & De Beni, 2003). Moreover, older adults seem to prefer to use sentences rather than imagery when any strategy instruction is given (Hulicka & Grossman, 1967; Rowe & Schnore, 1971). Using strategy reports for each paired-associate word of their study, Dunlosky and Hertzog (1998) showed that older adults are able to comply with instructions to use imagery, and interestingly that both young and older adults reported using imagery for only 70% of items. This observation suggests that another factor could determine the use of a given strategy.

The question of compliance with recommended strategies is also central in the literature concerning memory training for elderly people. Generally memory training involves presentation of several memory strategies that could help older people to reduce memory difficulties during daily life. The use of imagery strategy is regularly suggested to the elderly in order to improve their memory. Unfortunately the beneficial long-term effect of memory training is not constant (Ball et al., 2002; Scogin & Bienias, 1988; Stigsdotter & Bäckman, 1989), and O'Hara et al. (2007) observed that at 5-year follow-up, only 40% of participants reported using memory strategies versus 93% immediately after the training. In 1985, Yesavage noted that older adults often have difficulty in using memory strategies because of the difficulty to form visual images or encode associated visual images. Another

study by Yesavage and his team (Yesavage, Sheikh, Friedman, & Tanke, 1990) suggested that the benefit of learned mnemonics varied in relation to the complexity of mnemonics and to subtle cognitive impairment measured by Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Thus, they showed that low MMSE scores affect more the use of complex strategies than the use of easier strategies. This observation shows the need to consider the cost–benefit of a strategy and not only its expected benefit.

A possible explanation for this difficulty to use complex memory strategies in elderly people could be a decrease in cognitive resources. Derwinger, Stigsdotter Neely, and Bäckman (2005) studied the impact of self-generated strategy training in an 8-month follow-up. Using a four-digit number learning task, they compared a group of older adults with specific mnemonic instructions and a group of older adults without specific mnemonic instructions who were encouraged to use their own strategies. The aim was to encourage the group with self-generated strategies to process information in relation to their specific abilities and knowledge. Results 8 months later revealed that self-generated strategy training was more effective than standard mnemonic training when the testing task did not offer cognitive support. The authors suggested that 'memory intervention in old age may benefit from training procedures focusing on skills optimal to the cognitive repertoire of older individuals' (p. 38) and thus reduce the lack of compliance and/or transfer over time.

Considering the links between cognitive functions and strategy use (Mata et al., 2007; Yesavage et al., 1990), aging could affect the selection and execution of strategies, notably imagery, which is considered effortful and complex (Palladino & De Beni, 2003). Concerning sentence use, Delaney (1978) found that young adults with high verbal ability used more sentence strategies than did young adults with low verbal ability for learning foreign-language-English word pairs. This shows the importance of individual abilities in strategy choice, and suggests that people with high language skills could use sentence strategies more often. Thus, elderly adults could prefer sentence strategies. Indeed, older adults generally have more vocabulary and more language expertise than did younger adults (Mathey & Postal, 2008; Verhaeghen, 2003), which may influence their tendency to use sentences rather than imagery when any specific instruction is given (Hulicka & Grossman, 1967).

In this article, we focus more particularly on the impact of the characteristics of the information to be memorized on strategy selection. In 1993, McDougall and Velmans examined the use of imagery and sentence strategies in relation to word characteristics. Young participants studied words either spatially related (cake-oven) or categorically related (corn-oats), with the assumption that spatial relationship would be a cue for imagery use and

categorical relationship a cue for sentence use. Results were in accordance with this expectation, with participants adjusting strategy selection in relation to word characteristics.

The concrete-abstract dimension of words is well-known to influence strategy selection. Paivio and Yuille (1969) showed that imagery is used more for paired-associates composed of concrete words than of abstract words. According to these authors, the imagery strategy could be used more than other strategies with concrete words, while the verbal strategy (i.e., a word or phrase connecting words) might be used more than other strategies with abstract words. Furthermore, Treat and Reese (1976) found that imagery mediators are more facilitatory than verbal mediators for learning concrete pairs. This effect is explained by the fact that concrete pairs evoking mental imagery readily are much more easily remembered than abstract pairs, which are more difficult to mentally image (Richardson, 2003).

The purpose of this research was to study the effect of aging on strategy selection in relation to item concreteness during a paired-associate task. Recent research on decision-making and resolution of arithmetic problems suggested that older adults remain able to adapt to task characteristics, but that their adaptivity is not as good as that of young adults (Duverne & Lemaire, 2004, 2005; Lemaire et al., 2004; Mata et al., 2007; Yagoubi et al., 2003, 2005). Since previous studies suggested that older adults use less efficient strategies, notably for imagery (Dunlosky & Hertzog, 1998; Hulicka & Grossman, 1967; Whitbourne & Slevin, 1978), we investigated whether the ability to choose the best strategy for a given situation also changes during a paired-associate task. Consequently we chose to study strategy selection and execution in order to study strategy adaptivity. The design of our task resembles that of Dunlosky and Hertzog (1998). Young and older participants performed a paired-associate task and strategy production was estimated with item-by-item reports. However, we also manipulated the characteristics of the information to be memorized by presenting concrete, middle and abstract pairs of words. We hypothesized that manipulating the concreteness level would make it possible to examine strategy adaptivity. Several strategies were presented with instructions regarding the cost–benefit aspect of each. The choice of strategies and the cost–benefit estimations were taken from the literature concerning the use of strategies in a paired-associate task. The fact that the instructions stated the cost–benefit ratio of the strategy in relation to word characteristics meant that both younger and older adults had the same knowledge of this balance. Indeed, according to metamemory studies, the subjective estimation of strategies and memory tasks may be modified during aging (Cavanaugh & Poon, 1989; Dixon & Hultsch, 1983). Imagery was described as the best cost–benefit balance for concrete pairs and sentence as the best cost–benefit balance for abstract pairs. Given that middle concreteness level was not mentioned during instruction, we assumed that

middle pairs would provide information about participants' preferences for imagery and sentence strategies. Participants were requested to use the best strategy for each word pair in accordance with previous instructions about cost–benefits, but were also told that they should feel at ease when making decisions, in order to obtain the most natural-feeling decision. We hypothesized that with aging, there would a change of ratio in the strategies used and in the efficiency of recall, with specific strategies being used in relation to the task characteristics. We expected that older adults would use less imagery but more sentences than young adults, notably when the task characteristics influenced strategy selection less (middle pairs). Consequently we hypothesized a partial decrease in strategy use during aging, as shown by a decline when imagery was the adapted strategy and maintenance when sentence was the adapted strategy. Concerning strategy efficiency, we hypothesized a decrease of efficacy with aging for imagery and to a lesser measure for sentence. Furthermore, in accordance with Delaney (1978), we hypothesized that participants with higher verbal ability, measured by a vocabulary test, used more sentence strategy than participants with lower verbal ability.

METHOD

Participants

Twenty-eight young participants (university undergraduates, range 18–23 years, $M = 20.68$, $SD = 1.59$) and 28 older participants (senior university learners, range 63–80 years, $M = 68.46$, $SD = 4.58$) took part in this study. In order to screen for cognitive impairment, we included only participants with a Mini Mental State Examination (MMSE; Folstein et al., 1975) score of 26 or more. Older participants had more years of education than young ones (respectively, $M = 14.43$, $SD = 2.32$ and $M = 12.82$, $SD = 1.25$), $t(54) = -3.23$, $p < .01$. The level of vocabulary measured by the Mill–Hill test (Deltour, 1998) was also greater in the older group ($M = 41$, $SD = 2.07$ vs. $M = 35.89$, $SD = 3.45$), $t(54) = -6.72$, $p < .001$.

Design and materials

All participants studied a list of 39 paired associates distributed in 3 levels of concreteness. The 78 nouns were derived from norms of concreteness and subjective frequency of French words (Desrochers & Bergeron, 2000). Pairs were composed of nouns unrelated within each pair: 13 pairs of concrete nouns (e.g., lettuce/hammer), 13 pairs of middle nouns (e.g., childhood/apparatus) and 13 pairs of abstract nouns (e.g., regret/instinct). The values of imagery (Desrochers & Bergeron, 2000) extended from 6.27 to 6.89 for concrete pairs, from 4.58 to 5.41 for middle pairs and 2.17 to 3.12 for abstract pairs. The number of syllables of nouns ranged from 2 to 4 and the

mean subjective frequency was 4.79 for each word level (Content, Mousty, & Radeau, 1990). Each pair was presented on a computer screen for 8 s during which the participant had to memorize the words. We chose not to exceed 39 pairs in order not to exceed the cognitive resources of the participants, the older ones. Practice was composed of four items with two concrete pairs, one middle and one abstract pair. Given that concrete, middle, and abstract words resulted from concreteness norms obtained from young and older adults, we did not directly question participants about the concreteness level to make sure that they distinguished the different levels. However, during the instructions, examples of concrete and abstract words were given and the participant was encouraged to produce concrete and abstract words. The case of middle pairs was orally presented, like words situated between concrete and abstract level.

Procedure

Participants were tested individually and instructions were presented in four phases on the computer screen (see the Appendix). For each phase, after that the participant read the instructions, the experimenter explained these instructions and encouraged the participant to ask questions or details. The first slide displayed instructions to learn each of 39 pairs, presented for 8 s, in order to recall later the second word of a given pair when the word was prompted by the first word of the pair. The second slide described in a jargon-free manner the three stages (encoding, storage and retrieval) involved by memorization and highlighted the fact that the use of strategy may improve memorization. The third slide presented successively the three common strategies (imagery, sentence and repetition) and the cost–benefits of these strategies in relation to the pair's concreteness. The imagery strategy was described as the fact of linking words within the same image, preferentially in making interacted items. The concrete word pair 'guitar-church' was presented as example and the image of a guitar in the shape of church was given. The imagery strategy was depicted as very effortful but also very efficacious for concrete words which are easy to form an image. The abstract word pair 'ambition-theory' was presented then to illustrate the difficulty to create an image of abstract words. The sentence strategy was described as the fact of linking words within a same sentence. The sentence strategy was depicted as less effortful than the imagery strategy but also less efficacious for concrete words. On the contrary, sentence strategy was described as more efficacious than imagery for words which are not easy to form an image, such as abstract words. The abstract word pair 'ambition-theory' was presented and the sentence 'the ambition to make a theory' was proposed. The repetition strategy was described as less effortful but also as less efficacious than imagery or sentence strategies. Lastly, in the fourth slide, participants were instructed to use for each pair the strategy that appeared to them as the

most effective and with which they felt at ease. For concrete pairs, imagery was described as effortful but the most effective, whereas sentence was presented as less effective than imagery. On the contrary, for abstract pairs, sentence was presented as more efficient and less effortful than imagery. Repetition was also described as less effortful than imagery and sentence but too inefficient. Finally the benefit of using a strategy rather than no strategy was mentioned. Therefore, imagery was described as having the best cost–benefit balance for concrete pairs and sentence as the best cost–benefit balance for abstract pairs. No preferential strategy was mentioned for middle concreteness pairs. Four items of practice were used in order to allow familiarization with the task. After the oral recall of the practice items, the experimenter asked the name and a description of strategies used to make sure that the participant understood the characteristics of each strategy and how to implement it.

After practice trials, the fourth slide of instruction was again presented and if the participant had no questions, the test began. Thirty-nine pairs were displayed on a computer screen at a rate of 8 s per items in random order, and with 3 s between every pair in order to prepare the next pair and limit interference in the learning of the different pairs. Immediately after the end of this learning, an oral cued recall was proposed: The first word of a pair (e.g., lettuce – ?) was presented for a maximum of 15 s. Each pair appeared in a new random order. The experimenter asked the participants to try to recall orally the second word and to specify their strategy choice for this pair by categorizing it as 'imagery', 'sentence', 'repetition or other strategy', 'none'. The name of each strategy choice was written on a computer document given to the participant for the recall. When the participant reported the use of imagery or sentence, a description of mediator used was requested of the participants in order to be sure that they made the correct strategy classification. In this case, the first word of each pair remained on the screen until the production of the mediator. Recall, strategy reports, mediator reports, and verbatim were recorded by the experimenter.

This method of retrospective reports was shown to be a valid method of reporting strategy production (Dunlosky & Hertzog, 2001). The category 'repetition and other strategy' avoids 'imagery' and 'sentence' categories being used for strategies not relevant to them.

RESULTS

Like Dunlosky and Hertzog (1998), we calculated the percentage of time that participants reported producing a given strategy and the proportion of word pairs correctly recalled as a function of the reported strategy production. In order to investigate strategy adaptivity, we focused on the production

and execution of imagery and sentence strategies, which were the two main efficient strategies reported.

First, we studied the selection of these two strategies by young and older adults. We conducted analysis of variance on the percentage of strategy use with age as the between subjects factor and concreteness and type of strategy used as the within subjects factor. We also studied correlations for each age group between the Mill–Hill score and strategy production for each level of concreteness. Second, we studied the efficacy of strategy execution by conducting analysis of variance on the percentage of words correctly recalled (recall performance), firstly for all pairs and secondly in relation to concreteness level.

Strategy production

A 2 (age) × 3 (concreteness level) × 2 (strategy) analysis of variance (ANOVA) was conducted. Table 1 summarizes mean production by the two groups for the three concreteness levels. Analysis revealed a significant Age effect, $F(1, 54) = 9.58$, $p < .01$, partial $\eta^2 = .151$; with older adults producing fewer strategies than young adults (31.09 vs. 38.00%). Main effect of Strategy effect was not significant because participants used imagery and sentence at similar rates (36.63% of imagery and 32.46% of sentence), $F(1, 54) = 1.69$, $p = .20$, partial $\eta^2 = .030$, whereas an effect of level concreteness occurred, $F(2, 108) = 92.65$, $p < .001$, partial $\eta^2 = .632$. *Post-hoc* analysis with the Newman–Keuls test with an $\alpha = .05$ showed that more strategies were produced for concrete pairs than for middle pairs (43.34 vs. 37.22%) and more were produced for middle pairs than abstract pairs (37.22 vs. 23.08%). The interaction between Age and Strategy was significant, $F(1, 54) = 5.83$, $p < .05$, partial $\eta^2 = .097$. Analysis showed that older

TABLE 1. Percentage of strategy production and standard errors (in parentheses) for each concreteness level in relation to age and strategy

	Strategy		
Concreteness	Imagery	Sentence	*M*
	Younger adults		
Concrete	82.97 (3.22)	8.79 (1.94)	45.88
Middle	44.78 (3.82)	38.19 (3.68)	41.48
Abstract	4.12 (1.34)	49.18 (4.72)	26.65
M	43.96	32.05	
	Older adults		
Concrete	64.83 (3.94)	16.76 (2.65)	40.79
Middle	22.25 (3.05)	43.68 (5.17)	32.96
Abstract	0.82 (0.60)	38.19 (5.04)	19.50
M	29.30	32.88	

adults used less imagery (29.30%) than did young adults (43.96%), $F(1, 54) = 24.10$, $p < .001$, partial $\eta^2 = .308$. The difference between young and older adults was not reliable concerning sentence use, respectively 32.05 and 32.88%, $F < 1$. Young adults used more imagery than sentence, $F(1, 54) = 6.90$, $p = .01$, partial $\eta^2 = .113$, whereas older adults used as much as imagery, $F < 1$. Results also showed a non-significant interaction between Age and Concreteness level, $F < 1$. The interaction between Strategy and Concreteness level was significant, $F(2, 108) = 267.12$, $p < .001$, partial $\eta^2 = .832$, showing that imagery was used more than sentence for concrete pairs (73.90 vs. 12.77%), $F(1, 54) = 276.07$, $p < .001$, partial $\eta^2 = .836$, and that imagery was less used than sentence for abstract pairs (2.47 vs. 43.68%), $F(1, 54) = 136.27$, $p < .001$, partial $\eta^2 = .716$. Concerning middle pairs, no significant difference was observed between imagery and sentence (respectively 33.52 and 40.93%), $F(1, 54) = 2.19$, $p = .14$, partial $\eta^2 = .039$. Finally we observed a significant interaction between Age, Strategy and Concreteness level, $F(2, 108) = 9.91$, $p < .001$, partial $\eta^2 = .155$. For the concrete level, analysis revealed that both young (82.97 vs. 8.79%) and older adults (64.83 vs. 16.76%) produced more imagery than sentence, respectively $F(1, 54) = 203.26$, $p < .001$, partial $\eta^2 = .790$, and $F(1, 54) = 85.39$, $p < .001$, partial $\eta^2 = .612$. However, older adults used less imagery and more sentence than did young adults, respectively $F(1, 54) = 12.67$, $p < .001$, partial $\eta^2 = .190$, and $F(1, 54) = 5.81$, $p < .05$, partial $\eta^2 = .097$. For the middle level, young adults used imagery as much as sentence (44.78 vs. 38.19%), $F < 1$, whereas older adults used less imagery than sentence (22.25 vs. 43.68%), $F(1, 54) = 9.12$, $p < .01$, partial $\eta^2 = .144$. Older adults used less imagery but used as many sentence as young adults, respectively $F(1, 54) = 21.27$, $p < .001$, partial $\eta^2 = .283$, and $F < 1$. Lastly, for the abstract level, both young and older adults used more sentence than imagery (young adults: 49.18 vs. 4.12%, older adults: 38.19 vs. 0.82%), respectively $F(1, 54) = 81.45$, partial $\eta^2 = .601$, and $F(1, 54) = 56.01$, $p < .001$, partial $\eta^2 = .509$. Young adults produced more imagery than did older adults, $F(1, 54) = 5.02$, $p < .05$, partial $\eta^2 = .085$, but the same amount of sentence, $F(1, 54) = 2.53$, $p = .12$, partial $\eta^2 = .045$.

Both for young and older adults, we conducted correlations between Mill–Hill score and production of sentence for concrete, middle and abstract pairs. Results revealed only a significant correlation during abstract level for the young adults ($r = .44$, $p < .05$). The other correlations both for young and older adults were not significant.

Recall performance

To examine if the difference in strategy selection by young and older adults could be due to a difference in strategy execution, we conducted a 2 (age) × 2 (strategy) for each level of concreteness. This design was used

TABLE 2. Percentage of correct recall performance and standard errors (in parentheses) for each concreteness level in relation to age and strategy

	Strategy	
Concreteness	Imagery	Sentence
	Younger adults	
Concrete	86.42 (5.69)	81.35 (9.54)
Middle	80.81 (4.63)	69.31 (4.77)
Abstract	–	41.44 (4.39)
	Older adults	
Concrete	55.67 (4.74)	45.94 (7.96)
Middle	49.10 (5.13)	21.58 (5.28)
Abstract	–	10.62 (4.56)

given that repeated-measures ANOVA removes the results of participants with missing values, and because inclusion of concreteness level in ANOVA would increase the number of excluded participants.[1] Table 2 summarizes means recall performance by the two age groups for the three concreteness levels.[2] For the concrete level, analysis revealed that older adults recalled fewer pairs than did the young adults (50.81 vs. 83.89%), $F(1, 37) = 16.54$, $p < .001$, partial $\eta^2 = .309$. The main effect of strategy and the interaction between Age and Strategy were not significant, respectively $F(1, 37) = 1.42$, $p = .24$, partial $\eta^2 = .037$, and $F < 1$. For the middle level, older adults again recalled fewer pairs than did the young adults (35.34 vs. 75.06%), $F(1, 47) = 43.10$, $p < .001$, partial $\eta^2 = .478$. The imagery strategy was associated with better recall than the sentence strategy (64.96 vs. 45.44%), $F(1, 47) = 30.25$, $p < .001$, partial $\eta^2 = .392$. A significant interaction between Age and Strategy, $F(1, 47) = 5.10$, $p < .05$, partial $\eta^2 = .098$, revealed that the age differences in recall were larger with sentence (21.58 vs. 69.31%) than with imagery (49.10 vs. 80.81%). Lastly for abstract pairs, older adults recalled fewer pairs than did young adults with sentence strategy (10.62 vs. 41.44%), $F(1, 52) = 23.71$, $p < .001$, partial $\eta^2 = .313$.

DISCUSSION

The object of our study was to compare strategy adaptivity in two age groups during a paired-associate word task. The cost–benefit ratio varied in relation

[1]Consequently, the number of participants included in the ANOVA was different according to concreteness level. Only participants having used imagery and sentence were included for concrete level (i.e., 16 young adults and 23 older adults) and middle level (i.e., 27 young adults and 22 older adults) ANOVA. For abstract level, the factor 'strategy' was not studied given that too few participants used imagery for this level, so 28 young adults and 26 older adults were included in the analysis.

[2]Given the very low number of participants who used imagery for the abstract level, the corresponding averages are not indicated in the table.

to the selected strategies (imagery, sentence) and concreteness level of the word pairs. Results revealed that the older adults used less efficient strategies than the young adults. More precisely, the older adults use less imagery than the young adults but use as many sentences. This intergroup difference suggested a partial decrease in strategy adaptivity during aging that was confirmed by the significant interaction between Age, Strategy and Concreteness level. Whereas the young and the older adults used more imagery than sentence for concrete pairs and more sentence than imagery for abstracts pairs, suggesting a good selection of strategy, the older adults used less imagery than the young adults, which was particularly penalizing for concreteness level. The results obtained for middle pairs were interesting because they represented a certain level of uncertainty, given that no specific instruction was given for these pairs and that they did not fit with concrete or abstract categories. The older adults used less imagery but more sentence than young adults, whereas young adults chose both strategies to the same extent. Our results are in accordance with previous studies showing that older adults without specific strategy instruction, that is the case for middle pairs, seem to prefer to use sentence rather than imagery (Hertzog & Dunlosky, 2004; Hulicka & Grossman, 1967; Rowe & Schnore, 1971; Whitbourne & Slevin, 1978). However, when strategies are suggested by instruction, older adults remain capable of selecting effective strategies but to a lesser proportion than younger adults. This contrasts with other research showing no differences in selection of effective strategies when strategy instructions are given (e.g., Bailey, Dunlosky, & Hertzog, 2009). This discrepancy could be due to the adaptation component involved in the present study. The difference in strategy selection might be due to age-related changes in the efficacy of imagery use. In accordance with the literature concerning memory decline with aging, our results show that recall performance declined with aging. At each concreteness level, older adults recalled fewer pairs than young adults. However, both for concrete and middle pairs, imagery use seemed more efficient than sentence use for older adults. Consequently, the fact that older adults used less imagery than did young adults and preferred sentence use for middle pairs cannot be explained by a change in cost–benefit ratio, with less benefit from imagery use or more benefit from sentence use. Therefore, our hypothesis concerning strategy adaptivity during aging would seem to be confirmed, as reflected by a decline when the adapted strategy is imagery, but not when the adapted strategy is sentence. This result supports and extends similar findings obtained in decision-making and resolution of arithmetic problems, i.e. older adults remain able to adapt their strategies but to a lesser extent than young adults (Duverne & Lemaire, 2004, 2005; Lemaire et al., 2004; Mata et al., 2007; Yagoubi et al., 2003, 2005). In the present study, we chose retrospective reports (i.e., the participant reported the strategy after the recall of each pair) in order to avoid interference between the task (i.e., to learn

paired-associate word) and the procedure (i.e., report the strategy used). The retrospective reports allowed us to ask participants for a description of the image or sentence created without influencing the implementation of the strategy, because the question concerning the strategy was asked during the recall rather than during the encoding phase. However, the delay between the learning of the pair and the recall of the strategy could increase forgetfulness about the strategy used, notably with a population presenting episodic memory deficits such as older adults (Dunlosky & Hertzog, 2001). The fact that the strategy recall came after the recall of the pair could influence strategy reporting, with imagery or sentence being reported for pairs recalled successfully and repetition or no strategy for pairs not recalled. The presence of a description of the mediator used during imagery or sentence strategy may have reduced this impact. A future study with concurrent reports (i.e., the participant reports the strategy immediately after the learning of the pair, before the recall) would throw light on this issue.

Our study suggests that older adults are as efficient as young adults in selecting sentence strategies but not imagery strategies. Given that both imagery and sentence are effortful strategies, this modification with age could be the consequence of an aversion for imagery use or a preference for sentence use. An aversion for imagery use could be associated with specific difficulties in implementing it. Previous works have suggested a decline with aging of image-generation ability or image precision (Craik & Dirkx, 1992; Dror & Kosslyn, 1994; Kemps & Newson, 2005; Palladino & De Beni, 2003; Yesavage, 1985). On the other hand, older adults could prefer sentence use because they generally have more vocabulary than young adults (Verhaeghen, 2003) and because an extended vocabulary could have a facilitatory effect on sentence use. In the past, Delaney (1978) showed that younger adults with high verbal ability used more sentence strategies than younger adults with low verbal ability. We now replicate this result with young adults but not with older adults. The young adults with higher vocabulary scores used sentence strategy more for abstract pairs. The fact that this relation was only observed for abstract pairs could be explained by the presence at this level of only one effective strategy (i.e., sentence). Thus, young adults with high vocabulary level might use the effective sentence strategy more than rote repetition or no strategy. Regarding the absence of relation for older adults, we observed a ceiling effect on the Mill–Hill vocabulary test and less variability for older adults whereas scores of young adults were lower and more distributed. Since all the older adults had a high level of vocabulary, the scores did not discriminate between them, which could explain the absence of significant correlations between the level of vocabulary and the strategy in this group. A previous study showed multiple-choice vocabulary test like the Mill–Hill test tend to advantage older adults in comparison to production tasks that require words to be defined (Verhaeghen, 2003). Verhaeghen

postulated that multiple-choice synonym tasks are not sensitive to an age effect because they do not require word finding. More recently, Bowles and Salthouse (2008) emphasized the fact that each vocabulary test measures different vocabulary constructs by calling upon different cognitive processes. Regarding the links between high verbal ability and use of sentence strategy, Delaney (1978) measured verbal ability with a composite score of three tasks, including a task similar to verbal fluency, and required that subjects produce words beginning with a given prefix. Thus, the elaboration of sentences could be more associated with tasks requiring the production of words (e.g., definition tasks, verbal fluency).

Strategy selection may be modified by previous experience and reinforcement learning (Payne et al., 1993; Rieskamp & Otto, 2006). Consequently, previous experiences of success or failing could influence strategy selection. Thus, concerning pair recall, we observed a decline in efficiency with aging both for imagery and sentence use, with older adults recalling fewer pairs than young adults. This finding is in accordance with data suggesting that declines in episodic memory cannot be explained solely by strategy production (Dunlosky & Hertzog, 1998; Isingrini et al., 1994; Mason & Smith, 1977; Naveh-Benjamin et al., 2007). Interestingly, the fact that older adults recalled more middle pairs with imagery than sentence suggests that the lesser utilization of imagery is not due to the efficiency of each strategy. Hertzog et al. (2009) found that knowledge about the superiority of imagery over rote repetition during associative learning was relatively low for participants. Thus, despite our finding about effectiveness of each strategy, older adults might have a false perception of how efficient imagery use is, which makes them reticent to use imagery. Consequently, an important question concerns the ability of older adults to learn about the effectiveness of different strategies from their experience of tasks. By comparing strategy utilization of imagery and rote repetition for two distinct lists of word pairs, Price, Hertzog, and Dunlosky (2008) found that older adults learn about the superiority of imagery of rote repetition during associative learning, but to a lesser extent than young adults.

In this research we studied strategy selection during aging by considering the aspect of strategy adaptivity. Indeed, good strategy selection results from a balance between the characteristics of strategies, tasks and individual competence (Lemaire et al., 2004), so it depends on a ratio between the benefit of strategy use and the cost of cognitive effort (Mata et al., 2007). Our results confirm a difference in strategy selection concerning imagery and sentence use, as well as a difference in strategy use during aging. Older adults used less imagery and more sentences, and showed weaker recall than young adults for each strategy. Finally, our results show a partial reduction in strategy adaptivity during aging, with a decline when imagery is the adapted strategy and maintenance when sentence is the adapted strategy. Cognitive

change associated with aging could produce changes in strategy adaptivity, which is also influenced by previous experience (Payne et al., 1993) and reinforcement learning (Rieskamp & Otto, 2006).The question of strategy adaptivity during aging is essential because our daily environment changes, so 'aspects of a task change, the optimal strategy often changes, so adapting one's strategies is helpful' (Schunn, Lovett, & Reder, 2001, p. 254). Future studies should seek better understanding of the influence of individual characteristics and real life learning experience on the strategy adaptivity in older adults.

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APPENDIX

Slide 1

You are going to perform a memory task: 39 pairs of words (e.g., guitar–church) will appear, one after the other on the computer screen. The automatic emergence of a new pair will lead to the disappearance of the previous one. Each pair will stay 8 seconds on the screen and an X will announce the appearance of a new pair. You should try to memorize these 39 pairs in order to recall the second word (e.g., church) when the first word is presented (e.g., guitar).

Slide 2

The memorization is composed of three steps:

Encoding: when information is recorded and eventually stored.
Storage: maintenance of information in memory.
Retrieval: retrieval of information stored.

These steps can be made more efficient with the use of memory strategies.

Slide 3

To learn pairs of words, different strategies can be used depending on the nature of the words presented. Here are the three main ones.

Imagery: this is linking words within a same image, preferentially by making interacting items. Thus, for the pair "guitar–church", you could make the image of a guitar in the shape of a church. Although imagery is very effortful, it is a very efficacious strategy for concrete words for which it is easy to form an image. On the contrary, it will be difficult to form an image with the abstract pair "ambition–theory".

Sentence: this is linking words within the same sentence. The sentence strategy is less effortful than imagery, but also less efficacious than imagery for concrete pairs. On the contrary, sentence is more efficacious than imagery for abstract words, for which it is easy to form an image. Thus, for the pair "ambition–theory", you could create "the ambition to make a theory".

Repetition: this is rote repetition of words (e.g., guitar–church–guitar–church–etc.). Repetition is less effortful than imagery or sentence but also less efficacious.

Slide 4

For this task, you will try to memorize paired-associates, in order to recall the second word when the first word is presented on the screen (e.g., guitar–?). Using strategies (imagery, sentence or repetition) could help you better memorize, so you need to use a strategy that seems to you as the most effective and with which you feel at ease.

Do you have any questions?