Differential Involvement of Knowledge Representation and Executive Control in Episodic Memory Performance in Young and Older Adults

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Craik and Bialystok (2006, 2008) postulated that examining the evolution of knowledge representation and control processes across the life span could help in understanding age-related cognitive changes. The present study explored the hypothesis that knowledge representation and control processes are differentially involved in the episodic memory performance of young and older adults. Young and older adults were administered a cued-recall task and tests of crystallized knowledge and executive functioning to measure representation and control processes, respectively. Results replicate the classic finding that executive and cued-recall performance decline with age, but crystallized-knowledge performance does not. Factor analysis confirmed the independence of representation and control. Correlation analyses showed that the memory performance of younger adults was correlated with representation but not with control measures, whereas the memory performance of older adults was correlated with both representation and control measures. Regression analyses indicated that the control factor was the main predictor of episodic-memory performance for older adults, with the representation factor adding an independent contribution, but the representation factor was the sole predictor for young adults. This finding supports the view that factors sustaining episodic memory vary from young adulthood to old age; representation was shown to be important throughout adulthood, and control was also important for older adults. The results also indicated that control and representation modulate age-group-related variance in episodic memory.

Keywords: episodic memory, aging, knowledge representation, executive control

Research has shown that episodic memory involves both age-related losses and compensation mechanisms. Episodic memory is defined as the kind of memory that enables conscious recollection of personal happenings and events from the past (Wheeler, Stuss, & Tulving, 1997). It is classically assessed by free-recall, cued-recall, and recognition tasks.

In a seminal article, Craik and Bialystok (2006) proposed a framework comprising two components, cognitive representation and control, to account for these cognitive changes across the life span, and particularly during adulthood. This framework builds on Cattell’s model (1971), distinguishing between crystallized and fluid processes by specifying key factors explaining not only cognitive performance at a given period of life, but also cognitive changes across the life span. Representations are defined as the set of crystallized schemas that are the basis for memory and knowledge of the world. Control is the set of fluid operations that enable executive adaptive processes. According to Craik and Bialystok (2006), representations are crystallized schemas and can therefore be measured with classic tests of knowledge ability, such as the vocabulary and information subtests of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981). By contrast, control involves executive processes and can thus be measured using standard executive-function tasks, whose main goal is to overcome the prepotent “default mode” of automatic behaviour.

These two factors are also assumed to have different life-span trajectories. Representational knowledge increases during childhood, continues to accumulate at a slower pace throughout adulthood, and remains relatively stable in old age. This is the pattern classically depicted for crystallized abilities (Cattell, 1971; Horn, 1982). By contrast, cognitive control increases in power, speed, and complexity from infancy to young adulthood, and declines thereafter, as shown for fluid abilities (Cattell, 1971; Horn, 1982). Craik and Bialystok (2006) suggest that the relative growth and decline of these two factors may help explain the role played by these two components in sustaining cognitive abilities (e.g., intelligence, language, and memory) at different periods of life. This may also help identify factors explaining age-related changes in cognition. Based on Craik and Bialystok’s (2006, 2008) framework, the aim of the present study was to examine whether representation (crystallized knowledge) and control (executive components) play different roles in the episodic-memory functioning of young and older adults.
It is widely accepted that representations are helpful for the functioning of episodic memory, as they provide schematic support and allow learning material to be processed at a deep level (Craik & Bialystok, 2006, 2008; Bransford, Franks, Morris, & Stein, 1979; Craik & Lockhart, 1972; Craik & Tulving, 1975). As observed by Newcombe, Lloyd, and Balcomb (2011), the semantic-memory system—which provides a general understanding of the world—may give structure and meaning to the episodic-memory system. Greater representation abilities would thus enhance memory through richer and more elaborate encoding and retrieval cues, thanks to an organisational structure and the ability to chunk information in terms of familiar groupings (Salthouse, 2002). Some studies have confirmed a positive link between knowledge and memory measures (Hedden, Lautenschlager, & Park, 2005; Meinz & Salthouse, 1998; see Salthouse, 2002).

On the other hand, studies have shown that memory performance requires processes pertaining to executive functioning. Executive functions are classically defined as a set of cognitive processes encompassing a wide variety of control abilities, involved particularly when dealing with novel problems (Elliott, 2003). These mechanisms can be viewed as supporting the generation of memory-strategy processes (Bouazzaoui et al., 2010; Bryan, Luszcz, & Pointer, 1999; Taconnat et al., 2006; Taconnat, Clarys, Vanneste, Bouazzaoui, & Isingrini, 2007; Taconnat et al., 2009). This view is supported by studies on patients with frontal lobe lesions (Wheeler, Stuss, & Tulving, 1995) and neuroimaging studies which have shown that the prefrontal cortex (PFC), classically associated with executive functioning, sustains episodic memory functioning (Nyberg, Cabeza, & Tulving, 1996). The idea put forward by several authors (Moscovitch & Winocur, 1992; Shimamura, 1995) is that the PFC is not critically involved in the storage of new information but is used to manipulate and organise information to be learned or retrieved. It thus acts as an executive supervisor, viewed as a set of potential support processes aiding episodic-memory performance (Baddley, 1996; Shallice & Burgess, 1993; Moscovitch & Winocur, 1992).

Aging studies have consistently reported a decline in episodic-memory abilities with increasing age (for a review, see McDaniel, Einstein, & Jacoby, 2008). Some studies have attempted to show that such age-related differences can be modulated either by individual levels of representation and/or control, with smaller age-related decline for high-knowledge and/or high-control individuals. The results regarding representation are not conclusive, as we can infer that episodic memory relies on representation in both young adulthood and old age, and on representation and control with increasing age.

The aim of the present study was to examine the respective contributions to episodic memory performance of representation and control in young and older adults. We therefore assessed the performance on a cued-recall task of two age groups (young adults and older adults). The groups were also compared on two measures assumed to reflect representation abilities (WAIS Vocabulary Test, WAIS Information Test) and two assumed to reflect control abilities (Wisconsin Card-Sorting Test; WCST; Nelson, 1976 and Initial-Letter-Fluency Test; ILFT; Stuss & Benson, 1986). We expected first to confirm the classic pattern of an age-related change in episodic memory and control measures, with no age-related effect on representation measures. In keeping with Craik and Bialystok (2006, 2008), our second objective was to confirm whether the two assumed components (representation and control) could be described as independent psychological dimensions. A factor analysis was used to achieve this objective, expecting that two independent factors would be derived from the four measures. Third, we performed correlational and regression analyses to explore the hypothesis that young and older adults present different patterns of association between episodic memory and representation, and between episodic memory and control. To our knowledge, few studies have examined these relationships based on comparison of these age groups. Studies that have approached this issue have examined the influence of the two factors separately (Hedden et al., 2005; Glisky & Kong, 2008).

In the present study, we hypothesised that correlations between episodic-memory performance and control would be greater, or even only appear in older adults, indicating that memory relies more heavily on control in old age. On the other hand, we expected to find correlations between episodic memory and representation in young and older adults, indicating that representation continues to play an important role throughout adulthood. With regard to the regression analyses, we expected that control would be the main predictor of episodic-memory variance in older adults, whereas representation would be the main predictor for younger adults. This is consistent with the idea that factors that are central to memory performance differ between young and older adults, with
control becoming preponderant in old age. Finally, regression analyses conducted on the entire sample were performed in order to examine directly whether representation and/or control mediate age-group-related differences in episodic-memory performance.

**Method**

**Participants**

The sample comprised 120 participants divided into two age groups: 60 young adults aged between 25 and 46 \((M = 34.51, SD = 6.72)\) and 60 older adults aged between 60 and 80 \((M = 71.45, SD = 6.11)\). The proportion of men to women was similar in the two groups (young adults: 29 men and 31 women; older adults: 27 men and 33 women, \(\chi^2(1) = .13, p < .71\)). A significant and classic effect of age was found on educational level, younger adults having completed more years of education \((M = 12.38, SD = 3.66)\) for the young group; \(M = 10.45, SD = 4.04\) for the older group; \((t(1,118)) = 2.45, p < .05\). Due to the age-related differences in education, this variable was partialed out in the statistical analyses. All participants reported themselves to be in good physical and mental health and free from medication known to affect their intellectual abilities. They scored over the cut-off of 128 points on the Dementia Rating Scale (DRS, Mattis, 1976), ensuring that none suffered from dementia. The study was approved by the local ethics committee of the University of Tours, Tours, France, and all participants signed consent forms.

**Materials and Design**

**Episodic-memory task.** Stimulus items consisted of a list of 24 common nouns (e.g., soldier) presented for 5 s on a computer screen. Learning was incidental, as the participants were not informed about the imminent cued-recall test. They were asked to give a pleasant/unpleasant judgment of each word, with the aim of guiding them toward a semantic processing of to-be-remembered information (Craik & Lockart, 1972). They were told that their responses would be used to construct verbal materials for future experiments. The presentation was immediately followed by a 1-min interference task (back counting) to avoid any recency effect. This was followed by a cued-recall test in which only the first three letters of the words were provided (e.g., sol__). Participants were instructed to complete the stems only with a studied word, at their own pace. Each stem was unique. Memory score was the total number of correctly recalled items. After the cued-recall test, participants took the representation and control tests.

**Crystallized-Knowledge Tests (to Measure Representation Abilities)**

Two subtests of the WAIS (Wechsler, 1981) were administered. The vocabulary test consists of 35 words (including three examples), which participants are asked to define (e.g., “What does the word ‘fiction’ mean?”). The score is the sum of correct answers (two points for a complete definition and one point when the definition is incomplete).

The information test consists of 29 questions (including four examples) dealing with general knowledge (e.g., “How many months are there in a year?”). The score is the sum of correct answers (one point for each correct response).

**Executive-Functioning Tests (to Measure Control Abilities)**

The executive measures were two experimental tasks widely used in the neuropsychological literature (Lezak, 1995).

The Wisconsin Card Sorting Test (WCST; Nelson, 1976), modified, is a standardized test which measures set formation and attention shifts. Participants have to sort cards containing multidimensional drawings into different categories (colour, shape, and number of geometric patterns) by deducing the sorting criterion from feedback given by the experimenter (“right” or “wrong”). This test is a goal-oriented task that provides several scores believed to reflect executive functioning. The specific measure retained in our study was the number of perseverative errors, which are the most affected by age (Bryan et al., 1999).

The Initial Letter Fluency Test (ILFT; Stuss & Benson, 1986) in which participants are asked to produce as many words as possible beginning with the letters F, A and S in 1 min for each letter. The score is the total number of correctly produced words in three minutes.

**Results**

The data were analysed in three ways. The first examined the age-group-related effect on episodic-memory, executive, and crystallized-knowledge measures. The second aimed to differentiate representation (crystallized-knowledge measures) from control (executive measures) through factor analysis. Third, correlation and regression analyses were performed to determine which type of ability (representation and/or control) could best explain episodic-memory performance in each age group and mediate age-group-related differences.

**Age-Group Comparisons**

To examine age differences in episodic memory, crystallized knowledge, and executive functioning, \(t\) tests were performed on the cued-recall score, the two crystallized-knowledge measures, and the two executive-functioning measures. The mean scores of each measure are summarised in Table 1, showing that age group had a significant effect on cued recall and executive functioning, which decreased with age.\(^1\) An age-group effect was found on the information score, which increased with age, but not on the vocabulary score.

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\(^1\) Note that we used a younger adult sample aged between 25 and 46 to enhance variability in cognitive measures within this group, at the risk of minimizing age-related differences between young and older groups. Indeed, a recent longitudinal study (Singh-Manoux et al., 2012), indicated that age-related declines in executive skills and episodic memory may occur in the 30s and 40s. Nevertheless, when we split the young adults into two groups of 25–35 and 36–46 years, the age-related differences in cued-recall and executive measures were not significant. Likewise, no age-related differences were observed between the young, old group (60–70 years) and the old, old group (71–80 years).
Table 1

Means and Standard Deviations of Cued-Recall, Crystallized-Knowledge, and Executive Measures

<table>
<thead>
<tr>
<th></th>
<th>Young (n = 60)</th>
<th>Old (n = 60)</th>
<th>t(df = 118)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cued recall</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>t(df = 118)</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>7.98 (1.76)</td>
<td>5.75 (1.46)</td>
<td>7.54***</td>
</tr>
<tr>
<td>Information</td>
<td>55.88 (2.68)</td>
<td>55.20 (2.04)</td>
<td>1.56</td>
</tr>
<tr>
<td>WCST (perseverative errors)</td>
<td>20.95 (1.80)</td>
<td>25.18 (1.53)</td>
<td>-13.82***</td>
</tr>
<tr>
<td>ILFT</td>
<td>4.65 (2.98)</td>
<td>6.26 (5.25)</td>
<td>-2.07</td>
</tr>
<tr>
<td></td>
<td>34.15 (3.87)</td>
<td>29.70 (6.07)</td>
<td>4.78***</td>
</tr>
</tbody>
</table>

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

Factor Analysis

Our aim was to differentiate between crystallized knowledge and executive functioning, reflecting representation and control, and we therefore carried out a principal component analysis on the four variables (vocabulary, information, WCST, ILFT). The extracted factors were rotated using a varimax rotation, allowing independence between factors. Two factors with an eigenvalue greater than one were extracted. The factor-loading matrix is presented in Table 2. The two measures of executive functioning contributed mainly to the first factor, whereas the two crystallized-knowledge measures were mainly loaded on the second factor. This pattern confirms that crystallized-knowledge and executive functioning components can be viewed as independent psychological dimensions, and thus enabled us to interpret the first factor (accounting for 37.44% of the variance) as reflecting control abilities, and the second factor accounting for 30.20% of the variance) as reflecting representation abilities. Two composite z-score indexes were calculated in each age group and for each participant, a control index (CI), corresponding to the average of the standardized z scores on the two executive tests (with WCST z-score errors multiplied by 1), and a representation index (RI), corresponding to the average of the standardized z scores on the two crystallized-knowledge tests, and thus representing the performance of each participant on each of the two factors. A high score indicates a good level of representation and/or control.

Correlation and Regression Analyses

Pearson correlations were used to assess associations between the cued-recall score and crystallized-knowledge measures, executive-functioning measures, the RI, and the CI.

Correlation analyses revealed different patterns of results for young and older participants (see Table 3). In the young group, memory performance was positively correlated with the two crystallized-knowledge measures and with the RI, indicating that individuals with a high level of representation also exhibited high memory performance, whereas memory performance was not significantly related to the executive measures and the CI. In the older group, memory performance was negatively correlated with perseverative errors on the WCST and positively correlated with all other measures, and thus correlated with both control and representation measures and the two indexes. This result suggests that older individuals with a high level of representation and/or control exhibited high memory performance.

To determine whether representation or control constitutes the best predictor of memory performance in young and older adults, stepwise regression analyses using the RI and CI indexes were performed in each age group. In the young group, only the RI proved to be a significant predictor of the variance related to memory performance, accounting for 19% (p < .001). By contrast, the CI was the main significant predictor in the older group, accounting for 19% (p < .001) of the variance, the RI adding a significant 14% (p < .01). Overall, these results confirm that...

Table 2

Loading Extracted from the Factor Analysis

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCST</td>
<td>-.79</td>
<td>-.04</td>
</tr>
<tr>
<td>ILFT</td>
<td>.83</td>
<td>-.07</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.24</td>
<td>.81</td>
</tr>
<tr>
<td>Information</td>
<td>-.34</td>
<td>.73</td>
</tr>
<tr>
<td>% of variance accounted for</td>
<td>37.44</td>
<td>30.20</td>
</tr>
</tbody>
</table>

Table 3

Correlation Between Cued Recall and Crystallized-Knowledge Measures, RI, Executive Measures, and CI

<table>
<thead>
<tr>
<th></th>
<th>Younger (n = 60)</th>
<th>Older (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cued recall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.42***</td>
<td>.34**</td>
</tr>
<tr>
<td>Information</td>
<td>.38**</td>
<td>.26</td>
</tr>
<tr>
<td>RI¹</td>
<td>.44***</td>
<td>.37**</td>
</tr>
<tr>
<td>WCST (perseverative errors)</td>
<td>.03</td>
<td>-.40**</td>
</tr>
<tr>
<td>ILFT</td>
<td>.02</td>
<td>.33**</td>
</tr>
<tr>
<td>CI²</td>
<td>-.03</td>
<td>.43***</td>
</tr>
</tbody>
</table>

Note. We used a younger adult sample aged between 25 and 46 to enhance variability in cognitive measures within this group, at the risk of minimizing age-related differences between young and older groups. Indeed, a recent longitudinal study (Singh-Manoux et al., 2012), indicated that age-related declines in executive skills and episodic memory may occur in the 30s and 40s. Nevertheless, when we split the young adults into two groups of 25–35 and 36–46 years, the age-related differences in cued-recall and executive measures were not significant. Likewise, no age-related differences were observed between the young, old group (60–70 years) and the old, old group (71–80 years).

¹Representation index.  ²Control index.

* p < .05.  ** p < .01.  *** p < .001.
representation is important for younger adults’ memory, whereas both representation and control are significant predictors of the memory performance of older adults. These results remained unchanged in both groups after age and educational level had been controlled for.

Finally, regression analyses were computed to examine whether representation and/or control factors mediate age-related differences in cued recall. To this end, we calculated the age-related variance in cued recall before and after partialing out representation and control factors. To test the significance of the modified proportion of age-related variance, we used the significance test provided by Howell (2006). The statistical control of the representation factor increased the magnitude of the age-related variance by 32.68% ($t(120) = 33.00; p < .001$), thereby making the relationship between age and memory performance more negative. By contrast, partialing out the control factor reduced the magnitude of the age-related variance in cued recall by 31.10% ($t(120) = 64.34; p < .001$), making the relationship between age and memory performance less negative.

Discussion

In this study we examined whether young and older adults present different patterns of relationship between episodic memory and representation on the one hand and between episodic memory and control on the other. According to Craik and Bialystok (2006, 2008), this could explain age-related changes in factors influencing episodic-memory performance. First of all, the results of the factor analysis clearly differentiated two factors, one involving the two crystallized-knowledge measures and the other involving the two executive measures. This finding can be interpreted as reflecting the two psychological components, representation and control. Our data also replicate the classic finding that memory and control are more affected by age than representation (Park & Reuter-Lorenz, 2009). More precisely, our study confirms earlier findings (see Salthouse, 1991) that the age difference is not significant for vocabulary, but is significant for information, showing an increase with advancing age.

Second, with regard to our main objective, the results clearly confirm a different pattern of correlations between episodic memory and control measures in older and younger adults. The correlations were significant for older but not for young adults. However, correlations with representation were significant in both age groups. Regression analyses confirmed this age-related differential pattern by adding that the control index is the primary and greatest predictor of episodic-memory performance for older adults, although the representation index adds a reliable independent contribution. By contrast, this analysis yielded a different pattern in young adults, showing that the sole predictor appeared to be the representation index. The data from correlation and regression analyses also show that none of the significant associations were affected by adjustment for age and educational level in either group. This provides overall converging evidence of independent links between episodic-memory functioning and both representation and control variables. The pattern of findings observed in older adults suggests that the qualitative nature of memory processes may differ from that of younger adults. Finally, regression analysis showed that both representation and control factors modulated the age-group-related differences in episodic-memory variance. These results support the idea put forward by Craik and Bialystok (2006, 2008) that representation and control are key cognitive variables within episodic memory, sustaining cognitive abilities, and explaining cognitive changes across the life span.

Overall, the data confirm the hypothesis of an age-related dissociation between the factors that sustain episodic-memory functioning, raising a number of interesting questions. One concerns the mechanisms whereby representation and control influence memory functioning. The second concerns why memory abilities are not completely sustained by the same processes during early and late adulthood, with episodic memory seeming to rely on the control factor in old age, but not in earlier adulthood. Although further research is required to answer these questions, these issues and their implications for understanding memory functioning in older and young adults are discussed below from the perspective of Craik and Bialystok’s (2006, 2008) framework.

With regard to representation, what is notable in our results is that the role played by this factor in episodic memory appeared to remain roughly stable throughout the adult life span; the correlations between episodic memory and representation were very similar in young and older adults, and this factor explained a significant variance of memory performance in both age groups. These results highlight the interesting point that episodic-memory performance is influenced by the representational system. Mechanisms linking episodic memory and representation can be interpreted through the traditional view that new learning is facilitated when it is congruent with existing schematic knowledge (Bäckman, Small, Wahlin, & Larsson, 2000; Bransford et al., 1979; Craik & Bialystok, 2006, 2008; Newcombe et al., 2011; Salthouse, 2002). Thus, more information in semantic memory increases the opportunities to bind newly learned items to existing schematic knowledge at encoding. In other words, good episodic-memory performance reflects good encoding in terms of the person’s organized schematic knowledge, which is also the basis for the level-of-processing effect (Craik & Lockhart, 1972; Craik & Tulving, 1975). Because there is no age-related decrease in knowledge, correlations with memory could also remain stable throughout adulthood. Our results are not fully in line with those of Hedden et al. (2005), which showed that knowledge plays a greater role in sustaining cued recall in older than in younger adults. However, the two studies differ in the nature of the cued-recall task used, in that the cues in Hedden et al.’s (2005) study were weak associates, whereas in the present study they were the three first letters of the target word. This point suggests that the increasing involvement of representation in cued recall with age may vary, depending on the type of memory process enhanced by different cues; representation is likely to play a greater role when the association between cues and targets is semantically based, providing better environmental support in relation to knowledge, than when this association is based on phonological features. It would be interesting to carry out further research to investigate this hypothesis.

On the other hand, our observation of an age-related increase in representation and that the statistical control of representation increased the magnitude of the age-related variance is consistent with the view that the negative relation between age
and cued recall is attenuated when older age is associated with greater amount of knowledge. As suggested by Salthouse (2002), one possible interpretation of this pattern of result is based on the “migration” hypothesis, which postulates that the age-related effect on memory is reduced among people with high levels of representation because people tend to “migrate” into higher knowledge groups with increasing age. Thus, representation might function as an attenuating factor in the age-memory relationship when it is positively correlated with older age. This is consistent with similar findings observed in other types of cognitive measures (see Salthouse, 2002).

With regard to the role of control, our results are in line with those of Glisky and Kong (2008) on source memory, confirming that this factor is associated with episodic memory more in older than in younger adults. According to Craik and Bialystok (2006, 2008), this suggests that the reduced-memory ability of older adults is probably mainly associated with control processes reflecting difficulty accessing stored information about items and/or aspects of source. This view is supported by observations that the most common memory complaint of older adults is their difficulty in recalling names and words that are specific labels, although this information has not been lost in memory as it can be retrieved later, either spontaneously or with better cues (Cohen & Burke, 1993).

To explain the influential role of control on memory, we can refer to the view put forward by numerous authors, that executive functions serve to carry out higher order memory strategies to sustain episodic memory (Moscovitch & Winocur, 1992; Shimamura, 1995). These processes can be viewed as supporting the generation of memory-strategy processes, such as focusing and maintaining attention on abstract representations, to generate sequences of complex memory goals, implement deep encoding processes, or implement appropriate retrieval processes related to encoding orientation, to facilitate access to stored information (Bouazzaoui et al., 2010; Bryan et al., 1999; Taconnat et al., 2006; Taconnat et al., 2007; Taconnat et al., 2009). Given that executive functioning is mainly sustained by the PFC, the stronger relationship between executive functions and episodic-memory measures found in older adults may also help explain recent functional imaging findings showing age-related differences in the use of the PFC, with greater activation in older than young adults (Cabeza, 2002; Dennis & Cabeza, 2008). As PFC sustains executive functioning, this additional PFC recruitment in older adults may reflect greater use of executive functions to compensate for age-related, reduced-cognitive activity (Park & Reuter-Lorenz, 2009). The fact that executive functioning and episodic memory were only correlated in older adults suggests that this support is needed mainly in old age.

The influence of control in old age was confirmed by regression analysis, which showed a moderate but significant decrease in the age-related variance in cued recall when the control factor was controlled for. This result supports a moderation interpretation, indicating that older adults with a high level of control exhibit smaller age-related declines in cued-recall performance than those with a low level of control. This suggests that the greater resort of older adults to control processes may serve as a compensatory process to limit age-related memory difficulties. Thus, despite the age-related decrease in control, older adults are more likely to rely on control processes than younger adults under similar memory-task conditions. It should be noted that these results are not entirely consistent with findings of an age-related decline in recollection processes, which are classically associated with control (Jacoby, 1999; Jennings & Jacoby, 1997). This suggests that the correlation between memory and control would be greater in younger than in older adults. By contrast, our results show that, despite an age-related decrease in control, this factor affects the memory performance of older more than younger adults, suggesting a specific interplay between decrease and use of control processes with advancing age. Although control declines with advancing age, it seems to be needed more to aid memory performance, particularly when encoding and retrieval are somewhat effortful.

A final point to consider concerns the observation that episodic memory in young adults does not rely on executive functioning. This may seem surprising, and at first sight, suggests a structural difference between young and older adults. Alternatively, executive functions can be seen as memory-support processes enabling optimum performance when there are insufficient memory resources, as for example in the case of normal aging, or due to the level of task difficulty. In our study, the absence of relationship between control and memory in the younger group may reflect the fact that we used a memory task that limited the role of strategic and executive control because encoding was incidental and sustained by a semantically oriented task (judgment of agreement), and was followed by cued-recall retrieval. It could thus be supposed that if encoding and retrieval conditions were more open to strategy, then control would also become important for younger adults. A similar observation could be made about the effortful level of tests used to assess control. However, in line with our hypothesis of a differential pattern between younger and older adults, more stringent conditions could make control even more salient in older adults. Thus, although the young adults did not rely on executive functions to perform our memory task, they could call on them when carrying out particularly demanding memory tasks, such as for example a free-recall task. It would be interesting to carry out further research to investigate whether the pattern of the relationship between executive functioning and episodic-memory tasks varies with the level of task difficulty in young and older adults, for example using memory tasks differing in their dependence on strategic control at encoding and retrieval.

Résumé
Craik et Bialystok (2006, 2008) suggèrent que l’étude des modifications des connaissances et des processus de contrôle tout au long de la vie pourraient permettre de comprendre les changements cognitifs liés à l’âge. L’objectif de cette étude est d’explorer l’hypothèse selon laquelle les connaissances cristallisées et les processus de contrôle seraient différemment impliqués dans la performance de mémoire épisodique chez les adultes jeunes et âgés. Des adultes jeunes et âgés ont été soumis à une tâche de rappel indiqué ainsi qu’à des tests d’intelligence cristallisée et de fonctions exécutives afin de mesurer respectivement leur niveau de connaissance et de contrôle. Les résultats reproduisent les données classiques selon lesquelles le contrôle exécutif et le rappel indiqué diminuent avec l’âge alors que les connaissances cristallisées se maintiennent. Une analyse factorielle a confirmé l’indépendance de ces deux facteurs. Des analyses de corrélation ont montré que la performance mnésique des jeunes adultes est corréllée avec les mesures de connaissances
References


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