

# The Associative Memory Deficit of Older Adults: Further Support Using Face–Name Associations

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Previous studies have established an associative deficit hypothesis (Naveh-Benjamin, 2000), which attributes part of older adults' deficient episodic memory performance to their difficulty in creating cohesive episodes. In this article, the authors further evaluate this hypothesis, using ecologically relevant materials. Young and old participants studied name–face pairs and were then tested on their recognition memory for the names, faces, and the name–face pairs. The results extend the conditions under which older adults exhibit an associative deficit. They also show that reduced attentional resources are not the sole mediator of this deficit.

Studies show that memory abilities decline in old age (e.g., Craik & Jennings, 1992; Salthouse, 1991). This decline, however, seems to be differential, characterizing only some memory functions, with episodic memory being particularly vulnerable to the effects of age (e.g., Craik, 1999; Light, 1991). Past research has tried to explain the mechanisms underlying the age-related decline in episodic memory, and several hypotheses have been advanced to explain this decline in memory performance in old age (see Light, 1991, for a review).

Recently, Chalfonte and Johnson (1996) and Mitchell, Johnson, Raye, Mather, and D'Esposito (2000) suggested a binding deficit hypothesis, showing that older adults have a particular deficit in memory that requires the binding of information to contextual elements. Naveh-Benjamin (2000) extended this suggestion and proposed an associative deficit hypothesis (ADH), which focuses on the distinction between memory for single units and memory for the associations between these units. The ADH claims that older adults' deficiency in creating and retrieving links between single units of information is one of the main factors that leads to poorer episodic memory. The degree to which a given memory

task requires the creation or use of such associations is a significant determinant of old people's memory performance.

Naveh-Benjamin (2000) used procedures that allow the independent assessment of memory for component and for associative information (Humphreys, 1976; see the Methods section). The results of four studies provided support for the ADH by showing that older adults exhibit an associative deficit for different types of relationships, including interitem (word–word or nonword–word), as well as intraitem ones (a word and the font in which it was presented). Naveh-Benjamin, Hussain, Guez, and Bar-On (2003) have recently replicated some of these results by using item and associative recognition tests. In the Naveh-Benjamin et al. (2003) study, older adults were shown to be particularly deficient in memory tests that require associations. In addition, older adults showed an associative deficit even when pictures, which usually are remembered well by older adults, are used. Finally, the results of that study supported a prediction made by an ADH, namely, that older adults will show less of an associative deficit when the components of the episodes used are already connected in memory, facilitating their encoding and retrieval.

Our study is intended to replicate and further extend the tests of the ADH. First, we wanted to determine whether older adults show an associative deficit when the materials used include more complex and meaningful information with higher ecological validity than the word–nonword pairs and the word–font pairs used in our previous research. In particular, we used name–face associations, which resemble everyday situations where people meet and are introduced to each other. Anecdotal evidence (e.g., Cohen & Faulkner, 1984) indicates that a major complaint of older adults is their inability to recall the appropriate name of a familiar face they have seen in the past. Although controlled research also shows the performance of older adults to be inferior to that of young people in name recall (i.e., Cohen & Burke, 1993; Crook, Larrabee, & Youngjohn, 1993; Evrard, 2002; Maylor, 1997), there is some debate in the literature on whether older adults have a special

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deficit in remembering proper names. Some researchers (e.g., Maylor, 1997) suggest that the deficit that older adults show in proper name recall is not qualitatively different from their deficit in recalling common names. This deficit may stem from either the unique difficulty of this task for young people, too, or from the fewer acceptable alternatives relative to common names in case of a failure in this task (i.e., Maylor, 1997). One task used in research on memory for names is a cued-recall task. Participants are shown a series of faces labeled with proper names, and later in the procedure they are presented with the original faces and asked to give the particular name that appeared with each face (e.g., Crook et al., 1993; Evrard, 2002). However, such a task does not definitely tell us whether the deficit that older adults show stems from their poorer memory for the components (i.e., the face or name); there are indications that recognition memory for faces declines in late life, e.g., see Bartlett, Leslie, Tubbs, & Fulton, 1989; Crook & Larrabee, 1992; Smith & Winograd, 1978) or from their difficulty in accessing the appropriate name given a face in a cued-recall-type task.

By using the associative deficit framework, our working hypothesis suggests a third possibility; namely, that remembering the name of a given face involves, in considerable part, binding a specific name to a specific face. We wanted to see whether the complaints of older adults about name forgetting may be because of their inability to encode and retrieve associative information, which binds the name and the face together, rather than a deficit in remembering the name or the face, *per se*. To minimize any accessibility problems that older adults may face, we used recognition memory procedures. We presented participants with name-face pairs and then gave them separate recognition tests on the names, the faces, and the associations between the two.

The second purpose of our research was to test whether reduction in attentional resources, which is another suggested underlying cause of older adults' decline in episodic memory, may be a mediating factor in the associative deficit of older adults (e.g., Craik, 1983; Craik & Byrd, 1982; Rabinowitz, Craik, & Ackerman, 1982). To test this suggestion, the reported experiment used a group of younger adults under divided attention (DA) conditions, in addition to younger and older adults groups under full attention (FA) conditions. Testing younger adults under DA conditions presumably reduces their attentional capacity as some of their resources are directed to the secondary task. If the associative deficit shown in older adults is mediated by a decline in attentional resources, then we would expect younger adults under DA to show the same associative deficit as predicted for older adults. The results of our recent research (Naveh-Benjamin et al., 2003) were not in line with this prediction, and we wanted to assess whether this pattern of results would be replicated in the context of the name-face memory task. A perceptual-motor secondary task was used, which involves a continuous auditory three-choice reaction time (CRT). This secondary task was presented to a young-DA group during encoding of the name-face pairs.

Finally, to increase the generalizability of the reported results by Naveh-Benjamin (2000), which used a yes-no recognition-test format, we have opted for a different type of recognition test and used a forced-choice format. Our aim was to see whether the associative deficit shown by older adults would be evident when another type of test is used.

## Method

### Participants

Participants were 52 younger and 26 older adults. The younger participants were undergraduate students at the University of Missouri, Columbia, who participated in the experiment as part of their course requirements. Half of the students were randomly assigned to each of the attention conditions. The older participants were residents of Columbia, MO, who lived independently in the community. The mean age of the younger group was 20.6 ( $SD = 1.3$ ) and the mean age of the older group was 72.3 ( $SD = 4.9$ ). The mean number of years of formal education was 14.3 for the young ( $SD = 1.2$ ) and 14.5 for the old ( $SD = 1.5$ ),  $t(76) = 0.42$ , *ns*. All of the older adults in this experiment reported being in good health and having good hearing and vision.

### Design and Materials

Two independent variables were used: between-subjects group (young FA, old, young DA) and within-subjects test (components vs. associations). Study stimuli were 2 sets of 40 name-face pairs. The names (first and last; half of the names were masculine names and the other half were feminine names) were sampled randomly from a phone directory. The faces were chosen from yearbooks on the Internet with half of the faces belonging to young adults (ages 18–25) and half to older adults (ages 65–80). In addition, half of the faces belonged to women and half belonged to men. For each set, 2 versions of 40 name-face pairings were created (with the constraint that a face and a name were matched for gender), where a given display contained a face that appeared at the top with the name below it. Two random orders were created for each of these pairings for a total of 4 versions; 6 participants in each group were run in each version. The order of the sets was counterbalanced for each group.

### Procedure

Participants, who were tested individually, saw 40 name-face pairs on a computer monitor one at a time at a rate of 3 s per pair. Study conditions were intentional, and participants were told that they must pay attention not only to each face and name, but also to the name-face pairs, because their memory for the name, the face, and their pairings would be tested. Young participants in the DA group performed a secondary task during the study phase of the two sets. This secondary task was a continuous CRT task that involved a sequential presentation of auditory tones by the computer, presented one at a time, and a manual response on a computer keyboard to each tone. One of three tones (all of which differed from each other in frequency) was presented at random, and the participants' task was to press a predesignated corresponding key on the keyboard. A response caused the immediate presentation of one of the other two tones at random. Before the study phase of each set, the participants in the DA group were told to pay equal attention to memorizing the faces and names and performing the secondary auditory tones task. Participants in the DA group also performed the secondary CRT task alone in between the two memory sets.

For each set, after an interpolated activity of 90 s, the three memory tests (two for the components and one for their associations, which are described in the next three sections) were administered to all participants. The order of the tests was counterbalanced across all participants in each group, and any given name or face appeared on only one of the tests. All tests in this experiment were self-paced; that is, a response to one item made the next one appear.

*Forced-Choice Name Recognition test.* In the Forced-Choice Name Recognition test, participants saw 16 original target names, one at a time, each paired with a distractor name that had the same characteristics as the target word, except that it had not appeared in the study phase. Participants were asked to indicate for each test pair which of the names had appeared in the study phase.

**Forced-Choice Face Recognition test.** In the Forced-Choice Face Recognition test, participants saw 16 original target faces, one at a time, each paired with a distractor face that had the same characteristics as the target face, except that it had not appeared in the study phase. Participants were asked to indicate for each test pair which of the faces had appeared in the study phase.

**Forced-Choice Associative Recognition test.** In the Forced-Choice Associative Recognition test, on each presentation, participants saw one of two displays. In one display, two faces and a name were presented, and the task was to decide which of the two faces had appeared with the name; in the other display, two names and a face were presented, and the participants' task was to decide which of the names had appeared with the face. Participants saw eight presentations of each type, and all of the names and faces in this test had appeared during the study phase. The two faces or the two names in each display were matched for age and gender. In addition, the names in a given display were matched with the faces for gender. These matchings were done to eliminate the possibility of participants using mismatches to help them make a decision. Participants were told that all components had appeared in the study phase and that their task was to choose the appropriate pairing on each trial. Prior to the study session, all participants received a practice session on all of the relevant tasks.

## Results

### Memory Performance

We calculated for each participant the proportion of correct responses in each of the tests and averaged across each group. The three tests used were of comparable discriminating power (see standard errors in Figure 1), allowing their direct comparison as levels of the test independent variable. Chance-level performance on all tests was .50.

To specifically address the hypotheses tested in this experiment, several separate  $2 \times 3$  (group)  $\times$  3 (test) analyses of variance (ANOVAs) were computed on the memory measure. The .05 level of significance was used to interpret all of the statistical comparisons.

Figure 1 presents results of memory performance on the different tests for the three groups. To test an ADH for older adults, we performed a  $2 \times 3$  (young FA vs. old FA)  $\times$  test (face recognition, name recognition, and name-face associative recognition) ANOVA. The results showed a significant effect of group,  $F(1, 50) = 8.99$ ,  $MSE = 0.02$ , where the young group under the full attention condition ( $M = 0.81$ ) performed better than the old group ( $M = 0.74$ ) under the same condition. The effect of test was also significant,  $F(2, 100) = 96.29$ ,  $MSE = 0.01$ , with performance on the face test ( $M = 0.90$ ) being better than that on the name test ( $M = 0.79$ ),  $F(1, 50) = 44.77$ ,  $MSE = 0.01$ , and on the face-name associative test ( $M = 0.65$ ),  $F(1, 50) = 177.57$ ,  $MSE = 0.01$ . Performance on the name test was also better than the performance on the face-name associative test,  $F(1, 50) = 54.87$ ,  $MSE = 0.01$ .

It is more important to note that the interaction of the two variables was significant,  $F(2, 100) = 5.01$ ,  $MSE = 0.01$ . Follow-up interaction comparisons showed the interaction between age and the name and the association tests to be significant,  $F(1, 50) = 8.16$ ,  $MSE = 0.01$ , reflecting that older adults performed differentially poorer on the association test (.71 and .58 for young and old, respectively),  $F(1, 50) = 15.34$ ,  $p < .01$ ,  $MSE = 0.01$ , but not on the name test (.80 and .78 for young and old adults, respectively),  $F(1, 50) = 0.30$ ,  $ns$ ,  $MSE = 0.01$ . In addition, the follow-up interaction between age and the face and the asso-

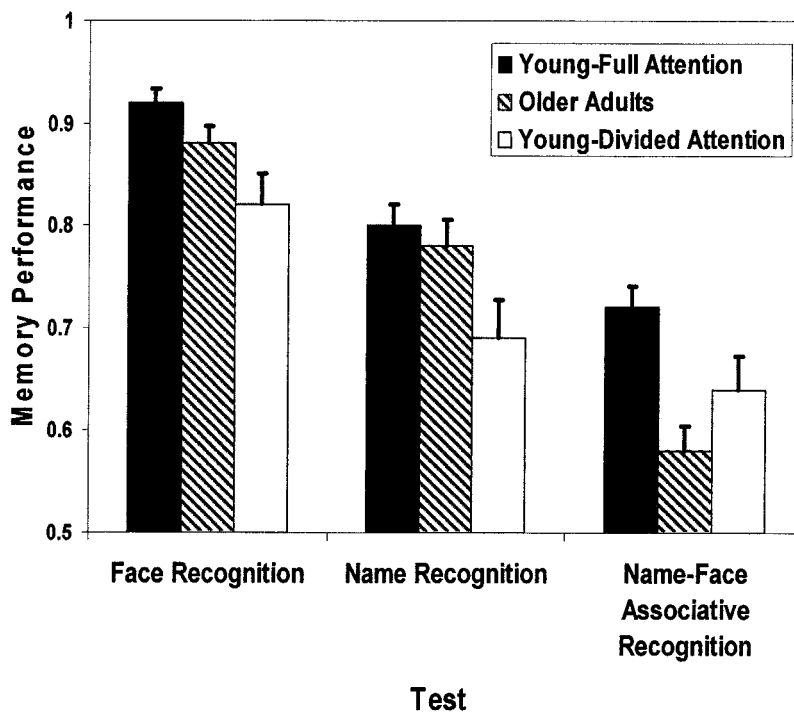


Figure 1. Memory performance (+SEs) in the face, name, and name-face associative recognition tests for younger adults under full- and divided-attention conditions and for older participants.

ciation tests was also significant,  $F(1, 50) = 4.72$ ,  $MSE = 0.01$ , reflecting that older adults performed differentially poorer on the association test (.71 and .58 for young and old adults, respectively),  $F(1, 50) = 15.34$ ,  $p < .01$ ,  $MSE = 0.01$ , than on the face test (.92 and .88 for young and old adults, respectively),  $F(1, 50) = 4.51$ ,  $p < .05$ ,  $MSE = 0.01$ .

Because there were small differences between the younger and the older adults groups on remembering each of the components (which were significant for face recognition), and because remembering associations may rely, at least partially, on remembering both components, we wanted to rule out the possibility that the obtained age differences in associative information were a result of older adults having a poor memory for the component information. Therefore, we took a sample of 14 younger adults under full attention and 14 older adults whose memory for the components was comparable (for face, young = .89 and old = .90; for names, young = .81 and old = .83) and looked at their memory for associative information. If memory for associations relies on memory for the components, then we should expect little or no associative deficit for these older adults. The results, however, showed the same pattern of associative deficit in these older adults as in the entire sample with younger adults performing much better than older ones (young = .75 and old = .62). A two-way ANOVA conducted for this sample showed a significant interaction of age and test,  $F(2, 52) = 7.55$ ,  $p < .01$ ,  $MSE = 0.01$ , reducing the possibility that the associative deficit of older adults shown in this experiment was a result of poorer memory for components.<sup>1</sup>

To test an ADH for young adults under DA conditions, a  $2 \times 3$  ANOVA was computed with group (young FA and young DA)  $\times$  test (face recognition, name recognition, and name–face associative recognition). The results indicated a significant effect of attention,  $F(1, 50) = 16.22$ ,  $MSE = 0.02$ , where the young adults performed better under FA (.81) than under DA (.72). The effect of test was also significant,  $F(2, 100) = 28.08$ ,  $MSE = 0.02$ , with performance on the face test ( $M = 0.87$ ) being better than on the name test ( $M = 0.75$ ),  $F(1, 50) = 25.10$ ,  $MSE = 0.02$ , and on the face–name associative test ( $M = 0.67$ ),  $F(1, 50) = 56.82$ ,  $MSE = 0.02$ . Performance on the name test was also better than on the face–name associative test,  $F(1, 50) = 6.74$ ,  $MSE = 0.02$ . It is more important to note that the interaction of the two variables was not significant,  $F(2, 100) = 0.09$ ,  $MSE = 0.02$ ,  $p > .10$ , reflecting an equally significant decline in performance from the full attention to the DA conditions on the face test ( $M_s = 0.92$  and  $0.83$ , for young FA and young DA, respectively),  $F(1, 50) = 7.81$ ,  $MSE = 0.02$ , on the name test ( $M_s = 0.80$  and  $0.70$ , for young FA and young DA, respectively),  $F(1, 50) = 5.54$ ,  $MSE = 0.02$ , and on the name–face association test ( $M_s = 0.71$  and  $0.63$ , for young FA and young DA, respectively),  $F(1, 50) = 4.25$ ,  $MSE = 0.02$ .

Finally, when performance of young adults under DA was compared to that of older adults on the face recognition, name recognition, and face–name recognition tests, the  $2 \times 3$  ANOVA yielded no significant effect of group,  $F(1, 50) = 1.10$ ,  $MSE = 0.03$ , with the young-DA group (.72) performing as well as the older adults group (.74). The effect of test was significant,  $F(2, 100) = 39.59$ ,  $MSE = 0.02$ , with performance on the face test ( $M = 0.85$ ) being significantly better than on the name test ( $M = 0.74$ ),  $F(1, 50) = 19.30$ ,  $MSE = 0.02$ , and on the face–name associative test ( $M = 0.61$ ),  $F(1, 50) = 81.70$ ,  $MSE = 0.02$ . Performance on the name test was also significantly better than on

the face–name associative test,  $F(1, 50) = 19.77$ ,  $MSE = 0.02$ . It is interesting to note that the effect of the interaction was significant,  $F(2, 100) = 3.22$ ,  $MSE = 0.02$ . This interaction reflects that whereas older adults performed better than the young DA in the component tests (face and name combined;  $M_s = 0.83$  and  $0.76$ , for older adults and young-DA adults, respectively),  $F(1, 50) = 4.12$ ,  $p < .05$ ,  $MSE = 0.03$ , the pattern was reversed in the face–name associative test where older adults performed poorer than the young-DA adults ( $M_s = 0.58$  and  $0.63$ , for older adults and young-DA adults, respectively), although the effect did not reach statistical significance,  $F(1, 50) = 1.52$ ,  $p = .21$ ,  $MSE = 0.02$ .

Performance in each combination of group and test was significantly better than chance level (.50). In addition, performance of the young adults under full attention in all recognition tests was significantly less than 1.00.

Given that the overall performance of the young and older adults under FA, as well as the younger adults under DA conditions, differed significantly (with the young-FA group performing at a higher level than the other two groups), we also analyzed the results reported in this article by using scaled scores (Salthouse, 1991). To obtain the standardized scores, we have calculated for each participant in the older adults group and in the young-DA group a score for each of the tests, reflecting performance scaled in pooled standard deviation units of the performance in the young group under the full attention condition (see Naveh-Benjamin & Craik, 1998, for a relevant discussion). Results using scaled scores, which appear in Table 1, showed the same patterns as those obtained for the absolute scores.

### Secondary Task Performance

Response times were calculated for the performance of younger adults under DA on the continuous auditory CRT task. A  $t$  test on response time showed that responses were faster on the baseline condition ( $M = 598$  ms,  $SD = 120$  ms) than on the DA condition ( $M = 874$  ms,  $SD = 267$  ms),  $t(25) = 7.05$ ,  $p < .05$ . These results validate our choice of secondary task by showing that the encoding of information about the pairs that were presented required attentional resources diverted from the secondary task.

### Discussion

The results reported in this article lend further empirical support to an ADH, and at the same time they clarify the role of attention in this deficit. These results demonstrate that rather than a generalized decrement in memory, older adults showed specific deficits in memory for associative information. The results of the experiment indicate that the associative deficit of older adults is not limited to simple word–word or word–context associations as shown in previous studies (see Naveh-Benjamin, 2000, 2002; Naveh-Benjamin et al., 2003). In this experiment, the episodes–events consisted of higher order meaningful units, such as face–name associations, which are commonly encountered aspects of everyday cognition.

The deficit seen in associative recognition versus item recognition tasks also cannot be accounted for by differences in the

<sup>1</sup> This idea was suggested to us by Karen J. Mitchell.

Table 1  
*Means and Standard Deviations of Scaled Scores for the Older Adults Group and the Young-DA Group in Pooled Standard Deviation Units of the Performance in the Young-Full Attention Group in the Different Tests of the Experiment*

Group	Recognition test					
	Faces		Names		Face-Name associations	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Older adults	-0.44	0.81	-0.12	0.93	-0.97	0.96
Young-DA	-0.90	1.49	-0.70	1.33	-0.58	1.22

Note. DA = divided attention.

response mode in the two tests; older adults show this deficit when either a yes-no (Naveh-Benjamin, 2000) or a forced-choice (the current experiment) procedure is used.

The results of the reported experiment are also interesting for other reasons. First, older adults showed a deficit, albeit small, in recognizing faces. This is in line with some reports in the literature that suggest that age is associated with a decline in face memory (e.g., Crook & Larrabee, 1992; Smith & Winograd, 1978). Second, considering the social importance of recognizing other people's names, the results of the experiment are encouraging in the demonstration of situations under which older adults do recognize names as well as young adults. This result seems to differ from studies that reported age-related changes in memory for proper names, as well as anecdotal complaints of older adults about the problems they encounter in the retrieval of proper names (e.g., Burke, MacKay, Worthley, & Wade, 1991; Cohen & Burke, 1993; Cohen & Faulkner, 1986; Evrard, 2002; James, 1997). However, much of the research showing age-related decline in memory for proper names has used free- or cued-recall tasks, where there are relatively few cues providing environmental support for retrieving the names, and where participants have to self-initiate the retrieval of these names ( Craik, 1983, 1986). The use of a recognition paradigm in our experiment provided older participants with the needed cues and environmental support, which raised their performance to the level of young participants.

Despite the good ability of older adults to recognize names and their relatively mild decline in recognizing faces, the results show that recognizing the associations between names and faces—that is, the ability to attach an appropriate name to an encountered face—declines appreciably in old age. This decline was observed despite the use of an associative task involving a recognition procedure, such that all of the information is provided to the participants and no independent recall is required.

We have also tested a group of younger adults under DA during encoding and found that in contrast to the effects of age, DA appears to similarly interrupt memory for both the episode's components and their association to each other. The different patterns of performance demonstrated in older adults and younger adults under DA conditions, despite the similar overall level of performance in the two groups, indicate the specificity of the older adults' deficit. In particular, aging seemed to especially disrupt the associative mechanism, whereas reduced attention at encoding in

younger adults was related to a general decline in memory performance. These results set boundary conditions on the proposal that the associative deficit of older adults is due to a special reliance on attentional resources during the encoding of associative information.

The performance costs imposed both on the primary task (as shown by poorer memory) and the secondary one (i.e., longer response times) confirmed that attention was effectively divided between the two. Note, however, that a recent study by Castel and Craik (2003), using the odd-digit secondary task in a word-pair study paradigm and with a somewhat different testing paradigm than the one used in our study, showed poorer performance of younger adults under DA in associative rather than in item memory, although this differential decline was smaller than the one shown by older adults.

One way to resolve the conflict between the sets of results on age-related changes and on the effects of DA in young adults is by suggesting that both common and distinct factors related to memory performance are at play in these two groups. Depleted attentional resources, which lead to information being encoded less distinctively and more schematically, which in turn results in poorer memory for item information, may be a mechanism that operates both in older adults and in younger adults under DA at encoding. The results reported here, as well as in previous studies (Craik, 1983, 1986; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003), showing both age and DA to have a clear detrimental effect on memory for item information, support this suggestion. Older adults, but not younger adults under DA conditions, show an additional unique associative deficit, which further affects their memory performance whenever explicit episodic memory is involved. Such a suggestion is consistent with recent neuroimaging evidence, which shows that age may affect the medial temporal/hippocampal (MTL/H) activity known to mediate mechanisms in the merging of different components of an episode into a cohesive unit, in addition to its effects on prefrontal regions. In contrast, DA at encoding results mostly in decreased brain activation in prefrontal areas (see Naveh-Benjamin et al., 2003, and Naveh-Benjamin, Guez, & Marom, 2003, for details).

In summary, the current study lends further support to an ADH, suggesting that older adults are especially deficient in memory tasks that require the merging of different aspects of an episode into a cohesive unit. This study indicates that the associative deficit appears when materials high in ecological validity, like name-face pairs, are used, increasing the external validity of the hypothesis. It also shows that the associative deficit of older adults does not depend on the format of the recognition test used. Furthermore, this study indicates that a deficit in attentional resources does not seem to be the sole mediator of the associative deficit shown by older adults.

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