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The effect of semantic orientation at encoding on free-recall performance in amnestic mild cognitive impairment and probable Alzheimer's disease

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The present study manipulated the nature of orientation provided at encoding in an intentional word memory task. Performance on the memory task was then compared between 23 elderly persons with amnestic mild cognitive impairment (aMCI), 13 patients with probable Alzheimer's disease (AD), and 23 healthy elderly persons. When tested following shallow (reading orientation) encoding, free-recall performance was impaired in AD compared to aMCI and healthy older adults. When tested following deep (categorical semantic orientation) encoding, both AD and aMCI groups were impaired relative to healthy older adults. The latter result was related to larger memory improvement due to semantic orientation in healthy controls than in aMCI and AD participants. Overall, these findings indicate that the encoding put up by aMCI and healthy elderly persons is comparably efficient in situations where shallow supportive cues are provided at encoding, but that healthy controls benefit more than aMCI and AD in situations where supportive cues are strong.

Keywords: Amnestic mild cognitive impairment; Alzheimer's disease; Aging; Episodic memory; Deep encoding; Semantic orientation.

Increasing the depth of information processing during the study phase of an episodic memory task is typically associated with better memory recall (Craik & Lockhart, 1972). However, several studies have shown that persons suffering from Alzheimer's disease (AD) do not improve their recall as much as healthy older adults when encoding favors the use of semantic information (Bäckman & Small, 1998; Bird & Luszcz, 1990; Dalla Barba & Goldblum, 1996; Goldblum et al., 1998; Herlitz, Adolfsson, Bäckman, & Nilsson, 1991; Herlitz & Viitanen, 1991). Moreover, the difficulty of patients with AD to benefit from cognitive support at encoding is accentuated as the severity of AD increases (Herlitz et al., 1991; for similar results, see Tounsi et al., 1999).

An important question is the extent to which older adults being in the preclinical phase of AD can improve their memory performance when cognitive support is provided during the study phase. Bäckman and Small (1998) have addressed this issue by investigating older adults with "incident AD." These persons were not demented at Time 1, but developed AD at Time 2 (three years later). The study used an intentional memory encoding paradigm. While persons with incident AD showed worse general performance than normal

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older adults at Time 1, their free-recall performance nevertheless benefited from semantic organization of the information at encoding; the magnitude of the benefit appeared comparable between incident AD cases and normal older adults. In contrast, Froger and collaborators (Froger, Taconnat, Landre, Beigneux, & Isingrini, 2009) reported that the benefit from deep (semantic) encoding in amnestic mild cognitive impairment (aMCI) was as important as that in control participants when tested using a recognition procedure, but reduced when tested with free recall. In the latter study, deep encoding was induced using an incidental paradigm where participants were asked to tell whether words represented a concrete or an abstract concept.

Overall, previous results suggest that memory performance of persons at risk of developing AD can gain from deep encoding when support is provided at retrieval (e.g., using a recognition procedure). However, in the absence of support at retrieval (i.e., free recall), previous findings are inconsistent. The discrepancy could first be accounted for by differences in the criteria used to define persons at risk of developing dementia as impairment was found in persons meeting criteria for aMCI, but not in those with incipient dementia. Alternatively, the inconsistency could depend on differences regarding learning conditions, as impairment was found with intentional, but not with incidental, learning. When words are encoded under incidental conditions, during the study phase participants are not aware that their memory will be tested later. For example, during the encoding phase, subjects might be asked to provide a semantic (e.g., category exemplar) or preference (e.g., like vs. dislike) judgment on series or words and then can be asked to retrieve those words in a subsequent "surprise" test. In this case, participants probably do not deploy conscious and elaborated encoding strategies. Therefore, it is possible that the performance of healthy controls does not reach optimal level when tested in incidental conditions, and this would prevent one from finding impairment in aMCI. Conversely, under intentional learning, participants are told explicitly that they will have to recall subsequently the items they are presented with. Therefore, individuals performing an intentional memory task have the opportunity to set up and manage encoding strategies in order to support future retrieval performance. These strategies can be most helpful in situations where no contextual or cognitive support is provided at retrieval (as in a typical free-recall task). Thus, one may assume that in intentional memory tasks, semantic encoding might be more beneficial in healthy older adults than in elderly persons with memory problems (e.g., older adults with aMCI or AD) and that this may support the finding of a difference between the two groups.

To our knowledge, no study as yet has investigated whether free-recall performance of elderly persons with aMCI can benefit from semantic orientation at encoding using an intentional memory task. Such an investigation is necessary in order to better understand the source of the episodic memory impairment in aMCI. It might also shed light on the discrepancy between previous studies regarding the effect of semantic orientation at encoding in persons at risk of developing AD. The principal objective of the present study was to examine free-recall performance of persons with aMCI following two intentional encoding conditions: shallow (read orientation) versus deep (semantic category orientation). Another objective was to compare aMCI and AD participants regarding their ability to benefit from semantic orientation at encoding. Since several persons with aMCI are actually in a preclinical phase of AD, direct comparison of these groups is important in order to understand better the progression of the memory deficits in Alzheimer's pathology. Quantitatively, there should be a continuum between groups regarding the numbers of words retrieved, with the control and AD groups recalling the highest and lowest numbers of words, respectively. As for the comparisons between orientation conditions, it is expected that all groups will benefit from semantic orientation compared to the reading condition. However, the magnitude of the benefit should be larger in healthy controls than in persons with aMCI or AD. When they know that their memory will be tested (i.e., intentional learning), healthy older adults would make better use of memory cues that are provided to them than would persons with aMCI or AD. As a result, group differences should be larger in the semantic orientation condition than in the reading condition.

METHOD

Participants

Participants in this study included 23 older adults with aMCI, 13 patients with probable AD, and 23 healthy older adults (control group). Older adults with aMCI or AD were recruited from consecutively encountered patients in memory clinics. Healthy older adults were volunteers recruited from the community through advertisements.

The diagnosis of aMCI or AD was clinical and was done by experienced clinicians (neurologists or geriatrician) who were not informed of the patients' scores on the experimental task. Persons in the *aMCI group* met the criteria for single-domain aMCI ($n = 4$) or multiple-domain aMCI ($n = 19$), as proposed by Petersen (2004). According to the actual conception of aMCI, the most likely cause of both single- and multiple-domain aMCI is incipient AD (Gauthier et al., 2006). By definition, while the cognitive impairment of persons with single-domain aMCI is restricted to episodic memory, in multiple-domain aMCI episodic memory is also affected but impairment in at least one other cognitive domain is present. The nonepisodic memory deficits in multiple-domain aMCI can affect executive functions, semantic memory, and language capabilities (Joubert et al., 2008; Kramer et al., 2006; Seidenberg et al., 2009), but in the present sample, most multiple-domain aMCI participants showed impairment in executive functions (Stroop performance) and information-processing speed (Digit Symbol performance) in addition to memory. Along with Petersen's (2004) criteria, in this study all participants of

the aMCI group had a memory complaint, which was preferably corroborated by an informant, and impaired performance (more than 1.5 standard deviations below expected performance based on normative data) on any of the memory tests used in the neuropsychological battery (see below for the description of the battery). Moreover, none of the aMCI participants had a significant decrease of functional autonomy, and none had dementia on the basis of the clinical assessment.

Patients in the *AD group* met the criteria of the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984) for probable AD and the *DSM–IV* (*Diagnostic and Statistical Manual of Mental Disorders–Fourth* Edition; American Psychiatric Association, 1994) clinical criteria for dementia of the Alzheimer type. Participants were included in the AD group if the severity of their dementia was mild ($n = 7$; score $\geq$24 on the Mini-Mental State Examination, MMSE), or mild to moderate ($n = 6$; score between 17 and 23 on the MMSE).

Healthy older adults of the *control group* reported good physical and mental health, and they showed normal cognitive functioning—that is, they all scored above the cut-off of –1.5 standard deviations on standardized neuropsychological tests (see below).

All participants were administered a comprehensive battery of clinical and neuropsychological tests (performance of the groups reported in Table 1). The battery included measures of depressive symptoms (5-item version of the Geriatric Depression Scale, GDS; Hoyl et al., 1999), instrumental activities of daily living (Functional Autonomy Measurement System, SMAF; Hébert, Guilbault, Desrosiers, & Dubuc, 2001), general cognitive status (MMSE; Folstein, Folstein, & McHugh, 1975), executive functions (Stroop–Victoria; Regard, 1981), information-processing speed (Digit Symbol; Wechsler, 1997), visuoconstructive abilities (Copy of the Rey Complex Figure; Rey, 1960), visual perception (Judgment of Line Orientation; Benton, Hamsher, Varney, & Spreen, 1983), naming (15-item Boston Naming Test; Calero, Arnedo, Navarro, Ruiz-Pedrosa, & Carnero, 2002), and episodic memory (Batterie d'Efficience Mnésique, BEM-144, and Rappel Libre/Rappel Indicé à 16 Items, RL/RI-16; Signoret, 1991; Van der Linden, Coyette, Poitrenaud, & GREMEM, 2004). Age-stratified norms and, when available, education-stratified norms were used to interpret performance on neuropsychological tests. Testing and scoring of these tests were accomplished by the first author and by senior research assistants with a master's degree in neuropsychology. The research assistants were supervised by the last author, who is an experienced scholar in clinical neuropsychology.

General exclusion criteria for all participants were: (a) history of traumatic brain injury; (b) history of stroke (and other cerebrovascular disorders) or transitory cerebral ischemia; (c) former intracranial surgery; (d) history of neurological disorder of cerebral origin or associated with another dementia state (e.g., multiple sclerosis, parkinsonism, frontotemporal dementia); (e) presence or history of a diagnosed psychiatric illness; (f) presence or history of alcoholism/drug addiction; (g) unstable metabolic or medical condition (e.g., uncontrolled diabetes, hypothyroidism); and (h) general anesthesia in the last six months.

French was the primary language for every participant. All individuals received monetary compensation (15$ per session) for their involvement in the study. Written informed consent was obtained at the start of the first evaluation. The study was approved by the Ethics Research Committee of the Institut Universitaire de Gériatrie de Montréal.

Materials

The experimental task was the *Indiçage* task of the *Batterie Memoria*, which is a standardized memory battery designed for French-speaking individuals (Chatelois et al., 1993). Two conditions of the task were used: the *reading orientation* and the *semantic orientation* conditions. In both versions, one list of 15 words (all belonging to different semantic categories) was utilized. The lists were comparable regarding word frequency (Baudot, 1970) and typicality (Giroux, 1982). They were also comparable as regards their category-specific membership. The experiment was implemented by Digimed Systems, Inc. (Montréal, Canada) and was run on a desktop PC computer.

Procedure

In the study phase of the reading orientation condition, a 15-word list was displayed on the computer screen within a 3 × 5 matrix. Participants were instructed to point to the word indicated in the examiner's instructions (e.g., "show me the word *broccoli*") and to memorize this word for subsequent recall. Once the word had been correctly pointed, the spatial localization of the 15 words in the matrix was modified in order to prevent the use of spatial strategies during encoding. Then, participants were asked to point and memorize another word (e.g., "show me the word *shoemaker*"). This procedure was repeated for every word in the list. Following the presentation of the 15th word, an interference task (counting upward by 2 for 60 s) was administered in order to prevent rehearsal. Then, participants were asked to retrieve as many words as possible from those seen on the computer screen during the study phase; there was no time limit for free recall. Performance was measured as the number of words correctly recalled (maximum score = 15). In the semantic orientation condition, the procedure was similar. However, in the study phase participants were instructed to point to the word that belonged to the semantic category provided in the instructions (e.g., instruction for the word *pepper*: "show me the *vegetable*"; instruction for the word *butcher*: "show me the *occupation*"). Thus, the two conditions of the task only differed regarding the type of orientation at encoding.

TABLE 1
Means and significance levels of demographic and neuropsychological characteristics of participants

					ANOVA	
	Measure	*Controls (n = 23)*	*aMCI (n = 23)*	*AD (n = 13)*	*F(2, 58)*	*p*
Participants' characteristics	Age (years)	71.1(6.8)	66.8(8.8)	76.9(4.7)**	8.1	.001
	Education (years)	14.7(4.1)	14.6(4.2)	13.7(3.9)	<1	.469
	Gender[a]	9 m/14 f	14 m/9 f	6 m/7 f	2.2	.327
Depressive symptoms	GDS (5-items)	1.0(1.1)	1.1(1.4)	1.2(1.3)	<1	.849
IADLs	SMAF	−0.1(0.2)	−1.5(3.0)	−3.8(4.6)**	7.0	.002
General cognitive state	MMSE	28.8(0.9)	27.7(2.0)	23.3(3.4)***†††	30.1	.000
Executive functions	Stroop–Victoria (errors)[b]	0.9(1.7)	2.2(3.2)	6.0(6.9)*††	7.0	.002
Information-processing speed	Digit Symbol (WAIS–III)	11.6(2.6)	9.0(2.9)†	7.1(3.1)†††	11.4	.000
Visuoconstructive abilities	Copy of Rey Figure (score)	31.9(3.1)	30.6(3.2)	23.3(8.8)**†††	12.2	.000
Visual perception	Judgment of line orientation	23.3(4.4)	23.6(4.7)	18.7(5.6)*†	5.0	.010
Language	Naming (Boston–15 items)	13.5(1.6)	12.7(2.2)	11.9(1.2)†	3.5	.037
Episodic memory	Immediate story recall (BEM 144)	9.0(1.8)	6.5(2.6)††	3.6(2.2)***†††	24.1	.000
	Delayed story recall (BEM 144)	8.5(1.8)	5.8(2.6)††	2.1(2.4)***†††	32.6	.000
	RL/RI-16 free recall[c]	10.4(1.8)	8.3(3.1)†	3.1(1.8)***†††	40.2	.000
	RL/RI-16 total recall[d]	15.5(0.8)	14.1(2.5)	9.1(4.0)***†††	28.3	.000
	RL/RI-16 delayed free recall	12.6(2.3)	9.7(4.1)†	2.9(3.6)***†††	34.1	.000
	RL/RI-16 total delayed recall	15.9(0.3)	14.4(2.7)	8.5(4.8)***†††	30.6	.000

Note. Standard deviations in parentheses. Groups were compared using one-way analyses of variance (ANOVAs). Controls = healthy older adults; aMCI = elderly persons with amnestic mild cognitive impairment; AD = patients with probable Alzheimer's disease; m = male; f = female; GDS = Geriatric Depression Scale; IADLs = instrumental activities of daily living; SMAF = Functional Autonomy Measurement System; MMSE = Mini-Mental State Examination; WAIS–III = Wechsler Adult Intelligence Scale–Third Edition; BEM 144 = Batterie d'Efficience Mnésique; RL/RI-16 = Épreuve de Rappel Libre/Rappel Indicé à 16 Items.

[a]Statistical differences for distribution of gender in each group were examined using Pearson chi-square.

[b]This score was calculated as the number of errors in the inhibition condition minus the number of errors in the control condition.

[c]This score was calculated as the mean number of words retrieved over the three free-recall trials.

[d]This score was calculated as the mean total number of words retrieved on all free-recall plus cued-recall trials.

*$p < .05$ compared to aMCI participants; **$p < .01$ compared to aMCI participants; ***$p < .001$ compared to aMCI participants.
†$p < .05$, compared to control participants; ††$p < .01$, compared to control participants; †††$p < .001$, compared to control participants.

Participants were assessed individually over three testing sessions, which were separated by one week. The neuropsychological battery described above was administered during Session 1. The reading orientation condition of the Indiçage task was administered in Session 2, and the semantic orientation condition was completed in Session 3. All participants were tested with the same order. This was done to ensure that participants did not generalize the categorical type of encoding provided during the semantic orientation condition to the reading orientation condition.

Data analyses

The statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL). On most demographic (age, education) and clinical measures, the groups were compared using one-way analyses of variance (ANOVAs; group as a between-subjects factor) followed by Scheffé tests to identify the source of significant main group effects. The only exception was for the distributions of gender in the groups, which were compared using the Pearson chi-square test. As regards the experimental task, the dependent measure was the number of words retrieved in each condition. These measures were analyzed using an ANOVA with group (controls, aMCI, AD) as a between-subjects factor and orientation (reading orientation and semantic orientation) as a within-subject factor. Analyses of simple main effects and pairwise comparisons (with Bonferroni adjustment for multiple comparisons) were used to locate specific significant differences. In all analyses, the alpha level was set at $p \leq .05$.

RESULTS

Demographic and clinical data

Table 1 reports the demographic and clinical characteristics of the participants. The three groups were comparable in terms of years of education, gender distribution, and the mean number of depressive symptoms. Persons with AD were significantly older than persons

with aMCI. However, the use of age as a covariate in the analyses of the experimental task did not change any of the effects involving the group factor. As expected, persons with aMCI were comparable to control participants regarding instrumental activities of daily living and general cognitive state, but they showed impairment on tasks of verbal episodic memory. A deficit of information-processing speed was also noted. Patients with AD showed significant impairment relative to controls in all cognitive domains. They were also cognitively impaired compared to aMCI participants, except for the Digit Symbol and Boston Naming tests.

Experimental task performance

Figure 1 illustrates the mean numbers of words retrieved correctly by the groups in the reading orientation and semantic orientation conditions of the Indiçage task. Visual inspection of the figure indicates that compared to control participants, the AD group was impaired in both task conditions, whereas the aMCI group was impaired in the semantic orientation condition only. In addition, while all groups seemingly performed better in the "semantic" than in the reading orientation condition, the memory performance of the aMCI and AD groups seemed to increase less than that of control participants upon semantic orientation. This was confirmed by the Group × Orientation ANOVA where factor group, $F(2, 56) = 21.9$, $p < .001$, $\eta^2 = .44$, factor orientation, $F(1, 56) = 42.1$, $p < .001$, $\eta^2 = .43$, and the Group × Orientation interaction, $F(2, 56) = 5.1$, $p < .01$, $\eta^2 = .15$, were all significant. The analyses of simple effects indicated that control ($p < .001$, $\eta^2 = .46$), aMCI ($p = .006$, $\eta^2 = .13$) and AD ($p = .037$, $\eta^2 = .08$) participants all improved their free-recall performance in the semantic orientation, compared to the reading orientation, condition but inspection of effect sizes suggested that the effect was larger in healthy controls than in AD or aMCI participants. In the reading orientation condition ($\eta^2 = .42$), AD patients reported fewer words than healthy controls and aMCI participants ($p < .001$, in both cases); the two latter groups were comparable ($p = .762$). In the semantic orientation condition ($\eta^2 = .41$), AD patients reported fewer words than control ($p < .001$) and aMCI ($p = .001$) participants. As for persons with aMCI, they reported fewer words than control participants ($p = .028$).

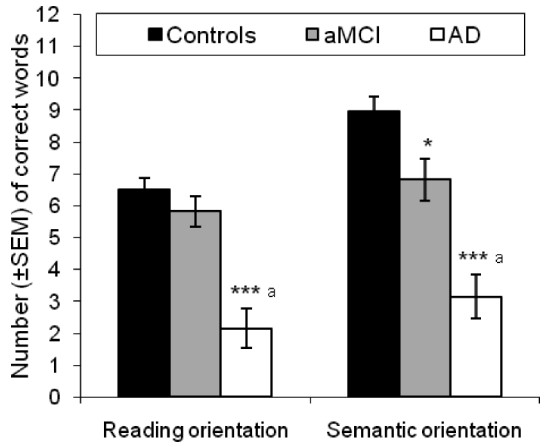

Figure 1. Mean numbers (±*SEM*) of words retrieved by healthy older adults (controls), elderly persons with amnestic mild cognitive impairment (aMCI), and patients with probable Alzheimer's disease (AD) in the reading orientation and semantic orientation conditions of the Indiçage test. $^{*}p < .05$; $^{***}p < .001$, compared to control participants. $^{a}p \leq .001$, compared to aMCI participants.

DISCUSSION

The principal objective of this study was to assess the effect of semantic orientation at encoding on the memory performance of aMCI and AD patients, relative to healthy older adults. Results revealed that when tested following shallow encoding (reading orientation), free-recall performance was impaired in AD only; the impairment was found relative to both aMCI participants and healthy older adults. When tested following deep encoding (categorical semantic orientation), both AD and aMCI groups were impaired relative to healthy older adults. Interestingly, memory performance in all groups benefited from semantic orientation at encoding. However, the benefit was greater in control participants than in aMCI and AD patients. Thus, the findings of the present study indicate that free-recall performance of aMCI and healthy elderly persons is comparably efficient in situations where shallow supportive cues are provided at encoding, but that healthy controls benefit more than aMCI and AD in situations where encoding supportive cues are strong.

The results of the present study highlighted interesting similarities between aMCI and AD patients regarding their pattern of memory performance. That is, free-recall performance in both groups benefited from deep encoding, and the benefit was smaller than that in control participants. This is consistent with cross-sectional studies reporting that the episodic memory impairment of aMCI and AD patients is characterized by weakened encoding and retrieval compared to healthy older adults (for a review, see Belleville, Sylvain-Roy, de Boysson, & Menard, 2008), although the impairment is less severe in aMCI than in AD. Thus, overall, the data of the present study support the notion that aMCI corresponds to a transitional state between normal cognitive aging and AD (Gauthier et al., 2006).

The deficit of aMCI and AD participants in the semantic orientation condition of this study could be related to the alteration of the semantic memory system in these individuals. Semantic memory is impaired in AD (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992), and there is growing evidence that semantic memory is also impaired in aMCI (Adlam, Bozeat, Arnold, Watson, & Hodges, 2006; Joubert et al., 2008). One must note that all participants in the present study (including aMCI and AD) were able to point to each category exemplar during the study phase of the semantic orientation

task. Thus, it could be assumed that participants were able to process the semantic category and that semantic encoding has been achieved to some extent by every participant. Nevertheless, it is possible that aMCI and AD patients were able to identify the semantic category of words but were unable to encode and process all the semantic properties that help in distinguishing members of a category. This would allow persons with aMCI to perform adequately during the encoding phase, as all items were from a different category; at retrieval, it would create problems of competition with members of the same category. A similar pattern has been proposed to account for the performance of AD patients in memory measures of semantic proactive interference (Belleville et al., 1992). Bearing this in mind, the results revealing that free recall of aMCI and AD groups benefited less from semantic orientation than did free recall of healthy elderly persons could imply that the former groups had difficulties in using semantic information at recall in a self-initiated way.

The results in the AD group corroborated previous findings showing that memory performance of these patients can improve when semantic support is provided at encoding, but that the improvement is not sufficient to normalize performance compared to healthy older adults (Bäckman & Small, 1998; Bird & Luszcz, 1990; Herlitz & Viitanen, 1991; Lipinska & Bäckman, 1997). Similarly, the results in the aMCI group were in line with those of Bäckman and Small (1998) indicating that free-recall performance in older adults with incident AD can benefit from deep encoding. However, at first sight the present results are not in line with those of Froger and colleagues (2009), where no benefit from deep encoding on free-recall performance was observed in aMCI. At least two interpretations can be proposed to account for the apparent discrepancy. First, it is important to note that the memory task in Froger's study was incidental, whereas the procedure was intentional in the present work. This difference is important because along with the environmental support hypothesis (Craik, 1990), one could postulate that when persons are instructed to memorize information, in some way the task instructions prompt the mobilization of cognitive resources that are likely to improve future retrieval; the cognitive resources then being mobilized are expected to be more efficient in deep than in shallow encoding conditions due to more elaborated environmental support in the former case. In other words, it could be that free-recall performance of aMCI and healthy elderly persons is hardly distinguishable using incidental memory tasks (whatever the level of processing at encoding) because the procedure does not prompt the use of memory resources in healthy older adults. Another interpretation can be proposed to account for the apparent discrepancies between the present results and those of Froger and colleagues. That is, even if our participants showed some benefit from semantic orientation, as in Froger's work the present study revealed a significant interaction between group and condition factors. This interaction reflected differences in the pattern of memory performance between the aMCI and control groups. As argued above, the reduced improvement of free-recall performance in the present aMCI group could reflect difficulties in using the semantic information at recall in a self-initiated way. To choose among these interpretations, it would be interesting that future studies manipulate both encoding (incidental vs. intentional) and retrieval (recall vs. recognition) procedures in persons with aMCI and AD.

While many studies have reported episodic memory problems in aMCI, this study has relied on innovative measures that attempt to specify the impaired processes in these individuals. Thus, the results reported above help in clarifying the source of the episodic memory impairment in aMCI. Related to this, the present study may have important clinical implications. First, findings are consistent with the idea that memory tests promoting deep encoding may be very useful for identifying preclinical AD cases. More precisely, memory tasks that compare shallow versus deep encoding conditions could be used in clinical settings to differentiate normal cognitive aging from aMCI or AD conditions. Nevertheless, it will be important to conduct longitudinal studies to test this hypothesis and to verify whether such tasks can help in tracking AD from its preclinical to its clinical phase. Second, the data of the present study have implications for the development of nonpharmacological interventions adapted to individuals with aMCI. Indeed, results suggest that aMCI patients are capable to some extent to develop mnemonic strategies when they are informed of a subsequent memory task and that their free-recall performance can benefit from deep encoding. This reinforces the need to develop memory interventions that favor rich, or deep, processing of to-be learned information. In addition, it may be profitable to teach persons with aMCI how to elaborate and apply complex memory strategies in order to maximize the benefit from deep encoding on retrieval. Since the cognitive impairment of these individuals is mild by definition, one can assume that they have the necessary cognitive resources to apply complex strategies.

The principal limitation of the present study relates to the generalization of the results. For instance, exclusion criteria in participants' selection were extensive. While this was aimed at reducing the possibility for external sources of errors, it somewhat limits generalization of the results to the whole aMCI or AD populations. In addition, the sample size was rather small, and there were almost twice as many aMCI as AD participants. Given the typical variability of cognitive deficits among aMCI and AD patients, this could affect to some extent the consistency of the results. However, the fact that we did find a Group $\times$ Orientation interaction indicates that we did have the power necessary to observe fine-grained effects. Another limitation was the absence of a recognition or cued recall condition in the task procedure. It is well known that aMCI and AD patients are impaired in cued recall tasks (Froger et al., 2009; Ivanoiu et al., 2005; Lekeu & Van der Linden, 2005). It would have been interesting to verify to what extent the impairment of aMCI and AD participants in the semantic orientation could have been minimized by increasing the specificity of the retrieval condition.

To summarize, the present study indicated that free-recall performance of both aMCI and AD patients can benefit from deep encoding, but to a lesser extent than healthy older adults. The data also suggest that administration of memory tasks that provide semantic support at encoding could help in differentiating normal cognitive aging from aMCI or AD conditions. Indeed, while the AD group had free-recall impairment following both shallow and deep encoding, aMCI persons were impaired following deep encoding only. It will be important to conduct longitudinal studies to verify whether memory tasks manipulating the level of semantic support at encoding can help in tracking AD from its preclinical to its clinical phase.

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