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Boosting Familiarity-Based Memory Decisions in Alzheimer's Disease: The Importance of Metacognition

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Abstract

Objective: Recent studies in Alzheimer's disease (AD) have suggested that AD patients are not always able to rely on their feeling of familiarity to improve their memory decisions to the same extent as healthy participants. This underuse of familiarity in AD could result from a learned reinterpretation of fluency as a poor cue for memory that would prevent them to attribute a feeling of fluency to a previous encounter. The primary goal of this study was to determine whether AD patients could relearn the association between processing fluency and past exposure after being repeatedly exposed to situations where using this association improves the accuracy of their memory decisions. Method: Thirty-nine patients with probable AD were recruited and asked to complete several recognition tests. During these tests, participants were put either in a condition where the positive contingency between fluent processing and previous encounters with an item was systematically confirmed (intervention condition) or in a condition where there was no correlation between fluency and prior exposure (control condition). The efficacy of the intervention was evaluated at three time points (baseline, posttest, and 3-month follow-up). Results: Our results indicated that all AD patients do not benefit to the same extent from the training. Two variables appeared to influence the likelihood that participants increase and maintain their reliance on the fluency cues after the intervention: the ability to detect the fluency manipulation and the preservation of implicit metacognitive skills. Conclusion: These findings indicate the importance of metacognition for inferential attribution processes in memory. (*JINS*, 2021, *27*, 239–248)

Keywords: Neurodegenerative diseases, Recognition, Memory, Fluency, Metacognition, Training

INTRODUCTION

Memory deficits stand in the foreground from the earliest Alzheimer's disease (AD) stages. Specifically, AD leads to pronounced deficits in recollection, that is, typically defined as the ability to mentally relive past events in vivid details (e.g., Ally, Gold, & Budson, 2009; Westerberg et al., 2006). However, despite their important difficulties in recollecting previous events, some data have suggested that AD patients could still be able to make accurate memory decisions on the basis of a feeling of familiarity, that is, defined as a vague sense of "oldness" associated with a past event (Yonelinas et al., 2002). Unfortunately, for every study displaying evidence in favor of a preservation of familiarity (Embree, Budson, & Ally, 2012; O'Connor & Ally, 2010), as many find results in favor of an alteration of these processes (Ally et al., 2009; Westerberg et al., 2006; Wolk, Signoff, & DeKosky, 2008). Interestingly, however, a research from Geurten, Willems, Salmon, and Bastin (2020) has recently suggested that a deeper examination of the processes underlying familiarity-based memory decisions could shed an interesting light on these seemingly inconsistent findings.

Typically, one mechanism that is supposed to account for the feeling of familiarity is processing fluency (i.e., the ease with which an information is processed). The idea is the following: because people intuitively know that an earlier encounter with a stimulus generally enhances processing fluency, a feeling of familiarity can result from attributional processes whereby people impute the experienced fluency to the past (Jacoby & Dallas, 1981; Kelley & Rhodes, 2002; Whittlesea, 1993). In other words, experiencing fluency is not sufficient to generate a subjective feeling of familiarity, people also have to decide whether fluency can be used as

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a source of evidence when making a memory decision (Whittlesea & Williams, 1998). According to this theory, familiarity results from the interaction between inferential processes and fluency experiences which both have to be preserved for familiarity-based decisions to occur. The fact that data from perceptual priming tasks regularly show that AD patients can experience fluency (Ballesteros & Reales, 2004; Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991), but that they cannot use this experienced feeling of fluency to improve their memory to the same extent as healthy participants (Geurten, Willems, et al., 2020; Simon, Bastin, Salmon, & Willems, 2018) is consistent with this view.

Interestingly, according to some authors, the underuse of fluency observed in AD possibly results not so much from an impairment but from a change in attribution processes (Geurten, Bastin, Salmon, & Willems, 2020; Geurten, Willems, et al., 2020; Willems et al., 2009). Specifically, AD patients would simply be reluctant to attribute strong feeling of fluency to their failing memory, preventing familiarity to improve their memory performance. Supporting this hypothesis, Geurten, Willems, et al. (2020) have reported that, when AD patients are exposed to several sources of fluency during a recognition test (i.e., past exposure *vs*. perceptual quality), they tend to attribute the overall feeling of fluency to the external source rather than to their memory, at least when their visual discrimination problems and diminished attentional resources allow them *notice* the alternative fluency source. On the reverse, at the same task, healthy participants were shown to faithfully rely on the absolute level of fluency when making their memory decisions, suggesting that they did not disqualify the alternative source as readily as AD patients (Geurten, Bastin, et al., 2020).

To explain these findings and, thus, the tendency of AD patients to underuse the fluency cue, the authors postulate that two interconnected modifications occur at the level of the attribution processes. First, due to the increased frequency of fluency-based memory illusions in their daily life, patients with severe memory problems would learn to reinterpret fluency as a poor cue for memory. Consistent with this assumption, Unkelbach (2006, 2007; see also Olds & Westerman, 2012) has shown that, when the ecological validity of the correlation between fluency and past occurrence of items is reduced (i.e., when the number of situations where fluency leads to memory errors became higher than the number of situations where fluency leads to correct decisions), young adults progressively learn to disqualify the metacognitive association between processing fluency and past experience. Second, this learned reinterpretation of the fluency signal would lead patients to implement – not necessarily conscious – strategies to track alternative fluency source. This would allow them to rely on fluency only when they can attribute it to pre-exposure with a high level of confidence (i.e., when no external sources are detected; Geurten & Willems, 2017 – Exp 2).

However, if the increased frequency of fluency-based memory illusions in daily life truly leads AD patients to unlearn the use of fluency in memory decisions, it should be possible for these patients to relearn the association between fluency and past experience. On that basis, the main goal of the present experiment was to investigate whether early AD patients could be trained to use processing fluency as a basis for their familiarity-based memory performance. To test this, an interventional study using a paradigm adapted from Geurten and Willems (2017; Exp 2) was conducted. Our primary aim was to determine whether AD patients could be implicitly trained to consider processing fluency as a relevant cue to guide their memory judgments by repeatedly exposing them to situations where enhanced processing fluency is systematically associated with previous encounter. We assessed the immediate efficacy of the intervention as well as its middle-term maintenance at 3-month follow-up. To our knowledge, the middle-term effect of a procedure designed to alter the use of a mnemonic cue in a particular context has never been examined.

Moreover, according to the integrative memory model (Bastin et al., 2019), for attribution processes to change and adjust themselves depending on people's and context's characteristics, preserved metacognitive skills are required. More specifically, people must be able to evaluate their own memory functioning in order to determine whether their decision processes are still adapted to the context (i.e., when memory skills decrease, people have to adjust how they make decisions to reduce memory errors). Indeed, according to the classical metacognitive model of Nelson and Narens (1990), in order to implement strategies to regulate their performance (e.g., using fluency as a cue to guide memory), people have first to determine the characteristics of the task at hand and monitor their own performance to decide which strategy to use. For this reason, one could hypothesize that preserved metacognitive abilities would predict the efficiency of our intervention. We expected that AD patients with poor metacognitive skills would not benefit from our training procedure to the same extent as patients with better metacognition because they would not be able to determine whether fluency is a useful cue to improve their memory. To explore this, both implicit (i.e., behavioral responses to uncertainty) and explicit (i.e., explicit judgments of one's own performance) measures of metacognition were collected to assess the integrity of metacognitive monitoring processes, considering that implicit or explicit forms of metacognition could be selectively impaired in AD (Bomilcar, Morris, Brown, & Mograbi, 2018; Geurten, Salmon, & Bastin, 2019; Mograbi, Brown, Salas, & Morris, 2012) and, thus, differently influence patients' cognitive functioning. Specifically, impairment of explicit metacognition in AD has been linked to their recollection deficit (Souchay & Moulin, 2009). Recollection being a powerful cue by which someone can estimate whether a previously given answer is correct or how likely an information will be remembered in the future, its impairment in AD could negatively affect the ability to make accurate explicit judgments. On the reverse, implicit metacognition appeared to be more frequently preserved in AD patients (Geurten, Salmon, et al., 2019).

Finally, as a previous study has revealed that visual discrimination problems or diminished attentional resources

Table 1. AD patients' clinical and demographic characteristics for the two experimental conditions (intervention *vs*. control)

	All sample ($n = 39$)	Intervention condition ($n = 19$)	Control condition ($n = 20$)
Age	77.47 (5.43; 63–88)	77.98 (6.12; 63–88)	77.93 (4.80; 65–88)
Education (years)	12.44 (3.32; 7–29)	12.53 (3.01; 7–20)	12.35 (3.67; 7–20)
MMSE	23.21 (1.92; 20–26)	23.26 (2.05; 20–26)	23.15 (1.84; 20–26)
FCSRT	10.67 (4.77; 0–16)	10.84 (4.40; 0–16)	10.50 (5.21; 0–16)
A'ROC – explicit	0.53 (0.08; .38–.8)	0.54 (0.11; .38–.8)	0.53 (0.05; .45–.71)
A'ROC – implicit	0.59 (0.11; .42–.82)	0.61 (0.11; .47–.79)	0.58 (0.11; .42–.82)

MMSE = Mini Mental State Exam; FCSRT = mean score (total recall) for the Free and Cued Selective Remembering test; A'ROC – explicit = score of metacognitive accuracy for the explicit measure of metacognition; A'ROC – implicit = score of metacognitive accuracy for the implicit measure of metacognition. Standard deviations, minimum and maximum are in parentheses.

(which are both very common in AD; see Cormack, Tovee, & Ballard, 2000; Levinoff, Li, Murtha, & Chertkow, 2004) could impact the ability of patients with AD to regulate their use of fluency by preventing them to detect perceptual differences between stimuli (Geurten, Willems et al., 2020), we expect patients' contrast detection skills to influence the outcome of our training.

METHOD

Participants

The sample was composed of 39 patients (15 females) with probable mild AD [Mini Mental State Examination (MMSE) between 20 and 26; Folstein, Folstein, & McHugh, 1975], recruited from the Memory Center of the Department of Neurology of CHU Liège (Belgium). Their age ranged from 63 to 88 years and their education level ranged from 7 to 20 years. Patients were diagnosed as having major neurocognitive disorder according to the Diagnostic and Statistical Manual of mental disorders (DSM-V) and criteria for clinically probable AD following the NIA-AA recommendations (McKhann et al., 2011), with hippocampal atrophy as biomarker of neurodegeneration. The patients had no mental retardation, no history of psychiatric or neurological illness. They were not engaged in substance abuse and were free of medication that could negatively affect cognitive functioning. They also had normal or corrected to normal vision. As our study aims at inducing changes at a functional level, patients were mainly selected on the basis of their cognitive profile which had to be characterized by a predominance of memory problems. Specifically, the Free and Cued Selective Remembering test (Grober, Merling, Heimlich, & Lipton, 1997) of episodic memory was used to ensure that all patients truly demonstrated significant memory impairments.

Patients were randomly assigned to one of the two experimental conditions (i.e., intervention, $n = 19$ *vs*. control, $n = 20$). These two groups did not differ significantly in age, education, MMSE, or level of episodic memory performance (all $ps > .59$). Characteristics of the patients included in both the intervention and the control conditions are displayed in Table 1. None of the participants received any compensation for their participation.

According to the power analysis conducted with G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007), 18 participants per group were needed to detect a medium within-between effect ($f = .25$; Cohen, 1988) of the intervention on fluency use with a predicted power of .80 ($\alpha = .05$, $\beta = .20$). This predicted effect size was determined on the basis of similar research in laboratory settings examining the impact of metacognitive training on young adults' use of fluency (Geurten & Willems, 2017).

Materials

Stimuli consisted of 7 sets of 60 abstract unfamiliar drawings. Unfamiliar pictures were used in order to limit preexperimental familiarity. These stimuli were selected on the basis of a pilot study. In each set, 30 stimuli were assigned randomly to Lists A and B. At the beginning of each recognition test, half of the participants were presented with List A as targets and List B as distractors; the other half of the participants were presented with the reverse design. Moreover, we created a low-fluency and a high-fluency version of each stimulus by manipulating the perceptual quality of stimuli by giving them a 20% contrast reduction. This manipulation has repeatedly been shown to influence processing fluency through its impact on various types of judgments inside and outside the memory domain, while remaining subtle enough not to prompt a disqualification of the mnemonic cue in healthy participants (e.g., Geurten & Willems, 2017; Reber, Schwarz, & Winkielman, 2004; Willems & Van der Linden, 2006). Finally, we prepared 7 sets of 30 target–distractor pairs with the 60 stimuli included in each set (see Figure 1). More specifically, three types of target–distractor pairs were prepared by combining stimuli with high and low visual quality: 10 Target+/Distractor−, 10 Target−/Distractor+, and 10 Target=/Distractor=. The "+" symbol indicated that the stimulus had a higher contrast quality than the other (i.e., high perceptual fluency). The "−" indicated that the stimulus had a lower contrast quality than the other (i.e., low perceptual fluency). The "=" indicated that both stimuli had a similar contrast quality. Stimuli that were assigned to these three contrast conditions were randomly counterbalanced between subjects.

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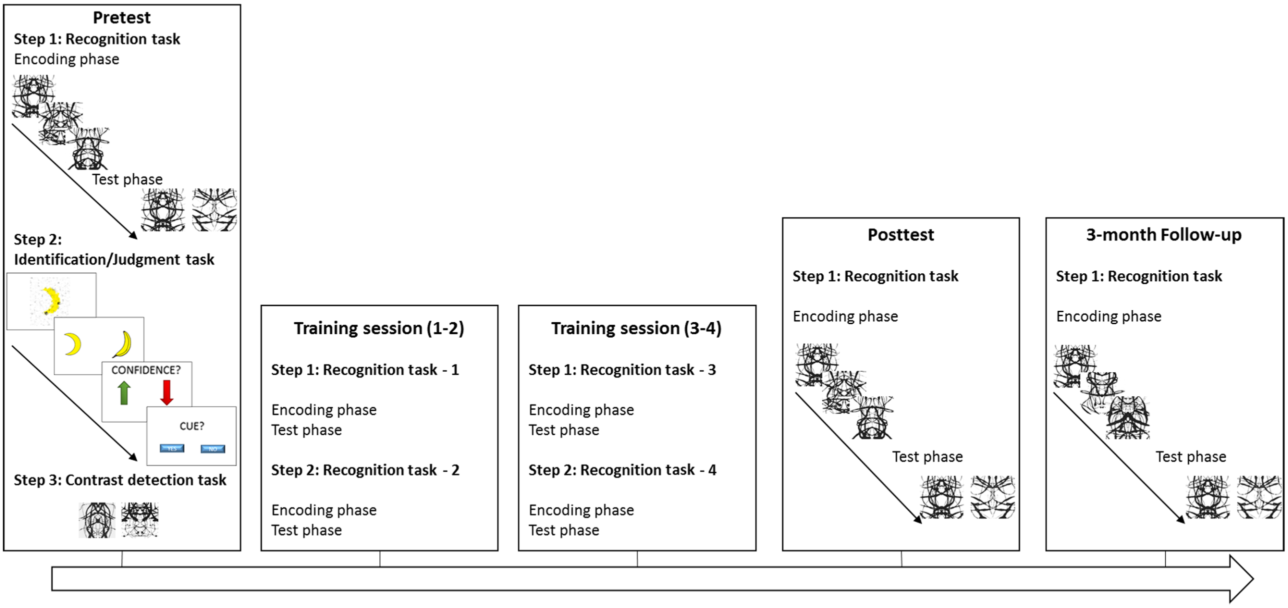

Fig. 1. Description of the experimental procedure.

Procedure

The study was conducted in accordance with the ethics committee of the participating institution (CHU of Liège, Belgium). Written consent was obtained before the study started. Participants were tested individually in a quiet room. Specifically, patients in both the control and the intervention condition went through seven main phases – a pretest (i.e., baseline), four training phases, a posttest, and a 3-month follow-up. These seven phases were regrouped in five sessions (i.e., pretest + two sessions of two training phases each + posttest + 3-month follow-up) that varied in length from 30 min to 1 hr. For each participant, the seven sets of stimuli were randomly assigned to one of these seven experimental phases. The details of the experimental procedure are presented in Figure 1.

Pretest phase

In the pretest, participants had to complete three main tasks: (a) a recognition task (baseline), (b) an identification task during which two types of metacognitive judgments (explicit *vs.* implicit) were requested, and (c) a contrast detection task.

Recognition task. All patients were shown and told to study 30 black-on-white figures, five times each, in random order. Each stimulus was presented in the center of the screen for 50 ms, followed by a 17-ms interval. This Rapid Serial Visual Presentation paradigm was used to promote fluency-based recognition and eliminate the influence of recollection (Whittlesea, Masson, & Hughes, 2005). A forced-choice recognition test directly followed the study phase. Participants were randomly presented with 30 target–distractor pairs (10 Target+/Distractor−, 10 Target−/Distractor+, and 10 Target=/Distractor=) for 2000 ms each followed by a self-spaced interstimulus interval. Participants were asked to point to the drawing they had previously seen. The side of the screen in which the target stimulus was displayed was randomized over the trials. This pretest gave a measure of baseline use of fluency to support recognition memory. The rate of correct recognitions was recorded for each type of pairs. The selection of the more perceptually fluent item in each pair indicated the use of fluency.

Identification/judgment task. We used the task created by Geurten, Salmon, et al. (2019) to assess both the explicit and implicit metacognitive skills of our patients. Specifically, a list of 33 degraded stimuli was displayed in random order for 1 s. After each item, participants were presented with a target–distractor pair of stimuli and were asked to point to the drawing they had previously seen (forced choice). The side of the screen in which the target stimulus was displayed was randomized over the trials. An adaptive staircase procedure (see Song et al., 2011) was used to equate identification performance across participants at around 60% of correct responses. Specifically, three consecutive incorrect responses or two incorrect responses out of three trials resulted in a reduction of the level of difficulty for the next trial, whereas two or more correct responses out of three trials resulted in an increase of the difficulty level for the next trial. After each response, a blank screen appeared for 100 ms, followed by either the explicit or the implicit judgment phase.

In the explicit judgment phase, participants rated their confidence in their responses using a 2-point pictorial scale depicting low and high confidence in the form of two arrows pointing either up (to indicate they were "really sure" about the correctness of their answers) or down (to indicate they were "not so sure" about the correctness of their answers). Low confidence was coded as 0 and high confidence was coded as 1.

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In the implicit judgment phase, patients had the opportunity to ask for a cue to help them to decide whether their response was correct. They were instructed to ask for a cue only when they felt they had made an error in identifying the target item. Accepting the cue was coded 0 and declining the cue was coded 1. Depending on the experimental order, the cue appeared either directly after the blank screen or after the explicit judgment phase. In that way, participants' explicit judgment was never affected by the presentation of the cue. After completing these three phases for each trial, participants were once again presented with the target–distractor pairs and asked whether they would like to change their previous answer, then they moved on to the next trial.

Contrast detection task. Once the identification/judgment task was completed, participants were randomly presented with 45 target–distractor pairs of abstract pictures similar to those selected as stimuli for our various recognition tests and asked to judge which of the two pictures was of better perceptual quality. This procedure was used to examine whether AD patients differed in their ability to detect the fluency manipulation when their attention is focused on the picture's perceptual quality. Indeed, a previous study has recently shown that the ability to perceive the contrast manipulation could influence the ability of AD patients to rely on the fluency cue (Geurten, Willems, et al., 2020). We thus planned to include this variable in our analyses. Specifically, we split our sample of patients into two subgroups. In their previous study, Geurten, Willems, et al. (2020) have found that at around 65% of contrast detection, there was a shift in how AD patients used fluency. On that basis, patients with a contrast detection rate higher than the mean ($M = .64$) were put in a "good detection" group ($M = .71$; $n = 20$). Nine were from the control condition and 11 were from the intervention condition. Patients with a contrast reduction rate lower than the mean were put in a "poor detection" group ($M = .59$; $n = 19$). Eleven were from the control condition and eight were from the intervention condition. We expected patients included in the "poor detection" group to benefit less from our fluency training than the patients included in the "good detection" group. We chose to split our sample into two groups instead of using the contrast detection rate as a metric variable because the shape of the curve depicting the correlation between the rate of contrast detection and the score of fluency use revealed an inflection point at around .65 after which the direction of the relation between the two variables started to be reversed.

Training phases

The training phases consisted in four recognition tasks spread over about 8 days (two tasks by session). During each task, participants studied 30 unfamiliar drawings, 5 times each, in random order at the same rate as in the pretest phase. A forced-choice recognition test immediately followed each study phase. As in the pretest, participants were randomly presented with 30 target–distractor pairs for 2000 ms followed by a self-spaced interstimulus interval. In the *control condition*, the level of fluency of the items was manipulated in the same way as in the pretest (10 Target+/Distractor−, 10 Target−/Distractor+, and 10 Target=/Distractor=). In the *intervention condition*, high-fluency items were always old and low-fluency items were always new (30 Target+/Distractor−) in order to implicitly reinforce the association between fluency and oldness. In both conditions, participants had to point to the stimulus they had previously seen and received feedback about the correctness of each decision ("correct" or "incorrect"). Although we are well aware that lots of works with AD patients recommend not to give negative feedback after an incorrect answer, we chose to provide feedback after each response because a pretest conducted in a sample of healthy adults had revealed that our training did not appear to be effective when no external feedback was given (see also Unkelbach, 2006).

Posttest and follow-up

At posttest and at 3-month follow-up, all patients were once again administered a recognition task. For these tasks, we used the same procedure and same measures as in the pretest.

Measures

Our main goal here was to determine whether our intervention program could increase the frequency at which patients rely on fluency to guide their memory decisions. To this end, we computed a score of fluency use. Specifically, participants' tendency to rely on fluency was estimated by subtracting the rate of correct recognitions (i.e., choosing the target) when the visual manipulation induced a weak feeling of fluency for targets (Target−/Distractor+) from the rate of correct recognitions when the visual manipulation induced a strong feeling of fluency for targets (Target+/Distractor−) in each of the three recognition tests (baseline, posttest, and follow-up). A positive score indicated a reliance on the fluency cue while a negative score indicated a disqualification of the fluency cue. We used this score instead of the global rate of correct recognition because, in our task, it is a purer index of fluency-based memory decision. Indeed, for one type of items (Target+/Distractor−), relying on fluency would lead participants to select the correct response more often while, for the other type of items (Target−/Distractor+), relying on fluency would lead them to select the incorrect response.

Beside the influence of contrast detection with subgroups, as described above, we also explored whether metacognitive processes could play a role in the ability of attribution processes to adjust to new regularities detected in the environment. To do so, we calculated a measure of metacognitive accuracy for both the implicit and the explicit judgment tasks: the A'ROC index (Galvin, Podd, Drga, & Whitmore, 2003). A'ROC is a nonparametric measure from signal detection theory that is theoretically uninfluenced by the overall propensity of a participant to give high or low judgments. To compute A'ROC, the concordances (e.g., a high-confidence judgment on correct identification) are plotted against the discordances (e.g., a high-confidence judgment on incorrect identification). An A'ROC of 0.5 indicates no metacognitive discrimination between correct and incorrect responses.

Data Analyses

All the analyses were conducted using Statistica 13.3 (TIBCO Software, 2017). First, the influence of the implicit training and participants' detection group on the score of fluency use was examined using a 2 (Condition: Intervention or Control) × 2 (Group: Good detection or Poor detection) × 3 (Time: Baseline, Posttest, Follow-up) mixed-factor ANOVA. Second, in a more exploratory way, the possible influence of metacognition on the effectiveness of the implicit training was investigated with regression analyses using the change in fluency use after the intervention and at follow-up as dependent variables.

RESULTS

In the following analyses, differences were considered as significant when the p value was <.05, unless otherwise mentioned. Moreover, before starting, we wanted to ensure that the performance to the forced-choice recognition task was not influenced by a general tendency of the participants to select either the left or the right picture on each trial. Logistic regression analyses were thus conducted to determine whether the localization of the target on the screen predicted the likelihood that a correct answer was given. The results revealed that the localization of the target did not significantly predict the recognition performance at baseline, posttest, or follow-up, respectively (all $ps > .21$).

Fluency Use

A 2 (Condition: Intervention or Control) × 2 (Group: Good detection or Poor detection) × 3 (Time: Baseline, Posttest, Follow-up) mixed-factor ANOVA was carried out to examine the influence of our implicit training on participants' use of the fluency cue. Time was the only within-participant factor. The results revealed a main effect of group [$F(1, 35) = 83.13$, $p < .001$, $\eta_p^2 = .70$], with the patients in the poor detection group showing a reliance on the fluency cue ($M = .09$; $SD = .13$) and the patients in the good detection group showing a disqualification of the fluency cue ($M = -.14$; $SD = .15$). Replicating the findings of Geurten, Willems, et al. (2020), this pattern indicated that patients who were able to detect the perceptual manipulation when explicitly asked to do so were more likely to disqualify fluency than participants who were less able to detect this manipulation. Moreover, the Condition × Group interaction was also significant [$F(1, 35) = 10.22$, $p = .003$, $\eta_p^2 = .23$]. This interaction was due to the fact that AD patients in the good detection group disqualified the fluency cue less often in the intervention condition ($M = -.09$; $SD = .15$) than in the control condition ($M = -.20$; $SD = .10$) [$F(1, 35) = 10.76$, $p = .002$, $\eta_p^2 = .31$]. No such a difference was found for AD patients in the poor detection group [$F(1, 35) = 1.63$, $p = .21$, $\eta_p^2 = .11$] ($M = .06$ and $.10$, $SD = .11$ and $.13$, respectively). More critically, the Condition × Group × Time triple interaction was not significant [$F(2, 70) = 2.69$, $p = .07$, $\eta_p^2 = .07$], suggesting that the implicit metacognitive training employed in the present experiment might not be powerful enough to significantly modify patients' use of the fluency signal from pretest to posttest sessions.

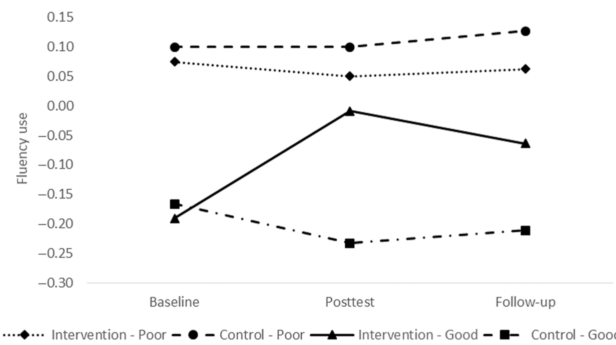

Fig. 2. Mean of fluency use at the three time points (baseline, posttest, and follow-up) in both experimental conditions (intervention *vs.* control) for the two groups (poor detection *vs.* good detection).

However, due to our strong hypotheses regarding the fact that only patients in the good detection group should demonstrate changes in fluency use after our intervention program, we decided to decompose this triple interaction. Bonferroni corrections were applied to avoid type 1 errors. At posttest, results indicated that patients of the good detection group included in the intervention condition showed more changes in their fluency use ($M = -.19$ *vs.* $-.01$) than patients included in the control condition ($M = -.17$ *vs.* $-.23$) [$F(1, 35) = 7.27$, $p = .01$, $\eta_p^2 = .25$]. A similar, but smaller effect was found at 3-month follow-up [$F(1, 35) = 3.82$, $p = .05$, $\eta_p^2 = .19$]. No significant differences were found between time and condition for the patients of the poor detection group neither at posttest [$F(1, 35) = 0.07$, $p = .79$] nor at follow-up [$F(1, 35) = 0.19$, $p = .66$] (see Figure 2).

The fact that our intervention program appears to influence AD patients' use of fluency at the group level does not mean that the intervention is useful for all participants. Indeed, the effect of our intervention appeared to differently influence each AD patient, as revealed by heterogeneity within the sample. Indeed, in the present experiment, only 52% of the patients included in the intervention condition ($n = 10$) used fluency as a memory cue at posttest (i.e., score of fluency use > 0) and only 42% ($n = 8$) still used the fluency signal at 3-month follow-up. While it is an improvement over the 21% ($n = 4$) who used fluency at baseline, these findings indicate that at least some of our patients did not benefit from the intervention training. Importantly, even if the results of the ANOVA suggested that the participants with high contrast detection rate benefited most from the intervention than patients with low contrast detection rate, 5 out of the 10

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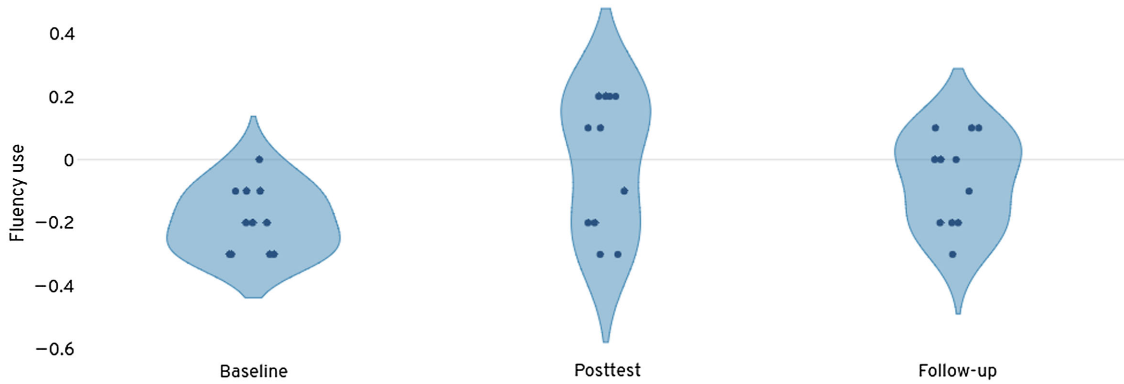

Fig. 3. Dispersion and individual scores of fluency use at the three time points (baseline, posttest, and follow-up) for the AD patients of the "good detection" group in the intervention condition.

patients included in the good detection group still disqualify the fluency cue after the training (see Figure 3). According to the integrative memory model (Bastin et al., 2019), one factor that could account for the heterogeneity observed in our sample is the presence of a metacognitive deficit that could have prevented some AD patients to learn the association between fluency and prior exposure during the intervention. We explored this hypothesis in the following analyses.

Relationships between Fluency Use and Metacognitive Accuracy

Given the possible influence of metacognitive skills on people's ability to learn an association such as the one trained in our intervention condition, we chose to explore whether the efficacy of our intervention at posttest and at follow-up could be predicted by the accuracy of AD patients' implicit and explicit metacognitive judgments (i.e., measures of metacognition). To estimate the efficacy of our training, we computed a difference between patients' score of fluency use at baseline and their score of fluency use at posttest and at follow-up, respectively. As the ability to detect the perceptual manipulation has been shown to influence the use of the fluency cue in our patients, the analyses were performed not only for each condition but also for each group (good *vs*. poor detection).

At posttest, in the intervention condition, regression analyses revealed that the efficacy of our implicit training was only predicted by the accuracy of participants' implicit metacognitive judgments in the good detection group ($\beta = .78$, $p = .006$), suggesting that AD patients with good detection skills and better implicit metacognition were more likely to take advantage of the intervention than participants with lower implicit metacognition. On the reverse, the accuracy of participants' explicit metacognitive judgments did not predict changes in the fluency use between the baseline and the posttest ($\beta = .15$, $p = .51$). Neither implicit nor explicit metacognitive scores were not found to predict changes in fluency use at posttest in the poor detection group (all $\beta s < .67$, $ps > .11$). Similarly, none of the variables included in our analyses predicted changes in fluency use in the control condition whether participants had good or poor detection skills (all $\beta s < .67$, $ps > .10$). Finally, at follow-up, the efficacy of our intervention was once again shown to be related to the accuracy of participants' implicit metacognitive judgments in the good detection group ($\beta = .79$, $p < .001$) but not to the accuracy of their explicit judgments ($\beta = .11$, $p = .48$). None of these variables predicted the changes in fluency use in patients with poor detection skills ($\beta s < .26$, $ps > .60$). In the control condition, changes in patients' score of fluency use between the baseline and the follow-up were not shown to be significantly related to the accuracy of their metacognitive judgments or their rate of contrast detection (all $\beta s < .18$, $ps > .56$).

DISCUSSION

The primary goal of the present study was to determine whether AD patients could relearn the association between processing fluency and previous exposure after being repeatedly exposed to situations where using this association improves the accuracy of their memory decisions. Our results indicated that all the participants included in our sample do not benefit to the same extent from the implicit training. Specifically, two moderating factors appear to influence the likelihood that patients increase and maintain their reliance on the fluency cue after the intervention: (a) the ability to detect the fluency manipulation and (b) the preservation of implicit metacognitive skills.

Contrast Detection Skills

Consistent with Geurten, Willems, et al. (2020), our findings regarding the influence of participants' contrast detection skills indicated that, even before the intervention, patients with a high level of contrast detection showed a negative score of fluency use, a pattern that is classically observed when fluency is disregarded as a relevant cue to guide recognition judgments. Conversely, patients with a low (but above chance) level of contrast detection showed a positive score of fluency use, a pattern that is usually obtained when fluency is actually used as a cue for memory. These results can be interpreted within the discrepancy-attribution framework

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(Whittlesea & Williams, 1998, 2000, 2001a, 2001b). According to this model, high processing fluency is interpreted as a sign of memory when the degree of fluency that is experimented is surprisingly greater than expected given the context. However, if an external source is detected that produces more fluency expectations than past experience, participants are likely to attribute the entire feeling of fluency to this source rather than to the past. In recognition tests, this usually leads them to give more "yes" responses to items with a lower level of fluency, resulting in a negative score of fluency use. As AD patients included in the "poor detection" group were not able to notice the perceptual manipulation, even when they were explicitly asked to do so, it seems logical that they did not disqualify the fluency signal. Interestingly, this pattern could also explain why the score of fluency use of these patients did not vary between the pretest and the posttest phases. As they already rely on fluency to guide their memory decisions before the intervention, they may not have needed to relearn to use it.

Implicit Metacognitive Skills

Another factor that seems to influence the likelihood that our patients relearn the association between fluency and past encounter is the ability to implicitly monitor one's own internal state (i.e., implicit metacognitive skills). Indeed, our results reveal that, in the intervention condition, implicit metacognition positively predicted the change in fluency use between the baseline and the posttest as well as between the baseline and the follow-up, suggesting implicit metacognitive processes may be involved in the ability to relearn the fluency-memory association.

From a theoretical perspective, these findings are important because they provide preliminary evidence in favor of the assumption made by the Integrative Memory Model (Bastin et al., 2019) according to which metacognition is critical for attribution processes to be able to flexibly adjust themselves in response to changes in the operating environment (see also Unkelbach & Greifeneder, 2013). The fact that the implicit, but not the explicit, measure of metacognition predicts changes in the fluency use after the intervention is consistent with data reported elsewhere in the literature showing a possible dissociation between implicit and explicit measures of metacognitive monitoring in AD (Bomilcar et al., 2018; Geurten, Salmon, et al., 2019; Mograbi et al., 2012). Indeed, if two distinct measures of metacognition differently influence participants' cognitive functioning and that this difference is not due to a statistical artifact (e.g., lack of variability for one of the two measures, which is not the case here), it could be taken as evidence that these measures may capture dissociated aspects of metacognition.

Moreover, the fact that, in the present study, no significant correlation was found between the score of fluency change and the explicit measure of metacognition appears consistent with the idea that learning the association between fluency and past occurrence does not necessarily require the intervention of conscious learning processes (Geurten, Willems, & Meulemans, 2015; Unkelbach, 2006). This does not mean that explicit metacognition is not at all involved in memory decision processes, it only suggests that the latter mechanisms are possibly not mandatory for attribution processes to adjust themselves depending on the context. Explicit metacognition, however, could still come into play at other stages of memory decision processes, for example, when post-retrieval monitoring is required (Bastin et al., 2019).

There are several limitations to this study. First, the a priori power analysis conducted to determine the sample size of the present experiment was calibrated to test the effect of the intervention. As our sample was also divided depending on the patients' contrast detection skills, however, it is possible that the analyses exploring the interaction between our two experimental conditions (control *vs*. intervention) and our two groups (good *vs*. poor detection) did not allow to detect effects of smaller size. Secondly, despite the fact that several studies have shown that metacognitive abilities are related to various cognitive and affective factors (i.e., executive functioning, depressive mood, etc.; Efklides & Petkaki, 2005, Fernandez-Duque, Baird, & Posner, 2000), these variables were not taken into account in this study. Assessing these factors could have helped to better understand the variables responsible for the reduced metacognitive skills of our patients. Third, due to the feedback procedure employed during the training, participants received negative feedback while completing some of the recognition tasks. This may have negatively influenced the performance of the patients, possibly by reducing the investment in the task, particularly in patients with lower initial level of performance. In order to partially rule out this hypothesis, we have examined whether there were any correlations between the correct recognition rate of participants at baseline and the score computed to estimate the effectiveness of our training procedure at posttest and at follow-up. None of these correlations was significant ($rs < -.26$, $ps > .10$).

Overall, while the results obtained in the present experiment should, of course, be corroborated and replicated using different types of materials (e.g., by using stimuli more relevant to patients' daily life) and procedures (i.e., the association between implicit metacognition and the efficacy of our intervention is correlational in nature and, thus, should be experimentally explored as should be the potential transfer effect of our intervention to a memory material that was not trained in session), they already provide important information both at a practical and a theoretical level. From a clinical point of view, our findings might be of use to practitioners by helping them to identify the patients who are more likely to positively respond to an implicit intervention aiming at improving familiarity-based memory decisions. Future work should assess whether such training to relearn the use of fluency cues has a beneficial effect on accuracy rate in traditional recognition memory task in which familiarity is a major contributor. At the theoretical level, these data are among the first to directly document the hypothesis according to which inferential attribution processes in memory are, at least partially, dependent on metacognitive skills.

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CONFLICT OF INTEREST

The authors have nothing to disclose.

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