Title: **Hunting down the source: how amnesic patients avoid fluency-based memory errors**

Running Title: **Hunting down the fluency source**

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**Abstract**

Objective: The primary aim of this study was to test whether differences in the ability of amnesic and healthy participants to detect alternative sources of fluency can account for differences observed in the use of fluency as a cue for memory.

Method: Patients with severe memory deficits and matched controls were presented with three forced-choice recognition tests. In each test, an external source of fluency was provided by manipulating the perceptual quality of the studied items during the test phase. The detectability of the perceptual manipulation varied in each test (i.e., a 10%, 20%, or 30% contrast reduction were given).

Results: The results indicated that all participants were able to rely on fluency when making recognition decisions as long as the perceptual manipulation remained unnoticed. Interestingly, our data also revealed that the level of contrast reduction at which the alternative source is detected differs between healthy controls and amnesic patients. Specifically, patients with amnesia appeared to disqualify fluency as a cue for memory even when the contrast reduction was moderate while healthy participants only disqualified fluency when the contrast reduction was clearly visible.

Conclusion: Overall, our results seem to suggest that the ability to use fluency is probably not impaired in amnesia but undergo metacognitive changes resulting in the implementation of explicit or implicit strategies aiming at tracking alternative sources in order to reduce memory errors.

Keywords: Recognition memory; Amnesia; Fluency; Metacognition

Public Significance Statements: Despite their severe deficits, some memory processes are preserved in amnesic patients. Unfortunately, they do not appear to take full advantage of these spared memory abilities. This study is an attempt to determine whether adaptive metacognitive changes could account for the apparent inability of amnesic patients to rely on their preserved memory skills.

**Introduction**

Over the past 50 years, research focusing on memory impairments associated with amnesia has generated a large array of findings which, in turn, has led to many theoretical advances. Specifically, much attention has been directed toward the identification of increasingly refined and sophisticated dissociations. Thereby, we have learned that amnesic patients usually show spared short-term memory versus impaired long-term memory (Baddeley & Warrington, 1970) and demonstrate intact non-conscious long-term memory versus altered conscious long-term memory (Squire & Zola, 1996). Within the conscious long-term memory deficits, patients with amnesia have also been found to exhibit pronounced deficits in recollection – i.e., defined as the ability to mentally relive past events in vivid details – while showing no or less impairment in familiarity – i.e., defined as a vague feeling of “oldness” associated with past experiences (e.g., Addante, Ranganath, Olichney, & Yonelinas, 2012; Bastin et al., 2004; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). Indeed, in a comprehensive review of studies focusing on recollection and familiarity in amnesia, Yonelinas et al. (1998) concluded that both processes are compromised in amnesic patients, but that the impairment in familiarity is typically less severe than that in recollection. Since that date, the question of whether and when familiarity is impaired in amnesia has been hotly debated (e.g., Keane, Orlando, & Verfaellie, 2006; Ozubko & Yonelinas, 2014; Squire, 2004).

According to many authors, processing fluency – i.e., the speed and ease with which a stimulus is processed – is a key factor to understand familiarity-based memory decisions (e.g., Jacoby & Dallas, 1981; Whittlesea, 1993; Willems, Germain, Salmon, & Van der Linden, 2009). Specifically, because people intuitively know that an earlier encounter with a stimulus generally enhances processing fluency, it is usually assumed that a feeling a familiarity can result from attributional processes whereby people ascribe fluency to the past. This view, however, has been challenged by studies showing that some patients with amnesia are not able - or at least less able - to use fluency as a cue for recognition memory, despite successfully completing priming-task conducted on the same set of stimuli (e.g., Levy, Stark, & Squire, 2004). These data suggest that processing fluency can occur without giving rise to better explicit memory judgements, leading several authors to conclude that fluency has no or only small influences on amnesic patients’ memory decisions (Conroy, Hopkins, & Squire, 2005; Squire & Dede, 2015).

In contrast with this radical vision, research documenting metacognition as a key factor to better understand the circumstances under which processing fluency can generate a subjective experience of familiarity has revealed that several steps have to be completed for people to make familiarity-based memory decisions on the basis of fluency: (a) participants have to understand at some general level that fluency is a cue that can be used to inform memory judgments, (b) they have to experience a feeling of fluency when processing a stimulus, and (c) they have to attribute this feeling of fluency to their memory (Jacoby, Kelley, & Dywan, 1989). In other words, fluency experiencers have to rely on metacognitive skills to decide whether fluency can be used as a source of evidence when making a memory decision (Whittlesea & Williams, 1998). This inferential process may not necessarily come in the form of a conscious strategy. Rather people may simply subconsciously note the occurrence of a feeling of fluency and with modest amounts of cognitive effort decide whether it is relevant to use this feeling to inform memory judgments. As evidence for this heuristic processing, studies revealed that although people can sometimes verbalize that fluency is a cue to memory (Schwartz, 1998), these verbal reports did not appear to be related with the actual use of the fluency rule when making a decision (Geurten, Willems, & Meulemans, 2015). Anyway, according to this theory, familiarity results from the interaction between metacognition and fluency experiences which both have to be preserved for familiarity-based decisions to occur.

By manipulating fluency at the time of test through masked visual priming, numerous studies have shown that the ability to experience fluency is spared in amnesia (Conroy et al., 2005; Squire, 2004; Verfaellie & Keane, 2002). What remains a subject of debate is the extent to which attributional (metacognitive) processes are also preserved in amnesic patients. Indeed, while it is generally assumed that a decrease in the ability to engage in attributional processes accounts for the impairment in familiarity observed in amnesia (Keane et al., 2006; Verfaellie, Giovanello, & Keane, 2001), two recent studies have shown that it is possibly not so much an impairment than a change in these processes that explains amnesic patients’ pattern of results in fluency-driven recognition tests (Geurten & Willems, 2017; Ozubko & Yonelinas, 2014).

More specifically, Geurten and Willems (2017; Exp 1) have examined the influence of the introduction of an alternative source of fluency on patients’ recognition decisions by manipulating the perceptual quality of stimuli during a forced-choice recognition test. Their results revealed that healthy participants relied on the absolute level of fluency when making recognition decisions, while amnesic patients appeared to disqualify fluency as a cue to memory when an external source of fluency is detected. The authors suggest that patients’ underuse of fluency could result from a learned reinterpretation of fluency as a poor cue for memory rather than from a real inability to rely on it. Because of the high number of situations where fluency leads to memory errors in patients’ daily lives, the ecological validity of the correlation between fluency and past occurrence gradually decrease. Consequently, in order to reduce fluency-based memory errors, participants progressively learn to implement –possibly unconscious– strategies to track biasing fluency sources. Behaviorally, this leads them to rely on fluency only when they can attribute it to pre-exposure with a high level of confidence.

In another experiment, Geurten and Willems (2017; Exp 2) have tested the first part of their hypothesis, showing that healthy participants repeatedly exposed to evidence that perceptual-quality-driven fluency lead to memory errors started to disqualify fluency as a cue for memory, mimicking the pattern of responses demonstrated by amnesic patients. To date, however, the second part of their hypothesis – according to which patients with amnesia should be able to track alternative sources of fluency more effectively than healthy participants – is still to be investigated.

In this context, the primary aim of the present study was to test whether differences in the ability of amnesic and healthy participants to detect alternative sources of fluency can account for differences observed in the use of fluency. To this end, patients with severe memory deficits and matched controls were recruited. The same procedure than the one used in the study of Geurten and Willems (2017; Exp 1) was employed except that participants were presented with three forced-choice recognition tests instead of one. In each test, in addition to exposure-related fluency, an external source of fluency was provided by manipulating the perceptual quality of either the studied or the unstudied items during the test phase. To do so, we prepared three types of target-distractor pairs by combining stimuli with high and low visual quality. It has been shown that pictures with a high figure-ground contrast are perceived as clearer and easier to process than low-contrast ones (Checkosky & Whitlock, 1973; Whittlesea, Jacoby, & Girard, 1990). Critically, here, the detectability of the contrast reduction varied in each of the three recognition tests (i.e., picture included in the three tests were respectively given a 10%, 20%, or 30% contrast reduction). Importantly, the representation of the stimuli is not manipulated here. Indeed, the representation of each item – created during the encoding phase – will be the same in our three experimental conditions. However, we have manipulated factors that should influence the results of the attributional processes (for a recent integrative memory model presenting the distinctions and the interactions between the level of representation and the level of attribution in memory, see Bastin et al., 2019).

In a similar experiment conducted in three different samples of healthy participants, Willems and Van der Linden (2006; Exp 1-3) have found that fluency due to pre-exposure influenced recognition responses less when the perceptual manipulation associated with the target was obvious as compared to when it was only detectable or barely noticeable. In this context, as in the study of Geurten and Willems (2017) and of Willems and Van der Linden (2006), we expect participants to produce a greater correct recognition rate for targets with higher picture quality when the picture quality manipulation remains undetected (Jacoby & Whitehouse, 1989). However, when the perceptual manipulation is detected and judged to be the principal source of the feeling of fluency, we expect participants to attribute fluency to this external source (Whittlesea & Williams, 2000). In the latter case, fluency is not expected to be used as a guide for recognition decisions. In addition, if amnestic patients truly implement strategies to more effectively detect alternative sources of fluency, we hypothesize that they would demonstrate reluctance to use fluency at a low level of contrast reduction (i.e., when the external source is relatively difficult to detect; i.e., 20% contrast reduction) while healthy patients would only disqualify fluency at a high level of contrast reduction (i.e., when the external source is easily detectable; i.e., 30% contrast reduction). Finally, if attributional processes are truly preserved in amnesia, all participants should be able to rely on fluency at a very low level of contrast reduction (i.e., when the alternative source is barely noticeable; i.e., 10% contrast reduction).

**Methods**

**Participants**

Eight French-speaking patients (3 females) with amnesia participated in this study. They were recruited from various neuropsychological rehabilitation units in Belgium. Major attentional and executive function deficits constituted an exclusion criterion. The time since diagnosis ranged from 1 to 11 years (*Mean* = 3.88, *SD* = 3.48). The mean age was 37.4 (*SD* = 12.09) years and the mean education level was 13.4 (*SD* = 2.4) years. General intellectual efficiency was estimated using the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler & Hsiao-pin, 2011). The Wechsler Memory Scale (WMS-III; Wechsler, 1997) was used to appraise patients’ working memory and episodic memory abilities. All patients showed normal intellectual functioning (*IQ* = 98.4; *SD* = 7.5) and working memory performance (Working memory index = 93.25; *SD* = 8.5). However, they had severe episodic memory deficits (general memory index = 58; *SD* = 5.8; visual delay index = 58.9; *SD* = 7.6; and auditory delay index = 64; *SD* = 7.1). Patients’ characteristics are presented in Table 1.

< Table 1 >

Moreover, two healthy participants who had no history of psychiatric or neurological illness were matched with each amnesic patient for age, gender (n = 16; 6 females), and education level. Their ages ranged from 21 to 55 years (*Mean* = 43.2 years; *SD* = 12.6); they had a mean IQ of 96 (*SD* = 10.15), and a mean education level of 13.7 (*SD* = 23.6) years. The control and amnesic groups did not differ significantly in age, education, or IQ, all *ps* > .50.

Required sample size was determined a priori on the basis of the medium to large effects that were observed in similar studies focusing on fluency use in amnesia (e.g., Geurten & Willems, 2017). Specifically, sample size was thus set in order to reach a predicted power of .80 for a within-between interaction (medium effect size).

**Materials**

As in the study of Geurten and Willems (2017), unfamiliar drawings created from abstract paintings were used as stimuli in order to limit pre-experimental familiarity. Specifically, three series of 60 drawings were created and randomly assigned to one recognition test. Each of the 60 figures of the three tests was randomly assigned to Sets A and B. Half of the participants were presented with Set A as targets and Set B as distractors; the other half of the participants were presented with the reverse design.

A high-fluency and low-fluency version of each drawing was created by manipulating the figure-ground contrast quality of the figures. To do so, we used the same method as the one employed by Reber, Winkielman, and Schwarz (1998) who degraded both the picture foreground and the picture background. This manipulation has repeatedly been shown to influence processing fluency through its impact on various types of judgments inside and outside the memory domain (e.g., Reber, Schwarz, & Winkielman, 2004; Willems & Van der Linden, 2006). Specifically here, in each of the three recognition tests, the high-contrast version of the figures was always the same (i.e., white on black). However, the quality of the low-contrast version of each abstract picture varied as a function of the test. In the first test, figures were given a 10% contrast reduction so the external source of fluency was barely noticeable. In the second test, figures were given a 20% contrast-reduction so the fluency manipulation was detectable but without attracting participants’ attention (Willems & Van der Linden, 2006). In the third test, figures were given a 30% contrast reduction so the external source of fluency was clearly visible. The level of contrast manipulation used in the second test were the same as the one used by Geurten and Willems (2017).

For each of the three test phases, 30 pairs of target-distractor figures were prepared based on the 60 figures: 10 Target+/Distractor– (i.e., targets had high alternative fluency), 10 Target=/Distractor= (i.e., no alternative fluency), and 10 Target–/Distractor+ (i.e., distractors had high alternative fluency) pairs. The “+” symbol indicated that the stimulus had a high-contrast (i.e., high perceptual fluency) while the “-” indicated that the stimulus had a low-contrast (i.e., low perceptual fluency). Stimuli that were assigned to these three contrast conditions were randomly counterbalanced between subjects. Figure 1 displays some examples of stimuli used in each contrast reduction test.

< Figure 1 >

**Procedure**

The study was conducted in accordance with the ethics committee of the participating institutions. Written consent was obtained before the study began. Participants were tested individually in a quiet room. They underwent an approximatively 60-minute session during which they completed three forced-choice recognition tests. These three tasks were administered in the following order: (a) the test in which the contrast manipulation was barely noticeable (contrast reduction of 10%), (b) the test in which the contrast manipulation was detectable (contrast reduction of 20%), and (c) the test in which the contrast manipulation was visible (contrast reduction of 30%). These three tasks were administered in that specific order so that the inevitable detection of the contrast manipulation in the 30% contrast reduction test would not induce participants to look for contrast differences in the other tests. The three recognition tests were composed of two experimental phases (i.e., a study phase and a test phase) and separated by approximatively 10-minute delays filled with cognitive tasks (i.e., the subtests of the WASI-II).

*Study phase.* As in the study of Geurten and Willems (2017), participants were shown and told to study 30 white-on-black figures, four times each, in random order. Each study stimulus was presented in the center of the screen for 50 ms, followed by a 17-ms interval. A rapid serial visual presentation (RSVP; Potter & Levy, 1969) was used in order to promote fluency-based recognition and eliminate the influence of declarative memory (Whittlesea, Masson, & Hughes, 2005).

*Test phase.* A forced-choice recognition test immediately followed the study phase. Participants were randomly presented with the 30 target-distractor pairs (10 Target+/Distractor-, 10 Target-/Distractor+, and 10 Target=/Distractor=). Both figures of each pair were presented simultaneously to each participant for 2000 ms followed by a self-spaced interstimulus interval. The side of the screen in which the target stimulus was displayed was randomized over the trials. Participants were asked to point to the drawing they had previously seen.

*Contrast detection.* At the end of the experiment, participants were randomly presented with 45 target-distractor pairs of abstract pictures (i.e., 15 pairs retrieved from each recognition test) and were asked to judge which of the two pictures was of better perceptual quality. This procedure was used to examine whether patients with amnesia and healthy participants truly differed in their ability to detect alternative sources of fluency when their attention is clearly focused on the picture’s perceptual quality.

**Manipulation check**

To ensure that the level of detection of the three contrast manipulations (10%, 20%, or 30%) truly differed from one another, but was still sufficient for participants to develop fluency expectations, a pretest was carried out. A group of 12 participants (aged between 21 and 55 years) was randomly presented with the 90 pairs of pictures (Target+/Distractor–, Target=/Distractor=, and Target–/Distractor+) and asked to judge which of the two pictures of the pairs (if any) was of better perceptual quality. Statistical analyses revealed that high-contrast stimuli were selected in a proportion greater than chance when targets were given a 10% contrast reduction (*Mean* = .57, *t*(29) = 2.8, *p* = .015, *d* = 1.03), a 20% contrast reduction (*Mean* = .70, *t*(29) = 3.2, *p* < .001, *d* = 2.09), and a 30% contrast reduction (*Mean* = .95, *t*(29) = 11.28, *p* < .001, *d* = 4.70). They also revealed that the level of detection was significantly lower with a 10% contrast reduction than with a 20% contrast reduction (*p* = .004), which was significantly lower than with a 30% contrast reduction (p < .001). These results indicated that, when the participants’ attention was focused on the detection of perceptual differences, the level of detection of the contrast manipulation differed across the three conditions while remaining noticeable in each of them.

**Results**

**Contrast detection rate**

A 2 (Group: control or amnesic) x 3 (Contrast reduction: 10%, 20%, 30%) mixed-factor ANOVA was carried out to determine whether the ability of participants to detect the perceptual manipulation differed across groups. The results revealed that the effect of contrast reduction was significant, *F*(2,34) = 184.27, *p* < .001, *η2p* = .92. Specifically, the high-contrast stimuli were selected more often after a 30% contrast reduction (*Mean* = .98) than after a 20% contrast reduction (*Mean* = .71), and after a 10% contrast reduction (*Mean* = .61). No other result reached significance, *Fs* < 1.01.

**Recognition rate**

A 2 (Group: control or amnesic) x 3 (Contrast reduction: 10%, 20%, 30%) x 3 (Target fluency: Target+/Distractor–, Target=/Distractor=, Target–/Distractor+) mixed-factor ANOVA was carried out to examine the influence of the perceptual fluency manipulation on participants’ correct recognition decisions. The group was the only between-participant factor. The results revealed a Contrast reduction x Target fluency interaction, *F*(4,88) = 6.74, *p* < .001, *η2p* = .23, and a Group x Contrast reduction x Target fluency triple interaction, *F*(4,88) = 4.17, *p* = .004, *η2p* = .16. The triple interaction resulted from the fact that, in the 10% contrast reduction test (i.e., barely noticeable manipulation), both healthy participants (*M* = .57 vs. .43), *F*(1,22) = 5.21, *p* = .03, *η2p* = .30, and patients with amnesia (*M* = .63 vs. .41), *F*(1,22) = 6.83, *p* = .016, *η2p* = .42, produced more correct “old” responses when the visual manipulation induced a strong feeling of fluency (Target+/Distractor–) as compared to when it induced a weak feeling of fluency (Target–/Distractor+). Conversely, in the 30% contrast reduction test (i.e., obvious manipulation), both groups gave fewer correct “old” responses when the competing source induced a strong feeling of fluency (Target+/Distractor–) than when it induced a weak feeling of fluency (Target–/Distractor+), *M* = .46 vs. .65, *F*(1,22) = 3.96, *p* = .05, *η2p* = .17 and *M* = .38 vs. .65, *F*(1,22) = 4.25, *p* = .04, *η2p* = .63, for controls and amnesic respectively. Finally, an opposite profile was observed between our two groups after a 20% contrast reduction (i.e., detectable manipulation). Indeed, our data showed that the controls produced more correct “old” responses when the visual manipulation induced a strong feeling of fluency than when it induced a weak feeling of fluency (*M* = .60 vs. .41), *F*(1,22) = 3.79, *p* = .05, *η2p* = .19, while patients with amnesia seemed to give fewer correct “old” responses when the competing source induced a strong feeling of fluency than when it induced a weak feeling of fluency (*M* = .31 vs. .65), *F*(1,22) = 7.04, *p* = .015, *η2p* = .63. No other result reached significance, *F* < 2 (see Figure 2).

Finally, to further ensure that the contrast reduction manipulation was truly successful to enhance participants feeling of fluency, we compared whether participants truly showed a higher rate of correct recognitions for the pairs where the fluency of the target was high (Target+/Distractor–) than for the pairs where fluency was not manipulated (Target=/Distractor=), at least when the level of contrast reduction was discreet enough not to induce a disqualification of the fluency cue. In control participants, results revealed a trend toward a higher hit rate for pairs with a high fluency target than for pairs where the fluency was not manipulated in the 10% contrast reduction test, *M* = .57 vs. .52, *F*(1,22) = 2.96, *p* = .08, *η2p* = .15. A higher hit rate was also found for pairs with high fluency target than for pairs where fluency was not manipulated in the 20% contrast reduction, *M* = .60 vs. .50, *F*(1,22) = 4.16, *p* = .04, *η2p* = .18. Similarly, in the 10% contrast reduction, amnesic patients gave more correct responses when the fluency of the target was high than when the perceptual fluency of the pairs were not manipulated, *M* = .63 vs. .49, *F*(1,22) = 6.18, *p* = .02, *η2p* = .52. Overall, these findings confirm the validity of the fluency manipulation.

< Figure 2 >

**Discussion**

The main goal of this experiment was to determine whether differences in how patients with amnesia and healthy controls rely on fluency can be explained by the fact that amnesic patients detect alternative sources of fluency more effectively than healthy participants, leading them to more often disqualify fluency as a cue for memory. Our findings seem to confirm this hypothesis. Indeed, our results indicated that all participants rely on the absolute level of fluency when making recognition decisions (i.e. the higher the fluency, the higher their correct recognition rate) as long as the perceptual manipulation (i.e., contrast reduction) that serves as an alternative source of fluency remains unnoticed. The main finding of the present study is that the level of contrast reduction at which the alternative source is detected differs between our groups.

Specifically, in the 10% contrast reduction test, our results revealed that both healthy participants and amnesic patients gave more correct responses on pairs where recognition of the target was facilitated by high contrast picture than on pairs where the processing of the distractor was facilitated. This pattern suggests that when the perceptual manipulation is sufficient to induce a feeling of fluency, but inconspicuous enough not to be explicitly detected, patients with amnesia are able to rely on fluency to guide their memory decisions in the same way as healthy participants. Many studies in which participants remain unconscious of the artificial manipulation of their processing experience demonstrate that type of pattern in healthy participants (e.g., Jacoby & Whitehouse, 1989; Willems & Van der Linden, 2006).

In the 30% contrast reduction test, our data showed that both healthy and amnesic participants better performed on pairs where the distractor was made easier to process than on pairs where the target was made easier to process. This pattern indicates that all participants disqualify fluency as a relevant cue for memory when an external source is clearly visible. Consistent with this view, our analyses revealed that when participants are explicitly asked to compare the perceptual quality of these pairs their detection rate was nearly perfect (*M* = .97), suggesting that the experimental manipulation is easily detectable. Interestingly, these results can be interpreted within the discrepancy-attribution framework (Whittlesea & Williams, 2000, 2001a, 2001b; Willems & Van der Linden, 2006). 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 produce more fluency expectations than past experience, even healthy participants are likely to attribute their 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.

Taken together, the results obtained in the 10% and 30% contrast reduction tests are interesting because, to our knowledge, it is the first time that, in the same experiment, a sample of patients with amnesia showed either a strong reliance or a disqualification of fluency depending on the characteristic of the test items. These findings are crucial as they could help to explain why, in previous studies, the influence of processing fluency on patients’ recognition decisions varied from large (Keane et al., 2006) to small (Verfaellie & Cermak, 1999) or even inconsistent (Levy et al., 2004) as a function of the experimental manipulation. For instance, using a very subtle manipulation of fluency including one condition in which the constituent letters for studied and unstudied words were distinct (non-overlap) and another condition in which the constituent letters for studied and unstudied words were the same (overlap), Keane et al. (2006) found a large influence of fluency on patients’ recognition judgments. Conversely, using a procedure manipulating fluency through (probably) detectable perceptual priming (83 ms), Verfaellie and Cermark (1999) only found a small effect of their manipulation on patients’ memory performance.

Finally, the results observed in the 20% contrast reduction test are particularly important because they replicated those of Geurten and Willems (2017) by showing different patterns of responses between healthy controls and patients with amnesia. Specifically, control participants performed better on pairs where the processing fluency of the target was high than on pairs where the processing fluency of the distractor was high. Conversely, in amnesic patients, poorer recognition performance was observed for pairs where the processing of the target was facilitated by higher picture quality, while better recognition performance was observed for pairs where the processing of the distractor was facilitated by higher picture quality. According to the discrepancy-attribution hypothesis, these findings suggest that patients with amnesia, but not controls, have detected the perceptual manipulation and judged it as the source of their feeling of fluency, leading them to disqualify fluency as a relevant memory cue. All this occurs although our analyses revealed that both patients and controls showed similar detection rate when they were explicitly asked to focus on the differences in perceptual quality between stimuli (*M* = .69 and .74, for control and amnesic participants, respectively). These findings indicate that differences observed in the correct recognition rate between our two groups are not due to a better ability of the patients to detect the contrast manipulation per se. Indeed, all our participants were shown to be able to detect the manipulation when their attention was focused on the pictures’ perceptual quality. In this context, we hypothesize that differences in fluency use between our groups result from the fact that patients with amnesia could allocate resources to the detection of perceptual differences during the recognition test, leading them to more readily detect the alternative source which remains unnoticed by control participants.

Overall, the findings of the present study seem to confirm the hypothesis of Geurten and Willems (2017) according to which patients with amnesia progressively start to track alternative sources of fluency in order to reduce the frequency of their fluency-based memory illusions. Specifically, given that recollection control processes are disturbed in amnesia (Bastin et al., 2004; Yonelinas et al., 1998), it is possible that amnesic patients frequently experienced situations where fluency leads to memory errors in their daily life, creating the need to implement strategies to help them to decide with a high level of certainty whether their feeling of fluency results from prior exposure or from another source. This could explain why patients only appear to use fluency in a context where the external manipulation is hardly noticeable. On the other hand, healthy participants have no reason to closely track alternative sources of fluency in an attempt to compensate for impaired recollection control processes. Consequently, as in the study of Willems and Van der Linden (2006), the manipulation of the perceptual quality of the picture has to be glaringly obvious for them to disqualify fluency as a cue to memory.

Despite the relative clarity of these results, the question of whether the monitoring processes involved in the tracking of external sources of fluency are explicit/effortful or implicit/automatic still has to be investigated. Indeed, according to the cue-utilization approach of memory (Koriat, 1997; 2007), monitoring processes can sometimes occur without explicit goals and even without consciousness. To test this hypothesis, future experiments in which patients with amnesia would have to verbally report the strategies they used while completing some recognition tasks should be conducted. Another option could be to put patients in a divided attention situation while performing our three recognition tests in order to determine whether a disqualification of fluency is still observed in the 20% contrast reduction.

Moreover, it is important to note that other metacognitive mechanisms may be suggested to account for the findings reported in the present study. Indeed, we postulate that patients with amnesia implement (implicitly or explicitly) strategies to track alternative sources of fluency in order to avoid memory errors. However, a pattern of responses similar to the one obtained in the present experiment would have been observed if patients had simply set a more conservative response threshold on their global feeling of familiarity in order to effectively discount fluency as a diagnostic cue of information. The perceptual manipulation presumably producing more fluency in the 20% contrast reduction test than in the 10% contrast reduction test, if patients had change their response criterion, the experienced fluency would have logically been more likely to be disqualified in the former than in the latter test. As patients with amnesia do not expect their impaired memory to produce a strong memory feeling, they would be more likely to reject strong as compare to weak feelings of familiarity. Within this framework, patients are not supposed to allocate more resources than healthy participants to the tracking of alternative fluency sources, but are assumed to react differently to the absolute level of fluency that is experienced. This could explain why in one study, Ozubko and Yonelinas (2014) found that amnesic patients’ recognition decisions were driven by fluency for new, but not for old, items. However, as in this experiment the prime used to enhanced fluency was detectable, the hypothesis that patients had tracked the alternative source of fluency is still plausible. To truly disentangle these two hypotheses, an experimental manipulation designed to induce a strong feeling of familiarity while the external source of fluency would remain undetectable should be carried out. If the changing criterion hypothesis is correct, such a manipulation would give rise to a disqualification of fluency in amnesic patients. On the reverse, if the tracking hypothesis is correct, patients with amnesia should rely on fluency to inform their recognition decisions in such a design.

There are several limitations on this study. First, the small number of patients with amnesia means that the results of our statistical analyses must be interpreted with caution. Nevertheless, the fact that, in the 20% contrast reduction test, we replicated the results of Geurten and Willems (2017) seems to speak in favor of the robustness and validity of our findings. Moreover, to determine whether our results could be generalized, it would be interesting to replicate these results in other clinical populations where severe memory problems are widespread and where, as in amnesia, fluency-based memory decisions are not shown to translate into better recognition performance (e.g., Simon, Bastin, Salmon, & Willems, 2018). In the same vein, the impact of the etiology of the amnesia could also be investigated. In this study, the recognition performance of all our patients was quite homogeneous. Of note, patients were selected to present only memory deficits. However, it could be interesting to explore whether all types of amnesic patients in more heterogeneous samples have the same profile of results at our tests. Given to potential involvement of frontal lobes in attributional processes, it is possible that amnesic patients with head trauma or Korsakoff syndrome (i.e., who frequently show frontal damage) demonstrate more deficits in attributional processes than, for example, patients with anoxia.

A second limitation of this study is that the three recognitions tests (10%, 20%, and 30% contrast reduction) were always presented in the same order. Although this specific procedure was selected because we wanted the fluency manipulation to remain undetected as long as possible, this confounding of test order may have influenced our results through, for example, an increase of proactive interference for the last tests. Even though the global performance of our participants was shown to remain stable across tests, which seems to rule out the possibility of an interference effect, our results should nevertheless be replicated using other types of designs. One possibility to overcome this problem could be, for example, to replace the block design used in this experiment by a between-subject design where three groups of patients saw pairs of stimuli with either a 10%, a 20% or a 30% contrast reduction at test.

Another concern is the fact that, in the present study, participants perform mostly at chance in the control condition (T=D=). This poses the question of whether the current results could generalize to tests in which the recognition performance is above chance. Although future experiments should be conducted to formally test this issue, some responses are already available in the literature. For instance, in studies where a counterfeit encoding is used (i.e., a procedure where participants are told that stimuli are presented in a subliminal manner at study when, in fact, there are not), participants’ performance is usually at chance on subsequent tests. Despite this, however, data reveal similar variations in fluency effects after a counterfeit encoding than after a classic encoding condition that leads to above-chance recognition performance (e.g., Lloyd, Westerman, & Miller, 2003; Westerman, Miller, & Lloyd, 2003).

Finally, one last point to discuss is the low detectability of the contrast manipulation in the 10% contrast reduction test. This condition allowed us to confirm that, in some circumstances, patients with amnesia are able to rely on fluency to guide their memory decisions in a similar extent than healthy participants. However, as the contrast reduction of most pairs included in this condition was not detectable (i.e., correct detection rate of 57% in the pilot data), we could not determine whether patients rely on fluency in this condition because they fail to *find* an alternative source of fluency or because their experienced level of fluency was not high enough to prompt them to *search* for an alternative source.

Despite these limitations, our results could already have major implications. From a theoretical perspective, our findings could help to resolve the conceptual debate on the question of whether and when familiarity is impaired in amnesia. Specifically, our study adds to the small amount of literature showing that attributional processes – which have long been assumed to account for the emergence of familiarity (Jacoby & Dallas, 1981) – are probably not impaired in amnesia but undergo some metacognitive changes that are the product of both a decrease in the ecological validity of the fluency-memory correlations in daily life and the implementation of a more conservative response criterion or of strategies aiming at tracking alternative sources in order to reduce memory errors (Geurten & Willems, 2017; Ozubko & Yonelinas, 2014). More generally, our findings emphasize the importance of looking beyond the mere behavioral pattern that are observed following a memory task in amnesia. Indeed, what could, at first sight, appears as an impaired or abnormal test performance may actually result from subtle metacognitive changes that are very adaptive for patients’ day-to-day functioning.

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Table 1

*Summary of Amnesic Patients’ Characteristics*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | WMS-III |
| Etiology | Age | Ed. | TD (years) | WASI–II | WM | GM | AD | VD |
| Anoxia | 31 | 12 | 2 | 90 | 91 | 63 | 60 | 72 |
| Anoxia | 51 | 16 | 7 | 106 | 105 | 62 | 59 | 68 |
| Anoxia | 25 | 17 | 3 | 102 | 108 | 66 | 74 | 68 |
| Encephalitis | 41 | 15 | 1 | 95 | 87 | 56 | 53 | 64 |
| Closed-head injury | 46 | 12 | 2 | 111 | 90 | 54 | 56 | 64 |
| Closed-head injury | 56 | 12 | 1 | 98 | 85 | 52 | 53 | 50 |
| Closed-head injury | 21 | 13 | 4 | 95 | 90 | 61 | 65 | 68 |
| Closed-head injury | 28 | 10 | 11 | 90 | 90 | 50 | 51 | 58 |

*Notes.* WASI–II: Wechsler Abbreviate Scale of Intelligence – Second edition; WMS–III: Wechsler Memory Scale – third edition; Ed.: education in years; TD: Time since Diagnosis; WM: working memory index; GM: general memory index; AD: auditory delay index; VD: verbal delay index.



*Figure 1.* Examples of pairs of abstract pictures used in each contrast reduction test. The items with the reduced contrast are on the left.



*Figure 1.* Mean proportion of “Old” responses for targets in the three contrast reduction tests (10%, 20%, and 30%) and the three picture quality (T+/D–: high-contrast target, low-contrast distractor; T=/D=: high-contrast target, high-contrast distractor; T–/D+: low-contrast target, high-contrast distractor) for each group (Control vs. Amnesic). Error bars display the standard deviations.