**The learned reinterpretation of fluency in amnesia**

Marie Geurten1 & Sylvie Willems2
1 Department of Psychology, Neuropsychology Unit, University of Liège, Belgium

2 Psychological and Speech Therapy Consultation Center (CPLU), University of Liège, Belgium

Word Count: 6991

E-mail: Marie Geurten, mgeurten@ulg.ac.be;

Sylvie Willems, sylvie.willems@ulg.ac.be

Correspondence concerning this article should be addressed to Marie Geurten, University of Liège, Quartier Agora, Place des Orateurs, 1, B33, 4000 Liège – Belgium; E-mail: mgeurten@ulg.ac.be; Phone number: +32 4 366 59 43

**Abstract**

Fluency is one of many cues that are involved in memory decisions. To date, however, the extent to which fluency-based decisions are preserved in amnesia is not yet clear. In this study, we tested and found differences in how patients with amnesia (n = 8) and control participants (n = 16) use fluency when making recognition decisions (Experiment 1). Our results suggested that these differences could be due to changes in the readiness with which patients attribute the subjective feeling of fluency to pre-exposure when an alternative explanation is available (i.e., the perceptual quality of the item). Secondly, we explored the hypothesis that changes in attribution processes in patients with amnesia are explained by a decrease in contingency between processing fluency and previous occurrence of stimuli in patients’ daily lives, leading them to consider that fluency is not a relevant cue for memory (Experiment 2). Specifically, 42 healthy participants were put either in a condition where the positive contingency between fluent processing and previous encounters with an item was systematically confirmed (classic condition) or in a condition where the classical association between fluency and prior exposure was systematically reversed (reversed condition). Results indicated that participants more readily attribute fluency to the alternative external source than to past experience in the reversed condition than in the classic condition, mimicking the pattern of results shown by participants with amnesia in Experiment 1. Implications of these findings are discussed.

*Keywords:* Amnesia; Fluency heuristic; Episodic memory; Attribution processes

**The learned reinterpretation of fluency in amnesia**

**1. Introduction**

Processing fluency – typically defined as the speed and ease with which a stimulus is processed (Reber, Wurtz, & Zimmermann, 2004) – is one of many cues that are involved in memory decisions (Jacoby & Dallas, 1981; Whittlesea, 1993). Because people intuitively know that an earlier encounter with a stimulus generally enhances processing fluency, a feeling of “oldness” can result from attributional processes whereby people ascribe fluency to the past. Several studies conducted on healthy people indicate that the use of fluency in recognition decisions is a reliable phenomenon. For instance, studies that have artificially manipulated fluency at the time of test through masked visual priming (e.g., Jacoby & Whitehouse, 1989) or by varying the perceptual clarity of stimuli (e.g., Whittlesea, 1993) have established that recognition decisions are influenced by processing fluency.

Because priming-fluency effects are spared in amnesia (see Verfaellie & Keane, 2002), researchers usually assume that some degree of fluency-based recognition is preserved in patients with amnesia. Indeed, Verfaellie and Cermak (1999) found that, when items of a recognition test were presented as a series of gradually unmasked words, patients with amnesia increased their rate of “old” responses to stimuli identified faster. That is, more fluently processed items were more likely to be called “old” on a recognition test by patients with amnesia (see also Verfaellie & Keane, 2002). However, the extent to which these processes are preserved is not yet clear and still remains a subject of debate. For example, Squire (2004) reported the case of patient E.P. who did not use fluency as a cue for recognition decisions although he successfully completed priming tasks (Conroy, Hopkins, & Squire, 2005).

More recently, Ozubko and Yonelinas (2014) found that conceptual fluency increased amnesia patients’ recognition responses, but surprisingly only for new items, not for old ones. They postulated that patients’ apparent inability to rely normally on fluency cues could result from a “reluctance to use fluency” and/or a “reduced ability to separate sources of fluency” (pp. 65-66). Patients with severe memory problems may be less inclined to regard a strong feeling of fluency (e.g., “old” items that have also been primed) as a reliable product of their impaired memory. The lack of attribution of fluency to memory could also be accentuated by their difficulty remembering the prior study phase as a possible source of their current feeling of fluency. So, in the context of multiple sources of processing fluency, amnesic patients may be more prone to attribute fluency to an external source. These hypotheses are consistent with the results of previous studies demonstrating that amnesic patients use fluency more readily when they are prompted to do so (Verfaellie, Giovanello, & Keane, 2001; for similar findings in patients with Alzheimer’s disease, see Simon, Bastin, Salmon, & Willems, 2016) or when no competing sources of fluency are available (Keane, Orlando, & Verfaellie, 2006).

These hypotheses mean that the conversion of processing fluency to a feeling of oldness is not automatic or mandatory, as proposed by Unkelbach (2006, 2007), who conceptualized the use of fluency as a malleable heuristic that can evolve as a function of context and daily learning. Within this framework, fluency is viewed as a cue whose impact on judgments depends on its expected ecological validity. That is, if people learn (e.g., via feedback or implicit repeated exposure) that fluency is an experience that does *not* correlate with the previous occurrence of stimuli, then the likelihood that people will use fluency to guide their recognition decisions will decrease (see also Geurten, Willems, & Meulemans, 2015). So it is possible that the fluency heuristic progressively evolves in amnesic patients if they learn that their impaired memory no longer provides reliable information or that the fluency cue can mislead their memory judgments. Indeed, fluency can frequently produce false recognitions in the absence of recollection of plausible or implausible previous encounters (Gold, Marchant, Koutstaal, Schacter, & Budson, 2007).

To our knowledge, however, the “reluctance to use fluency” account (Ozubko & Yonelinas, 2014) has never been tested directly. Yet such a finding could provide critical information on how to improve recognition memory in patients with amnesia. For this reason, in a first experiment, we examined the effect of the introduction of a competing source of fluency on amnesic and control participants’ recognition decisions (Experiment 1). To this end, patients with severe memory deficits and matched controls were recruited. In the study phase, we presented unfamiliar drawings in a rapid serial visual presentation (RSVP; Potter & Levy, 1969) in order to promote fluency-based recognition and eliminate the influence of declarative memory (Whittlesea, Masson, & Hughes, 2005). Then, we investigated the influence of an additional source of fluency at test by manipulating the perceptual quality of the studied items during forced-choice recognition judgments. More specifically, 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). If the picture quality manipulation is undetected or is not judged to be the source of the feeling of fluency, we would expect to observe a direct effect of the perceptual manipulation on participants’ decisions (i.e., a greater recognition rate for targets with higher picture quality; Willems & Van der Linden, 2006). However, if the perceptual manipulation is detected and judged to be the principal source of the feeling of fluency, we would expect participants to attribute fluency to this external source (Whittlesea & Williams, 2000). In this case, they should not use it to guide their recognition decisions. In Experiment 2, we further investigate the “reluctance to use fluency” hypothesis by examining whether healthy participants behave like patients with amnesia after they are repeatedly exposed to situations where the association between fluency and past experience is artificially broken (Unkelbach, 2006).

**2. Experiment 1**

The first requirement for patients with amnesia to use fluency as a cue for recognition is to attribute fluency to prior exposure rather than to other sources (e.g., intrinsic perceptual features of the stimuli). For these reasons, the primary aim of Experiment 1 was to test whether the changes in fluency-based memory decisions that are frequently observed in amnesia are due to the fact that participants with amnesia do not attribute fluency to their past experience as readily as control participants when an alternative explanatory source is available. If this is the case, we expect control participants to show a higher rate of correct recognitions when the competing source induces a strong feeling of fluency than when it induces a weak feeling of fluency. Conversely, we expect patients with amnesia to produce a lower rate of correct recognitions when the competing source induces a strong feeling of fluency than when it induces a weak feeling of fluency.

***2.1 Method***

*2.1.1 Participants*

Eight French-speaking patients (3 females) with amnesia participated in this study. Patients were recruited from several neuropsychological units in Belgium and France. Major attentional and executive function deficits constituted an exclusion criterion. Patients’ characteristics are presented in Table 1. The time since diagnosis ranged from 1 to 28 years (*Mean* = 7.8, *SD* = 9.01). The mean age of the amnesic group was 45 (*SD* = 9.3) years and the mean education level was 13 (*SD* = 2.6) years. General intellectual efficiency was assessed using the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997a). The Wechsler Memory Scale (WMS-III; Wechsler, 1997b) was used to appraise patients’ working memory and episodic memory abilities. All patients showed normal intellectual functioning (IQ = 119; *SD* = 18) and working memory performance (Working memory index = 94; *SD* = 17). However, they had severe episodic memory deficits (general memory index = 52.5; *SD* = 10; visual delay index = 60; *SD* = 14; and auditory delay index = 61; *SD* = 8). The evaluation of these patients took place in the context of a more global neuropsychological assessment. No prior revalidation or cognitive education work has been performed to inform these patients about the role of fluency in their memory decisions.

Table 1

*Summary of Amnesic Patients’ Neuropsychological Characteristics*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | WMS-III |
| Etiology | Age | Ed. | Time since diagnosis (years) | WAIS–III | WM | GM | AD | VD |
| Anoxia | 55 | 15 | 6 | 81 | 97 | 45 | 60 | 56 |
| Anoxia | 28 | 12 | 28 | 135 | 127 | 59 | 54 | 75 |
| Encephalitis | 51 | 16 | 3 | 96 | 88 | 69 | 79 | 75 |
| Korsakoff | 51 | 8 | 1 | 88 | 85 | 47 | 60 | 52 |
| Korsakoff | 52 | 12 | 1 | 118 | 111 | 65 | 60 | 78 |
| Closed-head injury | 37 | 15 | 4 | 110 | 82 | 45 | 57 | 52 |
| Closed-head injury | 43 | 12 | 7 | 103 | 80 | 45 | 57 | 45 |
| Closed-head injury | 40 | 15 | 13 | 119 | 82 | 45 | 60 | 45 |

*Notes.* WAIS–III: Wechsler Adult Intelligence Scale – third edition; WMS–III: Wechsler Memory Scale – third edition; Ed.: education in years; WM: working memory index; GM: general memory index; AD: auditory delay index; VD: verbal delay index.

Two healthy participants who had no history of psychiatric or neurological illness were matched with each amnesic patient for age, gender (6 females), and education level. Their ages ranged from 26 to 55 years (*Mean* = 46 years; *SD* = 11); they had a mean IQ of 118 (*SD* = 23), and a mean education level of 12 (*SD* = 2.2) years. The control and amnesic groups did not differ significantly in age, education, or IQ, all *ps* > .30.

*2.1.2 Material*

Sixty unfamiliar drawings created from abstract paintings (retrieved from http://gillesbalmet.free.fr) were used as stimuli in this experiment (see Figure 1). We selected unfamiliar pictures in order to limit pre-experimental familiarity. In a preliminary phase, we prepared 60 figures with homogeneous complexity. For this purpose, 150 figures were rated for “subjective complexity” by 12 undergraduate students on a 5-point Likert scale. Figures with the lowest and highest complexity were excluded to limit an additional fluency source. Figures were assigned randomly 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.

**

*Figure 1.* Sample pair of pictures used in the recognition test. The right-hand picture was given a 20% contrast reduction (low fluency).

We created a high-fluency and a low-fluency version of each figure: i.e., a high-contrast (white on black) version and a low-contrast (the picture was given a 20% contrast reduction) version of each abstract picture. We used this level of contrast manipulation because it has been shown to be perceptible enough to induce fluency expectations without attracting participants’ attention (Willems & Van der Linden, 2006). For the test phase, we prepared 30 pairs of target-distractor figures: 10 Target+/Distractor– (high alternative fluency), 10 Target+/Distractor+ (no alternative fluency), and 10 Target–/Distractor+ (low 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.

*2.1.3 Procedure*

The study was conducted in accordance with the local ethics committee. Written consent was obtained before the study began. Participants were tested individually in a quiet room. The experimental procedure was composed of two phases.

2.1.3.1 Study phase

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.

2.1.3.2 Recognition 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.

***2.2 Results***

*2.2.1 Manipulation check*

To ensure that the contrast manipulation was truly perceptible and, thus, could induce participants to develop fluency expectations, we carried out a pretest. A group of 10 individuals (aged between 23 and 57 years) was randomly presented with the 30 pairs of pictures (Target+/Distractor–, Target+/Distractor+, and Target–/Distractor+) and asked to judge which of the two pictures (if any) was of better perceptual quality. When the participants’ attention was clearly focused on the picture’s perceptual quality, statistical analyses revealed that high-contrast stimuli were selected in a proportion greater than chance (*Mean* = .75), *t*(29) = 8.70, *p* < .001, *d* = 1.61. This result indicated that the contrast manipulation is noticeable, at least when the participants’ attention is focused on the detection of perceptual differences. Moreover, no gender or order effects were found on participants’ rate of correct recognition, all *Fs* < 1

*2.2.2 Recognition rate*

A 2 (Group: control or amnesic) x 3 (Picture quality: 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 results revealed a Group x Picture quality interaction, *F*(2,56) = 5.173, *p* = .009, *η2p* = .16, and a main effect of group, *F*(1,28) = 8.174, *p* = .008, *η2p* = .23, with better recognition performance by the control group. The effect of picture quality was not significant, *F* < 1. The interaction was found because 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, *F*(1,28) = 2.928, *p* = .01, *η2p* = .09. Conversely, 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, *F*(1,28) = 3.920, *p* = .05, *η2p* = .26 (see Table 2). No other result reached significance, *F* < 2.

Table 2

*Mean Proportion of “Old” Responses for Targets by Test Pair Contrast (Standard Deviation) for Each Group (Control vs. Amnesic) in Experiment 1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total | T+/D– | T+/D+ | T–/D+ |
| Control | .66 (.15) | .70 (.16) | .64 (.17) | .59 (.23) |
| Amnesic | .52 (.16) | .39 (.17) | .52 (.20) | .57 (.20) |

*Note.* T+/D–: high-contrast target, low-contrast distractor; T+/D+: high-contrast target, high-contrast distractor; T–/D+: low-contrast target, high-contrast distractor.

***2.3 Discussion***

In this experiment, we manipulated the influence of different sources of fluency by presenting different picture quality levels during a forced-choice recognition test. Our results revealed that healthy participants performed well on pairs where recognition of the target was also facilitated by high picture quality (*Mean* = .70), but not on pairs where the distractor was made easier to process (*Mean* = .58). Thus, healthy participants seemed to base their judgment on a direct assessment of absolute fluency (the higher the fluency, the higher their correct recognition rate), as has been observed in various studies in which participants were unconscious of the influence of stimulus quality on their processing experience (Jacoby & Whitehouse, 1989; Willems & Van der Linden, 2006). For the amnesic group, the visual manipulation had the opposite effect. Poorer recognition performance was observed for pairs where the targets were facilitated by higher picture quality (*Mean* = .39), while better recognition performance was observed for pairs where distractors were facilitated by higher picture quality (*Mean* = .57).

Unlike the controls, the patients with amnesia seem to have detected the situations in which fluency was biased. Moreover, it seems that, once a participant with amnesia detected any variable that might generate fluency, the overall subjective feeling of fluency was attributed to this alternative explanatory source rather than to pre-exposure. Thus, they would attribute fluency to their memory only under conditions where there were no possible alternative explanations for their feeling of fluency (i.e., “old” items with lower perceptual quality). This result may be explained both by the absence of memory of the study phase and by a mistrust of fluency. Experiment 2 was carried out to help us to decide between these two hypotheses.

**3. Experiment 2**

The results of Experiment 1 seem to indicate that patients with amnesia disqualify fluency as a cue for memory when they detect an alternative source of fluency. The aim of Experiment 2 was to investigate what processes might explain these changes in patients’ use of fluency. According to Unkelbach (2006), the association between fluency and previous encounter is not unalterable. Consequently, one possible explanation for the fact that patients with severe memory deficits did not use fluency as a cue for memory is that the positive correlation between fluency and prior encounter with an item is reduced for amnesic patients in naturalistic environments. This leads them to progressively disqualify fluency or, at least, to more readily ascribe fluency to external sources rather than to their impaired memory. Experiment 2 attempted to test this hypothesis in a sample of healthy participants. To this end, we employed a procedure inspired from the study of Unkelbach (2006; Experiment 1) except that we used force-choice recognition tests instead of “yes/no” recognition tests. In this way, we could investigate the influence of an additional source of fluency on memory decisions after participants have learned that fluency was not a reliable cue to guide their memory decisions. Specifically, we recruited two groups of healthy participants and put them either in a condition where perceptual-quality-driven fluency was systematically is the same direction as fluency due to previous encounters (classic condition; “perceptually fluent items are old”) or in a condition where perceptual-quality-driven fluency conflicted with prior exposure (reversed condition; “perceptually fluent items are new”). Because participants in the reversed condition learn that perceptual fluency is not a reliable sign of a past encounter with a stimulus, we expected participants to more readily detect a biasing source in a subsequent recognition test and to attribute overall fluency to this external source (i.e., the contrast in clarity), potentially mimicking the pattern of results shown by patients with amnesia in Experiment 1. In other words, we expect participants in the classic condition to produce a higher rate of correct recognitions when the visual manipulation induces a strong feeling of fluency (Target+/Distractor-) than when it induces a weak feeling of fluency (Target-/Distractor+). On the contrary, we expect participants in the reversed condition to produce a lower rate of correct recognitions when the visual manipulation induces a strong feeling of fluency (Target+/Distractor-) than when it induced a weak feeling of fluency (Target-/Distractor+).

***3.1 Method***

*3.1.1 Participants*

A total of 42 healthy French-speaking individuals, whose ages ranged from 29 to 57 years (*Mean* = 41.44 years, *SD* = 8.97), participated in the study. The sample size was determined on the basis of Experiment 1. Data collection stopped when the number of participants was sufficient to reach a predicted power of .90. Participants’ years of education ranged from 9 to 18 (*Mean* = 13.95, *SD* = 1.75). All participants had normal or corrected-to-normal vision and hearing. None had an established diagnosis of learning disability or a history of neurological or psychiatric disorders. Thirty-seven percent of the subjects were females. The sample was recruited from the French community of Liège in Belgium. They all volunteered to participate. No remuneration was provided.

*3.1.2 Material*

Stimuli consisted of four sets of 60 items: 60 two-dimensional colored line drawings, 60 French nouns, 60 French first names, and the 60 unfamiliar drawings used in Experiment 1. Thirty stimuli from each set were assigned randomly 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.

Moreover, we created a low-fluency and a high-fluency version of each stimulus. We induced fluency expectations by manipulating the perceptual quality of stimuli in different ways. Specifically, in the set including colored line drawings, pictures were given a 20% blurring. In the set of French nouns, words were given a 20% contrast reduction. In the set of French names, items were manipulated by color contrast (i.e., high-fluency names had a high contrast and low-fluency names a low contrast against the colored background). The perceptual quality of unfamiliar drawings were manipulated in the same way as in Experiment 1. We used these various fluency manipulations because they have previously been shown to induce fluency expectations (see Alter & Oppenheimer, 2009, for a review). Finally, we prepared four sets of 30 target-distractor pairs with the 60 stimuli included in each set.

*3.1.3 Procedure*

The study was approved by the local ethics committee. Written consent was obtained from the participants before the study began. Participants were tested individually in a quiet room during an approximately 40-minute session. Each participant was randomly assigned to one of the two experimental conditions: the *classic* condition or the *reversed* condition. The procedure was composed of two phases: (a) a learning phase and (b) a test phase.

3.1.3.1 Learning phase

Participants were presented with three recognition tasks. During these tasks, participants were told to study either 30 colored line drawings, 30 words, or 30 names, 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 forced-choice recognition test immediately followed each study phase. Participants were randomly presented with 30 target-distractor pairs. Following the procedure described by Unkelbach (2006), in the *classic* condition, high-fluency items were always old and low-fluency items were always new (30 Target+/Distractor–). In the *reversed* condition, low-fluency items were always old and high-fluency items were always new (30 Target–/Distractor+). Both stimuli 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 stimulus they had previously seen and received feedback about the correctness of each decision (“correct” or “incorrect”).

3.1.3.2 Test phase

The procedure and materials used in the test phase were identical to those described in Experiment 1. In Experiment 2, however, participants were instructed to solve 5 two-digit addition problems (e.g., 32 + 47) after studying the 30 unfamiliar drawings and before doing the recognition test. This procedure was used to decrease their recognition performance by introducing both some interference and a delay. In Experiment 1, control participants’ performance was significantly better than the performance of patients with amnesia. Given the difficulty of the study phase, we expected the 2-minute delay to further reduce participants’ ability to rely on their few declarative memory. Our aim was to place our healthy participants in a situation as analogous as possible to what is experienced by patients with severe amnesia when making their recognition decisions.

***3.2 Results***

*3.2.1 Manipulation check*

Participants included in the two experimental conditions were equal in terms of both chronological age (*Means* = 43.39 vs. 39.50 years, *SD* = 8.46 vs. 9.28 years, for the classic and the reversed condition, respectively) and level of education (means = 13.90 vs. 14.00 years, SD = 1.67 vs. 1.87 years), all *ts* < 2. No gender or order effects were found on the rate of correct “old” responses, all *F*s < 1. A one-sample t test was also conducted to check whether the proportion of participants’ correct recognitions differed from chance (.50) in the two experimental conditions. No statistical differences were found either in the classic condition (*mean* = *.*49), *t*(20) = 0.147, *p* = .88, or in the reversed condition (*mean* = .51), *t*(20) = 0.662, *p* = .52. These results suggest that the procedure used to reduce healthy participants’ ability to rely on their episodic memory was successful.

*3.2.2 Recognition rate*

A 2 (Condition: classic or reversed) x 3 (Picture quality: 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 during the test phase. The results revealed a Condition x Picture quality interaction, *F*(2,80) = 6.94, *MSe* = 1.76, *p* = .002, *η2p* = .15, but no main effect of group, *F*(1,40) = 0.44, *MSe* = 1.39, *p* = .51, and no main effect of picture quality, *F*(2,80) = 0.44, *MSe* = 1.76, *p* = .41. The interaction results from the fact that participants in the classic condition produced more correct “old” responses when the visual manipulation induced a strong feeling of fluency than when it induced a weak feeling of fluency, *F*(1,40) = 5.07, *MSe* = 1.08, *p* = .029. Conversely, participants in the reversed condition 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, *F*(1,40) = 5.55, *MSe* = 0.99, *p* = .023 (see Table 3). No other result reached significance, *F* < 2.

Table 3

*Mean Proportion of “Old” Responses for Targets by Test Pair Contrast (Standard Deviation) for Each Experimental Condition (Classic vs. Reversed) in Experiment 2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total | T+/D– | T+/D+ | T–/D+ |
| Classic | .49 (.15) | .56 (.16) | .45 (.14) | .47 (.15) |
| Reversed | .51 (.17) | .44 (.17) | .52 (.18) | .59 (.17) |

*Note.* T+/D–: high-contrast target, low-contrast distractor; T+/D+: high-contrast target, high-contrast distractor; T–/D+: low-contrast target, high-contrast distractor.

***3.3. Discussion***

In this experiment, we manipulated the contingency between processing fluency and previous occurrences of items, then we examined the influence of different sources of fluency on participants’ recognition decisions. Our results indicate that participants in the classic condition performed better than participants in the reversed condition on pairs where recognition of the target was additionally facilitated by high picture quality (*Mean* = .56 vs. .44). Conversely, participants in the reversed condition showed a higher rate of correct recognition than participants in the classic condition on pairs where the distractor was made easier to process (*Mean* = .47 vs. .59).

Replicating the results observed for healthy controls in Experiment 1, our data show that participants in the classic condition base their judgments on a direct assessment of absolute fluency. Indeed, the more fluently an item was processed, the more likely participants were to give an “old” response. In the reversed condition, however, our findings suggest that, when the association between perceptual fluency and past encounter is artificially reversed during the learning phase, healthy participants – who could not rely on their declarative memory to guide their recognition decisions, as revealed by an overall correct recognition rate at chance – disqualify perceptual fluency as a relevant cue for their memory judgments, mimicking the pattern of responses observed for patients with amnesia in our first experiment.

**4. General discussion**

The primary aims of this study were (a) to document whether changes occur in how patients with amnesia use fluency as a cue for memory, and (b) to test whether these changes can be explained by a decrease in the contingency relation between fluency and past experience in the environment of patients with amnesia, decreasing the likelihood that these patients will attribute their feeling of fluency to their memory when an alternative source is available. To test this, we conducted two studies. In Experiment 1, we showed 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 guide their memory judgments when an external source of fluency was detected. In Experiment 2, the data collected suggested that healthy participants who were repeatedly exposed to evidence that perceptual-quality-driven fluency can lead to memory errors disqualified fluency as a relevant cue for memory.

In the following paragraphs, we discuss what these findings can tell us about the mechanisms that account for differences between healthy participants and patients with amnesia in the use of the fluency cue.

In Experiments 1 and 2, we found that control participants (Experiment 1) and participants in the classic condition (Experiment 2) seemed to rely on the absolute level of fluency when making their recognition decisions. In view of these findings, we postulate that the picture clarity manipulation in our study went completely unnoticed by the control group. The complexity of our stimuli may have meant that the picture quality variation was not salient enough to be detected by control participants when their attention was focused on the memory task rather than on the detection of perceptual differences (as was the case in our pretest). Conversely, the pattern of results obtained by patients with amnesia (Experiment 1) and participants in the reversed condition (Experiment 2) suggests that these subjects did detect the perceptual manipulation of our stimuli and attributed the overall subjective feeling of fluency to this alternative explanatory source rather than to pre-exposure. Still, how can we explain the fact that patients with amnesia and participants assigned to the reversed condition detected the contrast manipulation while control participants and participants in the classic condition did not? There are several complementary explanations of these findings.

First, it is possible that patients with amnesia could not remember the study phase and, thus, did not see a prior encounter as a potential source of their fluency experience. This hypothesis is consistent with the widespread finding in the literature that patients with amnesia live more in the here and now than control participants (e.g., Andelman et al., 2010). Their poor mental time travel ability may lead them to preferentially seek an explanation of their fluency experience in the present rather than in the past. However, although this hypothesis can explain the pattern of results observed in patients with amnesia (Experiment 1), it does not account for the results observed in healthy participants included in the reversed condition (Experiment 2), who certainly remembered the study phase even if they could not recall its specific content.

Another explanation for our findings may be found in the fact that people who are aware of their memory problems – or who have learned that they cannot rely on their memory for a specific task – can be reluctant to attribute a very high level of fluency (i.e., resulting from the combination of pre-exposure and contrast clarity) to their memory, which they know is unlikely to produce such a strong feeling of “oldness” (Ozubko & Yonelinas, 2014). The remaining question is why and when people start to perceive their memory as an unreliable source of fluency?

According to the discrepancy-attribution hypothesis (Whittlesea & Williams, 2000, 2001a, 2001b), fluency is interpreted as a sign of memory when the degree of fluency that is experienced is surprisingly greater than the degree of fluency that would be expected given the characteristics of the stimulus. However, if an alternative source is detected that produces more fluency expectations than past experience, high processing fluency is likely to be entirely attributed to this source rather than to prior exposure. In this context, the feeling of fluency is likely to be perceived as irrelevant for memory decisions. The findings of Experiment 2 are consistent with this postulate. Indeed, our results indicate that, when there is a decrease in the ecological validity of the correlation between fluency and past occurrence of items (i.e., in the reversed condition), participants seem to progressively implement strategies to track biasing fluency sources more effectively in order to reduce memory errors, leading them to detect the perceptual clarity manipulation and to entirely disqualify past experience as a source of fluency. In amnesia, fluency is one of the few cues that is still available for memory judgments. Consequently, patients with amnesia probably rely on this cue more often than healthy participants. Therefore, the number of situations where fluency leads to memory errors is probably higher for patients with amnesia than for control participants in their daily lives, especially given that their recollection control processes are disturbed (Gold et al., 2007). These recurrent encounters with fluency-based illusions could have led them, first, to allocate more resources to the detection of alternative fluency sources and, then, to use fluency only when they can attribute it to their memory with a good deal of certainty. Interestingly, this hypothesis is consistent with the findings of Keane et al. (2006), who demonstrated that the use of fluency as a sign of prior exposure is not fully put into practice in amnesia and that patients with amnesia are reluctant to rely on fluency unless they can attribute it to the past (i.e., their memory) with a high level of confidence; namely, when the relevance of the fluency cue is made salient.

There are several limitations on this study. First, the small number of patients with amnesia means that the results of our statistical analyses in Experiment 1 must be interpreted with caution. Nevertheless, the fact that our findings were replicated in a sample of healthy participants who were put into experimental conditions intended to reproduce the main characteristics of situations encountered by amnesic patients speaks in favor of the robustness and validity of our results. Secondly, in Experiment 2, we taught participants a reversal contingency between fluency and prior exposure (i.e., a negative correlation where low-fluency items were always old and high-fluency items were always new). Participants did not really learn that fluency and prior exposure were uncorrelated. As our main goal here was to induce participants to focus on the fact that fluency-based decisions could lead to memory errors, the procedure used in the present experiment perfectly fit our aims. However, future studies should still be conducted to test the hypothesis that individuals can learn that fluency and past encounter with a stimulus are unrelated. A large number of training trials where fluency manipulation would be orthogonal to the item status (target vs. distractor) should probably be included in that future experiment. Indeed, previous works have shown that teaching participants that there is no contingency between fluency and past experience is very difficult to achieve by a short training (Olds & Westerman, 2012). Moreover, these results should also be complemented by the study of anatomical data or structural connectivity in order to investigate whether any systematic differences in lesion location could account for amnesia patients’ disqualification of memory as a source of fluency. Finally, it would be interesting to replicate these results in other clinical populations where severe memory problems are widespread (e.g., a study conducted on patients with Alzheimer’s disease is currently in preparation in our lab) and where fluency-based memory decisions are not shown to translate into better recognition performance (e.g., Simon et al., 2016).

Despite these limitations, our study already have important implications. From a theoretical point of view, our results appears to confirm the postulate of Unkelbach (2006; see also Geurten et al., 2015) according to which the interpretation of fluency is subject to changes and depends on the strength of the ecological correlation between fluency and past occurrences of stimuli. Moreover, our study also provides evidence of the “fluency-memory” correlation evaluated in patients with severe memory deficits, explaining why they only use fluency as a cue for their memory judgments under very specific circumstances (e.g., Keane et al., 2006; Ozubko & Yonelinas, 2014). From a more practical perspective, our findings also suggest that patients’ underuse of fluency likely results from a learned reinterpretation of fluency as a poor cue for memory rather than from a real inability to rely on it.

**Acknowledgment**

This work was supported by a Grant from the Marie Skłodowska-Curie Co-funding of regional, national and international programs to MG. We have no conflict of interest to declare.

**References**

Alter, A. L., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form a metacognitive nation. *Personality and Social Psychology Review, 13,* 219–235. doi:10.1177/1088868309341564

Andelman, F., Hoofien, D., Goldberg, I., Aizenstein, O., & Neufeld, M. Y. (2010). Bilateral hippocampal lesion and a selective impairment of the ability for mental time travel. *Neurocase, 16*, 426–435. doi:10.1080/13554791003623318

Checkosky, S. F., & Whitlock, D. (1973). Effects of pattern goodness on recognition time in a memory search task. *Journal of Experimental Psychology, 100*, 341–348. doi:10.1037/h0035692

Conroy, M. A., Hopkins, R. O., & Squire, L. R. (2005). On the contribution of perceptual fluency and priming to recognition memory. *Cognitive, Affective, and Behavioral Neuroscience, 5*, 14–20. doi:10.3758/CABN.5.1.14

Geurten, M., Willems, S., & Meulemans, T. (2015). Beyond the experience: Detection of metamemorial regularities. *Consciousness and Cognition, 33*, 16–23. doi:10.1016/j.concog.2014.11.009

Gold, C. A., Marchant, N. L., Koutstaal, W., Schacter, D. L., & Budson, A. E. (2007). Conceptual fluency at test shifts recognition response bias in Alzheimer’s disease: Implications for increased false recognition. *Neuropsychologia, 45*, 2791–2801. doi:10.1016/j.neuropsychologia.2007.04.021

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 110*, 306–340. doi:10.1037/0096-3445.110.3.306

Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General, 118*, 126–135. doi:10.1037/0096-3445.118.2.126

Keane, M. M., Orlando, F., & Verfaellie, M. (2006). Increasing the salience of fluency cues reduces the recognition memory impairment in amnesia. *Neuropsychologia, 44*, 834–839. doi:10.1016/j.neuropsychologia.2005.08.003

Olds, J. M., & Westerman, D. L. (2012). Can fluency be interpreted as novelty? Retraining the interpretation of fluency in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 653–664. doi:10.1037/a0026784

Ozubko, J. D., & Yonelinas, A. P. (2014). The disruptive effects of processing fluency on familiarity-based recognition in amnesia. *Neuropsychologia, 54*, 59–67. doi:10.1016/j.neuropsychologia.2013.12.008

Potter, M. C., & Levy, E. I. (1969). Recognition memory for a rapid sequence of pictures. *Journal of Experimental Psychology, 81*, 10–15. doi:10.1037/h0027470

Reber, R., Wurtz, P., & Zimmermann, T. D. (2004). Exploring “fringe” consciousness: The subjective experience of perceptual fluency and its objective bases. *Consciousness and Cognition, 13*, 47–60. doi:10.1016/S1053-8100(03)00049-7

Simon, J., Bastin, C., Salmon, E., & Willems, S. (2016). Increasing the salience of fluency cues does not reduce the recognition memory impairment in Alzheimer’s disease! *Journal of Neuropsychology*. doi:10.1111/jnp.12112

Squire, L. R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory, 82*, 171–177. doi:10.1016/j.nlm.2004.06.005

Unkelbach, C. (2006). The learned interpretation of cognitive fluency. *Psychological Science, 17*, 339–345. doi:10.1111/j.1467-9280.2006.01708.x

Unkelbach, C. (2007). Reversing the truth effect: Learning the interpretation of processing fluency in judgments of truth. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 219–230. doi:10.1037/0278-7393.33.1.219

Verfaellie, M., & Cermak, L. S. (1999). Perceptual fluency as a cue for recognition judgments in amnesia. *Neuropsychology, 13*, 198–205. doi:10.1037/0894-4105.13.2.198

Verfaellie, M., Giovanello, K., & Keane, M. (2001). Recognition memory in amnesia: Effects of relaxing response criteria. *Cognitive, Affective, and Behavioral Neuroscience, 1*, 3–9. doi:10.3758/CABN.1.1.3

Verfaellie, M., & Keane, M. M. (2002). Impaired and preserved memory processes in amnesia. In L. Squire & D. L. Schacter (Eds.), *Neuropsychology of memory* (pp. 35–46). New York: Guilford Press.

Wechsler, D. (1997a). *WAIS-III, Wechsler adult intelligence scale: Administration and scoring manual.* San Antonio, TX: Psychological Corporation.

Wechsler, D. (1997b). *WMS-III: Wechsler memory scale administration and scoring manual.* San Antonio, TX: Psychological Corporation.

Whittlesea, B. W. A. (1993). Illusions of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 1235–1253. doi:10.1037/0278-7393.19.6.1235

Whittlesea, B. W. A., Jacoby, L. L., & Girard, K. (1990). Illusions of immediate memory: Evidence of an attributional basis for feelings of familiarity and perceptual quality. *Journal of Memory and Language, 29*, 716–732. doi:10.1016/0749-596X(90)90045-2

Whittlesea, B. W. A., Masson, M. E. J., & Hughes, A. D. (2005). False memory following rapidly presented lists: The element of surprise. *Psychological Research, 69*, 420–430. doi:10.1007/s00426-005-0213-1

Whittlesea, B. W. A., & Williams, L. D. (2000). The source of feelings of familiarity: The discrepancy-attribution hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 547–565. doi:10.1037/0278-7393.26.3.547

Whittlesea, B. W. A., & Williams, L. D. (2001a). The discrepancy-attribution hypothesis: I. The heuristic basis of feelings and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 3-13. doi:10.1037/0278-7393.27.1.3

Whittlesea, B. W. A., & Williams, L. D. (2001b). The discrepancy-attribution hypothesis: II. Expectation, uncertainty, surprise, and feelings of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 14–33. doi:10.1037/0278-7393.27.1.14

Willems, S., & Van der Linden, M. (2006). Mere exposure effect: A consequence of direct and indirect fluency–preference links. *Consciousness and Cognition, 15*, 323–341. doi:10.1016/j.concog.2005.06.008