**Feeling the ease: how the use of oral motor fluency changes in amnesia**

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**Abstract**

The present study examined the evolution observed in amnesic patients’ use of motor fluency when making recognition memory decisions. In this experiment, 9 patients with amnesia and 18 matched controls were presented with two recognition memory tasks composed of 3 types of items: (a) natural words, (b) nonwords difficult to pronounce, and (c) nonwords easy to pronounce, the latter having been shown to be processed in a surprisingly fluent manner as long as participants can articulate them at a subvocal level (i.e., oral motor fluency). Our results provide evidence that the motor-movement manipulation was successful to induce a fluency effect. More specifically, data revealed that both amnesic patients and control participants showed a pattern of response consistent with the use of fluency as a cue to memory for studied items. However, only control participants relied on fluency to increase their rate of “yes” responses for unstudied items. These results suggest that patients with amnesia set a more conservative response criterion before relying on oral motor fluency, showing a pattern consistent with the idea that fluency is only used as a cue to memory when it exceeds a certain threshold. These findings are discussed in terms of adaptative metacognition strategies implemented by amnesic patients to reduce fluency-based memory errors as well as in terms of the variations that seem to occur in these strategies depending on the type of fluency that is experienced.

**Keywords:** Amnesia; Recognition memory; Fluency; Attribution

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Amnesia is typically defined as a severe impairment in the ability to consciously retrieve past experience. However, over the past 30 years, some studies have revealed that while amnesic patients exhibit pronounced deficits in recollection – i.e., the ability to mentally relive past events in vivid details – they show no (or less) impairments in familiarity – i.e., a vague feeling of “oldness” associated with a past experience (e.g., Addante, Ranganath, Olichney, & Yonelinas, 2012; Aly, Knight, & Yonelinas, 2010; Keane, Orlando, & Verfaellie, 2006). Others studies, however, have not found such a dissociation (e.g., Squire, 2004; Stark & Squire, 2000). To understand these discordant findings, some authors have attempted to explore whether certain mechanisms underlying familiarity-based recognition could change in amnesia (Geurten, Bastin, Salmon, & Willems, 2020; Geurten & Willems, 2017; Ozubko & Yonelinas, 2014).

Usually, research documenting factors that can generate a subjective experience of familiarity emphasizes the importance of processing fluency – i.e., the ease with which an information is processed. The logic is that because previous exposure to an item generally enhances processing fluency, people learn to interpret the feeling associated with fluency as a sign of prior encounter with a stimulus. This attribution of fluency to memory gives rise to the familiarity experience (Jacoby & Dallas, 1981; Kelley & Rhodes, 2002; Whittlesea, 1993). According to this attributional theory, several steps have to be completed for a feeling of familiarity to occur: (a) participants have to learn 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 the feeling of fluency to their memory which implies deciding whether fluency can accurately inform memory judgments in a specific context (for an overview, see also Bastin et al., 2019).

Typically, in studies of fluency-based recognition, participants use fluency as a cue to memory only when it cannot be attributed to an external source such as the perceptual quality of the stimulus (e.g., Willems & Van der Linden, 2006). Similar results are observed in participants with amnesia. However, patients with amnesia seem to detect or attribute fluency to external sources more readily than control participants (e.g., Geurten, Bastin, et al., 2020; Geurten & Willems, 2017). Specifically, fluency was shown to influence patients’ responses only when the alternative source is barely noticeable (i.e., a subtle improvement of the perceptual quality of the items) whereas it still influenced control participants when the external manipulation is detectable. In other words, amnesic patients were more prone than controls to detect subtle manipulations that could explain the feeling of fluency.

These findings are crucial because they suggest that both the ability to experience and to attribute fluency are preserved in amnesia but that changes occur in attribution processes that drive amnesic patients to become reluctant to use fluency as a memory cue (Geurten, Bastin, et al., 2020; Geurten & Willems, 2017). Further evidence for this has been provided by Ozubko and Yonelinas (2014). In the latter study, fluency was enhanced at a conceptual level by preceding the presentation of half of the tested items with a semantically related context word that was clearly visible on the computer screen. The results revealed that fluency increased amnesic patients’ recognition endorsement of unstudied, but not of studied words. The authors explain these findings by assuming that patients with amnesia tend to disregard fluency as a cue for memory when it exceeds the level they think they should be able to experience given their impaired memory. As studied items combined fluency from preexposure and from the experimental manipulation, the amount of fluency experienced when processing these items was more likely to be higher than the set threshold than the amount of fluency experienced when processing unstudied items. This would explain why fluency was disqualified as a relevant memory cue for the former type of items and not for the latter.

The hypothesis of highly adaptive attribution processes is attractive. However it is still unknown how flexible amnesic patients can be when setting a threshold for the use of fluency cues. Specifically, we do not know whether these metacognitive changes depend on the task’s characteristics or on the phenomenology associated with the feeling of fluency. Indeed, it is now well-established that enhanced processing fluency can occur at various levels of cognitive operation, such as perceptual (Jacoby & Whitehouse, 1989), conceptual (Whittlesea, 1993), lexical (Whittlesea & Williams, 2000), or motor (Topolinski, 2012). To date, however, only conceptual and perceptual fluency have been explored in amnesia. Examining how amnesic patients adjust their use of fluency when other types of fluency are manipulated could help us to better understand not only the changes occurring in familiarity-based memory in amnesia, but also the mechanisms that underlie the dynamic nature of attribution processes.

For these reasons, the main goal of the present experiment was to document changes in fluency use in amnesic patients when processing ease is experienced at a motor and lexical level. To test this, a procedure inspired from Whittlesea and Williams (2000) was employed as this paradigm allowed to manipulate processing fluency while making the external source of this manipulation to remain undetectable. In their experiment, these authors presented healthy participants with a recognition test composed of three types of stimuli: (a) natural words, (b) nonwords that are difficult to pronounce, and (c) nonwords that are easy to pronounce. Their results revealed that the latter items gave rise to a higher rate of “yes” responses than the two other types of stimuli. They postulated that the easy-to-pronounced nonwords produced a stronger feeling of fluency than natural words because the ease with which they were processed at a lexical/motor level was surprising and contrasted with their total lack of meaning. On the reverse, the processing ease of natural words, although higher in absolute terms, was consistent with participants’ expectations and, thus, did not generate any surprising feeling of ease. While Whittlesea and Williams (2000) interpreted these findings as evidence that relative fluency was more important than absolute fluency to generate a feeling of familiarity, their data also indicated that fluency may occur at a lexical/motor level. Consequently, here, patients with amnesia and matched controls were recruited and presented with two recognition tests including the same three classes of stimuli than those used in Whittlesea and Williams’ study. Specifically, participants performed a recognition task in a condition that allows to experience the feeling of fluency produced by the articulation of the easy-to-pronounce nonwords (i.e., oral motor condition). Then, they also performed a recognition task in a condition that prevents the experience of such a processing ease by prohibiting the articulation of any items at a subvocal level (i.e., a non-oral motor condition) (Topolinski, 2012). Indeed, several authors have shown that the fluency effect first observed in Whittlesea and Williams’ study is eliminated when oral motor movements are prevented (e.g., by asking participants to eat or chew during the memory task; Topolinski & Strack, 2009).

With this procedure, we plan to examine whether and how the use of oral motor fluency changes in amnesia. Several scenarios are possible. First, if patients rely on the fluency cue to guide their memory decisions in the same way as controls, we expect both groups to give a higher rate of “yes” responses for easy-to-pronounce nonwords in the oral motor condition (where motor fluency can be experienced) as compared to the non-oral motor condition (where motor fluency was prevented) while no such a difference should be found for natural words or difficult-to-pronounce nonwords albeit for two different reasons. Natural words because other types of fluency (e.g., conceptual) could still be available to guide participants decisions despite the articulatory suppression. The difficult-to-pronounce nonwords because they have a low level of oral motor fluency to begin with and, thus, should not be significantly affected by the manipulation. Second, if patients with amnesia are not able to rely on fluency to guide their memory (as opposed to controls), a similar rate of “yes” responses for all classes of stimuli in both experimental conditions was expected. However, if attribution processes are spared in amnesia, but undergo some metacognitive changes that account for the reduction that is sometimes observed in the literature regarding their use of fluency, it is possible that, reluctant to attribute a strong feeling of fluency to their impaired memory, amnesic patients only disqualify fluency as a cue for memory when it exceeds a certain threshold (Ozubko & Yonelinas, 2014). If this is the case, then amnesic should respond differently whether it is targets or distractors that are processed fluently. Specifically, we should observe a reduction of the fluency effect for easy-to-pronounced targets, but not for easy-to-pronounced distractors in patients as compared to control participants. Indeed, as easy-to-pronounced targets combine two sources of fluency (prior exposure + surprising oral motor fluency), they are more likely to exceed the threshold than distractors.

**Method**

**Participants**

Nine French-speaking patients (4 females) with amnesia recruited from various neuropsychological rehabilitation units in Belgium participated in this study. Major attentional and executive function deficits constituted an exclusion criterion (i.e., for various cognitive tasks, all patients had scores within two standard deviations from the mean of their normative group at the most recent neuropsychological assessment; range = 1 to 5 months since the last evaluation). Time since diagnosis ranged from 1 to 13 years (Mean = 4.11, SD = 3.95). The mean age was 34.4 (SD = 10.33; range = 22–52) years old and the mean education level was 14.0 (SD = 2.87) 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 = 100.2; SD = 9.19) and working memory performance (Working memory index = 90.2; SD = 8.44). However, they had severe episodic memory deficits (general memory index = 57.7; SD = 7.84; visual delay index = 63.9; SD = 8.82; and auditory delay index = 59.8; SD = 5.49). Patients’ characteristics are presented in Table 1.

< Table 1 about here >

The control group consisted in 18 healthy participants who had no history of psychiatric or neurological illness and were matched with amnesic patients for age (Mean = 43.2 years; SD = 12.6; range = 21 – 54), gender (8 females), and education level (Mean = 14.27; SD = 2.84). They had a mean IQ of 110.4 (SD = 11.91). The control and amnesic groups did not differ significantly in age or education, all *ps* > .80. However, they differed in IQ, *t*(25) = 2.25, *p* =.03.

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 set in order to reach a predicted power of .80 for a within-between interaction (medium effect size).

**Material**

Three sets of bisyllabic items retrieved from Majerus, Linden, Mulder, Meulemans, and Peters (2004) served as stimuli in the present experiment (see Appendix): 32 hard to pronounce nonwords (low phonotactic frequency (LF) nonwords), 32 easy to pronounce nonwords (high phonotactic frequency (HF) nonwords), and 32 natural French words. Each stimulus had the same syllabic structure. The LF nonwords were composed of diphones that are rare in French (e.g., in the nonword /foeglos/) while the HF nonwords contained diphones that are frequent in French (e.g., /pebmyn/). Furthermore, the diphones of the HF nonwords had the same phonotactic frequency as the diphones of the natural words used in this study. Sixteen items of each collections (natural words; HF nonwords, and LF nonwords) were then randomly assigned to one of the two experimental list (List A and B). These two lists were counterbalanced between the two conditions: Half of the participants were randomly presented with List A in the oral motor condition while the other half were presented with List A in the non-oral motor condition. Within each list of 48 items, two set of stimuli were created (Set 1 and 2). In the recognition tests, half of the participants were presented with Set 1 as targets and Set 2 as distractors; the other half of the participants were presented with the reverse design.

We chose to use words, LF nonwords, and HF nonwords because these kinds of stimuli have been shown to induce different levels of fluency expectations in control participants (e.g., Whittlesea & Williams, 2000). Specifically, natural words were revealed to induce high initial fluency expectations which match the level of ease experienced during subsequent processing. Nonwords hard to pronounce and not resembling any particular words (LF nonwords) were shown to induce low initial fluency expectations which match the level of ease experienced during subsequent processing. On the reverse, nonwords easy to pronounce that resemble words existing in the language (HF nonwords) were revealed to produce a discrepancy between initial (i.e., expectation) and latter (i.e., experience) aspects of processing. Indeed, HF nonwords tended to give rise to low fluency expectations that do not match actual processing.

**Procedure**

The study was conducted in accordance with the ethics committee of the participating institutions (Central committee: CHU-Liege). Written informed consent was obtained before the study started. Participants were tested individually in a quiet room at their house. They underwent an approximatively 40-min session during which they completed two recognition tests : one in the oral motor retrieval condition and one in the non-oral motor condition, the order of these two conditions being counterbalanced between participants. These two tasks were both composed of two phases (i.e., a study phase and a test phase) and separated by approximatively 15-min delays filled with the four subtests of the WASI-II. Stimuli included in the recognition tasks were presented electronically using the E-Prime 3.0 software (Psychology Software Tools, Pittsburgh, PA).

***Study phase.*** Participants were randomly presented with 24 items (8 words, 8 LF nonwords, and 8 HF nonwords) in black on white (Calibri, font size = 18). They were told to read these items in a quiet voice and study them in prevision of an upcoming test of unspecified nature. Each studied stimulus was presented in the center of the screen for 3000 ms, followed by a 500-ms interval. At the end of the study phase, participants were asked to solve arithmetic problems (e.g., 27 + 36) to fill a 2-min delay before moving to the test phase.

***Test phase.*** Once the 2-min delay had elapsed, a recognition test (“yes/no”) was administered. Participants were randomly shown 48 items (16 words/16 LF nonwords/16 HF nonwords) one-by-one. For each stimulus, they were asked whether they thought to have seen it during the study phase. There was no time limit for responding. Twenty-four items were studied items (i.e., targets) and 24 items were new items (i.e., distractors). The presentation of each stimuli was followed by a 500-ms interstimulus interval.

In the oral motor condition where oral motor processing was allowed, participants were simply instructed to carefully look at each stimulus before making their memory decision. In the non-oral motor condition where we wanted to prevent oral motor processing, participants were asked to keep a small wooden stick between their teeth for the whole duration of the test. This procedure allowed us to insure that our participants could not sub-vocally pronounce the items before giving their answer to the experimenter (for a similar procedure, see Topolinski & Strack, 2009). We chose a wooden stick instead of asking to eat or chew in order to prevent amnesic patients to unconsciously stop chewing when engrossed with the task.

**Results**

**Data analyses**

2 (Group: amnesic vs. control) x 2 (Retrieval condition: oral motor vs. non oral motor) x 2 (Item Type: words, LF nonwords, or HF nonwords) mixed-factor ANOVAs were conducted on the proportion of “yes” responses. Group was the only between-participants factor. As prior work has shown differences in how fluency manipulation influenced the response of amnesic patients to targets and distractors (Ozubko & Yonelinas, 2014), separate analyses were conducted on hit and false recognition rates. Furthermore, we also performed a signal detection analysis to determine the contributions of sensitivity and response bias to participants’ pattern of recognition responses (Macmillan & Creelman, 2005). The sensitivity (d’) and response bias (C) scores were also analyzed with mixed-design ANOVAs.

Additionally, to establish whether the pattern observed at the group level was reliable for individuals across group, data were also analyzed using a logistic mixed model with subjects and items modelled as crossed random effects and group, retrieval condition, and item type as predictors. The dependent variable was whether participant gave a “yes” response at each item.

Differences were considered as significant when the *p* value was <.05 for the omnibus ANOVAs. For linear contrasts, a Bonferroni correction was applied. Preliminary analyses indicated homogeneity of variance between groups on our dependent variables. Similarly, no order effects were found on any of our dependent variables, all *ts* < 1.69, *ps* > .10.

**Group data**

**Hit.** The results of the mixed ANOVA on “yes” responses for targets revealed a main effect of group, *F*(1, 25) = 9.22, *Mse* = 3.83, *ηp2* = .27, with amnesic patients giving less correct responses (*M* = .52) than controls (*M* = .72). Furthermore, the retrieval condition x item type interaction was also significant, *F*(2, 50) = 6.27, *Mse* = 1.57, *ηp2* = .20. This effect resulted from the fact that a higher level of “yes” responses was given for HF nonwords in the oral motor condition (*M* = .66) as compared to the non-oral motor condition (*M* = .52), *F*(1, 25) = 9.96, *Mse* = 0.64, *p* = .004, while no such effect was found for the natural words, *F*(1, 25) = 0.17, *Mse* = 0.78, *p* = .69, nor the LF non words, *F*(1, 25) = 3.48, *Mse* = 0.97, *p* = .074. No other main or interaction effect reached significance (Retrieval condition: *F*(1,25) = 0.04, *Mse =* 0.82, *p* = .84; Item type: *F*(2,50) = 1.96, *Mse =* 2.05, *p* = .15; Group x Condition: *F*(1,25) = 0.13, *Mse =* 0.82, *p* = .72; Group x Item type: *F*(2,50) = 0.50, *Mse =* 2.05, *p* = .61; Group x Condition x Item type: *F*(2,50) = 0.30, *Mse =* 1.57, *p* = .74). These results are illustrated in Figure 1 (Top panels).

<Figure 1 about here>

**False recognition.** The results of the mixed ANOVA on “yes” responses for distractors revealed a main effect of group, *F*(1, 25) = 7.68, *Mse* = 2.90, *ηp2* = .24, with amnesic patients having a higher false recognition rate (*M* = .35) than controls (*M* = .19). A main effect of Item type was also found, *F*(2, 50) = 6.26, *Mse* = 2.09, *ηp2* = .20. This difference was due to the fact that participants had lower false recognition rates for words (*M* = .19) than for HF nonwords (*M* = .33), *F*(1, 25) = 14.18, *Mse* = 0.82, *p*<.001. Furthermore, albeit not significant, a Group x Retrieval Condition x Item type interaction of medium effect size was found, *F*(2, 50) = 2.78, *Mse* = 1.44, *p* = .07, *ηp2* = .10. As we had strong hypotheses regarding how patients and controls should react to our fluency manipulation, we decided to further explore this interaction. Planned contrast comparisons revealed that HF nonword distractors were recognized at a higher rate in the oral motor condition (*M* = .32) than in the non-oral motor condition (*M* = .16) by control participants, *F*(1, 25) = 5.94, *Mse* = 0.97, *p* = .02, but not by amnesic patients (*M* = .41 vs. .42), *F*(1, 25) = 0.00, *Mse* = 0.97, *p* = .99. On the reverse, no such differences were found for natural words or LF nonwords, all *F*<1.61, *ps*>.22. No other main or interaction effect reached significance (Retrieval condition: *F*(1,25) = 2.14, *Mse =* 0.73, *p* = .16; Group x Condition: *F*(1,25) = 0.03, *Mse =* 0.73, *p* = .87; Group x Item type: *F*(2,50) = 0.62, *Mse =* 2.09, *p* = .54; Condition x Item type: *F*(2,50) = 0.49, *Mse =* 1.44, *p* = .62). These results are displayed in Figure 1 (Bottom panels).

**Sensitivity.** Results revealed a main effect of group, *F*(1, 25) = 32.50, *MSe* = 1.29, *ηp2* = .56. Controls were better at discriminating between studied items and distractors (*M* = 1.56) than amnesic patients (*M* = 0.48). Participants’ ability to discriminate between studied items and distractors was also found to depend on the type of items, *F*(2, 50) = 12.15, *MSe* = 0.53, *ηp2* = .33. Planned comparisons revealed higher sensibility score for natural words (*M* = 1.44) than for HF nonwords (*M* = .76), *F*(2, 50) = 4.56, *MSe* = 0.14, *p* < .001, or LF nonwords (*M* = 0.86), *F*(2, 50) = 3.89, *MSe* = 0.14, *p* < .001. No other main or interaction effects were found, *F*s < 1.74, *ps* > .18 (see Table 2).

< Table 2 about here >

**Response Bias.** Results revealed a significant Condition x Item interaction, *F*(2, 50) = 7.45, *MSe* = 0.11, *ηp2* = .23. This effect resulted from the fact that participants responded more conservatively for HF nonwords in the non-oral motor condition (*M* = .28) than in the oral motor condition (*M* = -.05), *F*(2, 50) = 3.03, *MSe* = 0.11, *p*= .01, while no such difference were found for the natural words or the LF nonwords, all *Fs* < 1, *ps* > .56. No other main or interaction effects reached significance, all *Fs* < 0.74, *ps* > .48 (see Table 2).

Overall, the results of the signal detection analysis indicated that the fluency effect observed for HF nonwords in the oral motor condition seems to be due to a change in participants’ response criterion rather than to a change in their ability to discriminate between studied items and distractors.

**Individual data**

**Descriptive analyses.** In order to ensure that the pattern demonstrated by amnesic patients at the group level (i.e., reliance on fluency for hits but not for distractors) could also be found at the individual level, we compared for each participant separately the number of “yes” responses for HF nonwords in the oral motor and non-oral motor condition.

Regarding amnesic patients, results revealed that 7 patients out of 9 numerically gave more “yes” responses for targets in the oral motor condition as compared to the non-oral motor condition. The 2 remaining patients showed no differences between the two conditions. On the reverse, analyses conducted on distractors revealed no differences between the oral motor and the non-oral motor condition for 6 patients. Two patients gave more “yes” responses for distractors in the oral motor condition and only one patient was found to demonstrate an advantage for the non-oral motor condition. In sum, 6 out of 9 patients were found to rely on fluency for targets, but not for distractors; one patient was found to rely on fluency for distractors, but not for hits; one patient used fluency for both type of items; the last patient relied on fluency neither for targets nor for distractors.

Regarding control participants, results indicated that 6 participants out of 18 gave more “yes” responses for both targets and distractors in the oral-motor condition as compared to the non-oral motor condition. Four participants gave more “yes” responses for targets only in the oral motor condition as compared to the non-oral condition, and 4 participants gave more “yes” responses for distractors only in the oral motor condition as compared to the non-oral motor condition. Finally, the remaining 4 participants appeared to rely on fluency neither for targets nor for distractors.

**Mixed-effects model.** As analyzing the global proportion of “yes” response did not allow testing whether the pattern of responses observed at the group level is reliable for each participant across group on a trial-by-trial basis, two additional mixed-effects modellings (binary logistic regressions) were also conducted for targets and distractors separately using SPSS (version 25) to further investigate our previous results. Trials were modelled as level 1 units and participants as level 2 units. Subjects and items were modelled as crossed random effects. More specifically, the model included random intercepts for both subject and item, and by-subject random slopes. The dependent variable represented whether participants gave a “yes” response to each item. The group was added as first-level predictor, the retrieval condition given as second-level predictor, and item type was added as third-level predictor. Cross-level interactions between these variables were also investigated. The three main effect estimates were conditional upon set default values so, in the model, the main effect of one variable represented its effect when the others were at their default value. The default value for group was “control”. The default value for the retrieval condition and item type were “non-oral motor” and “HF”, respectively. This mixed-effects analysis included trials as level 1 units (n=1296) and participants as level 2 units (n=27).

*Hit.* The results revealed that the effect of group, *β*=-.35, *SE*=.18, *p*=.04, and the retrieval condition × item type interaction, *β*=.46, *SE*=.16, *p*=.03, were significant. Follow-up mixed-effects analyses for each item type (HF, LF, word) revealed that HF nonwords, but not the other item types, increased the likelihood of a participant to give a “yes” response in the oral motor condition, *β*=.65, *SE*=.17, *p*=.017, but not in the non-oral motor condition, *β*=.25, *SE*=.16, *p*=.14.

*False recognition.* The effect of group, *β*=-.75, *SE*=.48, *p*=.03, and item type, *β*=-.99, *SE*=.42, *p*=.004 were significant. Critically, a significant group x retrieval condition × item type interaction was also found, *β*=-.36, *SE*=.24, *p*=.04. Follow-up mixed-effects analyses for each group indicated that the probability of giving a “yes” response for HF nonwords, but not the other item types, was higher in the oral-motor retrieval condition for the control group, *β*=.56, *SE*=.27, *p*=.03, but not for the amnesic group, *β*=.12, *SE*=.59, *p*=.64.

Overall, these results indicated that the differences found in fluency use at the group level could also be observed at the individual level. Moreover, our data indicate that the pattern of results revealed at the group level in amnesic participants (i.e., use of fluency for targets, but not for distractors) appears relatively stable from patient to patient.

**Discussion**

The primary aim of the present study was to document a possible evolution in the use of fluency in amnesia when it is experienced at a motor/lexical level. Confirming previous findings obtained using perceptual or conceptual fluency (Geurten, Bastin, et al., 2020; Ozubko & Yonelinas, 2014), our data suggest that amnesic patients do not rely on fluency in the same way as healthy controls when making recognition decisions. Specifically, while control participants present a pattern consistent with a reliance on fluency for both studied and unstudied items, giving more “yes” responses to fluent items (i.e., easy-to-pronounce nonwords) in the oral motor condition than in the non-oral motor condition, amnesic patients appear to use fluency as a cue for memory only for studied items. Indeed, no differences were found between the rate of “yes” responses of easy-to-pronounce unstudied items in the oral motor condition as compared to the non-oral motor condition.

Regarding the results obtained by control participants, our findings are interesting because they replicate the pattern obtained by Whittlesea and Williams (2000), showing that nonwords that are easy to pronounce can generate a subjective feeling of fluency able to influence memory decisions while items with higher levels of absolute fluency (i.e., natural words) do not. This is consistent with the attribution-discrepancy model (Whittlesea & Williams, 2001a, 2001b) according to which differences between fluency expectations and outcomes are more important than the absolute level of processing ease to produce a feeling of fluency. Furthermore, the fact that the fluency effect for easy-to-pronounce nonwords disappeared in the non-oral motor condition where the subvocal articulation of the items was prohibited suggests that the feeling of fluency influencing participants’ responses in the oral motor condition truly resulted from an enhanced processing fluency at a motor level (e.g., Topolinski, 2012), confirming that our manipulation was successful to produce a fluency effect that was neither of a perceptual nor a conceptual nature, but was associated with a motor/lexical phenomenology. Furthermore, as a study recently failed to replicate the mediating role of motor movements in fluency-based memory (Westerman, Klin, & Lanska, 2015), our results provide evidence that the motor-movement effect can be found using procedure and stimuli differing from those used by Topolinski (2012; Topolinski & Strack, 2009).

The most important finding of the present study, however, concerns the pattern of results demonstrated by amnesic patients. Indeed, in addition to show that amnesic patients can rely on motor fluency to guide their memory decisions, confirming that neither the ability to experience fluency nor the ability to attribute fluency to the past are impaired in amnesia (see also Geurten, Bastin, et al., 2020; Geurten & Willems, 2017), our data indicate that patients tend to use fluency in the same way than controls only for studied items, not for distractors. Several factors could account for these findings. First, it is possible that – while not totally impaired – the ability to experience fluency was reduced in amnesic patients, making more difficult for them to experience subtle enhancement of fluency (i.e., unstudied items), but allowing them to detect higher level of fluency (i.e., studied items that combined fluency from preexposure and oral motor articulation). Given the number of previous studies showing no differences in the ability of patients and controls to experience fluency outside the memory domain (Conroy, Hopkins, & Squire, 2005; Squire, 2004; Verfaellie & Keane, 2002), however, this hypothesis seems quite unlikely. An alternative explanation could be that amnesic patients simply set a more conservative criterion than controls before deciding to rely on the fluency signal. Indeed, if amnesic patients only use fluency when the amount of fluency experienced is higher than a certain threshold, it could explain why their recognition performance was influenced by fluency for studied items, but not for distractors. This postulate is consistent with some findings reported by Verfaellie, Sullivan Giovanello, and Keane (2001) showing that inducing amnesic patients to relax their response criterion improved their recognition performance by enhancing familiarity-based responses.

Moreover, the latter hypothesis is interesting because it suggested that some metacognitive changes occur at the level of attribution processes, making participants more careful in their use of fluency, possibly in an attempt to avoid memory errors. In substance, this theory is consistent with the hypotheses made by Ozubko and Yonelinas (2014, see also Geurten, Bastin, et al., 2020; Geurten & Willems, 2017; Geurten, Willems, Salmon, & Bastin, 2020) to explain the reduction of fluency-based memory decision in amnesia. The pattern of results obtained in our study, however, is the exact opposite of the one observed by these authors. Indeed, in Ozubko and Yonelinas’ study (2014), amnesic patients appeared to rely on fluency for distractors, but not for targets, a finding that has led them to postulate that patients with amnesia are reluctant to use fluency when the experienced feeling of fluency is higher than what they believe they should be able to experience given their memory problems. An explanation for these opposite results could be that, in their attempt to avoid fluency-based memory illusions, amnesic patients both (a) set a more conservative response criterion in order to prevent weak feelings of fluency to influence their decisions and (b) disqualify higher feeling of fluency when they could not attribute it to the past with a sufficient level of confidence, e.g. when an alternative source of fluency is detected (Geurten, Bastin, et al., 2020). In the study of Ozubko and Yonelinas (2014), the conceptual fluency manipulation was clearly visible possibly explaining why, when the level of experienced fluency was too high, patients showed no hesitation in disqualifying the fluency signal. On the reverse, in the present experiment, the fluency experience took root in the phonotactic characteristics of the stimuli, a manipulation that is potentially extremely difficult to detect. Furthermore, a study of Silva, Chrobot, Newman, Schwarz, & Topolinski (2017) revealed that even when explicitly trained and instructed to ignore the oral-motor effect, participants failed to correct for the impact of this type of fluency on their judgments, suggesting that even if our participants had detected the manipulation it would not have been enough for them to suppress the fluency effect. According to this new hypothesis of a dual-threshold pressure, differences between amnesic and control participant in the use of fluency thus occur because patients with amnesia metacognitively reduce the window within which they tolerate to attribute a feeling of fluency to their memory.

The data collected in the present experiment do not allow us to decide between these two hypotheses. Future experiments should thus be conducted, first, to replicate the present findings (as most studies on amnesic patients, our sample size remained quite small) and, second, to determine which hypothesis is more likely to account for the pattern of performance observed in amnesia. This could be done, for example, by examining how amnesic patients’ recognition performance evolves when both the strength and the phenomenology of the fluency signal are manipulated within the same experiment. Additionally, the present study should also be replicated using a different type of manipulation to suppress subvocalization in the non-oral motor condition. Indeed, according to the classical study of Strack, Martin, & Stepper (1988), it is possible that keeping a stick between one’s teeth did not only interfere with articulation resources but also induced a positive mood. Although a replication report including 17 groups recently failed to replicate this effect (Wagenmakers, et al., 2016), confirming our results using another procedure would remove any ambiguities regarding this issue. Despite this limitation, however, our findings already appear to provide some major information regarding fluency-based memory functioning in amnesia. Indeed, the present results add to the small amount of data that have recently shown 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 adjust themselves to compensate for the loss of control recollection processes. Specifically, these changes seem to induce patients to become more conservative in their use of fluency, leading to a reduction of familiarity-based memory decisions in an attempt to avoid memory errors (Geurten, Bastin, et al., 2020; Geurten & Willems, 2017; Ozubko & Yonelinas, 2014). Intriguingly, our results also reveal that various behavioral patterns may be observed in amnesic patients depending on how fluency is enhanced, suggesting that attribution processes may be flexible enough to adapt in such a way as to take the task’s characteristics into consideration when they have to decide whether it is appropriate to interpret fluency as a sign of past encounter.

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Table 1

*Summary of Amnesic Patients’ Characteristics*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | WASI–II |  | WMS-III |
| Etiology | Age | Ed. | TD (years) | Tot | Ma | Sim | Voc | Blo |  | WM | GM | AD | VD |
| Anoxia | 36 | 14 | 2 | 100 | 10 | 10 | 11 | 9 |  | 91 | 59 | 57 | 75 |
| Anoxia | 22 | 13 | 8 | 99 | 10 | 9 | 9 | 11 |  | 90 | 61 | 65 | 68 |
| Anoxia | 24 | 12 | 3 | 98 | 8 | 9 | 11 | 10 |  | 79 | 41 | 54 | 45 |
| Encephalitis | 25 | 12 | 1 | 90 | 11 | 3 | 8 | 10 |  | 90 | 50 | 51 | 58 |
| Encephalitis | 41 | 15 | 1 | 104 | 11 | 10 | 10 | 12 |  | 97 | 55 | 59 | 61 |
| Closed-head injury | 52 | 16 | 3 | 106 | 11 | 13 | 9 | 12 |  | 105 | 62 | 69 | 68 |
| Closed-head injury | 33 | 10 | 2 | 90 | 7 | 11 | 7 | 7 |  | 91 | 63 | 60 | 72 |
| Closed-head injury | 31 | 20 | 4 | 120 | 14 | 14 | 13 | 15 |  | 92 | 62 | 60 | 64 |
| Closed-head injury | 46 | 14 | 13 | 96 | 10 | 8 | 9 | 9 |  | 77 | 66 | 63 | 64 |

*Notes.* WASI–II: Wechsler Abbreviate Scale of Intelligence – Second edition; Tot: total score for the WASI-II; Ma: Matrix score; Sim: Similarities score; Voc: Vocabulary score; Blo: Block Design score; 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.

Table 2

*Means of Sensitivity (d’) and Response bias (C) by Group for the Two Conditions (Oral vs. Non Oral) and the Three Item Type (Words, HF nonwords, LF nonwords).*

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Amnesic (n = 9) | Control (n = 18) |
| ORO | NORO | ORO | NORO |
| Sensitivity (d’) | Words | 0.77 | 1.05 | 1.93 | 1.99 |
|  | HF nonwords | 0.44 | 0.03 | 1.24 | 1.42 |
|  | LF nonwords | 0.03 | 0.63 | 1.40 | 1.39 |
| Response bias (C) | Words | 0.18 | 0.18 | 0.25 | 0.27 |
|  | HF nonwords | 0.04 | 0.24 | -0.14 | 0.31 |
|  | LF nonwords | 0.29 | 0.14 | 0.15 | -0.07 |

**Note.** Standard Errors ranged from .09-.23 for d’ and C.

**Figure caption**

**Figure 1.** Rate of hit (top panels) and false recognition rate (bottom panels) for or two groups (amnesic vs. control) in the two experimental conditions (oral motor vs. non-oral motor)



**Appendix**

Sets of bisyllabic items retrieved that have served as stimuli in the present experiment

|  |  |  |  |
| --- | --- | --- | --- |
| **Item type** | **Stimuli** | **Item type** | **Stimuli** |
| word | Choyer | word | Jument |
| word | Miteuse | word | Piailleuse |
| word | Badine | word | Diatribe |
| word | Pistache | word | Richement |
| word | Flouer | word | Noyée |
| word | Abstrait | word | Tintement |
| word | Tourneur | word | Commode |
| word | Drainage | word | Partie |
| word | Brillant | word | Radis |
| word | Pingre | word | Rocheuse |
| word | Carpette | word | Pirate |
| word | Papier | word | Gagnant |
| word | Chipie | word | Esbroufe |
| word | Sigle | word | Osselet |
| word | Urger | word | Gadoue |
| word | Lotus | word | Charade |
| LF nonword | Fuznuv | LF nonword | Nobzob |
| LF nonword | Chodfang | LF nonword | Mizgnob |
| LF nonword | Chubtug | LF nonword | Lumduz |
| LF nonword | Kêpboeug | LF nonword | Kanfoeub |
| LF nonword | Kêpbub | LF nonword | Ruvvov |
| LF nonword | Rainzkêg | LF nonword | Punbtonr |
| LF nonword | Lunsdainb | LF nonword | Mubtaing |
| LF nonword | Kungzonne | LF nonword | Dagnerun |
| LF nonword | Tonznoz | LF nonword | Chobchyf |
| LF nonword | zunpanb | LF nonword | Pozpanm |
| LF nonword | Lofpainb | LF nonword | Fummuv |
| LF nonword | Kogzaf | LF nonword | Ronbronb |
| LF nonword | Munzdunm | LF nonword | Muffanp |
| LF nonword | Gofsoeub | LF nonword | Dunbzod |
| LF nonword | Poemduk | LF nonword | Vonllug |
| LF nonword | Rozfryed | LF nonword | Vetsuicf |
| HF nonword | Chamchaze | HF nonword | Cubtale |
| HF nonword | Komsar | HF nonword | Fitsique |
| HF nonword | Lonchofe | HF nonword | Consgule |
| HF nonword | Zansbof | HF nonword | Romruque |
| HF nonword | Badmafe | HF nonword | Tidlive |
| HF nonword | Pebmun | HF nonword | Sasale |
| HF nonword | Chobtad | HF nonword | Podsule |
| HF nonword | Cutfique | HF nonword | Suslet |
| HF nonword | Rêmsante | HF nonword | Vontibe |
| HF nonword | Fêctime | HF nonword | Tobnaile |
| HF nonword | Cusbousse | HF nonword | Vancelab |
| HF nonword | Guprove | HF nonword | Vailrude |
| HF nonword | Mantise | HF nonword | Cancosse |
| HF nonword | Rairnit | HF nonword | Poquemet |
| HF nonword | Duplur | HF nonword | Vacefofe |
| HF nonword | Beltil | HF nonword | Valtrob |