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RESEARCH ARTICLE

The subjective feeling of a gap between conceptual and perceptual fluency is interpreted as a metacognitive signal of pastness

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Abstract
The present study aimed to address the following question: does the discrepancy between an expected word and its readability enhances or impair its memorability? We used an adaptation of the sentence stem paradigm (Whittlesea in J Exp Psycol 19:1235–1253, 1993) and manipulated the perceptual clarity of the words by introducing some Gaussian noise (Reber in Psycol Sci 9:45–48, 1998). The target words were semantically predictable or otherwise (conceptual fluency) or were easy or difficult to read (perceptual fluency). The first experiment was conducted to ensure that the two manipulated factors had an impact on the readability of the words. In particular, results showed that when the words were written against a noisy background their predictability enhanced the judgement of readability. The second experiment aimed to test the hypothesis that recognition would be influenced by the discrepancy between conceptual and perceptual fluency. The results showed that with a noisy background, the predictability of the target words had an impact on recognition judgement; with a clear background, the effect on the recognition judgement was caused by the non-predictability of the target words. Conversely, confidence in judgement increased when the two factors went in the same direction, that is, predictability with clarity and non-predictability with low clarity. The results showed that (a) depending on the task, the effects of conceptual and perceptual fluency did not go in the same direction; (b) the kinds of fluency (conceptual and perceptual) were not independent; and (c) recognition judgements were affected by the gap between conceptual and perceptual fluency.

Keywords Certainty judgement · Conceptual fluency · Discrepancy · Perceptual fluency · Readability · Recognition

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Introduction

The link between perceptual fluency[1] and semantic fluency and its effects on memory have been the subject of several studies. Whittlesea's Experiment 4 (1993) pointed out that judgements about the semantic relatedness of present or past events were influenced by both the perceptual (masking density) and conceptual (semantic relatedness) dimensions of current processing and that the perceptual dimension was involved only when differences in fluency were interpreted as differences in the fluency of conceptual processing. But, as the author stressed, the degree to which feelings of familiarity relied on the fluency of conceptual versus perceptual processing was unclear. It seems that the

[1] It has now been established that fluency occurs at various levels: perceptual fluency (Jacoby and Dallas 1981) reflects the ease of low-level processes and concerns the physical characteristics of the item; conceptual fluency (Whittlesea 1993) reflects the ease of high-level processes and is associated with previously acquired knowledge; and motor fluency (Yang et al. 2009) reflects the ease with which a gesture is performed.

nature of what the subject felt (perceptual vs. conceptual fluency) "…*depend[ed] only on what question the subject was predisposed to answer when encountering the item*" (Whittlesea 1993, p. 1244). In particular, "*To sponsor a feeling of familiarity, the fluency of current processing need not be due to a normatively appropriate source, but it must feel as though it is*" (p. 1244).

Despite Whittlesea's stance, the dependence or independence of fluency on or from its source (i.e. perceptual vs conceptual fluency) is still a matter of debate. The present study aimed to contribute to the discussion by exploring the interaction between conceptual and perceptual fluency from the perspective that there may have been a discrepancy between the two. While authors such as Alter and Oppenheimer (2009) or Schwarz (2004) considered fluency to be independent of its source, several researchers have argued the opposite (Doss et al. 2016; Lanska et al. 2014; Lanska and Westerman 2018; Miller et al. 2008; Silva et al. 2017, Silva et al. 2017; Vogel et al. 2020; Wang et al. 2018).

Miller et al. (2008) showed that perceptual fluency was sensitive to a modality change between learning and recognition but conceptual fluency was not. Lanska et al. (2014) examined the effect of perceptual and conceptual manipulations of fluency in the same encoding context. If the results showed some differences in the way that perceptual and conceptual fluency influence recognition, depending on both encoding and test factors, they did suggest that participants were influenced by conceptual and perceptual fluency manipulations to a similar degree. Lanska and Westerman (2018) observed that when instructions during the learning phase focused attention on perceptual features, responses in the test phase were more affected by perceptual than phonological fluency. Similarly, when attention was focused on the phonological features in the learning phase, responses in the test phase were more affected by phonological than perceptual fluency. Doss et al. (2016) showed that a combination of conceptual and perceptual fluency contributed independently to recollection. The effects were selective for false recognition and not just memories in general; the effects were replicated with emotionally-based material (Doss et al. 2016). Wang et al.'s (2018) results suggested that recognition memory was influenced by both conceptual and perceptual fluency, but that they had different effects on recognition judgements that were manifested in the form of distinct event-related potential (ERP) correlates. Thus, perceptual fluency selectively affected "know" hits, whereas conceptual fluency affected "remember" hits and "know" false alarms. Silva et al. (2017) contrasted conceptual fluency (repetition effect; Experiment 1) with perceptual fluency (Experiment 2) regarding subjective judgements of truth and according to the participant's engagement in the task. The results showed that, while participants who were not highly engaged were biased by perceptual fluency, all participants (highly engaged vs. not highly engaged) were sensitive to conceptual fluency.

Finally, Silva et al. (2017) showed that for illusions of truth to occur, variations of conceptual fluency (repetition vs. contradiction) were more relevant than variations in perceptual fluency (repeating vs. changing). In light of these results, Vogel et al. (2020) proposed the fluency specificity hypothesis: the effects of fluency are the result of a match between the source of fluency and the nature of the judgement. In particular, judgements concerning the content of a statement would be predicated on conceptual fluency, whereas judgements concerning perception would be predicated on perceptual fluency.

The present study adopted the following suggestion: "[i]t seems likely…that the process of interpreting fluency, which results in the feeling of familiarity, was undertaken only when the fluency was surprising in the context" (Whittlesea 1993, p. 1251). This idea has been taken up through what several authors have referred to as the *discrepancy attribution hypothesis* (Whittlesea 2002; Whittlesea and Leboe 2000, 2003; Whittlesea and Williams 1998, 2000, 2001a, 2001b), which states that a feeling of familiarity can arise depending on the subjective perception of the gap between what is expected and what is perceived; for instance, it may be more fluent than expected. Several studies have since confirmed this hypothesis (Breneiser and Mcdaniel 2006; Brouillet et al. 2017; Goldinger and Hansen 2005; Hansen and Wänke 2013; Thomas et al. 2010; Wilbert and Haider 2012).

Therefore, we believed that the question was not whether conceptual fluency would be more important than perceptual fluency or vice versa. If the presence of a gap is the basis for attributing to an external source its origin and thus experiencing a feeling of familiarity, then the subjective perception of a gap between conceptual and perceptual fluency should influence memory judgement. In particular, we expected the recognition rate to be high when conceptual fluency was associated with perceptual non-fluency and when conceptual non-fluency was associated with perceptual fluency. In other words, when the situation is more fluent than expected, the propensity to express a recognition judgement is increasing.

To manipulate conceptual fluency, we used an adaptation of the sentence stem paradigm (Whittlesea 1993), in which the word that completes the sentence is more fluent when predictable than otherwise. To manipulate perceptual fluency, we introduced some Gaussian noise (Reber et al. 1998) because high contrasts have been shown to be more fluent than low contrasts (Hansen et al. 2008; Reber and Schwarz 1999; Reber et al. 1998). Participants were subjected to four experimental conditions: predictable words against a noiseless background; predictable words against a noisy background; unpredictable words against a noiseless background; and unpredictable words against a noisy background.

A first experiment was conducted to ensure that the two manipulated factors (predictability and visibility) had an impact on the readability of the words. We expected that words written against a noiseless background would be judged easier to read than words written against a noisy background. We expected also that predictable words would be judged easier to read than non-predictable words. Because expectations shape perception (Bruner et al. 1951; for a review, see Lange et al. 2018) we expected that when the target words appeared against a noisy background, their predictability (conceptual fluency) would enhance their perception and consequently their readability.

The second experiment tested the hypothesis that memory is influenced by the discrepancy between conceptual and perceptual fluency. We expected that the recognition score would be higher when a gap arose between what was expected and what was perceived. In particular, when the words that followed the sentence stems were those expected (conceptual fluency) and were written against a noisy background (non-perceptual fluency), the recognition score would be higher than when they were written against a noiseless background (perceptual fluency). Conversely, when the words that followed the sentence stems were the non-expected words (non-conceptual fluency) and were written against a noiseless background (perceptual fluency), the recognition score would be higher than when they were written against a noisy background (non-perceptual fluency).

Experiment 1

Method

Participants

Thirty-six undergraduated psychology students (22 female and 14 male, all French-speaking, with an average age of 26.7 [$SD = 10.11$] and normal or corrected to normal vision) gave their informed consent to take part, and they duly signed the laboratory's charter of ethics. We checked the power analysis with G*Power software (Faul et al. 2007): for an effect size of 0.25,[2] a probability of 0.05, and a power of 0.80, G*Power indicated 34 participants.

[2] We used an effect size of 0.25 following Lanska and Westerman (2018) and Brouillet et al. (2021). To overcome the possible inadequacy of a binary rejection or acceptance of H0 (i.e., $p > .05$ vs. $p < .05$), we used Bayesian inference (Rouder et al. 2009). In the Bayesian framework, the value of hypotheses is updated based on the success of the prediction: hypotheses that predict the observed data relatively well are more credible than those that predict the data relatively poorly (Wagenmakers et al 2016). Moreover, it is now recognised that the Bayesian framework is a useful complement to the more frequent *p* value (Dienes and Mclatchie 2018).

Material

A set of 48 sentences was selected following a pre-test carried out on two groups of participants other than those involved in the experiment (50 participants per group). A set of 80 sentences, referring to widely shared knowledge, had been collated by the experimenter (see "Appendix" section). The sentences were presented in an incomplete form (i.e. with the last word missing) to the first group of participants who had to finish them using any word that came to mind.

Only the sentences that were completed with a word (5 to 7 letters long) used by at least 80% of the participants were retained. The 54 sentences selected were then given to the second group of participants who had to judge on a 5-point Likert scale whether the last word of the sentence was the one they expected (1 = *not expected at all*, 5 = *totally expected*). Only sentences for which the last word was judged to be the expected word (a score above 4) were selected. This gave a set of 48 sentences in which the word was predictable.

Then, using a random word generator, we replaced the last word of these sentences with a randomly produced word after checking that it had not been used by the first group of participants. Thus, in contrast with Whittlesea (1993), the words in the unpredictable sentences were not semantically plausible. We wanted to avoid an inhibition effect (Gernsbacher 1997; Gernsbacher et al. 2001) that could affect memory judgement (Carretti et al. 2004; Syssau et al. 2000). Indeed, if the word was not predictable but plausible (e.g. "To drive a nail we use a … STONE"), a competition between the predictable word (hammer) and the plausible word (stone) would exist and the participant would have to inhibit the predictable word for the plausible word to be accepted. To that end, we used the judges' method (5 individuals who are not part of the experiment) to check that these words were not plausible (1 or 2 on a 5-point Likert scale). This allowed us to have a set of 48 sentences in which the last word was not predictable.

For each sentence, we included a predictable word ("To drive a nail we use a… HAMMER"; "Bees make honey in a… HIVE ") and a non-predictable word ("To drive a nail we use a… PENCIL"; "Bees make honey in… CREAM").

The perceptual fluency of words was manipulated by the change in background contrast (Reber et al. 1998). Following Forster et al. (2015), we added 60% Gaussian noise to the background with the function imnoise in MATLAB to obtain low perceptual clarity. Thus, all words (i.e. predictable and unpredictable) were either written in font size 45, in black uppercase on an unaltered white background (high perceptual clarity), or in black uppercase on a grey altered background (low perceptual clarity).

Procedure

Because of the coronavirus crisis, the participants were unable to conduct the experiment in the laboratory. They were contacted individually, and after they gave their consent, they received a program developed with Opensesame (Mathôt et al. 2012) that they installed on their personal computer. They were asked to conduct the experiment in a quiet room at a time when they knew they would not be disturbed. Upon completion, they sent the results file back to the experimenter.

The participants read the instructions on the screen. They were asked to press the centre of the space bar on the keyboard to bring up sentences followed by the word to be judged (the readability ratings were self-paced). The order of presentation of the sentences was randomised. Sentences appeared at the centre of the screen, written in black on a white background and displayed long enough to be read, that is, 5000 ms. We used Faust et al.'s (1997) calculations for the longest sentence to establish the minimum time needed to read the sentences, namely, a constant 500 ms, 100 ms per character, and 150 ms between words. Words were a size 35 font. The last word of each sentence was replaced by three dots (…). The disappearance of the sentence was followed by a white screen lasting 250 ms (i.e. the time used to generate expectations; Whittlesea, 2002). After this, a word written in black uppercase (font size 45) on a white background or a word written in black uppercase with Gaussian noise appeared at the centre of the screen and remained for 300 ms.

Experimental design

Two experimental factors were manipulated within-subject: word predictability (predictable vs. non-predictable) and perceptual clarity (high perceptual clarity vs. low perceptual clarity). Participants had to judge 48 words, of which 24 were predictable and 24 were non-predictable. Of the 24 predictable and non-predictable ones, 12 appeared with high perceptual clarity and 12 with low perceptual clarity. The conditions were counterbalanced amongst the participants.

Results

Statistical analysis was carried out using JASP software (Wagenmakers et al. 2018a, 2018b). We performed a frequentist repeated measures analysis of variance (ANOVA) followed by a Bayesian repeated measure ANOVA. Following Schönbrodt and Wagenmakers (2018) recommendations, a Bayes Factor (BF)10 ≥ 10 was interpreted as strong evidence for the alternative hypothesis, a 3 ≤ BF10 < 10 as moderate evidence for the alternative hypothesis, and a BF10 < 3 as anecdotal evidence for the alternative hypothesis, with a BF10 close to 1 considered as no evidence.

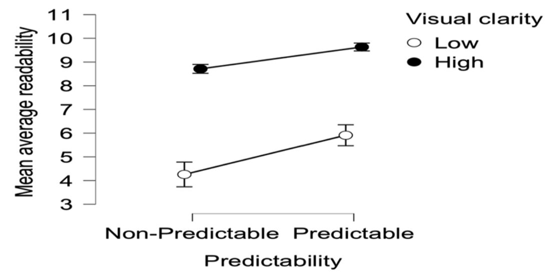

Fig. 1 Mean average judgement of word readability based on predictability (predictable vs. non-predictable) and clarity (low vs. high). Error bars: confidence interval (95.0%)

Figure 1 shows the average judgement of word readability. The results showed a predictability effect: $F(1, 33) = 119.37$, $p < 0.001$, $\eta^2_p = 0.78$, $BF_{10} = 22.85$. Predictable words were judged easier to read than unpredictable words. There was a clarity effect: $F(1, 33) = 396.34$, $p < 0.001$, $\eta^2_p = 0.92$, $BF_{10} = 1.10^{+40}$. High clarity words were judged easier to read than low clarity words. The interaction between predictability and clarity was significant: $F(1,33) = 12.24$, $p < 0.001$, $\eta^2_p = 0.27$, $BF_{10} = 2.33^{+51}$. The decomposition of the interaction showed that non-predictable words were judged easier to read when visual clarity was high rather than low: $t(33) = 20.48$, $p < 0.001$, $\eta^2_p = 0.92$, $BF_{10} = 1.68^{+17}$; for predictable words, $t(33) = 9.75$, $p < 0.001$, $\eta^2 = 0.74$, $BF_{10} = 3.16^{+8}$. Predictable words were judged easier to read than non-predictable words with low visual clarity: $t(33) = 5.06$, $p < 0.001$, $\eta^2_p = 0.43$, $BF_{10} = 1414.15$. With high visual clarity, predictable words and non-predictable words were judged as easy to read: $t(33) = 1.70$, $p = 0.09$, $\eta^2_p = 0.08$, $BF_{10} = 0.67$.

Conclusion

The experiment was conducted to ensure that the two manipulated factors (predictability and clarity) affected the readability of the words. On the one hand, the words written against a noiseless background (high perceptual fluency) were judged to be easier to read than words written against a noisy background (low perceptual fluency); on the other hand, the predictable words (i.e. high conceptual fluency) were easier to read than the non-predictable words. In addition, the results showed that when the words were written against a noisy background (low visual fluency) their predictability (high conceptual fluency) enhanced the judgement of readability. Finally, in high perceptual clarity, readability was equal between the predictable and non-predictable words.

Experiment 2

Experiment 2 tested the hypothesis that memory judgements in a recognition task are influenced by the discrepancy between conceptual and perceptual fluency. We predicted that the non-expected words (non-conceptual fluency) written against a noiseless background (high perceptual fluency) would be better recognised than when they were written against a noisy background (low perceptual fluency), and conversely, the expected words (high conceptual fluency) written against a noisy background (low perceptual fluency) would be better recognised than when they were written against a noiseless background (high perceptual fluency). For example, in the case of the sentence "The magician takes a rabbit out of his… (predictable word "HAT") we predicted that the participants would be more likely to recognise HAT when the background was noisy (low perceptual fluency) than when it was noiseless (high perceptual fluency). The opposite prediction was made for the sentence "She's going to see a film in a… (non-predictable word "VASE"). We expected that the participants would be more likely to recognise VASE when the background was noiseless (high perceptual fluency) than when it was noisy (low perceptual fluency).

Method

Participants

Twenty-four undergraduated psychology students, different from Experiment 1, (15 female and 9 male, all French-speaking, with an average age of 35.3 years [$SD = 9.65$] and normal or corrected to normal vision) gave their informed consent to take part (for an effect size of 0.25,[3] a probability of 0.05, and a power of 0.90, G*Power indicates 24 participants; Faul et al. 2007). They duly signed the laboratory's charter of ethics. The participants were not told of the purpose of the experiment.

Material

We used the same material as in Experiment 1.

Procedure

Participants were tested individually in a quiet room. The experimenter gave them instructions but was absent during the experiment itself. The participants were invited to sit in front of the computer at a distance of around 70 cm from their eyes. The experiment was run on a DELL Latitude Laptop (e5510) using Windows 7 Pro (graphics card: INTEL Integrated Chipset; processor: Intel Core i5; screen size: 15.6 in). The experiment was programmed and run using OpenSesame (Mathôt et al. 2012).

Once seated, the participants read the instructions on the screen. They were told that the experiment would consist of two phases: in the first phase they had to learn a list of words that would appear one after the other automatically, and in the second phase they had to indicate, at their own pace, whether the words that appeared after a truncated sentence had already been presented in the first list. They were told that they had to initiate each phase by pressing the space bar on the keyboard and were asked to use only the index finger of their dominant hand to type on the keyboard.

Learning phase

In each trial, a cross indicating that a word was going to appear was displayed for 150 ms, followed by a white screen for 200 ms, after which a word appeared automatically at the centre of the screen, written in black uppercase on a white background in size 45 font. The 24 words selected appeared randomly and were displayed for 950 ms. We used Faust et al.'s (1997) calculations for the longest word to establish the minimum time that would be needed to read the words.

Recognition phase

After this first phase, participants read the instructions for the recognition phase and were asked to press the mark in the middle of the space bar to bring up the sentences followed by the words being judged. The sentences, which were written in black on a white background, appeared randomly at the centre of the screen. The words were written in size 35 font and remained displayed for 5000 ms to be read. (We used Faust et al. (1997) calculations for the longest sentence to establish the minimum time needed to read the sentences). The last word of each sentence was replaced by three dots (…). The sentence disappeared and a white screen lasting 250 ms followed to generate expectations (Whittlesea 2002). After this, a word written in size 45 font, in black uppercase on a white background or with Gaussian noise, appeared at the centre of the screen and remained displayed for 950 ms. Once the word disappeared, participants had to make a memory decision followed by confidence.

The recognition judgement was to say whether the word was present in the learning phase ("yes" or "no"). Participants could only respond when the words yes or no appeared on the screen. The mapping between judgement and key was balanced between the participants.

Once they had responded, they had to indicate on a 7-point Likert scale their degree of certainty (1 = *not very*

[3] We used an effect size of 0.25 as in Experiment 1 and following Lanska and Westerman (2018) and Brouillet et al. (2021).

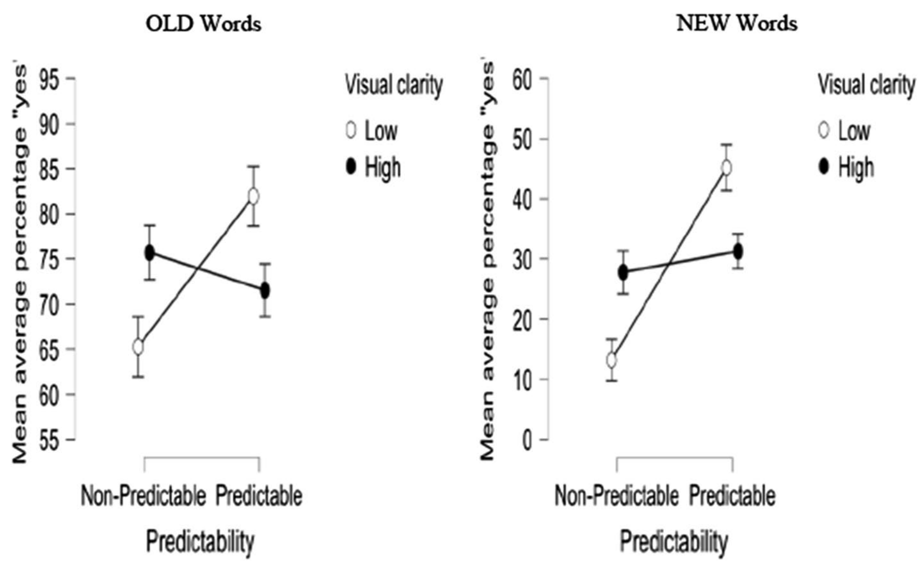

Fig. 2 Mean average percentage of "yes" responses for old and new words based on whether or not they were predictable and whether or not visual clarity was high or low. Error bars: confidence interval (95.0%)

certain, 7 = *quite certain*; the numbered keys 1, 2, 3, 4, 5, 6, and 7 corresponded to the keys E, R, T, Y, U, I, and O on the AZERTY keyboard).

Once the participants had responded, they had to press the mark in the middle of the space bar to display the next sentence followed by the word to be judged. They were reminded to use the index finger of their dominant hand to answer. Tapping with the index finger of the dominant hand on the mark in the middle of the space bar ensured that the finger was always equidistant from the extreme values of the judgement scale.

Experimental design

Three experimental factors were manipulated intra-subject: word status (old vs. new), word predictability (predictable word vs. non-predictable word), and visual clarity of words (high visual clarity vs. low visual clarity). Participants had to judge 48 words. Of these, 24 were old and 24 were new. Of the 24 old and new ones, 12 were predictable and 12 were non-predictable. Finally, for the 12 predictable and non-predictable words, six appeared with high visual clarity and six with low visual clarity. The conditions were counterbalanced between participants.

Results

As in Experiment 1, the statistical analysis was carried out using JASP software (Wagenmakers et al. 2018a, 2018b) and we performed a frequentist repeated measures ANOVA followed by a Bayesian repeated measures ANOVA.

Recognition

Figure 2 shows the mean average percentage of "yes" responses for old and new words (meaning participants believed they saw the words in the learning phase).

The results revealed a classic effect of the status factor (i.e. new or old): $F(1, 23) = 147.8$, $p < 0.001$, $\eta^2_p = 0.86$, $BF_{10} = 1.35^{+38}$. Old words were recognised more than new words. The interaction Status * Word predictability * Perceptual clarity was not significant: $F(1, 23) = 1.65$, $p = 0.21$, $\eta^2_p = 0.06$, $BF_{10} = 1.15^{-8}$.Therefore, we analysed separately the old and new words separately.

Old words

The results showed an effect of predictability: $F(1, 23) = 7.66$, $p = 0.011$, $\eta^2_p = 0.25$, $BF_{10} = 2.52$. Predictable words were more easily recognised than non-predictable words. There was no effect of clarity ($F[1, 23] = 0.00$, $p = 1.00$, $\eta^2_p = 0.000$, $BF_{10} = 1.63^{-8}$), but the interaction between predictability and clarity was significant: $F(1, 23) = 17.78$, $p < 0.001$, $\eta^2_p = 0.43$, $BF_{10} = 377.210$. The decomposition of the interaction showed that non-predictable words were more easily recognised when visual clarity was high rather than low ($t[23] = 4.30$, $p < 0.001$, $\eta^2_p = 0.44$, $BF_{10} = 114.42$), while predictable words were better recognised when visual clarity was low rather than high: $t(23) = 2.53$, $p = 0.019$, $\eta^2_p = 0.21$, $BF_{10} = 2.88$. Predictable words were more easily recognised than non-predictable words with low visual clarity: $t(23) = 4.60$, $p < 0.001$, $\eta^2_p = 0.47$, $BF_{10} = 223.57$. On the other hand, when visual clarity was high there was no effect of predictability: $t(23) = 1.36$, $p = 0.18$, $\eta^2_p = 0.07$, $BF_{10} = 0.48$.

New words

The results showed an effect of predictability: $F(1, 23) = 33.40$, $p < 0.001$, $\eta^2_p = 0.59$, $BF_{10} = 37{,}187.53$. Predictable words were falsely judged more as old than non-predictable words. There was no effect of clarity ($F[1, 23] = 0.01$, $p = 0.89$, $\eta^2_p = 0.001$, $BF_{10} = 1.63^{-8}$), but the interaction between predictability and clarity was significant: $F(1, 23) = 26.42$, $p < 0.001$, $\eta^2_p = 0.53$, $BF_{10} = 5.15^{+7}$. The decomposition of the interaction showed that high visual clarity induced more false recognition than low visual clarity for non-predictable words ($t[23] = 4.53$, $p < 0.001$, $\eta^2_p = 0.47$, $BF_{10} = 186.61$), while for predictable words low visual clarity induced more false recognition than high visual clarity: $t(23) = 3.29$, $p = 0.003$, $\eta^2_p = 0.34$, $BF_{10} = 12.84$. Low visual clarity induced more false recognition for predictable words than for non-predictable words: $t(23) = 6.80$, $p < 0.001$, $\eta^2_p = 0.66$, $BF_{10} = 27{,}954.31$. On the other hand, when visual clarity was high there was no effect of predictability: $t(23) = 1.00$, $p = 0.32$, $\eta^2_p = 0.04$, $BF_{10} = 1.23^{-4}$.

To summarise, the results showed (in the case of both old and new words) that the predictability-clearness coupling (conceptual-perceptual fluency) resulted in reversed recognition scores depending on whether the words were predictable or unpredictable and easy or difficult to read. When visual clarity was low (low perceptual fluency), participants were more likely to judge a word as old for predictable words (conceptual fluency) than when visual clarity was high (high perceptual fluency). When visual clarity was high (perceptual fluency), participants were more likely to judge a word as old for non-predictable words (non-conceptual fluency) than when visual clarity was low (low perceptual fluency). Overall, these results suggest that judgements of recognition were biased by the gap between conceptual and perceptual fluency, as was expected.

However, following a remark by one of the reviewers, we wanted to know if this pattern of results applied to every participant. We hypothesised that the number of words recognised in the low perceptual fluency condition would be higher in the conceptual fluency condition than in the non-conceptual fluency condition. This was the case for 22 out of 24 participants ($p < 0.001$)[4] for the old words and for 17 out of 24 participants ($p = 0.03$) for the new words. We also hypothesised that the number of words recognised in the high perceptual fluency condition would be greater in the non-conceptual fluency condition than in the conceptual fluency condition. This proved to be the case for around 5 out of the 24 participants ($p = 0.999$) for the old words and for 8 out of 24 participants ($p = 0.96$) for the new words. In sum, for a large majority of participants, it was only the difficulty in reading the expected words that biased their recognition judgement.

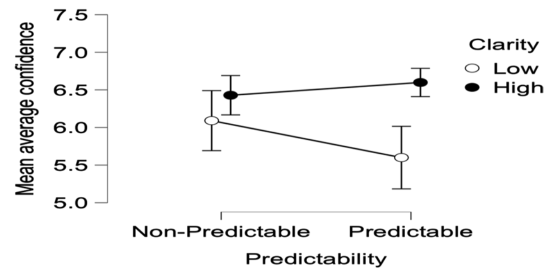

Fig. 3 Average confidence judgements (max.7) according to the predictability (non-predictable vs predictable) and the visual clarity (low vs high) of the words. Error bars: confidence interval (95.0%)

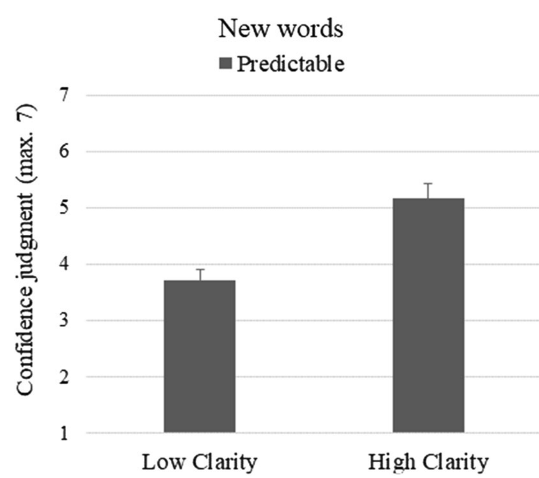

Fig. 4 Average confidence judgements (max.7) according to the perceptual clarity (low vs high). Error bars: confidence interval (95.0%)

Confidence

We present the results for Old and New words separately (see Figs. 3 and 4). For New words, we have only presented the results for predictable words because we did not have some of the data for the non-predictable words; few words were falsely recognised for some participant.

Old words

The analysis revealed no effect of predictability: $F(1, 23) = 1.12$, $p = 0.30$, $\eta^2_p = 0.04$, $BF_{10} = 0.34$. However, an effect of clarity was observed: $F(1, 23) = 28.85$, $p < 0.001$, $\eta^2_p = 0.55$, $BF_{10} = 3959.69$. Confidence was higher for high clarity than for low clarity. Moreover, the interaction was significant: $F(1, 23) = 8.69$, $p < 0.01$, $\eta^2_p = 0.27$, $BF_{10} = 6620.52$. The decomposition of the interaction revealed a significant difference between low and high

[4] Binomial test.

visual clarity when the word was predictable: $t(23) = 7.17$, $p < 0.001$, $\eta^2_p = 0.69$, $BF_{10} = 61{,}870.68$. When the words were predictable, confidence was higher for high visual clarity than for low visual clarity. The difference between predictable and non-predictable words in low visual clarity was also significant: $t(23) = 2.11$, $p = 0.04$, $\eta^2_p = 0.16$, $BF_{10} = 1.40$. When the words appeared in low visual clarity, confidence seemed higher for unpredictable words than predictable words, but the BF_{10} result urged caution. There was no difference between low and high visual clarity for non-predictable words: $t(23) = 1.76$, $p = 0.09$, $\eta^2_p = 0.11$, $BF_{10} = 0.817$, nor between predictable and non-predictable words in high visual clarity ($t[23] = 1.29$, $p = 0.20$, $\eta^2_p = 0.06$, $BF_{10} = 0.45$).

New predictable words

When the words were predictable, confidence was higher for high visual clarity than for low visual clarity: $t(23) = 3.94$, $p < 0.001$, $\eta^2_p = 0.40$, $BF_{10} = 51.82$.

In sum, the results for old words show that while predictability alone did not seem to influence confidence, clarity did. For the predictable words, high perceptual clarity induced higher confidence than low perceptual clarity; whereas when perceptual clarity was low confidence was higher for the non-predictable words, though this last result may not be reliable. The results overall suggest that confidence in judgement was influenced by the predictability-clarity matching: predictable and high clarity, non-predictable and low clarity induced higher confidence. For a few predictable words, high perceptual clarity induced higher confidence in judgement than low perceptual clarity. Therefore, it may be argued that confidence was influenced by the correspondence between conceptual and perceptual fluency.

General discussion

We asked the following question at the beginning of the present study: would the discrepancy between an expected word and its readability enhance or impair memory ability? In addition to the fact that this situation occurs in everyday life, there is a substantial body of work that has highlighted that the familiarity felt at the origin of the feeling of memory is associated with the gap between what is expected and what is perceived (the discrepancy attribution hypothesis; Breneiser and Mcdaniel 2006; Brouillet et al. 2017; Goldinger and Hansen 2005; Hansen and Wänke 2013; Thomas et al. 2010; Whittlesea 2002; Whittlesea and Leboe 2000, 2003; Whittlesea and Williams 1998, 2000, 2001a, 2001b; Wilbert and Haider 2012). To answer the aforementioned question, we used an adaptation of the sentence stem paradigm (Whittlesea 1993) and changed the background (Reber et al. 1998) to make the target words either predictable or non-predictable (i.e. conceptual fluency) and easy to read or difficult to read (i.e. visual fluency). In Experiment 1, participants were asked to rate the readability of the target words, and Experiment 2, they were asked to make a recognition judgement about the target words followed by a confidence rating for their recognition judgement.

The results from Experiment 1 show that the predictability and clarity of the target words facilitated their comprehension, but when the target words appeared against a noisy background their predictability enhanced their readability, which was not the case with a noiseless background. Thus, when the task of the participants was to evaluate the readability of the target words, the relevant factor was the clarity of the background, and when it was not, the predictability factor had an influence. In other words, visual fluency was more relevant than conceptual fluency except when the former was low.

The recognition results in Experiment 2 showed an effect of predictability and no effect of clarity and an interaction between the two. In particular, the two factors had an inverse effect on recognition judgement for both old and new words. With a noisy background, the predictability of the target words affected recognition judgement, while with a clear background, the non-predictability of the target words had an effect. However, this pattern was not found amongst all participants. It was only the effect of low perceptual fluency (difficulty in reading the word) on an expected word (conceptual fluency) that biased the recognition judgement for a large proportion of the participants.

The results on confidence in judgement showed an effect of clarity but not of predictability. But, we observed that confidence in judgement increased when the two went in the same direction (i.e. predictability with clarity and non-predictability with low clarity).

The contribution of the present study is twofold. On the one hand, it addresses the issue of the respective roles of conceptual and perceptual fluency (Doss et al. 2016; Lanska et al. 2014; Miller et al. 2008; Wang et al. 2018; Whittlesea 1993). It seems that the effects of perceptual fluency and/or conceptual fluency depend largely on the task performed (Silva et al. 2017). More specifically, it would be the instruction associated with the task that would lead to the formulation of a hypothesis on what is expected and to base the subsequent evaluations upon it (see the concept of *self-consistency*, Luu and Stocker 2018; Stocker and Simoncelli 2007). Thus: a) readability judgement leads to a focus on perceptual features (clarity) and, therefore, readability judgement is sensitive to perceptual fluency (Jacoby and Dallas 1981); b) recognition judgement leads to focus on meaning (see Morris et al. 1977) and, therefore, recognition judgement is sensitive to conceptual fluency (predictability);

c) it would seem that confidence judgement leads to focus on readability and, therefore, confidence judgement would be sensitive to perceptual fluency. In sum, the goal associated with the task influenced the interpretation of the same phenomenological dimension: fluency (Kelley and Jacoby 2014; Schwarz 2004). This interpretation was congruent with the *fluency specificity hypothesis* proposed by Vogel et al. (2020). It also accords with Whittlesea (1993); see the introduction of this article). But the main contribution of the present study concerns the relationship between conceptual and perceptual fluencies. If it was a gap between conceptual and perceptual fluency that affected memory judgement and to a lesser extent readability judgement, it was the matching between conceptual and perceptual fluency that affected confidence judgement. Therefore, one can infer that it was not the same fluency heuristic underlying participants' judgements in these three kinds of tasks. According to Whittlesea and Leboe (2003) it is important of discriminating between two ways in which people make use of fluency of their processing in arriving at a subjective experience of familiarity: absolute fluency versus relative fluency. It is referred to absolute fluency when it is the absolute magnitude of processing that influences people's decision processes. It is referred to relative fluency when a feeling of surprise accompanies processing of a stimulus that is unexpectedly fluent. Consequently, it could be argued that it was relative fluency that underlined recognition judgement, as well as readability judgement, and absolute fluency that underlined confidence judgement. In any case, conceptual fluency and perceptual fluency have a mutual influence, so, they may no longer be considered independent (Doss et al. 2016; Wang et al. 2018).

On the other hand, the present study supports the idea that memory judgements depend on what is going on currently and not exclusively on the activation of stored items (Brouillet 2020). Moreover, our results highlighted that memory judgement was underlined by the interpretation of the gap arising from the ongoing processes and not simply because the perceived fluency was higher than expected (i.e. "*when the fluency was surprising in the context*"; Whittlesea 1993, p. 1251). Indeed, in one case an increase in a feeling of fluency emerged at the origin of the gap (when a word was unexpected and easy to read), while in another case a decrease in a feeling of fluency emerged at the origin of the gap (when a word was expected and difficult to read). Therefore, we suggest that the subjective perception of a gap between conceptual and perceptual fluency might have acted as a metacognitive signal that (in the context of a recognition task) might have been used as an indicator of pastness. As the participants were not aware of the origin of this gap, they attributed the feeling that *has to do with the past* to the target words (Goldinger and Hansen 2005). Accordingly, we would argue that the feeling of pastness was nothing more than an inferential process associated with the monitoring of the ongoing process and the resulting subjective feeling of fluency.

The idea that inferential processes underlie cognition is not new; Hermann von Helmholtz (1867) was the first to point this out. Brunswik (1956) claimed that perception derived from an inference based on cues present in the environment. More recently, the famous predictive processing model has extended this concept to the entire functioning of the brain (for a synthesis, see Hutchinson and Barrett 2019; Wiese and Metzinger 2017). The brain continually builds a predictive model of the causes of its sensations through several processes. It encodes the conditional probability of a stimulus ("expectation"), makes predictions regarding expected inputs (the mismatch between predictions and what is perceived [surprise/error]), and forwards these errors to a higher level where they are adjusted to eliminate future such cases. To predict precision, our brain must include beliefs about the precision of its own predictions (Friston 2005, 2009, 2010). We would argue that fluency might be used as an indicator of the precision of the prediction.

It may be worth considering the effect induced by the discrepancy between conceptual and perceptual fluency from this perspective. In the present study, when a participant read the stem sentence, they made a prediction about which word should appear and expected it to be easy to read, thus ensuring fluency. Perceptually, the word that appeared was difficult to read, which generated non-fluency. This prediction error[5] led the participant to be more attentive to the process. Contrary to what the a priori difficulty of identifying a word suggests, fluency can be felt (it is the word expected) and when someone is experiencing fluency, they may conclude that the word is not as new as it seems. Indeed, "… *fluency is a reliable cue to the past, because past experience does facilitate present re-experience*…" (Kelley and Jacoby 1990, p. 54). We are aware that this interpretation is speculative and should be tested using brain activity data during the performance of this type of procedure.

Appendix

Phrases	Mot cible
Elle boit son chocolat chaud dans un …	BOL
Le pneu est à plat il faut changer la …	ROUE
Le serveur a versé du café dans la …	TASSE
Un chronomètre sert à mesurer le …	TEMPS

[5] Several studies have highlighted the role of prediction errors in the memory process (Calderon et al. (2021); Exton-McGuinness et al. 2015; Kim et al. 2014; Rouhani et al. 2020; Sinclair et al. 2021).

Phrases	Mot cible
Pour couper le pain il utilise un …	COUTEAU
Au marché elle met ses achats dans son …	PANIER
Après avoir mangé il faut se brosser les …	DENTS
Les satellites sont envoyés dans l'espace avec une …	FUSEE
Dans les plats on met du sel et du …	POIVRE
Le boucher découpe la …	VIANDE
Une main est composée de cinq …	DOIGTS
Avant d’enfiler sa veste il boutonne sa …	CHEMISE
Sous le nez il y a la …	BOUCHE
Les oiseaux peuvent voler grâce à leurs …	AILES
Sur un gâteau d'anniversaire il y a des …	BOUGIES
La terre tourne autour du …	SOLEIL
Pour signaler une faute l'arbitre souffle dans un …	SIFFLET
Je sens avec mon nez, et j'entends avec mes …	OREILLES
Au début du repas elle verse la soupe dans chaque …	ASSIETTE
Pour se faire couper les cheveux on va chez le …	COIFFEUR
Pour trouver l'itinéraire on doit lire la …	CARTE
Pour ne pas avoir froid aux mains elle met une paire de …	GANTS
La ligne droite entre deux points est le plus court …	CHEMIN
Le matin il met dans son café deux morceaux de …	SUCRE
Pour effacer le trait au crayon elle se sert d’une …	GOMME
Après avoir transpiré c'est agréable de prendre une …	DOUCHE
L'été à la plage les enfants construisent des châteaux de …	SABLE
Il déchire la feuille et la jette dans la corbeille à …	PAPIER
Pour rentrer dans la maison il doit ouvrir la …	PORTE
En voiture pour changer de direction on tourne le …	VOLANT
A la banque les objets de valeur sont enfermés dans un …	COFFRE
Pour la remercier il lui a offert un bouquet de …	FLEUR
Les footballeurs jouent avec un …	BALLON
Au petit-déjeuner, il étale la confiture sur sa …	TARTINE
On prépare généralement le repas dans la …	CUISINE
Pour faire couleur l'eau elle ouvre le …	ROBINET
Il n'habite pas dans une ville mais dans un	VILLAGE
Le Père-Noël utilise des reines pour tirer son …	TRAINEAU
Les enfants jouent au chat et à la …	SOURIS
Quand la vue baisse il faut porter des …	LUNETTES
Ils se sont assis dans le jardin sur un vieux …	BANC
La personne ivre est tombée dans le …	COMAS
Le chat léchait la dernière goutte de …	LAIT
Pour se protéger de la pluie il ouvre son …	PARAPLUIE
Elle marche sur la pointe des pieds sans faire de …	BRUIT
Son mari a pensé que ce serait bien d’avoir un …	ENFANT
Pour traverser la rivière il emprunte le …	PONT
Les abeilles fabriquent le miel dans une …	RUCHE
À la fin du repas, il nettoie la …	TABLE
Lorsqu'on va à la gare, c'est pour prendre le …	TRAIN
Elle nettoya le sol de la cuisine avec un …	BALAI
Les lunettes de soleil servent à protéger les …	YEUX

Phrases	Mot cible
Il a mis la voiture à l'abri dans son …	GARAGE
Dans une bibliothèque il y a des …	LIVRES
Le capitaine a pris les commandes du …	VAISSEAU
Pour son bac elle a reçu un …	CADEAU
Le magicien sort un lapin de son …	CHAPEAU
Pour monter au grenier, il a utilisé une …	ECHELLE
Tous les matins le facteur distribue le …	COURRIER
En automne les arbres perdent leurs	FEUILLES
Pour ouvrir la serrure on utilise une …	CLEF
On va au cinéma pour aller voir un …	FILM
Après l’accident de voiture, il était couvert de …	SANG
Ils sont allés au bar pour boire une …	BIERE
Le marin a nettoyé le pont du …	BATEAU
Avant d'aller au lit, il regarde la …	TELEVISION
Dans l’obscurité de la cave, elle a allumé une …	LAMPE
Ce genre de médicament est bon pour la …	SANTEE
Au camping, les touristes montent leur …	TENTE
Ils vendent du vin à la bouteille ou au …	VERRE
Il se lave en chantant sous la …	DOUCHE
Pour dessiner un cercle, on utilise un …	COMPAS
La carotte n'est pas un fruit, c'est un …	LEGUME
Ils ont tout mangé jusqu’à la dernière …	MIETTE
Pour enfoncer un clou on utilise un …	MARTEAU
A midi, à l'école, les enfants vont manger à la …	CANTINE
Elle n’a pas pu trouver d’endroit où garer la …	VOITURE
En classe l'enseignant écrit au …	TABLEAU
Généralement dans les aquariums il y a des …	POISSONS
Au tennis on frappe la balle avec une …	RAQUETTE

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