Experience of memory: transfer of the motor feeling of fluency linked to our interaction with the environment

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Experience of memory: transfer of the motor feeling of fluency linked to our interaction with the environment

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Summary

In the field of memory, it is now admitted that an experience of memory is not only the consequence of the activation of a precise content, but also results from an inference associated with the transfer of the manner in which the process was carried out (i.e., fluency) in addition to the transfer of the process itself. The aim of this work was to show that experience of memory is also associated with the fluency that is due to the transfer of a processing carried out in our interactions with our past environment. Firstly, participants performed a perceptual discrimination task (geometric shapes: circle or square) that involves a fluent or a non-fluent gesture to respond. Motor fluency vs. non-fluency was implicitly associated with the colour of the geometric shapes. Secondly, participants had to perform a classical memory recognition task. During the recognition phase, items appeared either with the colour associated with motor fluency or with the colour associated with motor non-fluency. We used a Go-NoGo task to avoid having a confused factor (response space). Results show that items were better recognised with a colour associated with motor fluency than with a colour associated with non-motor fluency. These findings support the idea that an experience of memory is also associated with the transfer of the motor feeling of fluency linked to our interaction with the environment.

Key words. Memory, inference, motor fluency, transfer of processing, environment

Whether for common sense or for the large majority of models of memory, it is widely accepted that remembrance is the consequence of the activation of contents stored in memory. However, it would seem that an experience of memory result more from an inference than from the retrieval of a precise content. The aim of this short article is to show that if an experience of memory is linked to an unconscious inference associated with the processing of a stimulus, it is also linked to an unconscious inference associated with features of our interactions with the environment in which we are embedded, for instance the fluency of the gestures performed in the context of the experiment, which is the feature we will consider here.

Hermann von Helmholtz (1867) was the first to point out that cognitive processes are inferential processes. This conception is also present in Brunswik's (1956) who considered that perception derives from an inference made on the basis of cues present in the environment. More recently the famous Predictive Processing model has extended this concept to the whole functioning of the brain (for a synthesis, see Hutchinson & Barret, 2019; Wieze & Metzinger, 2017).

In the field of memory, Jacoby and colleagues (Jacoby & Dallas, 1981; Jacoby, Kelley & Dywan, 1989; Jacoby & Whitehouse, 1989; Kelley & Jacoby, 1990; Whittlesea, Jacoby & Girard, 1990) are the ones who popularized this conception. On their analysis, the experience of memory originates in an inference based on a phenomenological cue, namely the ease with which a stimulus is processed and becomes conscious (i.e., fluency). They say: « ... fluency is a reliable cue to the past, because past experience does facilitate present re-experience ...» (Kelley & Jacoby, 1990, p. 54). However, fluency is opaque to its own causal source to the effect that it does not represent such a source. Introspecting fluency will not reveal what brought it about. This is why assigning it a source must rely on an attributional process, which attributes the supposed source of the fluency to the conscious stimulus (Whittlesea, 1997). For instance, as one is remembering, if one's processing of the different traces by the means of which one is constructing one's memory is relatively fluent, this processing feature can be interpreted as due

to past similar processing, and the mental scene constructed will be attributed to the past experience of the system accordingly: "… *'pastness' cannot be found in memory trace, rather, reflects an attribution of transfer in performance"* (Jacoby, Kelley & Dywan, 1989, p. 400), called "*transfer-like effects*" (p. 397). Because I have experienced that processing before, my presently doing carrying it out again induces a feeling of fluency, and when I feel this fluency I conclude that the situation is not as new as it seems.

But it is not fluency by itself that triggers the feeling of familiarity, it is more precisely the subjective detection of a discrepancy in the ongoing cognitive activity, that is an unpredicted fluency. Hence, on the core idea of the attributionalist analysis, the subjective experience that follows an experienced cognitive discrepancy is at the root of the attributional process (for a review see Kelley & Jacoby, 1998). This was particularly well highlighted in the *discrepancy attribution hypothesis* proposed by Whittlesea and colleagues (Whittlesea, 2002; Whittlesea & Leboe, 2000, 2003; Whittlesea & Williams, 1998, 2000, 2001a, 2001b) In the context of a recognition test, participants unconsciously attributed the source of fluency to a prior experience of the items (Breneiser & Mcdaniel, 2006; Brouillet et al., 2017; Goldinger & Hansen, 2005; Hansen & Wänke, 2008 ; Hansen, Dechene & Wänke, 2008; Kronlund & Whittlesea, 2006; McDaniel, 2013).

More recently, Lanska and Westerman (2018) have proposed the concept of "*transfer of appropriate fluency*"[1]. The originality of Lanska and Westerman's work is to show that in addition to the transfer of processes, there is also a transfer of the manner in which the process was carried out (i.e., fluency).

[1] The idea that retrieval past experience depend upon the transfer of the processes used to realize them than upon the activation of contents stored, has been developed by authors such as Kolers (1975, 1976); Morris, Bransford & Franks (1977); Bransford et al. (1979); Kolers et Rodiger (1984), through the Transfer Appropriate Processing – TAP - (a process approach of memory, Craik & Lockart, 1972; Franks et al, 2000; Roediger, Gallo et Geraci, 2002). There is today neurophysiological evidence that retrieval is considered to be mediated by the reinstatement of the brain activity that was present during processing of the original event (Schendan & Kutas, 2007; Bramao & Johansson, 2018).

However, a question remains at this stage: does the feeling of pastness stem only from the fluency that is due to the transfer of a stimulus-related processing, or also from the fluency that is due to the transfer of a processing carried out in our interactions with our past environment? The possibility that our interactions with the environment participates in the feeling of pastness is supported by the early work of Thomson & Tulving (1970) and Tulving and Thompson, (1973) who established that when we process an item we integrate in the same construct not only various information related to the stimulus (i.e., perceptual features, meaning, etc.), but also those related to the context in which the item is processed (Mandler, 1980, 1991; Smith, 1994). If this is correct, we can consider that the features of our interactions with our environment, in particular fluency, is part of this construct. But does this motor feeling of fluency obey the same rule as the transfer of appropriate fluency described by Lanska and Westerman (2018)?

To answer this question, we have constructed an experiment that consists of two steps. The first step is a perceptual discrimination task (distinguishing a square from a circle) that involves a fluent (ipsilateral) or non-fluent (contralateral) gesture to respond. Motor fluency vs. non-fluency is implicitly associated with the colour of the geometric shapes (blue vs. magenta). The second step is a classical memory recognition task (learning phase and recognition phase). During the recognition phase, items appear either with the colour associated with motor fluency or with the colour associated with motor non-fluency. The subjects' task is a Go-NoGo task (answer only if the item is considered as belonging to the learning phase) to avoid having a confused factor (response space). The hypothesis is that items with the colour associated with motor fluency will receive a higher recognition score than those with a colour associated with motor non-fluency. Furthermore, we predict that NEW items with the colour associated with motor fluency will receive higher false recognition scores than those with a colour associated with motor non-fluency. If the results go in the expected direction, then we will have shown

that memory performance is associated with the transfer of the subjective embodied experiences that the person has had, regardless of the item.

Method

Participants. We checked power analysis with G*Power software (Faul, Erdfelder, Lang & Buchner, 2007) to know the total sample size: for an effect size 0,25; a probability 0,05; a power 0,95; G*Power indicates 36 participants. The thirty-six participants were not informed about the purpose of the experiment. The age of participants was ranged from 26 to 38 years, mean: 30, SD: 3.5 (20 women and 16 men). All participants were native French speakers and all right-handed. Their vision was normal or corrected to normal. They gave their informed consent to take part in this experiment and duly signed the Laboratory's Charter of Ethics.

Material. We used two geometric shapes (circle or square) coloured in blue or in magenta for the perceptual discrimination phase. For the recognition phase we used 32 bisyllabic pseudowords (font type Times New Roman, font size 18) formed from 64 different syllables: kosjal, hapnoz, nelkam, havruj, levtap, gecfok, kefjal, cadjep, tisyac, zamcig, sivnag, nagteh, tospav, hefnap, myptor, rivnut, fimcug, febnoc, kazrup, vabcij, rykbuj, gozfup, hydzor, relvaj, tahjos, lopqih, nyztad, hedsih, nipsek, sarfom, lafkob, gidvez. The pseudo-words were coloured in blue or magenta.

Procedure. The experiment was programmed using OpenSesame (Mathôt, Schreij & Theeuwes, 2011) and was performed at distance. We used a procedure derived from Brouillet et al. (2014). When the program has started participants could read the general instructions. They were told that the experiment would consist in two tasks: first a perceptual discrimination task, next a recognition task.

For the perceptual discrimination task, it was indicated that after the apparition of a fixation cross (displayed 250ms), a geometric shape (circle or square) will appear coloured in blue or in magenta in the center of the computer screen (for half of the participants, the shape coloured in blue became coloured in purple for the other half). Half of the participants had to press the key P on the keyboard (AZERTY) with their right hand when it was a square and on the key A when it was a circle. For the other half it was the reverse. Each geometric shape appeared sixteen times in random order, thus participants performed 16 gestures in their ipsilateral space (key P) and 16 gestures in their contralateral space (key A). Once the answer was given, the participants had to press the space key to display the next geometric shape, in order to control the starting point of the gesture.

For the recognition task, it was indicated that there were two phases, a learning phase and a recognition phase. For the learning phase, it was indicated that after the apparition of a fixation cross (displayed 250ms), 16 pseudo-words (Times New Roman, 24) will appear one by one automatically in the centre of the screen and that it would remain displayed long enough to learn it (800ms). The pseudo-words appeared in a random order.

For the recognition phase it was indicated that 32 pseudo-words (16 OLD and 16 NEW presented in random order) will appear on the computer screen after a fixation cross (250ms) and remained on display until the participants responded. It was specified that participants should respond with their right hand and only if they thought the pseudo-word was present during the learning phase (a Go-NoGo task to avoid an ipsilateral or contralateral gesture and in this case a confounded factor). Participants had to press the key B to respond. For half of the participants, the pseudo-words OLD were the pseudo-words NEW of the other participants, and for the other half it was the reverse. Half of the pseudo-words was coloured in blue and the other half in magenta (the colours used in the perceptual discrimination task that were associated with an ipsilateral gesture—fluent or a contralateral gesture—non-fluent). The

nature of the words to be recognized (OLD vs NEW) and the colour (blue or purple) were manipulated within participants.

Results

Statistical analyses were carried out using JASP software (Wagenmakers et al., 2018a, 2018b).

Perceptual discrimination task

The average error rate was less than 1%. Results (Figure 1) show no effect of the colour. The geometric shapes coloured in blue are as quickly discriminated as geometric shapes coloured in magenta, $F(1,35) = 0.43$, $p = 0.52$, $\eta^2_p = 0.01$; whether in contralateral, $t(35) = 0.60$, $p = 0.54$, $\eta^2_p = 0.01$, or ipsilateral, $t(35) = 0.21$, $p = 0.82$, $\eta^2_p = 0.001$. Results show an effect of laterality. Participants were faster when the response key was located in their ipsilateral space than in their contralateral space: $F(1,35) = 23.59$, $p < 0.001$, $\eta^2_p = 0.40$. There was no interaction between colour and gesture: $F(1, 35) = 0.06$, $p = 0.80$, $\eta^2_p = 0.002$.

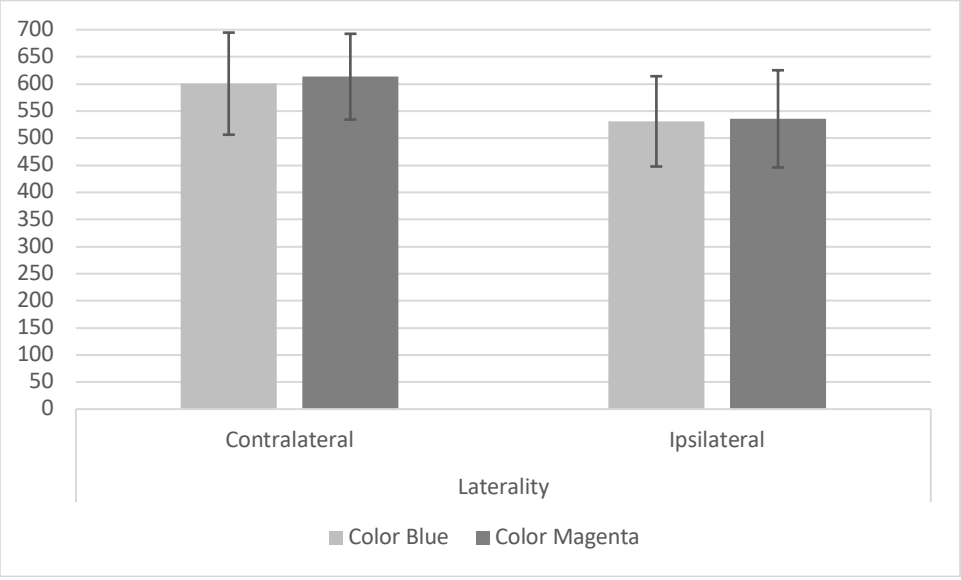

Figure 1. Average time to discriminate the geometric shapes according to the colour and the laterality of the gesture to give the answer

Recognition task

Before analysing the results (Figure 2) according to the nature of the pseudo-words (OLD vs. NEW) and the laterality associated with the colour of the pseudo-words (contralateral vs ipsilateral), we verified that there was no effect of the colour (blue vs. magenta). Pseudo-words were equally well recognized when they were blue or magenta, $F(1,17) = 2.58$, $p = 0.12$, $\eta^2_p = 0.13$. The colour-laterality interaction is not significant, $F(1,17) = 0.46$, $p = 0.50$, $\eta^2_p = 0.20$; as well as the colour-nature of the pseudo-words interaction, $F(1,17) = 1.17$, $p = 0.29$, $\eta^2_p = 0.06$, and the double interaction colour-laterality-nature of the pseudo-words, $F(1,17) = 0.02$, $p = 0.87$, $\eta^2_p = 0.002$.

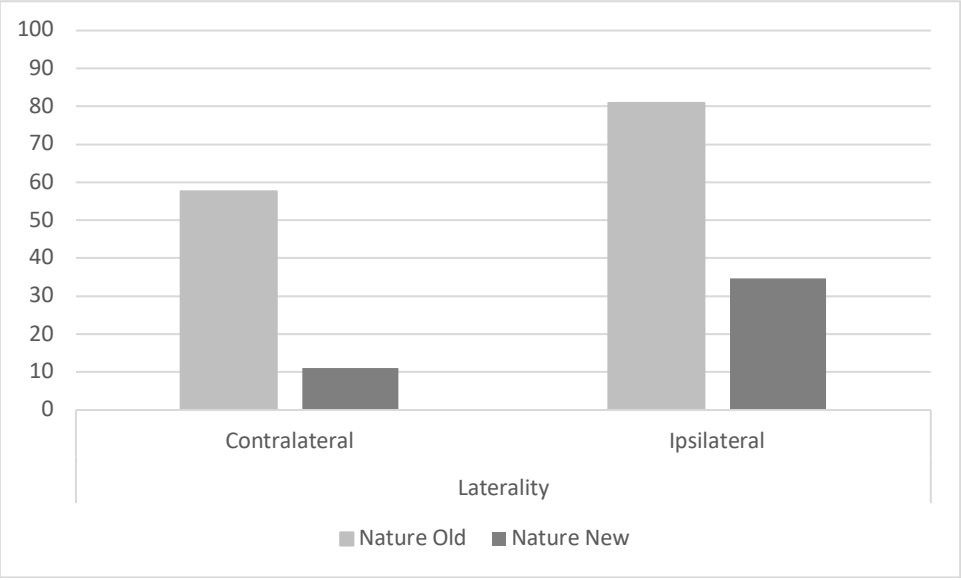

Figure 2. Mean percentage of Go responses according to laterality associated with the colour of the pseudo-words (contralateral vs. ipsilateral) and the nature of the pseudo-words (Old vs. New). For the Old pseudo-words this corresponds to correct responses (Hit), whereas for the New pseudo-words it is false responses (FA).

Results show a classic effect of the nature of the pseudo-words. The recognition score of Old pseudo-words (HIT) is higher than the recognition score of New pseudo-words (FA), $F(1,35) = 353.57$, $p < 0.001$, $\eta^2_p = 0.91$. Results show a main effect of laterality. Recognition scores are higher when the colour of the pseudo-words was associated with an ipsilateral gesture than when the colour of the pseudo-words was associated with a contralateral gesture, $F(1,35) = 93.27$, $p < 0.001$, $\eta^2_p = 0.72$. The interaction between the nature of the pseudo-words and the laterality is non-significant, $F(1,35) = 0.02$, $p = 0.86$, $\eta^2_p = 0.0008$. Although the interaction is non-significant we verified that the effect of laterality was present for both Old and New pseudo-words, which is the case: respectively, $t(35) = 5.95$, $p < 0.001$, $\eta^2_p = 0.50$; $t(35) = 6.22$, $p < 0.001$, $\eta^2_p = 0.52$.

Conclusion

The results highlight that participants are sensitive to the fluency of the gesture associated with the colour of the pseudo-words to be recognized, which means that memory judgement is influenced by their embodied experience and not only by the experience with the pseudo-words. The calculation of d' confirms that participants are more sensitive to the colour of the item when it is the colour associated with an ipsilateral gesture (fluent gesture) than with a contralateral gesture (non-fluent gesture) : $t(35) = 3.81$, $p < .001$, $\eta^2_p = 0.29$. That is to say that they provide more Go responses with a colour associated to a fluent gesture than with a colour associated to a contralateral gesture.

General discussion

In the field of memory, it is now admitted that an experience of memory is not only the consequence of the activation of a precise content, but also results from an inference associated with a feeling of fluency, possibly in wider proportion. More precisely, the inference that one is remembering a past experience is based on the transfer of the manner in which the process

was carried out (i.e., fluency) in addition to the transfer of the process itself (Jacoby, Kelley & Dywan, 1989; Lanska & Westerman, 2018).

The aim of the present work was to answer the following question: does the feeling of pastness stem only from the fluency that is due to the transfer of a stimulus-related processing, or also from the fluency that is due to the transfer of a processing carried out in our interactions with our past environment? To answer this question, the experiment we carried out consisted of two steps. Firstly, participants performed a perceptual discrimination task (distinguishing a square from a circle) that involves a fluent (ipsilateral) or a non-fluent (contralateral) gesture to respond. Motor fluency vs. non-fluency was implicitly associated with the colour of the geometric shapes (blue vs. magenta). Secondly, participants had to perform a classical memory recognition task (learning phase and recognition phase). During the recognition phase, items appeared either with the colour associated with motor fluency or with the colour associated with motor non-fluency. We used a Go-NoGo task to avoid having a confused factor (response space).

Results from the discrimination task confirmed that participants were faster when the response key was located in their ipsilateral space (i.e., fluent gesture) than in their contralateral (i.e., non-fluent gesture). If results from the recognition task confirmed the classic effect that Old pseudo-words were better recognised than New pseudo-words, they also show that Old and New pseudo-words with a colour associated with motor fluency were more recognised than those with a colour associated with non-motor fluency. The calculation of d' highlighted that colour associated with a fluent gesture generates more GO responses (i.e., the pseudoword was part of the learning list) than colour associated with a contralateral gesture.

This allows us to conclude that a colour associated to a fluent gesture performed during the experimental situation, independently to the pseudo-words to be learned, influences the recognition performance of the participants. To our knowledge, it is the first time that it has

been established that past memory experience is also associated with the transfer of the motor feeling of fluency linked to our interaction with the environment.

The contribution of this experiment to the understanding of human memory is twofold. For one thing, it enriches the mechanism that underlines the *discrepancy attribution hypothesis*; for another, it leads to interesting questions about the notion of episodicity of memory.

If our results support the *discrepancy attribution hypothesis* (Whittlesea, 2002; Whittlesea & Leboe, 2000, 2003; Whittlesea & Williams, 1998, 2000, 2001a, 2001b), they provide a new knowledge. Let us recall that according to this hypothesis, it is the gap between what is expected (i.e., I don't know, a priori, if the pseudo-word was learned or not) and what is felt (i.e., fluency) that leads to attribute to the past the item to be judged. In our experiment, if the feeling of fluency that arises is a feature of the processing of pseudo-words (Old are better recognized than New), it is also a feature of the processing of colour (colour associated with a ipsilateral gesture is more fluent than colour associate with a contralateral gesture). If for the Old pseudo-words these two sources of fluency are present, for the New pseudo-words only the one linked to colour is present. Yet, the results on New pseudo-words highlighted that participants unconsciously attribute this source of fluency to a prior experience of the pseudo-words. So, the gap that underlies the experience of discrepancy and consequently the attribution process, could arise from the subjective feeling linked to the gestures performed in the context of the experiment. In other words, the process of attribution can have its origin in the subjective feeling associated with our actions in the situation of the experience, and more generally with our interactions with the environment.

According to Tulving (1985; 2002), the consciousness that an episode is part of our past is due to our capacity of being aware that it is located in one's subjective time (see also Perrin & Michaelian, 2017 about memory as mental time travel). Our results show that the consciousness

that an episode is part of our past is due to an unconscious inference associated with the subjective embodied experiences the person lived in addition to the stimulus itself.

Consequently, the experience of memory, the so-called episodicity of memory (see Perrin & Rousset, 2014, for a discussion) is not only linked to the transfer of fluency associated with our history with the pseudo-words, but also to the transfer of fluency associated with the subject's body history in interaction with the environment. In other words, episodicity would have two sides: that of the object and that of the subject in motion.

Compliance with Ethical Standards

Conflict of Interest: Authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in these studies were in accordance with the ethical standards of the university research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

Open Practices Statement (TOP)

Data are available at: https://doi.org/10.7910/DVN/SOIS4M

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