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A dual systems perspective on temporal cognition: Implications for the role of emotion

Filip M. Nuyens [a]

Email: filip.nuyens@ntu.ac.uk

Mark D. Griffiths [a]

Email: Mark.Griffiths@ntu.ac.uk

URL: http://www.ntu.ac.uk/apps/Profiles/51652-1-4/Professor_Mark_Griffiths.aspx

Phone number: 0044-115-8482401

(a) International Gaming Research Unit, Psychology Division, Nottingham Trent University, Nottingham NG1 4BU, United Kingdom

Abstract: This commentary explores how emotion fits in the dual-system model of temporal cognition proposed by Hoerl and McCormack. The updating system would be affected by emotion via the attentional/arousal effect according to the attentional gate model. The reasoning system would be disrupted by emotion, especially for traumatic events. Time discrepancies described in the dual-system model are also explained.

Hoerl and McCormack's (2018) model of temporal cognition is based on two parallel systems: (i) a primary system available to any sentient creature (i.e., the updating system) and (ii) a cognitive-based system only available to humans (the reasoning system). Furthermore, according to the model, the reasoning system would only be accessible to children from about the age of three years, although this access would remain partial until the age of about five years. However, the model did not mention the potential implication of emotion in either of these systems. Therefore, we try to broach how emotion could affect these two systems separately amongst humans (because the literature on the emotional interference in time perception is scarce amongst animal studies).

According to the model, the updating system would include a simple timer accessible to any creature, allowing them to measure duration between two events, or to monitor time passing by after a specific event. This timer appears to fit the timing mechanism – the Scalar Expectancy Model – proposed by Gibbon, Church and Meck (1984) which was first validated amongst animals, and further supports the validity of this timer mechanism in the model. According to this timer model, a pacemaker-like mechanism emits pulses which would be recorded in an accumulator, the emission starting at the beginning of an interval and finishing at the end of it. The accumulated pulses would then be compared to previously stored duration, facilitating decision-making. Interestingly, a modification of this model (i.e., the Attentional Gate Model [AGM], Zakay, 2000) accounts for the emotional interference. According to the AGM, two potential processes would be at stake in the presence of emotional stimuli, an attentional effect and an arousal effect. The attentional effect could either redirect the attention of the individual on time (i.e., as the individual "avoids" the emotional stimuli) or – on the contrary – distract the individual from time (i.e., as the individual is "attracted" by the emotional stimuli). In this case, the individual could either underestimate the duration (i.e., as they record fewer pulses due to distraction) or overestimate the duration (i.e., as they record more pulses due to their increased attention). In relation to the arousal effect, the effect would be uniform across the situations because the arousal would lead to an increase in the pulse rate, therefore leading to an overestimation of the duration.

Concerning the model's reasoning systems, the explanation of emotional interference is more complex because this system regroups several distinct processes governing temporal cognition. Briefly, this system, compared to the updating one, is supposed to include not only information about the world as it is in the present, but also as it was in the past and may be in the future. Therefore, a creature able to use this system should be able to order events which occurred in the past, plan a future task in the correct order, and discriminate the recency of past events.

Although the literature on these specific processes is scarce, research tends to point toward a disruptive effect of emotion, diminishing the ability for one to use this system. Indeed, Huntjens, Wessel, Postma, van Wees-Cieraad and de Jong (2015) showed that when presented with highly arousing pictures depicting a story (i.e., either positively or negatively valenced), participants had a harder time ordering them in chronological order. Furthermore, it has been shown that experiencing a traumatic event can lead to a disrupted narrative of the event (e.g., amongst abused children, Miragoli, Camisasca, & Di Blasio, 2017) which is supported by studies showing a disruptive effect of negative emotions on episodic memory (Bisby, Horner, Bush, & Burgess, 2018). Furthermore, traumatic events would tend to bias the temporal order of the event preceding and following the event itself (Byrne, Hyman, & Scott, 2001).

Interestingly, the separation between the updating and the reasoning systems is relatively close to the separation between the absolute and relative dating (Shimojima, 2002). Absolute dating is when an individual uses the stored memorized date of an event to judge how long has passed since the event, while the subjective timing refers to an approximation made without the use of the exact date. Shimojima (2002) demonstrated that although his participants knew the exact date of an event, and therefore the exact time passed since, they felt that subjectively more or less time has passed since that event, showing a discrepancy between the absolute and relative dating. Furthermore, Shimojima (2004) also demonstrated that emotionally charged events (i.e., whether negatively or positively valenced) would lead to discrepancies between absolute and relative dating, further supporting the disruptive effect of emotion. It is noteworthy that Hoerl and McCormack's model mentions that discrepancies have been observed between the reasoning and the updating system, which could be supported by Shimojima's study (2004). These assumptions are also partially supported by the effect of emotion on episodic memory because it has been consistently shown that emotional events are more vividly remembered (e.g., Bowen, Kark, & Kensinger, 2018; Kuriyama, Soshi, Fujii, & Kim, 2010; Phelps & Sharot, 2008), as well as the spatiotemporal context of these events (Schmidt, Patnaik, & Kensinger, 2011). Therefore, the absolute dating of such emotional events would be highly precise (i.e., the context being remembered more intensely), while relative dating would suffer from the telescoping effect (i.e., the tendency to underestimate the time passed since a distant memory, e.g., Shimojima & Koyazu, 1999; Thompson, Skowronski, & Lee, 1988), leading to a discrepancy between the two types of dating (i.e., resembling the discrepancies broached in Hoerl and McCormack's model).

In this commentary, we have demonstrated that emotion could be incorporated as a major variable in Hoerl and McCormack's model. The research outlined appears to fit in almost

seamlessly for both systems in the model, although further research is required to fully explain how emotion and the reasoning system interact. Interestingly, the interaction between emotion and temporal cognition provides more explanation to the model's discrepancies between the two systems.

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