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Title: Self-evaluation and self-regulation of brain and body states: evidence from neurofeedback-guided motor imagery and cardiac feedback training

Abstract:

The ability to monitor and report on our own thoughts, and the extent to which we have real access to our own internal processes, has long been a subject of interest in the psychological sciences. In 1977, Nisbeth & Wilson reported several experiments where participants seemed unaware of the stimuli presented to them, unaware of the responses they had given, or unaware of the influence that some stimulus had on their responses. This led many to claim that humans were not capable of direct introspection, and that when asked to report on their higher order cognitive processes, they relied on "a priori, implicit causal theories" to explain their behaviours to themselves and to others. Ericsson and Simon (1980), however, showed that when participants were asked about knowledge available in working memory, the reports became superior in information to those obtained by external observers, or those that would have otherwise been obtained by the use of causal implicit models.

In Nelson and Narens' (1990) influential framework for metacognition ('thinking about thinking'), the lower-level processes (e.g. primary sensory areas), responsible for the objective performance in a task, constitute the 'object', which then serve as input for the higher-order 'meta-level', which controls and monitors the former, and is responsible for subjective reports (e.g. confidence or judgements of visibility). Experimental evidence has indeed shown a dissociation between this objective performance (e.g. the discrimination of stimuli in a perceptual task) and participant's report of confidence in their performance (e.g. believing they are correct or wrong) (Maniscalco & Lau, 2012). Advances in the recent years have demonstrated that this metacognition in perceptual tasks is supported by the interplay of different brain regions and neural mechanisms: mainly the lateral and medial prefrontal cortex (dorsolateral PFC; dlPFC and anterior PFC; Fleming & Dolan, 2012), as well as regions in the parietal cortex (Kiani & Shadlen, 2009).

Although these judgements of subjective certainty have often been studied using perceptual tasks, where the input is more easily controlled and matched between participants, metacognition can also be studied in the context of other cognitive modalities. For instance, in interoception (the perception of our internal bodily states), individual differences exist between interoceptive accuracy (the objective performance in detection of an internal signal, e.g. a heartbeat) and interoceptive awareness (the correspondence between the interoceptive accuracy and associated ratings of confidence; Garfinkel et al, 2015). Another example is the field of neurofeedback and brain-computer interfaces, where recently developed technologies have allowed to study metacognition of actions performed in the absence of somato-sensory signals, using neurofeedback-guided motor imagery (Schurger et al., 2017).

In this talk, I will present preliminary evidence from two ongoing studies from my PhD thesis project (expected defense in 2019), in which I study how feedback training shapes introspective conscious access. (i) In the first study, I present results from an fMRI experiment studying self-evaluation of performance in the context of a neurofeedback-guided motor imagery task. Participants completed multiple sessions of self-regulation of regional fMRI activation in the supplementary motor area (SMA), by performing drawing motor imagery. In each trial, they modulated their mental drawing strategy to achieve two different levels of BOLD percentage change. Participants performed mental drawing and then reported their expected feedback (i.e. self-evaluation) and the confidence in the evaluation, before receiving delayed BOLD-activation feedback. Analysis of neurofeedback learning, metacognitive accuracy and confidence in early versus late trials will be presented. (ii) In the second study, I present preliminary results from a cardiac feedback training investigating the effect of improving access to interoceptive states, on cardiac awareness measures (accuracy and confidence in a heartbeat detection task) and cardiac control (the control of one's own heart rate). For both studies, I will discuss whether improvements reflect real improvements on introspective access or can be accounted for by changes in a priori or implicit causal models.