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Commentary

Me or not me – An optimal integration of agency cues? ☆

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ABSTRACT

Recent work has demonstrated that the sense of agency is not only determined by efference-copy-based internal predictions and internal comparator mechanisms, but by a large variety of different internal and external cues. The study by Moore and colleagues [Moore, J. W., Wegner, D. M., & Haggard, P. (2009). Modulating the sense of agency with external cues. *Conscious and Cognition*] aimed to provide further evidence for this view by demonstrating that external agency cues might outweigh or even substitute efferent signals to install a basic registration of self-agency. Although the study contains some critical points that, so we argue, are central to a proper interpretation of the data, it hints at a new perspective on agency: optimal cue integration seems to be the key to a robust sense of agency. We here argue that this framework could allow integrating the findings of Moore and colleagues and other recent agency studies into a comprehensive picture of the sense of agency and its pathological disruptions.

1. The basic sense of agency and its contributing factors

The sense of agency and its neurocognitive underpinnings have increasingly received attention in the last years. Within this research, it has been commonly recognized that the sense of agency comprises at least two different levels of agency registration (Synofzik, Vosgerau, & Newen, 2008): on the level of agency attribution – which has been tested by most studies – subjects have to make explicit *judgments* about the agent of an action. This level integrates many complex cognitive cues, e.g. prior expectations about the task, background beliefs, and context estimations. However, it does not directly reflect the immediate *feeling* of agency. It is this default level of agency that is most prevalent in our everyday life: when we grasp, type or walk, our sensorimotor system implicitly registers these sensory consequences as self-caused and they are withhold from further demanding processing and, in particular, further rationalization modules. This basic representation is commonly thought to depend mainly on the coherence of motor and sensory cues that are related directly to the action itself, in particular on internal predictions based on an efference copy of the motor command, proprioception and vision, respectively, (Synofzik et al., 2008).

The study by Moore, Wegner, and Haggard (2009) now provides evidence that not only explicit agency judgments (as already shown before (Sato, 2009)), but also basic implicit self-agency registrations might be modulated by explicit prior cues (here: supraliminal priming). These cues could complement action-intrinsic cues like efference-copy-based internal predictions to establish a basic registration of self-agency or even substitute these predictions if movements were performed

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involuntarily. Although this hypothesis per se seems to be highly attractive, a few central aspects of the study might deserve some further conceptual and experimental clarification in the future.

(I) When investigating the sense of agency – and, in particular, the non-conceptual, implicit feeling of agency – we need to examine carefully what is actually measured. The fact that perceived time intervals between movement and effect were decreased by priming also in case of involuntary movements opens up the possibility that the binding between movement and effect might not be specific to agency and intentionality, but can also present – at least in part – a more unspecific anticipation or temporal binding effect between two sensory or perceptual events (in this case between the two congruent sounds, i.e. between prime and effect). We certainly do not question the well-established phenomenon of intentional binding in general (Haggard, Clark, & Kalogeras, 2002) and acknowledge its general difference to perceptual linkage between two events (Haggard, Aschersleben, Gehrke, & Prinz, 2002; Haggard & Cole, 2007). In fact, in line with this phenomenon, the factor *movement type* clearly had an effect on temporal binding, demonstrating that agency certainly influences binding. However, the stronger interpretation – namely that binding indicates just and only agency – does not necessarily follow in all contexts. In the present study, the particular congruency between prime and effect might warrant a control condition to rule out any putative contributions of purely sensory or perceptual temporal binding effects (in particular prime-effect links) or to estimate their respective effect size, especially in the involuntary condition.

(II) The study design might also not allow us to conclude that "the agency processing system does infer agency from *external* cues" (p. 7; our italics). What could be external about a cue? Usually this means that some external property (i.e. a property "out there in the world") is represented (as e.g. in sensation or perception). And, in fact, the prime is such an external cue. However, throughout the paper, it is not the (sensation or perception of the) prime that is taken to be critical for subsequent binding, but the fact that supraliminal primes "induce an intention ('prior conscious thought')" (p. 2). An intention, however, is not external in any good sense but *internal*, since it does not represent a property "in the world" (it rather represents a goal that is not yet realized "in the world"). Thus, two alternative interpretations remain: Either priming is viewed as an external cue and its sensation or perception is taken to be critical for subsequent binding; then its contribution is confined to a sensory or a perceptual level. Or it is viewed to trigger an intention and this intention is seen as the critical state for subsequent binding; then the critical cue is not external anymore and one cannot conclude that "the agency system infers agency from external cues".

This point is not only a theoretical point, but a point central to a proper interpretation of the data. If a putative prime-induced *intention* is taken as the critical state for subsequent binding, then the observed effect does not seem to reflect any kind of cue integration of multiple cues (as suggested by the authors). Instead, the study would demonstrate another form of the already well-established phenomenon of *intentional* binding. In any case, more evidence might be required to demonstrate that supraliminal primes induce an 'intention' and/or 'prior conscious thought' (rather than e.g. a general anticipatory state). Moreover, it should be considered that both 'intentions' and 'thoughts' are each specific cognitive processes with distinct functional roles (Pacherie, 2000; Vosgerau & Synofzik, in press). In particular, evidence might be required to demonstrate that the auditory prime induced a '"Proximal intention' or 'P-intention'" (p. 2). Finally, if indeed a (P-)intention was induced, the same intention would have been present in both voluntary and *involuntary* movements. But it is difficult to conceive of movements that are preceded by an intention as *involuntary*, because the presence of an intention is usually seen as the hallmark of volition.

But if the external *priming* (and its perception) is taken as the critical state, then one might ask why this cue should be called an *agency* cue: priming of a tone is not intrinsically an agency cue; it only becomes an agency cue by its putative capacity to induce a temporal binding effect that is analogous to the temporal binding observed in intentional tasks. However, as pointed out above, more evidence would be required to demonstrate that the prime-induced temporal binding observed in the involuntary condition is not just a purely perceptual prime-induced effect, unrelated to any agency representation at all.

2. Optimal cue integration as the basis of the sense of agency

Apart from the aforementioned difficulties, the study of Moore and colleague points to a highly interesting, new perspective on agency: The brain's agency system functions as a central processing system that assembles a large variety of different internal and external cues which are not mutually exclusive, but which are used in combination to establish the most robust agency representation.

One of these cues, which has been endorsed most strongly (Frith, Blakemore, & Wolpert, 2000; Tsakiris, Haggard, Franck, Mainy, & Sirigu, 2005), are internal predictions: by comparing an internal prediction about the sensory consequences of one's own behavior with an afference, we are able to perceive the afference as self-caused or as externally produced. In case of match, the afference is interpreted as a result of self-action; in case of mismatch, the difference corresponds to an externally caused event. Although internal predictions might serve as one of the most reliable and robust signals, heavily constraining agency registrations, other factors might outweigh or even substitute these efferent signals to install a basic registration of self-agency in certain contexts (cf. Moore et al. 2009, p. 8). Moore and colleagues discuss their results as support for this view, a view which also agrees with other recent studies demonstrating an important, but only partial contribution of internal predictions and comparator mechanisms to the sense of agency (Synofzik et al., 2008).