Attentional control and inferences of agency: Working memory load differentially modulates goal-based and prime-based agency experiences

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ABSTRACT

Previous research indicates that people can infer self-agency, the experience of causing outcomes as a result of one's own actions, in situations where information about action-outcomes is pre-activated through goal-setting or priming. We argue that goal-based agency inferences rely on attentional control that processes information about matches and mismatches between intended and actual outcomes. Prime-based inferences follow an automatic cognitive accessibility process that relies on matches between primed and actual information about outcomes. We tested an improved task for a better examination of goal-based vs. primed-based agency inferences, and examined the moderating effect of working memory load on both types of inferences. Findings of four studies showed that goal-based, but not prime-based agency inferences dwindled under working memory load. These findings suggest that goal-based (vs. primed-based) agency inferences indeed rely on attentional control, thus rendering goal-based agency inferences especially prone to conditions that modulate goal-directed control processes.

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1. Introduction

The sense of agency – the feeling that one causes one's own actions and their subsequent outcomes – is a pervasive and fundamental aspect of human self-perception and social functioning. The sense of agency has been explained in two separate, but complementary models. Initially, self-agency has been studied as a product of comparator processes described in models of motor control (Frith, Blakemore, & Wolpert, 2000; Wolpert & Flanagan, 2001). The execution of a goal-directed action is accompanied by the prediction of sensory action-outcomes based on internal copies of movement-predicting signals (i.e., efference copies) generated by the sensorimotor system. These internal motor predictions are generally short-lived but very reliable, and sensory outcomes are readily perceived as self-produced until this prediction no longer corresponds with the actual outcomes. However, some situations are too ambiguous for motor predictions to be reliable. Interestingly, people still experience self-agency in these situations, for example when there is no causal link between action and following event (Moore & Haggard, 2008), when people move involuntarily (Dogge, Schaap, Custers, Wegner, & Aarts, 2012; Moore, Lagnado, Deal, & Haggard, 2009) or when actions have multiple causes and outcomes (Van der Weiden, Ruys, & Aarts,

2013; Wegner, 2002). This recent work points to an additional – non-motor prediction – process of agency experiences. This so-called inference account of agency suggests that when motor signals are absent or unreliable, agency can still be established when there is a match between the actual outcome and pre-activated information that is related to the outcome (Aarts, Custers, & Wegner, 2005; Wegner & Wheatley, 1999).

Whereas the motor-prediction process of agency has received much theoretical and empirical attention (see Hughes, Desantis, & Waszak, 2013), research on the mechanism underlying agency inferences has been relatively limited. The present research aims to further the understanding of agency inferences by examining how two distinctive sources of information shape the experience of self-agency (Aarts et al., 2005; Van der Weiden et al., 2013). Firstly, the experience of self-agency can emerge from *goal-based* inferences, which is the case in situations where people engage in goal-oriented behavior and their attention is directed toward subsequent outcomes they intend to attain. Additionally, other situations can give rise to *prime-based* self-agency inferences, for example when people engage in actions that are more spontaneous and prepared without much attention, and observe outcomes that are in line with information that is merely pre-activated in mind. Both types of agency inferences can occur independent of motor predictions, and contribute to a sense of selfhood, feeling of control and social behavior during daily social interaction (Frith, 2013). Despite the importance of both types (goals and primes) of agency inferences for human functioning, little is known, however, about whether and how goal and prime-based inferences differ in shaping self-agency experiences. Here, we report a set of studies that (a) tested an agency inference task that allows for a clear examination of goal-based vs. primed-based agency inferences, and (b) explored whether the occurrence of goal-based agency inferences vs. primed-based agency inferences differ as a function of attentional control processes that are installed by goal-directed thought and action.

As alluded to above, research on agency inferences distinguishes two routes to the experience of agency that are based on the pre-activation of outcome information. Based on whether actual outcomes match or mismatch with the mental preview of the outcome, self-agency is inferred. In daily life this is often experienced as a result of our explicitly set goals as part of intentional behavior. That is, if one had the goal of bringing about a specific outcome and that outcome actually occurred, one must have caused it. If there is a mismatch, one may infer that one was not the cause. However, recent findings suggest that self-agency experiences can also arise from a more implicit source of information. Specifically, observing action-outcomes that were previously primed also provides the feeling we caused the outcome to occur. This implicit route pertains to agency inferences that can result from instances in which the source of the experience of agency is likely to remain outside of awareness, as is, for example, often the case during social interactions. Both goal-setting and mere priming have been found to contribute to agency inferences across various tasks (e.g., Aarts et al., 2005; Linser & Goschke, 2007; Sato, 2009; Van der Weiden, Aarts, & Ruys, 2011; Van der Weiden et al., 2013; Wegner & Wheatley, 1999), suggesting that agency experiences result from a cognitive process that relies on agency-relevant outcome information, irrespective of whether this information is pre-activated by goal-setting or priming.

However, recent research suggests that goals and outcome-primes impact self-agency experiences differently. Specifically, whereas explicitly set goals to produce an action-outcome and implicit priming of the action-outcome both increase agency experiences when the actual outcome matches the pre-activated outcome, only goals substantially decrease agency experiences when outcomes mismatch the goal. This finding has been taken to suggest that the underlying mechanism of goal-based agency inferences and prime-based agency inferences differ (Van der Weiden et al., 2013). Building on the proposed distinctive effects of goal-setting and mere priming on information processing and behavior (Aarts, 2012; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Fishbach & Ferguson, 2007), goal-based effects on agency inferences are considered to involve attentional control in which the person attends to specific outcomes she wants to obtain. However, outcome-priming effects on agency inferences are proposed to rely on a more automatic cognitive accessibility process that follows principles of spreading of activation and, in principle, does not heavily engage attentional control processes (Van der Weiden et al., 2013). Accordingly, goal-setting (but not outcome-priming) causes individuals to focus attention on the attainment of the intended outcome and to process feedback information and learn from expected (matches) and unexpected (mismatches) results (Baddeley, 2007; Carver & Scheier, 1998; Conway et al., 2005; Custers & Aarts, 2007; Frith et al., 2000).

If this notion about the difference between goal-based and prime-based agency inferences is correct, then taxing attentional control (i.e., by working-memory load) should differentially affect these inferences. Increasing working-memory load has been demonstrated to diminish the ability to freely focus attention on secondary tasks and process feedback information, showing impaired performance in goal attainment (e.g., Baddeley, 1986; Baddeley, 2007; Hester & Garavan, 2005; Lavie, 2010; Lavie, Hirst, de Fockert, & Viding, 2004; Ward & Mann, 2000). Accordingly, taxing attentional control should deteriorate goal-based, but not prime-based agency inferences, as outcome-priming effects are suggested to not heavily rely on attentional control. There is some preliminary evidence supporting this notion (Hon, Poh, & Soon, 2013). Hon et al. (2013) asked their participants to set goals to produce an outcome in an action-outcome dependency task (pressing an up and down arrow to move a dot in the direction consistent or not with the arrow) and required them to maintain either two or six consonants in memory while performing the task. Results showed that a higher working-memory load (i.e., remembering six consonants) caused decreased experiences of agency of matching (but not mismatching) outcomes. Although these findings suggest that working-memory load affects experiences of agency, this study is unclear in delineating motor prediction from cognitive inferences. Moreover, participants only set goals and were not primed with outcome information. Accordingly, this study does not directly speak to the issue of whether goal-based and prime-based agency inferences differ in the way they materialize.