



Original Articles

Physical and mental effort disrupts the implicit sense of agency[☆]

Emma E. Howard, S. Gareth Edwards, Andrew P. Bayliss*

School of Psychology, University of East Anglia, UK

ARTICLE INFO

Article history:

Received 19 May 2016
 Revised 19 August 2016
 Accepted 30 August 2016

Keywords:

Sense of agency
 Temporal binding
 Intentional binding
 Experience of effort
 Time perception

ABSTRACT

We investigated the effect of effort on implicit agency ascription for actions performed under varying levels of physical effort or cognitive load. People are able to estimate the interval between two events accurately, but they underestimate the interval between their own actions and their outcomes. This effect is known as ‘intentional binding’, and may provide feedback regarding the consequences of our actions. Concurrently with the interval reproduction task, our participants pulled sports resistance bands at high and low resistance levels (Experiments 1 and 2), or performed a working memory task with high and low set-sizes (Experiment 3). Intentional binding was greater under low than high effort. When the effort was task-related (Experiment 1), this effect depended on the individual’s explicit appraisal of exertion, while the effect of effort was evident at the group level when the effort was task-unrelated (physical, Experiment 2; mental, Experiment 3). These findings imply that the process of intentional binding is compromised when cognitive resources are depleted, either through physical or mental strain. We discuss this notion in relation to the integration of direct sensorimotor feedback with signals of agency and other instances of cognitive resource depletion and action control during strain.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

It is important that the human motor system can efficiently process events which are the result of its own actions, and to discriminate these from events in the world for which it is not responsible. For instance, if I kick a ball and it knocks over and smashes a vase of flowers, I know my action of kicking the ball was responsible for the vase smashing. Self-authored events like this tend to be easy to identify and this feeling that ‘I did it’ is known as a *sense of agency*. Some actions are more effortful than others; kicking a ball as hard as one can might break a vase, but so might brushing one’s arm against it as one walks past it precariously positioned near the edge of a table. Both these actions have the same outcome, but might require the action monitoring system to respond differently in order to correctly ascribe agency. Here, we tested the role of physical and mental effort on the ascription of the sense of agency, using an implicit measure.

1.1. The attribution of agency

Self-agency is detected where there are cues relating to intentionality, volition, predictability and contiguity. An interesting phenomena occurring under these conditions is that actions and their effects are perceived as occurring closer together in time than they did, an effect known as temporal or intentional binding (Barlas & Obhi, 2013; Engbert & Wohlschläger, 2007; Engbert, Wohlschläger, Thomas, & Haggard, 2007; Haggard, Clark, & Kalogeris, 2002; see Moore & Obhi, 2012, for a review). One theory of subjective time perception suggests that ‘ticks’ of an ‘internal clock’ give rise to our sense of time passing. The pace of this clock varies with arousal and motor activity (Gibbon, Church, & Meck, 1984; Treisman, 1963; Wearden, Pilkington, & Carter, 1999). When the pace of neural ‘ticks’ slows, durations appear shorter due to the accumulation of fewer pacing ‘ticks’. Conversely, when the pace of the ‘ticks’ quickens, durations appear longer. Contexts characteristic of self-agency are believed to slow the pace of the internal clock as a consequence of motor prediction. This results in the shortening of subjective time and temporal binding (Wenke & Haggard, 2009). This may be an adaptive process to help to create a sense of agency, and in a general sense this process could assist the sensorimotor system to identify and monitor its effects and optimise performance (Buhrmann & Di Paolo, 2015; Wenke & Haggard, 2009).

[☆] EEH and APB conceived the idea and all authors contributed to experimental design. EEH conducted the experiments and analysed the data. All authors interpreted the data. EEH and APB wrote the manuscript with critical revisions from SGE. This research was supported by a University of East Anglia PhD Studentship to EEH. The authors are grateful to Jelle Demanet for discussion regarding apparatus and procedure for Experiments 1 and 2.

* Corresponding author at: School of Psychology, Lawrence Stenhouse Building, University of East Anglia, Norwich NR4 7TJ, UK.

E-mail address: Andrew.P.Bayliss@uea.ac.uk (A.P. Bayliss).

Several accounts as to how agency is attributed to the self have been suggested, including the forward predictive comparator model (Blakemore, Frith, & Wolpert, 2001; Blakemore, Wolpert, & Frith, 2002; Wegner, Sparrow, & Winerman, 2004), the post-hoc inference account (Wegner & Wheatley, 1999), and the optimal cue integration account (Moore & Fletcher, 2012; Synofzik, Thier, Leube, Schlotterbeck, & Lindner, 2010; Synofzik, Vosgerau, & Lindner, 2009; Synofzik, Vosgerau, & Voss, 2013). The comparator model provides a predictive account of agency attribution, characterised by the comparison between predicted action effects with actual action effects. Congruence between these effects results in perceived self-authorship and a sense of agency, whereas incongruence between them results in a diminished sense of agency.

An alternative model, the post-hoc inference account, provides a post-dictive re-constructionist account of agency attribution. Here, sense of agency self-attribution is dependent upon reflection on the action-effect relationship after the outcome has occurred. For instance, when there is an intention to act, when the perceived effects can be explained by the intended action, and when there is no other plausible cause for the effect, sense of agency is then experienced and retrospectively introduced into consciousness. Finally, the optimal cue integration account recognises the importance of both pre- and post-dictive cues. These cues are then weighted for their reliability for agency attribution depending on the context and then used to determine self-authorship. The ability to construct these cues and make comparisons between expected and actual effects of actions may depend on the availability of cognitive resources. Indeed, diminished attentional resources have been shown to impair explicit ratings of agency (Hon, Poh, & Soon, 2013). Moreover, studies concerning cognitive load, kinematics and motor awareness offer support to this prediction. Dual task paradigms employing mental arithmetic, memory tasks and fine motor movements during balance, gait, posture and walking tasks have shown reductions in motor control and motor awareness (Kannape, Barré, Aminian, & Blanke, 2014; Lindenberger, Marsiske, & Baltes, 2000; Woollacott & Shumway-Cook, 2002). Dual task performance models suggest that motor control and cognitive activity compete for cognitive resources (Huxhold, Li, Schmiedek, & Lindenberger, 2006; Lacour, Bernard-Demanze, & Dumitrescu, 2008). In such cases motor control and awareness become less efficient due to cross-domain resource competition. The deficits in motor awareness caused by limited cognitive resources are especially of relevance to the sense of agency as, in accordance with the forward models of motor control, it is a crucial factor in the ability to monitor self-initiated actions. This cognitive resource limitation notion therefore has interesting implications regarding the role cognitive resource availability may have on constructing the attribution of agency.

1.2. Mental and physical effort

We are concerned primarily with how effort might influence the implicit sense of agency. It is important then to note that despite appearing to be independent concepts, physical and mental effort similarly put strain on the cognitive system by expending cognitive resources (Dietrich, 2003; Dietrich & Sparling, 2004; Franconeri, Alvarez, & Cavanagh, 2013). Mental and physical effort therefore draw from and deplete a common cognitive resource. It is also important to note that exertion influences perception in other domains. For instance, perceived distance increases and hills seem steeper under conditions requiring more physical exertion (e.g. when carrying a heavy load; Bhalla & Proffitt, 1999; Sugovic & Witt, 2013; Witt, Proffitt, & Epstein, 2004). These apparent spatial distortions as a function of required effort are also mirrored for the perception of time.

A recent meta-analysis investigating the effect of physical load on duration judgements revealed that physical workload results in longer perceived durations (Block, Hancock, & Zakay, 2016; seven studies spanning from 1963–2011). However, the impact of effort on perceived duration need not be experiential, as stimuli that allude to motion, action, or exertion also elongate perceived durations. For example, faster moving non-biological stimuli are perceived to last longer than slower moving stimuli (Brown, 1995; Kaneko & Murakami, 2009), and the perceived duration of images of ballet dancer statues are lengthened when the poses reflected greater levels of exertion (Nather, Bueno, Bigand, & Droit-Volet, 2011). The elongation of subjective time as a result of effort are also found for mental activity. Depleted attentional resources and increased cognitive load result in longer retrospective subjective time judgements (for a review see Block, Hancock, & Zakay, 2010). Given these findings highlighting the similarities between the effects of physical and mental effort on time perception, one can hypothesise that physical and mental exertion could have similar disruptive effects on temporal measures of the sense of agency, driven by the depletion of cognitive resources (Dietrich, 2003; Dietrich & Sparling, 2004; Franconeri et al., 2013; Hon et al., 2013).

1.3. Sense of agency and effort

Given what we know about the effects of physical and mental exertion on performance and perception, and assuming that ascribing agency is a costly cognitive process, the hypothesis follows that agency should be reduced under conditions of mental or physical effort. There is some support for this hypothesis from a study using an explicit measure, where participants reported the degree to which they felt agency over an event (Hon et al., 2013). These authors found that explicit ratings of agency over a dot that moved following an arrow key press were reduced under conditions of high cognitive load, which was manipulated using a working memory task. This is an interesting finding but converging evidence using an implicit task would be valuable in understanding the processes involved in agency attribution during strain. This is especially important given that explicit and implicit measures are sometimes found to be dissociated (Dewey & Knoblich, 2014; Obhi & Hall, 2011).

Some studies that have used implicit measures lend indirect support to the notion that mental effort disrupts the implicit sense of agency, though their research questions did not directly address the role of cognitive load. Specifically, temporal binding for self-actions has been shown to be weaker when the outcome of the action is socially negative (Yoshie & Haggard, 2013), or when the actor performs the action under coercion (Caspar, Christensen, Cleeremans, & Haggard, 2016). Individual ratings of agency over outcomes to actions have also shown to be lower when there is conflict in action selection caused by distractor stimuli (Sidarus & Haggard, 2016). Indeed, each of these acts imply a significant degree of cognitive conflict (see Greene, Nystrom, Engell, Darley, & Cohen, 2004), which would make their findings appear broadly in line with our hypothesis.

A general explanation of these effects could be drawn from the effect of resource depletion on time perception. As noted above, subjective time lengthens under load (Block et al., 2010, 2016), which would result in less temporal binding (i.e. smaller underestimation errors) in agency conditions due to the resources required to bind the action and its effect together already being committed to the cognitively effortful primary task. However, the only research to have directly addressed cognitive effort during the task itself used an explicit measure (Hon et al., 2013), as did the research inducing conflict in action selection (Sidarus & Haggard, 2016). The work by Caspar et al. (2016) and Yoshie and Haggard (2013), although employing implicit measures, manipulated the

Download English Version:

<https://daneshyari.com/en/article/7285743>

Download Persian Version:

<https://daneshyari.com/article/7285743>

[Daneshyari.com](https://daneshyari.com)