Consciousness and Cognition 65 (2018) 304–309

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Action-effect binding and agency

Katharina A. Schwarz[a,*], Sebastian Burger[a], David Dignath[b], Wilfried Kunde[a], Roland Pfister[a,*]

[a] Department of Psychology, University of Würzburg, Germany
[b] Department of Psychology, University of Freiburg, Germany

ARTICLE INFO

Keywords:
Agency
Action-effect binding
Action control
Ideomotor theory

ABSTRACT

The sense of agency is a pervasive phenomenon that accompanies conscious acting and extends to the consequences of one's actions in the environment. Subjective feelings of agency are typically explained in terms of predictive processes, based on internal forward models inherent to the sensorimotor system, and postdictive processes, i.e., explicit, retrospective judgments by the agent. Only recently, research has begun to elucidate the link between sense of agency and more basic processes of human action control. The present study was conducted in this spirit and explored the relation between short-term action-effect binding and explicit agency judgments. We found evidence for such a link in that the participants' short-term action-effect binding predicted subsequent agency ratings. This offers a new perspective on the sense of agency, providing an additional mechanism (together with predictive and postdictive processes) that may underlie its formation.

1. Introduction

The sense of agency, i.e., the feeling of control over one's own actions and, through these actions, also over one's environment, is a crucial mental state for human beings and their functioning in society (Haggard & Tsakiris, 2009; Haggard, 2017). Agency allows the correct identification of actions as "own" or "other" which helps to distinguish between the self and the external world (Gallagher, 2000; Haggard & Tsakiris, 2009; Moore, 2016). Agency has further been linked to feelings of responsibility for actions (Frith, 2014; Moore, 2016) and abnormal experiences of agency are associated with severe mental illnesses, such as passivity symptoms in schizophrenic patients (Blakemore, Smith, Steel, Johnstone, & Fritz, 2000; Franck et al., 2001; Haggard, 2017; Lindner, Thier, Kircher, Haarmeier, & Leube, 2005; Oestreich et al., 2016).

Because of its strong impact on action and action-related processing, the concept of agency has received much scientific attention in recent years (Chambon, Sidarus, & Haggard, 2014; Haggard & Chambon, 2012; Haggard, 2017; Moore, 2016; Synofzik, Vosgerau, & Newen, 2008; Synofzik, Vosgerau, & Voss, 2013). Previous studies mostly targeted two distinct sets of processes that contribute to agency: (1) predictive processes thought to be based on internal forward models inherent to our sensorimotor system, i.e., sensory attenuation (Beck, Di Costa, & Haggard, 2017; Schwarz, Pfister, Kluge, Weller, & Kunde, 2018; Weller, Schwarz, Kunde, & Pfister, 2017) and intentional binding (temporal and spatial; Haggard, 2017; Haggard & Tsakiris, 2009; Kirsch, Pfister, & Kunde, 2016; Ruess, Thomaschke, Haering, Wenke, & Kiesel, 2017), and (2) postdictive processes, i.e., explicit reasoning employed by the agent to infer authorship for an action (Wegner & Wheatley, 1999; Wegner, 2003).

More recent evidence suggests that despite predictive and postdictive processes, additional factors, for instance the fluency of

* Corresponding authors.
E-mail addresses: katharina.schwarz@uni-wuerzburg.de (K.A. Schwarz), roland.pfister@psychologie.uni-wuerzburg.de (R. Pfister).

https://doi.org/10.1016/j.concog.2018.10.001
Received 19 July 2018; Received in revised form 28 September 2018; Accepted 2 October 2018

action selection, might also contribute to agency (Chambon et al., 2014; Sidarus & Haggard, 2016; Sidarus, Chambon, & Haggard, 2013; Wenke, Fleming, & Haggard, 2010). These studies suggest that dysfluent action selection, e.g., when response-incompatible subliminal primes precede an imperative signal, lead to reduced feelings of control over an action's outcome (Sidarus et al., 2013; Wenke et al., 2010). This provides first evidence that basic processes of action selection, initiation, and/or evaluation might play a role in the formation of agency. The present study follows this line of reasoning by investigating a possible link between basic processes of action control – i.e., action decisions, action planning, initiation, and execution – and corresponding judgments of agency.

As sense of agency pertains to the perceivable consequences (or effects) of own actions, we consider effect-based accounts to human action control as particularly promising to study potential links between action control and agency (Hommel, 2015). A classical formulation of such effect-based accounts is ideomotor theory, i.e., the assumption that actions are represented in terms of their sensory consequences and that actions are selected and initiated by anticipating these sensory consequences (for empirical evidence, see e.g., Elsner & Hommel, 2001; Kunde, 2001; Pfister, Kiesel, & Hoffmann, 2011). The bi-directional relation between action and effect is evident in both, long-term associations of actions and their effects (Eder & Dignath, 2017; Elsner & Hommel, 2001; Hoffmann, Lenhard, Sebald, & Pfister, 2009; Wolfensteller & Ruge, 2011), as well as in short-term bindings of stimulus, response, and effect into an event file (Dutzi & Hommel, 2009; Janczyk, Heinemann, & Pfister, 2012; Moeller, Pfister, Kunde, & Frings, 2016). Now, if action control mechanisms affect the sense of agency, as is suggested by the impact of action selection fluency on agency, it seems plausible that action-effect binding might contribute to sense of agency.

To test this idea, the present study employed a simple two-step paradigm which is based on previous studies on short-term action-effect binding (Dutzi & Hommel, 2009; Janczyk et al., 2012). In the first step of each trial, participants were asked to press one of two keys which then randomly elicited one of two tones. In the second step, either the previous tone or an alternative tone was played, and participants were then asked to press either of the two keys again. In this procedure, participants' response choices can serve as a proxy for action-effect binding, as high frequency of tone-contingent choices – action repetition in the face of tone repetition, and action switches in the face of tone switches, i.e., choice consistency – can be explained parsimoniously with bindings of actions and effects into event files (cf. Hommel, 2004). Following this sequence of events, participants had to provide an agency rating regarding the first tone, i.e., they were asked to indicate, how strongly they believed to have caused that tone to appear during the first part of the trial. We hypothesized that action-effect binding should affect sense of agency. More specifically, action-effect binding should go along with higher agency ratings for this effect tone in a given experimental trial, i.e., consistent choices should be followed by higher agency ratings.

2. Methods

2.1. Participants

We recruited 34 participants (mean age 24.3 years ± 0.7 SEM; 27 female) to allow for a power of 0.80 when assuming a medium effect size of $d_z = 0.50$ when testing the mean regression coefficients against zero. We further assumed a two-tailed test despite the directional hypothesis. Participants received either course credit or monetary compensation (7 €) for their participation in the experiment. Due to technical issues during data acquisition, two participants had to be excluded from data analysis. All participants gave written informed consent and they received payment or course credit as compensation.

2.2. Apparatus and procedure

Participants were asked to sit in front of a computer screen with a standard German QWERTZ keyboard and headphones attached. They were instructed to respond with the index and middle finger of their left hand on the keys "1" and "2" of the number row, and to operate the computer mouse with the right hand.

Each trial was segmented into three parts as shown in Fig. 1. At the beginning of each trial (prime segment), a fixation cross was displayed for 1000 ms, followed by a line of five asterisk signs in the center of the screen which prompted the participants to choose between both response keys. Participants were asked to press both keys equally often, but to avoid strategies in selecting a key on any given trial. After choosing a key, a low (400 Hz) or high (800 Hz) pitch marimba MIDI sound was triggered randomly and was presented for 500 ms, either immediately after the keypress or after 1250 ms (based on Haering & Kiesel, 2015). This manipulation was based on findings suggesting that the integration of stimulus and response features into event files depends on the temporal spacing between two events (Akyürek, Riddell, Toffanin, & Hommel, 2007; but see also Dignath, Pfister, Eder, Kiesel, & Kunde, 2014), so that immediate effects should yield considerable binding whereas trials with delayed effects should yield less binding.

After an interval of 1000 ms, the probe segment started with the presentation of an exclamation mark together while a second low or high pitch tone presented for 500 ms. This tone could either match (tone repetition) or differ from (tone switch) the first tone in the prime segment. Upon the onset of the second tone, participants were to choose spontaneously between both response keys while not using strategies such as taking any of the previous events into account. Finally, participants were asked to rate how strongly they felt to have caused the first tone (in the prime segment) on a visual analogue scale with the computer mouse (agency rating; original wording in German: "Wie sehr fühlen Sie sich als Verursacher des ersten Tons?", English translation: "How strongly do you feel that you caused the first tone?"). Anchor points on either end of the scale were labelled as "überhaupt nicht" (English: "not at all") and "völlig" (English: "completely"). Error messages appeared if participants pressed a key too early, i.e., before the line of asterisk signs appeared.