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Non-action effect binding: A critical re-assessment

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ABSTRACT

Humans typically act to cause effects in their environment, but at times they also voluntarily omit an action to cause a predictable effect. These effects may become bound to the causing non-actions, just as actions and their effects can become associated. In three experiments, we provide a critical re-assessment of previous reports of non-action effect binding. Following this work, participants completed an acquisition phase to associate actions and non-actions with particular effects. In a subsequent test phase, the former effects were presented as stimuli and participants were allowed to choose an action or non-action freely as a response. Binding should lead to more effect-consistent choices than predicted by chance. Previous studies, however, did not control for deliberate strategies of participants that might inflate the consistency bias and, also, did not address overall preferences for either acting or non-acting, which might introduce additional artifacts. We show that these confounds have a strong impact in common experimental designs and introduce ways to mitigate these effects. This improved assessment still corroborated evidence of binding between non-actions and their effects.

1. Introduction

Voluntarily influencing the world through own actions is an essential part of the human self. At first sight, such voluntary control seems to consist mainly of the ability to choose what to do in a given situation rather than being controlled by a reflex or an external stimulus. But intentional action not only comprises the idea that people can decide what to do, but also when to act and even whether to act at all (Brass & Haggard, 2008). That is to say, the omission of an action can lead to specific consequences and intentionally not acting can be chosen deliberately to bring these consequences about.

The voluntary omission of an action - i.e., intentional non-action - differs from voluntary actions for the simple reason that it does not involve any (distinctive) motor patterns but it is rather characterized by the absence of any visible change in motor activity. However, it has been proposed that actions and non-actions also share certain properties, especially a representation in terms of the sensory effects they produce (Kühn & Brass, 2010a, 2010b; Kühn, Elsner, Prinz, & Brass, 2009; Röttger & Haider, 2016). Empirical evidence for this claim has been gathered within the framework of ideomotor action control and we will therefore selectively review relevant studies from this domain in the following.

1.1. Non-actions in the context of ideomotor theory

Research on non-actions and their effects has been motivated by ideomotor theory, which proposes that voluntary actions are initiated by anticipating the consequences of these actions - or *action effects*. More precisely, it assumes that people acquire bidirectional associations between a movement and its effects. The movement can then be re-initiated by anticipating the corresponding action effects (see Shin, Proctor, & Capaldi, 2010, for a review). Numerous studies have accumulated evidence to support this idea (e.g., Elsner & Hommel, 2001; Hommel, 1993; Janczyk, Skirde, Weigelt, & Kunde, 2009; Kunde, Hoffmann, & Zellmann, 2002; Pfister, Janczyk, Gressmann, Fournier, & Kunde, 2014; Pfister, Kiesel, & Melcher, 2010; Wirth, Pfister, Brandes, & Kunde, 2016; Wolfensteller & Ruge, 2011).

Particularly relevant for the present purposes are studies that examined the assumed acquisition of bidirectional action-effect associations. Elsner and Hommel (2001) used an experimental setup with two phases to test this assumption. In an acquisition phase, participants performed left or right key presses which were consistently followed by specific, task-irrelevant tones. In the subsequent test phase, these tones were used as imperative stimuli and participants had to respond to the tones by choosing a left or right button press (Exp. 2–4). According to ideomotor theory, the tones should activate the associated response automatically, leading to an overall preference for effect-consistent responses over inconsistent responses (Elsner & Hommel, 2001; Greenwald, 1970). That is, participants should favor the action that had produced the tone in the acquisition phase and this very pattern was observed in the test phase (see also Eder, Rothermund, De Houwer, & Hommel, 2015; Hoffmann, Lenhard, Sebald, & Pfister, 2009;

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Maes, 2006; Pfister, Kiesel, & Hoffmann, 2011). The preference for consistent responses, of course, did not occur in an all-or-none fashion. That is, the consistent response was not chosen in 100% of the trials, but the former effect tone influenced response selection in a way that the consistent response was slightly favored over the inconsistent response.

Kühn et al. (2009) used a similar setup as Elsner and Hommel (2001) to investigate non-actions. In the acquisition phase, they provided their participants with three possible choices, a left key press, a right key press, or no key press, which were followed by specific sounds. In the test phase, participants were allowed to choose one of the three responses to react to the former effect sounds. Again, participants preferred the consistent action and, crucially, they also preferred not to act when the former non-action sound was presented. These findings suggest that non-actions and their effects indeed became associated with each other (see also Kühn & Brass, 2010b).

1.2. Methodological pitfalls

Even though the consistency effects in previous studies on non-action effect binding appear convincing at first, they might also be explained in terms of strategic response choices rather than reflecting actual effect-based priming. In the most simple case, participants might have remembered the (non-)action-effect mapping from the acquisition phase and decided to stick with this mapping as a default in the test phase. This decision does not necessarily have to involve ideomotor processes and might even be issued before presentation of the previous effect stimuli.

In contrast to studies on non-action effect binding, a possible role for such strategies has been acknowledged at least by a subset of previous studies on action effect binding. A first and straightforward way to address strategic factors is eliminating participants with implausible (i.e., near-perfect) consistency effects (Eder et al., 2015). Additionally, two variations of the test phase have been suggested to counter strategic factors by design. For one, a secondary task has been implemented in the free choice test phase to deplete the participants' cognitive resources: Under high cognitive demands participants should be less likely to apply deliberate response strategies, but the action effects should still activate the consistent response. Indeed, results show that the consistency effect persists under high cognitive demands (Elsner & Hommel, 2001, Exp. 4). For another, a forced choice task has been implemented in the test phase: Effects from the acquisition phase are presented as imperative stimuli and one half of the participants has to react with the consistent response to the former effects, while the mapping is reversed for the other half. Typically, responses are faster if the mapping is consistent rather than inconsistent (e.g., Dignath, Pfister, Eder, Kiesel, & Kunde, 2014; Elsner & Hommel, 2001; Hoffmann et al., 2009; Hommel, Alonso, & Fuentes, 2003; Wolfensteller & Ruge, 2011) and the small reaction time (RT) differences do not leave time for strategical decisions. This is particularly true when visual actions effects are additionally masked in the test phase to a degree that precludes any deliberate choice strategies (Kunde, 2004).

Forced choice test phases have also been used to corroborate evidence for non-action effect binding (Kühn et al., 2009, Exp. 2). But since RTs of non-actions (or the decision not to act) could not be measured, only RTs of actions were analyzed. Faster RTs were observed for the consistent mapping (acting when the former action effect is presented) compared to the inconsistent mapping (acting when the former non-action effect is presented). However, this RT difference can be explained by action effect binding alone: Presentation of an action effect activates the corresponding action and, thus, this action is retrieved more easily when the action effect is presented than when it is not presented. Non-action effect binding does not necessarily have to be involved. Röttger and Haider (2016, Exp. 3a), thus, expanded the experimental setup and introduced a neutral tone in the test phase. As expected, presentation of the compatible tone facilitated responding and participants reacted faster when the compatible tone was presented compared to the neutral tone. On the other hand, participants reacted slightly slower when the incompatible non-action tone was presented compared to the neutral tone, suggesting that the non-action effect hindered responding. Although these results are in line with the assumption that non-action effects can activate the corresponding non-action, these forced choice test phases only provide information about actions and, thus, the facilitation of non-actions via their effects cannot be analyzed. Studies on non-action effect binding using a free choice test phase, however, lack critical control conditions to weaken alternative explanations, such as strategy use, for the consistency effect. Thus, the present study was designed to scrutinize strategy use in a free choice test phase and to provide unambiguous evidence for non-action effect binding while controlling for strategy use.

A related finding of previous studies on non-action effect binding was that, generally, participants seemed to prefer acting over not acting - even if they were instructed to aim at an equal distribution of actions and non-actions (Kühn & Brass, 2010b). An unequal distribution of actions and non-actions, however, distorts the typical comparison of the observed frequency of consistent responses to chance (e.g., 50% for a two choice task of action vs. not acting, 33% for a choice between pressing a left key, pressing a right key, or not pressing any key). The relevance of this potential pitfall becomes evident when assessing previous findings that indicated overall choice frequencies to amount to 57% for acting and to 43% for not acting (computed as the mean percentage of action/non-action choices from the information provided in Kühn & Brass, 2010b, about absolute response frequencies in the acquisition and test phases). This statistical effect likely biases the assessment of non-action effect binding and should therefore be taken into account when analyzing consistency effects for actions and non-actions.

1.3. The present experiments

The present study comprises three experiments to critically re-assess if non-actions, like actions, can become associated with their effects. Following previous methods, participants completed an acquisition phase to associate actions and non-actions with specific effects (visual effects in Experiment 1; auditory effects in Experiment 2–3). In the subsequent test phase, participants reacted to the former effects and were free to choose between effect-consistent or effect-inconsistent (non-)actions.

In Experiment 1 and 2, we used an experimental setup that closely resembles the setup of Kühn et al. (2009) and we examined if participants used deliberate response strategies in this setup. As a first indicator of deliberate strategies, we identified participants who showed an implausibly large consistency effect. According to ideomotor theory, (non-)action effects should prime the consistent response but other response tendencies can influence response selection as well (e.g., tendencies toward repetition or alternation; Elsner & Hommel, 2001) so that the amount of consistent choices should be substantially lower than 100%. This assumption is supported by previous studies on action effect binding, which showed mean consistency effects of only up to 64% for two-choice test phases (Elsner & Hommel, 2001; Hoffmann et al., 2009; Pfister et al., 2011). We, therefore, excluded participants who chose the consistent response in more than 75% (given the fact that participants could choose between three rather than two potential responses in the present setup, 75% largely exceeds the mean consistency effect of up to 64% of previous studies).

Since choosing the consistent response is not the only possible response strategy, we decided to examine our data further to detect other potential strategies. Two additional strategies suggested themselves. First, participants could also deliberately choose an inconsistent mapping, which would reduce the possibility to find evidence for non-action effect binding. Data from such participants would also distort the assessment of (non-)action effect binding and we therefore also identified