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Other-self confusions in action memory: The role of motor processes

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ABSTRACT

People can come to falsely remember performing actions that they have not actually performed. Common accounts of such false action memories have invoked source confusion from the overlap of sensory features but largely ignored the role of motor processes. We addressed this lacuna with a paradigm in which participants first perform (vs. do not perform) actions and then observe another person performing some of the non-performed actions. In this paradigm, observation of videos showing another's actions can later induce false self-attributions of these actions, the observation-inflation effect. Contrary to a sensory-feature account but consistent with a motor-simulation account, we found the effect even with perceptually impoverished action videos in which the majority of sensory features is absent, but motion cues are preserved (Experiment 1). We then created conditions during action observation that should (vs. should not) impede motor simulation. As predicted we found that the effect of observation was reduced when participants executed movements that were incongruent (vs. congruent) with the observed actions (Experiment 2). We discuss the processes that can produce associations of self with observed others' actions and later affect observers' action memory.

1. Introduction

Human memory can be biased and influenced in various ways. Demonstrations of memory's fallibility (Loftus, 2005; Schacter, Guerin, & St. Jacques, 2011) have been important from both a conceptual and applied perspective, and have thus drawn widespread interest by psychologists and the public (Loftus, 2003). A particularly interesting instance of false memory is the erroneous recollection of having performed an action that one has not performed. In the management of everyday life, false memories of performing actions like taking a pill or switching off a stove could have grave consequences. Indeed, research shows that when people imagine performing an action they later tend to falsely claim that they have actually performed the action, an effect dubbed imagination inflation (Goff & Roediger, 1998). In this case, the source of false action memory is the mental activity of imagining self-performance.

Another intriguing source of false action memory is observation of another person's actions. Several studies have demonstrated that merely observing others' actions can induce observers to falsely remember having performed these actions, the observation-inflation effect (Lindner, Echterhoff, Davidson, & Brand, 2010; Lindner, Schain, Kopietz, & Echterhoff, 2012; Schain, Lindner, Beck, & Echterhoff, 2012). In the typical paradigm, participants first perform or just read simple action statements (e.g., *Squeeze the sponge*). Next, they observe—via short video clips—another person performing some of these actions. Two weeks later in a surprise source-memory test, participants claim that they have performed a significant portion of initially only observed actions themselves.

Illuminating the processes underlying false memories has been a perennial challenge for researchers. A starting point to explain observation inflation is the common account for its "sister effect", imagination inflation. According to this account, which draws on the source-monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993), imagination inflation arises from the overlap of various sensory features (such as texture, color, or shape of moving hands and the object of an action) between imagination and self-performance (Lampinen, Odegard, & Bullington, 2003; Thomas, Bulevich, & Loftus, 2003; see also Schacter et al., 2011). The similarity of sensory features induces perceivers to confuse the sources of remembered actions, that is, to misattribute imagined actions to self-performance.

Applying this account to observation inflation seems straightforward: Observers encode sensory details like the color and shape of the manipulated object and the sound of the action, both when they perform the action themselves and observe someone else

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doing so. Thus, observers of actions form a perceptually rich representation that is largely similar to representations created by self-performance. At the time of a memory test, this perceptual similarity may lead people to falsely remember an observed action as self-performed. However, there is initial evidence that is not easily reconciled with this explanation: Lindner et al.'s (2010, Exp. 3) finding that observation inflation is not reduced under decreased sensory overlap is difficult to reconcile with this sensory-overlap account. As we will argue explanations should take into account the motor nature of the phenomenon. In the following, we elaborate this possibility.

The experience of self-performing an action entails the sense of agency (Haggard & Tsakiris, 2009). The present effect, observation inflation, fundamentally involves a confusion of agency between other and self. However, from early infancy on, humans have a reliable sense of agency, which prevents them from experiencing others' actions as self-performed under most circumstances (Decety & Sommerville, 2003; Rochat & Hespos, 1997). While we observe another person's action we can hardly be misled to think we are performing the action ourselves (unless with contrived experimental set-ups, Wegner, Sparrow, & Winerman, 2004). Why do we make this confusion when *remembering* others' actions? At least two types of processes appear to be implicated in the present effect: (1) processes that create a sense of self-performance for observed actions and thus bridge the gap between other and self at the time of observation, (2) memory processes that ultimately lead to other-self confusions in hindsight. Note that the first issue does not arise for imagination inflation because participants imagine performing the actions *themselves* (cf. Lindner & Echterhoff, 2015).

An intriguing account for agency confusion between other and self is afforded by research on automatic motor simulation (Wilson & Knoblich, 2005; Zentgraf, Munzert, Bischoff, & Newman-Norlund, 2011). This research shows that the observation of other's actions triggers covert, internal motor programs that are also activated during one's own action performance. Motor simulation thus produces a vicarious, imitative activation of the observers' motor systems and is thus assumed to bridge the gap between other and self (Decety & Sommerville, 2003; Uddin, Iacoboni, Lange, & Keenan, 2007). To be sure, motor simulation does not induce simultaneous, on-line agency confusions, specifically, false self-attributions, during the observation of others' actions, arguably due to processes of self-other discrimination operating during action perception (Decety & Sommerville, 2003; Jeannerod, 2004). Motor simulation per se can merely activate a sense of "*as if* I do it" in observers rather than a sense of "I do it." However, the observation-inflation effect has shown that, a while after initial action observation, observers can succumb to a false sense of "I did it." When the initial observation episode recedes into the past, self-attributions are made with hindsight and in the absence of on-line processes allowing immediate self-other discrimination. Under these conditions, other-self confusions become possible.

So far, motor simulation has not been invoked to explain source-memory confusions by other researchers, except by Sommerville and Hammond (2007). These authors argued that false self-attributions in children's memory are rooted in motor simulation, but did not examine motor simulation or related memory processes empirically.

We suspect that the observation-inflation effect occurs when observed actions are associated with motor codes indicating self-performance, and this association later guides observers' agency attributions. In the following, motor codes indicating self-performance will be referred to as (internally generated) cues to self-performance. As suggested by the extensive body of recent research on the observation of others' actions (e.g., Zentgraf et al., 2011), motor simulation is a possible mechanism by which the association can be initially created during action observation, that is, during Phase 2 of the paradigm. As a result of this association, cues to self-performance are integrated into representations of observed actions (Anderson, 1981). By this process of cue integration, representations of observed actions come to share critical components (i.e., self-performance cues) with the representations of actually performed actions. Indeed, neuroscientific studies have found similar neural activity during retrieval of previously performed and observed actions (Senkfor, Van Petten, & Kutas, 2002; Wutte, Glasauer, Jahn, & Flanagin, 2012).

By this rationale, processes that interfere with the association between observed actions and self-performance cues should reduce the effect. As elaborated below, one such process could be the execution of movements that are incongruent with the movements involved in the observed actions. Note that this account differs from the above source-monitoring explanation by which the observation-inflation effect is driven by the similarity (overlap) of sensory features between observed and self-performed actions.

In two experiments we examined the role of these processes in the observation-inflation effect. In Experiment 1, we altered the video display of the actions such that sensory cues were largely eliminated, but motion cues were preserved. There is evidence that motor simulation can even be triggered by observing action displays that are reduced to motion cues as long as the displays still allow identification of the action (Saygin, Wilson, Hagler, Bates, & Sereno, 2004). If sensory overlap is critical, the false memory effect (observation inflation) should decrease or fully disappear with the perceptually impoverished displays. However, if the activation of corresponding motor processes in observers is critical then the effect should persist even with impoverished displays.

In Experiment 2, we created conditions that should (vs. should not) impede the formation of an association between the observed actions and internal cues to self-performance during action observation. One interfering condition, that is, the execution of incongruent movements during action perception, is suggested by research on the common coding of action and perception (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Casile & Giese, 2006; Costantini, Ambrosini, & Sinigaglia, 2012; Zimmermann, Toni, & de Lange, 2013). Participants in Experiment 2 were instructed to perform movements in the action-observation phase that were either incongruent or congruent with (dissimilar or similar to) the movements involved in the observed actions. The execution of incongruent movements during action observation should impede motor simulation of observed actions (for details, see Experiment 2). We thus predicted that performing incongruent movements during the observation phase should decrease observation inflation.

We note that a few studies in embodied memory processes have successfully employed self-performed movements that are assumed to interfere with internal motor processes (Topolinski, 2012; Topolinski & Strack, 2009; Yang, Gallo, & Beilock, 2009). These studies assessed various parameters of old/new memory such as familiarity or remember/know judgments; however, they were not concerned with source memory, which is the key outcome in our studies.

2. Experiment 1

A minimal condition for motor simulation is the perception of motion cues, such as cues to hand or arm movements. Motion cues allow observers to perceive movements involved in action