On The Nature of Experiencing Self-Agency:

The Role of Goals and Primes in Inferring Oneself as the Cause of Behavior

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Abstract

People often find themselves in situations where the cause of events may be ambiguous. Surprisingly though, the experience of self-agency, i.e. perceiving oneself as the causal agent of behavioral outcomes, appears quite natural to most people. How then do these experiences arise? We discuss common models proposing that self-agency experiences result from the comparison between actual action-outcomes and the outcomes one explicitly set as a goal. However, recent developments in psychology and neuroscience suggest that our behaviors and the outcomes they produce can be primed and implicitly guided by environmental cues, and yet are accompanied by experiences of self-agency. Hence, we also review research revealing how self-agency experiences may arise over behavioral outcomes that are implicitly primed before they occur, and how such implicitly cued agency experiences may differ from agency experiences that are the result of explicitly set goals. Directions for future research are briefly addressed.

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In daily life, people perform numerous actions that can each have multiple consequences. They perform these actions in contexts where others perform actions and cause action-outcomes as well. For example, one may push a button to cause one of four elevators to move down to one's floor, while someone already inside the elevator may also cause the elevator to descend. Hence, it is sometimes hard to tell whether one caused a certain outcome by one's own action, or whether someone else did. Yet, people often have a clear understanding of whether they or someone else caused an outcome to occur. How do people arrive at these experiences of agency?

Over the last 40 years, research on causal attribution has shown that when reflecting on the possible cause of an outcome, people convey biases as a function of both outcome expectancies and motivation. That is, people are inclined to attribute causation over successful outcomes to themselves and unsuccessful outcomes to other causes (see for a review Shepperd, Malone, & Sweeny, 2008). However, much less attention has been devoted to experiences of self-agency during action performance and the observation of behavioral outcomes, that is, when execution and awareness of behavior co-occur in close proximity.

Although such on-line experiences of self-agency may very well be biased too, they are quite pervasive and appear very natural to most people. Humans already develop a sense of agency in early infancy, enabling them to distinguish the outcomes of their own actions from those of others (e.g., Brownell & Carriger, 1990; Decety & Chaminade, 2003; Piaget, 1954; Rochat & Striano, 2000). The experience of self-agency is important for a sense of control over the environment, and for how people perceive themselves and interact with others (e.g., Walker, Kestler, Bollini, &

Hochman, 2004; Wegner, 2002). The basic nature and fluency of establishing self-agency experiences in our social environment is intriguing and raises questions as to when and how such experiences emerge.

Current views generally assume that on-line experiences of self-agency occur when the outcome of one's action matches the outcome one had in mind. People can have outcome representations accessible in mind as a result of their explicitly set goals. Hence, goals are central to agency as part of the process underlying goal achievement (e.g., Blakemore, Wolpert, & Frith, 2002; van der Weiden, Ruys, & Aarts, 2013). Interestingly, however, recent research suggests that people are not always aware of the actual causes of their behavior, including goals (e.g., Bargh, Gollwitzer, & Oettingen, 2010; Custers & Aarts, 2010; Libet, Gleason, Wright, & Pearl, 1983; Moskowitz, 1993, 2012; Moskowitz & Grant, 2009; see also Nisbett & Wilson, 1977). Such behavior might be the result of habits and routines that people engage in without much deliberation and attention. Still, such implicitly cued behaviors and their observable outcomes are often accompanied by experiences of self-agency. How can people have these pervasive agency experiences if their behavior does not directly follow from explicit goals?

This paper addresses this issue by examining how people establish a sense of self-agency over operant behavior, i.e., when actions produce outcomes in the direct environment. We will present two general accounts for the occurrence of self-agency experiences over action-outcomes, i.e., the motor prediction account and the cognitive inference account. We will then zoom in on the cognitive inference account to examine how agency experiences over action-outcomes may ensue from outcome representations that are accessible in mind as a result of explicitly set goals, or that are implicitly pre-activated or primed. In doing so, we will explore a few important

boundary conditions (i.e., perceived causality between actions and outcomes, and the way people attend to and represent their behavior) to outcome priming effects on self-agency inferences, and examine how agency experiences resulting from implicit primes may differ from agency experiences resulting from explicitly set goals. Finally, we will elaborate on directions for future research.

How Experiences of Self-Agency Arise: An Intentional Stance

Only recently, researchers have begun to explore how experiences of self-agency arise. Generally, experiences of self-agency are considered to emerge when the outcome of one's action corresponds with the outcome one explicitly set as a goal (e.g., Pacherie, 2008; Synofzik, Vosgerau, & Newen, 2008; Wegner & Wheatley, 1999). Such a matching process can take place at both sensorimotor and cognitive levels (Pacherie, 2008; Synofzik et al., 2008). Figure 1 shows a heuristic model depicting how experiences of self-agency can arise at these different levels.

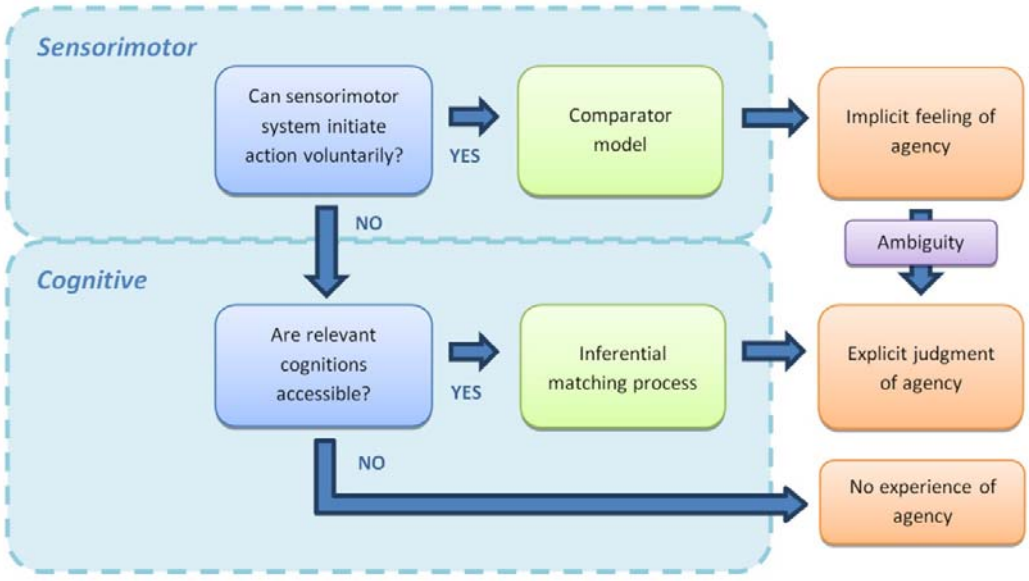

Figure 1. This model illustrates how implicit and explicit experiences of self-agency result from motor (upper part of the model) and cognitive (lower part of the model) processes.

Motor Predictions Underlying the Emergence of Self-Agency Experiences

On the most basic level of operant behavior, depicted in the upper part of Figure 1, experiences of self-agency are produced by an action-perception system that guides goal-directed actions (Mogenson, Jones, & Yim, 1980; Prinz, 1990; Wolpert, Ghahramani, & Flanagan, 2001). When pursuing a goal, people voluntarily initiate actions directed at goal achievement (e.g., grabbing a glass of water when thirsty). Along with the voluntarily initiation of action, the sensorimotor control system predicts the sensory outcomes of the action (e.g., the amount of pressure needed to grab the glass; e.g., Frith & Done, 1989; Wolpert & Flanagan, 2001). These outcome predictions are compared to the actual sensory outcomes of action, producing an implicit feeling of agency when predicted and actual outcomes match (e.g., when sufficient pressure is applied to actually grab the glass). Figure 1 shows this sensorimotor comparator model as issued by voluntary action initiation.

The implicit feelings of self-agency that are produced by these motor prediction processes are commonly measured indirectly. Based on the notion that cause and effect typically occur close together in time (Hume, 1888), Haggard, Clark, and Kalogeras (2002) introduced temporal binding of actions and outcomes as an indirect measure of self-agency. In this paradigm, participants watch a clock hand while performing simple, voluntary, self-paced actions (i.e., pressing a left or right key) that are followed by outcomes (i.e., a low or high pitch tone). Participants are required to report the time at which they performed the actions and perceived the outcomes. Typically, the outcomes are reported to occur earlier than their actual occurrence when preceded by a self-produced (i.e., voluntarily initiated) rather than involuntary or externally induced (e.g., by a transcranial magnetic stimulated, or other-produced) action. Thus, the temporal binding of actions and outcomes reflects

the cause of voluntary (goal-directed) actions and resulting outcomes and as such forms an indirect measure of implicit feelings of self-agency.

Implicit feelings and explicit judgments of agency. These implicit feelings of self-agency can, in turn, serve as input for explicit judgments of agency (see the right part of the model in Figure 1). Explicit judgments of agency enable people to communicate about who caused what and, as such, play a key role in self-awareness and social interaction. After all, if people could not explicitly reflect on who was the causal agent in a situation, they would not know who they should thank, blame, or apologize to (e.g., Brownell & Carriger, 1990; Kelly, 1972; Ruys & Aarts, 2012).

Ambiguity The motor prediction model provides a compelling account for both implicit feelings and explicit judgments of self-agency because internal motor predictions are generally very reliable. However, when the cause of an outcome becomes ambiguous, internal sensorimotor predictions become less reliable and hence less informative for explicit judgments of agency. The cause of an outcome becomes ambiguous when one's action may cause a variety of outcomes and/or when different actions/actors may have caused the outcome. To illustrate, one may experience that one's friends start laughing because one said something funny, whereas they were actually laughing about the funny haircut of someone passing by. Although one may have general knowledge about the relation between actions and outcomes in such situations (i.e., knowledge of which outcomes may possibly follow one's action or the chance that the outcome resulted from one's own versus another person's action), the sensorimotor system cannot precisely predict the outcome of action, and hence, motor predictions are less informative for explicit judgments of self-agency.

Also, there are situations in which the motor control system cannot voluntarily initiate action, i.e., when one's behavior is triggered accidently or reflexively. For

example, when one impulsively reaches for sweets, one's action is stimulus-driven rather than voluntarily initiated (e.g., Brass & Haggard, 2008). The involuntary nature of such accidently or reflexively triggered actions does not provide the comparator model with the proper sensorimotor input to arrive at a feeling of agency (Haggard et al., 2002). Nevertheless, people can still experience self-agency in such situations where self-agency experiences are unlikely to result from motor prediction processes. How then do experiences of self-agency arise?

In line with recent advances in the area of action understanding (Brass, Schmitt, Spengler, & Gergely, 2007), it has been proposed that in such situations, experiences of self-agency may result from cognitive inferences rather than motor processes (Wegner, 2002). That is, in addition to the sensorimotor system, people can also rely on cognitive inferential processes that evolved much later in human ontogenetic development (Fuster, 2002). That is, people can infer self-agency over action-outcomes based on outcome-related cognitions that were accessible before action performance. The inferential process is depicted in the lower part of the model in Figure 1.

Cognitive Inferences Underlying the Emergence of Self-Agency Experiences

According to the inference account of self-agency (Wegner, 2002), and in line with other cognitive approaches to the emergence of self-agency (such as Pacherie's (2008) conceptual model of the phenomenology of action), people infer self-agency over outcomes that match pre-activated cognitions related to the actual outcome. Often, such cognitively accessible outcome representations result from people's goals to produce a specific outcome. One is likely to think about a light being turned on when one wants to turn on a light, for instance.

However, outcome representations can also be pre-activated or primed by environmental cues. As a consequence, people can also experience self-agency when they are not aware of their own goals or have no prior goals at all. In fact, considering that much of human behavior seems to be instigated outside of conscious awareness (e.g., Bargh & Chartrand, 1999; Custers & Aarts, 2010; Dijksterhuis & Bargh, 2001; Fourneret & Jeannerod, 1998; Moskowitz, 2002; Soon, Brass, Heinze, & Haynes, 2008), the mind seems to be designed to produce experiences of self-agency even over outcomes that people did not explicitly set as a goal.

In a first test of the influence of environmentally triggered outcome representations on experiences of self-agency, Wegner and Wheatley (1999) designed an experiment in which participants together with a confederate were asked to move a square board that was mounted atop a computer mouse in slow sweeping circles. This movement led the cursor to move around 50 small objects (e.g., car, swan) that were displayed on a computer screen. After 30 seconds of moving, the participants heard music through their headphones. They were instructed to stop moving a few seconds after the music began. Importantly, shortly before the stop, subjects heard names of items that were either displayed on the screen or not. This rendered representations of possible outcomes of stopping the movement accessible in mind. Crucially, on some prime trials, the confederate received instructions over the headphone to force the cursor to stop on the primed item (producing a match between prime and outcome). After each stop, participants indicated the extent to which they felt to have caused the stop. Results showed that experienced control over forced stops was higher when the cursor stopped on the primed item. It is noteworthy that on trials where stopping was not forced, priming did not cause participants to stop on the primed item, indicating

that outcome priming can create the illusion of self-agency over outcomes that are in actuality produced by another agent.

These priming effects on experiences of self-agency have been replicated with different priming durations (either consciously perceivable or too brief to be consciously perceived), across different tasks using a variety of actions and outcomes such as stopping a moving square on a specific location, watching vicarious limb movements, or causing other people's emotions (Belayachi & Van der Linden, 2010; Gentsch & Schütz-Bosbach, 2011; Jones, de-Wit, Fernyhough, & Meins, 2008; Linser & Goschke, 2007; Ruys & Aarts, 2012; Wegner, Sparrow, & Winerman, 2004; Wegner & Wheatley, 1999; van der Weiden, Aarts, & Ruys, 2010), and across different cultures (Aarts, Oikawa, & Oikawa, 2010; Sato, 2009). Importantly, these converging findings suggest that people experience self-agency when the outcome of their action matches the outcome that they have in mind, irrespective of the source of the pre-activated outcome representation (an explicit goal or an implicit prime). At first glance, then, it seems that the same matching process induces inferences of self-agency over both outcomes that are explicitly set as a goal, or that are merely primed.

More recently, though, research has zoomed in on the mechanism underlying this matching process and has provided new insights on *when* and *how* inferential experiences of self-agency emerge over *primed* outcomes. Although previous studies compellingly demonstrate that the mere pre-activation of outcome representations enhances experiences of self-agency, this recent research indicates that there are boundary conditions to these priming effects. Two key factors that crucially determine priming effects on experienced self-agency are the perceived causality between action and outcome and the level at which people represent their behavior. In the following sections, we will present evidence for these boundary conditions. Furthermore, we

will review recent research that reveals how experiences of self-agency over primed outcomes differ from experiences of self-agency over outcomes that are explicitly set as a goal.

Perceived Causality and Inferences of Self-Agency

The theory of apparent mental causation advocates that for experiences of self-agency to emerge, the perceived (rather than actual) causal relation between actions and outcomes is central (Wegner, 2002). Whether people perceive causal relations between events (e.g., actions and outcomes) in turn depends on three principles: priority, consistency, and exclusivity (Einhorn & Hogarth, 1986; Gilbert, 1998; Kelly, 1972; McClure, 1998; Wegner, 2002). That is, people perceive a causal relation between actions and outcomes when a representation of the corresponding (consistency) outcome was accessible before action performance (priority), especially when there is no other likely cause (exclusivity) of the outcome. Considering that people only experience self-agency over an outcome when they can pinpoint a likely cause of the outcome, they should especially experience self-agency over outcomes that are consistent with the action they performed (see also Wenke, Fleming, & Haggard, 2010). This notion forms an essential part in models of goal-directed behavior, in which an agent is proposed to act on knowledge that precisely predicts the instrumentality of certain actions for attaining one's goal (e.g., Aarts & Elliot, 2012; Dickinson & Shanks, 1995).

However, knowledge that predicts the exact outcome of an action, or causal prediction in general, may be less essential when experiences of self-agency result from mere outcome priming. Indeed, in most research that demonstrated outcome priming effects on self-agency, subjects have no knowledge that precisely predicts which specific outcome will occur after action performance (e.g., Wegner, 2002;

Wegner et al., 2004). Yet, in the absence of such specific causal predictions, people may still perceive their actions and outcomes to be related, relying on more general knowledge of the potential causal relation between the actions they perform and their possible outcomes. However, when knowing from experience that the action one performs cannot cause the outcome, this may form a boundary condition to the experience of self-agency, also in case of primed outcomes. After all, it would be odd to experience self-agency over outcomes that cannot bear a causal relation to the action one performed, for example, when pushing the ENTER-button is followed by rainfall. In such cases, outcome priming effects on self-agency may be constrained by people's understanding of reality (cf. Kunda, 1999).

Evidence for the crucial role of perceived causality in priming effects on self-agency comes from recent studies that examined the effect of the consistency of action-outcome relations on explicit judgments of self-agency (Sato, 2009; van der Weiden, Aarts, & Ruys, 2011). In one study (van der Weiden et al., 2011), participants first engaged in a probability learning task in which they acquired knowledge of specific action-outcome relations (e.g., left and right key presses, followed by a red or a blue light for some participants, and by a green or a yellow light for others). Next, they engaged in a self-agency task in which outcomes (red and blue lights) were primed or not before performing an action (a left or right key press) and observing the corresponding outcome. When actions and outcomes were learned to be causally related (80% co-occurrence), outcome primes enhanced self-agency on top of a main effect of action-outcome predictability. These additive effects provide support for the combined contribution of motor predictions and cognitive inferences to experienced self-agency. However, when actions and outcomes were learned to be causally unrelated (50% co-occurrence), experiences of self-agency were no longer

affected by outcome priming (see also Sato, 2009). Thus, when subjects learned that the outcomes cannot be causally related to the action they performed, both motor prediction and inference processes did no longer contribute to experiences of agency.

Importantly, this is not the whole story. In line with previous research, results further showed that outcome primes did enhance experienced self-agency when participants had no knowledge about the action-outcome relations over which self-agency was assessed (i.e., when left and right key presses were learned to be unrelated [50% co-occurrence] to green and yellow lights, while self-agency was assessed over red and blue lights). Notably, these priming effects were as strong as when actions and outcomes were learned to be causally related (80% co-occurrence), providing further support that cognitive inferential processes can affect experiences of self-agency independent of motor predictive processes.

Other research also underscored the importance of consistent action-outcome relations for inferences of self-agency by showing that priming of actions (e.g., an arrow pointing left or right) before action performance (e.g., pressing a left or right key) enhances experiences of self-agency over outcomes that follow these actions (e.g., a colored dot on the computer screen; Chambon & Haggard, 2012; Wenke et al., 2010). The effect of action primes on experienced self-agency over outcomes is suggested to occur because the experience of smooth action selection and execution as induced by the action primes enhances people's feelings of control over the behavior and hence cause them to infer self-agency over the behavioral outcomes. In other words, people are more inclined to experience self-agency over actions and outcomes when knowing that they are causally related and when the action is performed fluently rather than erred.

These findings indicate that perceived causality is a key determinant of outcome priming effects on experienced self-agency and that people rely on different cues (e.g., a match between prime and outcome, experience of action fluency) when inferring self-agency. These findings also converge with research showing that when perceived causality between actions and outcomes is otherwise obstructed, people no longer experience self-agency over the outcomes. For example, outcome primes no longer affect experienced self-agency when another cause obviously produced an outcome (e.g., when the outcome occurs irrespective of whether one performed an action), and hence, the exclusivity principle is violated (Buehner & Humphreys, 2009). Also, when people are primed with an outcome representation *after* action-performance (e.g., as when acting on impulses and thinking of the consequences of action only after action performance), which violates the priority principle of perceived causation, experienced self-agency is not enhanced (Wegner & Wheatley, 1999).

To summarize, although people can experience enhanced self-agency over primed outcomes when they have *no* specific knowledge of causal action-outcome relations, priming effects on experienced self-agency cease to occur when people know or believe that the action they performed cannot be causally related to the outcome that followed. People only tend to infer self-agency over (primed) outcomes if they consider the action they performed as a potential cause of the outcome that followed.

Behavior Representations and Inferences of Self-Agency

In addition to the notion that perceived causality modulates effects of priming of outcome representations on people's experiences of self-agency, there is evidence that further suggests that the *way* people attend to and represent their behavior plays a

central role in the mechanism underlying inferences of self-agency (Pacherie, 2008; van der Weiden et al., 2010). According to Action Identification Theory (Vallacher & Wegner, 1987; Wegner & Vallacher, 1986), any behavior (e.g., turning on a light) can be identified at multiple levels. People who attend to and represent their behavior at a low level define their behavior in terms of *how* an action is done (e.g., they focus on moving their finger), whereas people who attend to and represent their behavior at a higher level define their behavior in terms of *why* an action is done (e.g., they focus on illuminating the room). As a consequence, how people perceive the outcome of behavior depends on the level at which the behavior is represented. People who represent their behavior at a low level generally perceive their behavior in terms of producing sensorimotor outcomes (a low level outcome, e.g., the tactile perception of one's finger touching the light switch), whereas people who represent their behavior at a high level generally perceive their behavior in terms of serving an overarching goal or outcome (a high level outcome; e.g., the room being illuminated).

The notion that behavior can be represented at different levels has been acknowledged by several models and theories dealing with the cognitive architecture and control of behavior (e.g., Aarts & Dijksterhuis, 2000; Gallistel, 1985; Jeannerod, 2006; Powers, 1973; Vallacher & Wegner, 1987). For instance, behavior representation levels play an important role in the understanding of behavior (Aarts & Hassin, 2005; Kozak, Marsh, & Wegner, 2006; Vallacher & Wegner, 1989; Wegner, Vallacher, Macomber, Wood, & Arps, 1984). Importantly, the level at which people represent their behavior has also been suggested to play an important role in the matching process underlying experiences of self-agency (Pacherie, 2008). Whether people represent their behavior in terms of moving one's finger, flipping the light switch, or illuminating a room crucially determines whether they perceive the

outcome of an action (e.g., tactile perception versus an illuminated room) to match a pre-activated outcome representation (e.g., the room being illuminated,) and hence whether they infer self-agency over the outcome. Thus, primes and actual action-outcomes might have to be represented at the same level.

In a recent study that examined this idea (van der Weiden et al., 2010), participants performed the wheel of fortune task (Aarts, Custers, & Wegner, 2005). This task requires participants to stop the movement of a square rapidly traversing a rectangular path consisting of eight tiles (see Figure 2). At the same time, the computer also moves a square in the opposite direction. After stopping the moving squares, participants are presented with the stop location of only one of the squares. This location thus represents the stop location of subjects' own square or the computer's square, rendering the cause of the outcome ambiguous. On each trial, participants indicate the extent they feel that they caused the square to stop at the

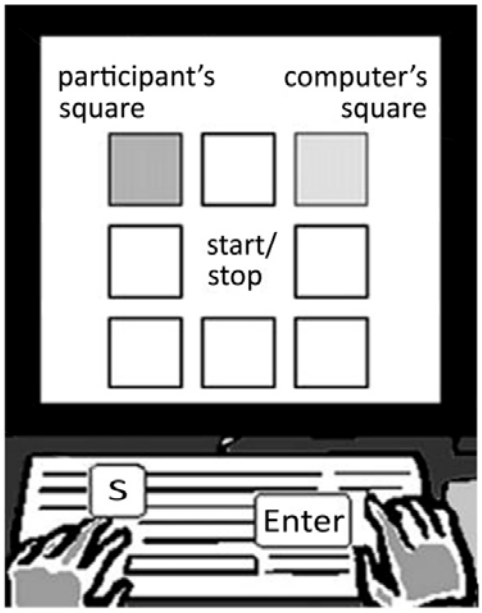

Figure 2. Visualization of the wheel of fortune task, adapted from *Consciousness and Cognition, 14*, Aarts, H., Custers, R., & Wegner, D. M., "On the inference of personal authorship: Enhancing experienced agency by priming effect information", pages 439-458, Copyright 2005, with permission from Elsevier.

presented location. The experiment contained two manipulations. First, each participant was primed with the corresponding outcome (stopped location) or not, just before they had to stop the moving squares. Second, the level at which participants represented the behavior was manipulated by emphasizing different task aspects. Importantly, all participants learned that after pressing the enter button, the square would stop on one of the eight positions. Also, all participants were strongly encouraged to focus on the computer screen during the task. However, for half of the participants, the instructions emphasized that the task was about pressing the enter button when the stop cue appeared (focusing them on how the action is done). For the other participants, the instructions emphasized that the task was about determining where the square would stop after pressing the enter button (focusing them on why the action is done).

Results showed that priming the square's stop location (i.e., the potential aim of the action) enhanced experiences of self-agency when participants represented their behavior at a corresponding level (i.e., in terms of stopping the square, rather than in terms of pushing a button). Although people are generally inclined to represent their behavior in terms of why they perform the behavior (at relatively high levels), behavior representation levels vary as a function of both context and individual differences. In line with this notion, further experimentation showed that outcome priming effects on experienced self-agency are more pronounced for individuals who generally represent their behavior at a higher rather than a lower level, as assessed by the Behavior Identification Form (van der Weiden et al., 2010).

This influence of behavior representation level renders outcome priming effects on inferences of self-agency susceptible to a variety of factors. That is, the level at which people represent their behavior, and hence the experience of self-

agency, depends on many contextual and individual factors. Both task difficulty and failure, for instance, cause people to focus on lower level representations: "How should this action be executed?", or "How to accomplish this task successfully in the future?" (Dannenberg, Förster, & Jostmann, 2012; Vallacher & Wegner, 1987, 1989). Similarly, people who tend to act on their impulses are likely to represent their behavior at a relatively *low* level, because they are *less* inclined to think about the consequences of their behavior (Martin & Potts, 2009; Vallacher & Wegner, 1989). Also, the way people represent their behavior may be influenced by social norms and beliefs (e.g., Desantis, Roussel, & Waszak, 2011; Dogge, Schaap, Custers, Wegner, & Aarts, 2012). For example, people who believe that their behavior is self-caused rather than pre-determined (e.g., by higher powers, natural laws, or random factors) may be more likely to represent their behavior at a relatively *high* level, because they are *more* inclined to think about the consequences of their behavior (Baumeister, Masicampo, & DeWall, 2009; Vohs & Schooler, 2008).

Goals versus Primes as Sources of Self-Agency Inferences

The research on outcome priming effects on self-agency inferences discussed so far suggests that the process by which primes enhance self-agency experiences is identical to the process underlying self-agency experiences associated with goal-directed behavior. People infer self-agency when they perceive a causal relation between a pre-activated higher level outcome representation and the actual outcome, irrespective of whether this outcome representation is induced by an explicit goal or an implicit prime. In line with this notion, goals and outcome primes have been shown to enhance experiences of self-agency over outcomes that match these goals and primes to the same extent (Aarts et al., 2005). Thus, goals do not seem to make self-agency experiences more special than do mere outcomes primes.

Yet, although outcome priming effects on the enhancement of experienced self-agency mimic the effects of goals, this does not necessarily suggest that primes affect agency processing in the same way as goals do. While outcome primes merely render the representation of the outcome accessible, goals also have a regulatory function. That is, goals evoke specific control processes that deal with shielding, monitoring, and feedback processing in the service of attaining the specific desired outcome (e.g., Carver & Scheier, 1998; Moskowitz, Li, & Kirk, 2004), processes that may be especially important when outcomes mismatch one's goal. Thus, the cognitive processes accompanying goals and outcome primes may lead to different effects on experiences of self-agency over matching than over mismatching outcomes.

In a recent test of this idea (van der Weiden et al., 2013), participants performed an adapted version of the wheel of fortune task (see Figure 2). Instead of measuring experienced self-agency only over matching outcomes, experienced self-agency over mismatching outcomes was also assessed. Participants were either assigned the goal of stopping their moving square on a certain location or were primed with the location instead. On matching trials, the square's stop location was the same location participants were primed with or explicitly set as their goal. On mismatching trials, the spatial distance between the outcomes and the goals or primes was systematically varied (i.e., 1, 2, 3, or 4 locations distance). Results showed that the extent to which actual outcomes mismatched was associated with different decrease patterns of experienced self-agency as a function of whether participants had a goal to produce a specific outcome or whether they were merely primed with the outcome. Experienced self-agency dropped instantly and remained low when an outcome mismatched a goal, regardless of the distance between the actual and intended outcome. In other words, participants only experienced self-agency over

outcomes that matched their goal. In case of outcome priming, however, experienced self-agency decreased gradually as a function of the distance between the actual outcome and the primed outcome (see Figure 3).

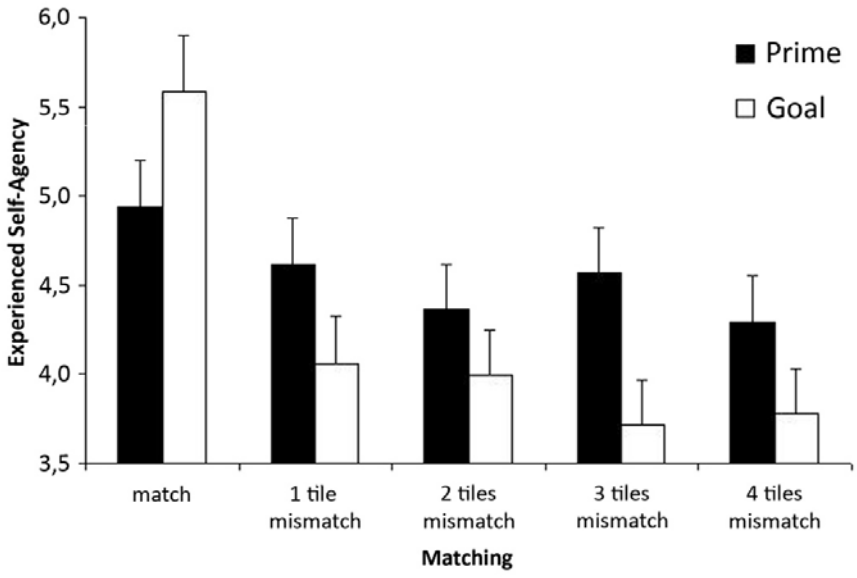

Figure 3. Experienced self-agency over outcomes that mismatched to an increasing degree with either a goal or a prime. Error bars represent standard errors of the means. Copyright © 2012 by the American Psychological Association. Reproduced with permission. The official citation that should be used in referencing this material is: van der Weiden, Ruys, & Aarts, 2013. The use of APA information does not imply endorsement by APA.

These results provide evidence for the idea that experiences of self-agency as produced by goals versus outcome primes take on a different form and quality: Goals affect the inferential process of self-agency by focusing people's attention on one specific outcome (i.e., the goal) and by incorporating both matching and mismatching outcome information. Outcome priming, on the other hand, affects self-agency via an inferential process that is open to associative processing of related (e.g., spatially close) outcome information and that incorporates matching outcome information only. Accordingly, goals reduce self-agency over mismatching outcomes whereas outcome

primes do not affect self-agency over mismatching outcomes, but in fact even enhance self-agency over mismatching proximate outcomes.

Conclusion and General Discussion

The experience of self-agency is an exciting and important topic for the understanding and examination of human self-perception and volition. Research in this field suggests that self-agency arises from both sensorimotor predictions that originate from people's goals and retrospective inferences that result from both goals and outcomes primes. Here, we focused on the inferential processes underlying self-agency experiences and explored a few key aspects that modulate the effects of outcome primes on experienced self-agency, such as the perceived causality between action and outcome, and the level at which people represent their behavior. Furthermore, we highlighted recent research showing differences in experienced self-agency resulting from inferences that we draw from our purposes to engage in behavior (i.e., goals) and from inferences that originate from primes that implicitly cause us to presage an outcome before it occurs.

The study on inferences of self-agency is particularly interesting from a social perspective since people often perform actions and observe outcomes in contexts where other agents might also have caused these outcomes. In such ambiguous situations, inferences of self-agency leave room for biases in the perception of one's own behavior. Hence, cues that refer to the outcomes of action are likely candidates to bias the agency ascription process. Importantly, in most of the studies we discussed, participants had no actual control over the outcomes. This allowed the researchers to assess the extent to which experienced self-agency over an outcome is augmented or weakened as a result of outcome cues that match or mismatch the outcome, independent of effects of actual control. The general gist of this research is that people

tend to over-attribute causation to themselves when action-outcomes match the outcome that was primed or set as a goal. Only when people have a goal in mind, biases in experienced self-agency can also unfold in the other direction. That is, people may under-attribute causation to themselves (and over-attribute causation to other causes) over outcomes that mismatch their goal. Thus, whereas priming mainly biases agency ascription to the self, goals (in the case of failure) also bias agency ascription to others. We briefly address a few implications of these findings for future research.

Agency and motivation. The finding that experiences of self-agency over mismatching outcomes are only reduced in the context of goal-directed behavior may have consequences for human motivation and self-regulation. In line with research in the area of self-attribution, one likely reason why goals are attuned to both successful and unsuccessful outcomes is that success and failure are key aspects of learning, decision making, motivation, and performance in the service of goal attainment (Aarts & Elliot, 2012). Importantly, recent research suggests that success and failure affect motivation and goal-directed performance only when outcomes were ostensibly self-caused (e.g., Neumann, 2000; Steinhauser & Kiesel, 2011). Also, it has been suggested that being the cause of an outcome directly enhances motivation (see Eitam, Kennedy, & Higgins, 2013; White, 1959). Thus, when agency appears unambiguous and the sensorimotor system can voluntarily initiate action, experienced agency and motivation seem to go hand in hand.

Yet, one may wonder whether success and failure in goal pursuit always modulate motivation through experiences of self-agency. That is, the present analysis on the inferential nature of self-agency in ambiguous social situations might open new avenues to study the interrelation between self-agency and motivation.

One such avenue concerns the effect of self-chosen versus externally assigned goals on agency and motivation. An extensive body of research on goal setting and self-determination has shown that people become more motivated after success when they have chosen their own goal, compared to when they are assigned a certain goal (e.g., Patall, Cooper, & Robinson, 2008; Deci & Ryan, 2000). Consequently, if inferences of agency and motivation are directly related, people should also experience more self-agency over the attainment of self-chosen goals rather than assigned goals.

However, the research discussed earlier suggests that, in ambiguous situations, self-agency experiences rely on a cognitive matching process that is crucially affected by goal-directed control processes (Wegner, 2002; van der Weiden et al., 2013). Because self-chosen as well as assigned goals instigate similar control processes that support goal attainment (Aarts & Elliot, 2012), it follows that self-chosen and assigned goals may have similar effects on self-agency. If this is indeed the case, effects of choice on motivation are unlikely to be mediated by experienced self-agency. In other words, although success and failure in goal pursuit may alter agency and motivation in a similar fashion, agency and motivation may not necessarily be related. Thus, the present examination of inferences of self-agency in ambiguous social situations where execution and awareness of behavior co-occur in close proximity may have implications for research on goal setting (Locke & Latham, 2002) and intrinsic motivation (Deci & Ryan, 1985). For instance, self-agency experiences and motivation may share strong overlap only when goals are self-chosen, and not when goals are assigned. This argumentation is of course speculative and awaits future testing.

Internal versus external sources of agency In the majority of studies on inferences of self-agency, the focus has been on the distinction between self versus other agency. Yet, whereas the attribution of causality to external agents may decrease experienced self-agency (cf, an agentic shift; Milgram, 1963), there may also be situations in which people experience self-agency over outcomes that obviously resulted from the behaviors of others. From this perspective, two social instances are relevant to explore in further detail.

First, merely watching other people perform actions activates corresponding motor areas in the observer's brain through so-called mirror neurons (Decety, Chaminade, Grèzes, & Meltzoff, 2002; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Rizzolatti & Craighero, 2004). When performing actions together with others, people often even include others' actions in their own action representation, assuring smooth joint actions (e.g., Obhi & Sebanz, 2011; Ruys & Aarts, 2010; Sebanz, Bekkering, & Knoblich, 2006). Remarkably, people occasionally also include other agents in their *self*-representation, for example, when they identify strongly with other in-group members (e.g., Brewer & Gardner, 1996; Tropp & Wright, 2001). Consequently, people may experience self-agency over the outcomes of other people's actions because they feel like their own actions. Perceiving the actions of others as one's own has important implications for perspective taking and empathy, for example, causing people to become distressed by the distress of others (Decety & Chaminade, 2003) and to feel guilty for the wrongdoing of others (Lickel, Schmader, Curtis, Scarnier, & Ames, 2005). As the observation of other people's behavior likely provides people with relevant outcome information, the inference process of experienced self-agency addressed here may provide an account for such vicarious agency effects (cf. Wegner et al., 2004).

The second instance pertains to when one's own goals are influenced by others, especially when one is unaware of such influence. In social contexts, one's goal-directed behavior is regularly affected by what other people do and seem to find interesting (Aarts & Hassin, 2005; Ackerman, Goldstein, Shapiro, & Bargh, 2009; Bar Anan, Wilson, & Hassin, 2010; Dik & Aarts, 2007; Fitzsimons & Finkel, 2010; Friedman, Deci, Elliot, Moller, & Aarts, 2010; Lebreton, Kawa, d'Arc, Daunizeau, & Pessiglione, 2012; Loersch, Aarts, Payne, & Jefferis, 2008). This social influence on goal setting is not limited to exposure to narratives, physical movements, or object-oriented actions of other people but also occurs for more subtle behavior, such as eye gaze or emotional facial expressions (Bayliss, Frischen, Fenske, & Tipper, 2007; van der Weiden, Veling, & Aarts, 2010). Whereas the sharing of goals can be beneficial for social functioning (Tomasello & Carpenter, 2007), it raises the important and intriguing question how one arrives at the experience of self-agency when goal-directed behavior is the mere product of social influence. It may be the case that goals that are automatically induced by the behavior of others function as outcome primes, or alternatively, affect experienced self-agency in the same way explicitly set goals do (van der Weiden et al., 2013). Future research could explore this issue by investigating the effect of matches and mismatches on experienced self-agency.

A final note on inferential effects on implicit feelings of agency Until recently, research mainly assessed the effects of outcome priming on agency inferences by measuring explicit judgments of agency. However, lately a few studies have reported priming effects on implicit measures of self-agency, such as Haggard and colleagues' (2002) temporal binding paradigm (e.g., Gentsch & Schütz-Bosbach, 2011; Moore, Wegner, & Haggard, 2009). These findings raise the question whether

outcome priming effects on implicit feelings of self-agency result from cognitive inferential or motor prediction processes (cf. Frith, in press).

Suggestive evidence that implicit feelings of agency can derive from cognitive inferences as well as from motor predictions comes from a recent study that investigated the combined contribution of inferences and predictions to implicit feelings of agency (Moore et al., 2009). In this study, participants performed actions that where either voluntarily initiated or externally triggered (i.e., by an experimenter or a stepper motor). These actions led to low or high pitch tones that could be primed prior to the action. After each trial, the perceived interval between actions and outcomes was assessed as a measure of temporal binding. Results showed that both voluntary action initiation and outcome primes (i.e., the low or high pitch tones) caused temporal binding. Importantly, these effects were not additive, suggesting that outcome primes especially enhance feelings of agency when actions cannot be voluntarily initiated, and hence, motor predictions are less reliable.

Thus, it seems that inferences of self-agency can affect implicit feelings of self-agency. This finding paves the way for future research on the relation between implicit feelings and explicit judgments of agency. Previous research has produced mixed results regarding the relation between implicit and explicit experiences of self-agency in a context where actions were voluntarily initiated (Ebert & Wegner, 2010). In such contexts, implicit feelings of agency most likely resulted from motor predictions, while explicit judgments of agency may (at least partly) have resulted from cognitive inferences. Hence, it would be worthwhile for future research to investigate the relation between implicit feelings and explicit judgments of agency when both result from cognitive inferences.

Concluding Remarks

Most people experience self-agency over their behavior. These agency experiences often result from inferences and arise when the outcome of an action matches the outcome one had in mind when performing the action. Essentially, experiences of self-agency inform us that we cause our own actions and resulting outcomes: It is I who is doing it. Whereas the experience of agency often appears natural to us, a closer look at the topic indicates that there are many situations where the establishment of agency is not a straightforward affair (e.g., when there are other potential causes or when we are unaware of the goals we pursue). The study of self-agency experiences is still in its infancy and deserves more theoretical and empirical attention to enhance our understanding of how we perceive ourselves and how we perceive and interact with other selves (e.g., Walker et al., 2004; Wegner, 2002).

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Henk Aarts is a professor of psychology at Utrecht University. His main research interest concerns the study of the human capacity of behavior regulation and the experience of agency.With his research team, he has published work in these areas in a wide range of different journals and chapters in edited books. He also recently co-edited a book on goal-directed behavior. Before coming to Utrecht University, he worked at Eindhoven University of Technology and Leiden University. He was trained as an experimental social psychologist and received his PhD at the Radboud University in Nijmegen.

Kirsten Ruys is an assistant professor in psychology interested in emotional reactions, affective processes, and feelings of self-causation. She has authored papers in these areas for the Journal of Experimental Social Psychology, Journal of Personality and Social Psychology, and Emotion. Her career as experimental psychologist started at the University of Amsterdam, where she also acquired a PhD in social psychology. Since then, Kirsten worked at the university of Louvain-la-Neuve in Belgium, Tilburg University, and Utrecht University.