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On the Foundations of Beliefs in Free Will: Intentional Binding and Unconscious Priming in Self-Agency

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Abstract

The concept of an ability to make choices and to determine one's own outcomes fits well with experiences that most people have, and these experiences form the basis for beliefs in free will. However, the existence of conscious free will is challenged by modern research findings highlighting the unconscious origins of goal-directed behavior that gives rise to free-will beliefs. This report expands on these insights by revealing that both conscious and unconscious processes play an important role in free-will beliefs. Specifically, Experiment 1 demonstrates that free-will beliefs are strengthened when conscious intentions to produce action outcomes bind the perception of action and outcome together in time. Experiment 2 shows that these beliefs are strengthened when unconscious priming of action outcomes creates illusory experiences of self-agency when the primed outcomes occur. Together, these findings suggest that beliefs in free will are associated with self-agency and are enhanced by both conscious and unconscious information processing of goal-directed behavior.

Keywords

beliefs, free will, self-agency, conscious and unconscious, intention, priming

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Human behavior is often understood in terms of conscious intentions to produce behavioral outcomes. This conscious route to goal-directed behavior plays a vital role in experienced action coherence and self-agency (i.e., the feeling that one causes one's own actions and outcomes) and serves as an important building block for beliefs in free will. Indeed, beliefs in free will can be strong and pervasive, and have been shown to play a role in social conduct (Vohs & Schooler, 2008). However, modern psychological research suggests that goal-directed behavior can also originate in the unconscious and is primed and controlled by the environment (Custers & Aarts, 2010), thereby challenging important assumptions pertaining to the existence of free will (e.g., Bargh, 2008; Libet, 2004; Wegner, 2002).

In this article, we do not aim to solve the issue of whether free will does or does not exist. Instead, our goal is to further the understanding of the mechanisms that potentially underlie free-will beliefs. Beliefs in free will are important for human social functioning and require higher-level cognition. However, little is known about how such beliefs build on the processing of information relevant to people's own behavior and experiences of self-agency. Here, we examine whether beliefs in free will are associated with self-agency. Specifically, we propose that beliefs in free will shape and are reinforced by the way people process basic information about actions and outcomes involved in self-agency, and that this information may come from conscious (intentional) as well as unconscious (outside awareness) sources. Appreciating that individuals differ in their beliefs in free will, in two experiments we tested the idea that beliefs in free will are positively associated with the extent to which (a) conscious intentions to produce action outcomes bind actions and outcomes together in time and (b) unconscious priming of action outcomes creates experiences of self-agency when the primed outcomes occur. By establishing this association between free-will beliefs and the process of self-agency, we aim to open new ways to explore the foundations of beliefs in free will.

There is general agreement that the concept of free will refers to the ability to make choices and to determine one's own outcomes free from constraints. The existence of such a mental faculty fits well with personal experiences that most

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people have and share. Thus, when one pushes a button to get a Coke from a vending machine, one's feeling of causing that outcome is intimately linked to the belief in a free will. Studies consistent with this notion have shown that people with stronger beliefs in free will are more concerned with controlling and accounting for action outcomes (e.g., Nichols, 2004; Vohs & Schooler, 2008; Waldman, Viney, Bell, Bennett, & Hess, 1983). We argue that this focus on action outcomes indicates that beliefs in free will are related to both conscious and unconscious processing of information related to actions and outcomes involved in self-agency.

Specifically, we note that previous research suggests two basic pathways that model this process. The first deals with the conscious intentional nature of behavior and involves perceived coherence and agency of behavior resulting from predictive signals of the sensory outcomes of actions (e.g., Blakemore & Frith, 2003). The second pathway involves unconscious sources of behavior and the inferential nature of agency experiences resulting from priming of the representation of action outcomes before they occur (e.g., Wegner & Wheatley, 1999).

In an examination of the first pathway, Haggard, Clark, and Kalogeras (2002) asked participants to press a key, which on some trials was followed 250 ms later by a tone. Participants' task was to judge the timing of the key press and tone by reporting the corresponding positions of a moving clock hand. Participants judged the key press to occur 15 ms later and the tone to occur 46 ms earlier when they intentionally produced the tone by pressing the key (agency condition) than when the two events occurred alone (baseline condition). This temporal binding effect diminished when the tone was preceded by an involuntary key press resulting from transcranial magnetic stimulation. Thus, when an action intentionally causes a sensory outcome, and hence sends out a predictive signal of that outcome before it actually occurs, action and outcome are perceived to occur closer together in time. We propose that this intentional binding between action and effect could be a crucial component in people's beliefs in free will. Experiment 1 examined this idea directly by assessing whether participants with weak and strong free-will beliefs differed in intentional binding between action and effect. Specifically, building on the idea that temporal binding between action and effect reflects the extent to which behavior is experienced as self-caused, we hypothesized that this binding should be positively associated with belief in free will.

This hypothesis indicates that conscious intention creates a sense of agency by binding action and outcome together in time. Thus, it focuses mainly on the conscious nature of behavior, and remains silent about the possibility that unconscious priming of behavior by the environment also leads to beliefs in free will (Aarts, Custers, & Marien, 2009). In support of this second possibility, researchers have argued that people's experience of self-agency is an inference that is made fluently and perfunctorily after performance of an action and is not accurate per se (Aarts, Custers, & Wegner, 2005; Wegner & Wheatley, 1999). Specifically, they have argued that one's experience of self-agency is augmented when the representation of an outcome is unconsciously primed just before one performs an action and then observes the outcome—whether one truly causes the outcome or not.

In a test of this idea (Aarts et al., 2005), participants moved a single gray square in a counterclockwise direction on a computer screen while the computer moved another gray square in the opposite (clockwise) direction. The movements of the two squares were displayed in rapid alternation. When participants pressed a key, they saw one of the two squares stopped at a specific location. Thus, the observed stop could have been caused by the participants or the computer. Participants indicated whether they or the computer had caused the square to stop at that position. In actuality, the computer always determined where the square stopped, so participants had no control. Results showed that self-agency experiences were more frequent when participants were subliminally presented with the location of the stopped square just before they pressed the key than when they were not primed. This result suggests that self-agency was inferred from a match between the preactivated and actual outcomes, which influenced the extent to which the outcome was experienced as willfully caused (Wegner, 2002). Building on these ideas, we argue here that unconscious outcome-priming effects on self-agency are associated with belief in free will. Experiment 2 examined an important implication of this line of reasoning. Specifically, it tested the novel prediction that the more strongly subliminal outcome priming biases experienced self-agency, the stronger free-will beliefs will be.

Experiment 1

Method

Participants. Forty-four undergraduates participated in Experiment 1 in return for a small payment.

Procedure. To assess intentional binding of action and outcome, we employed the method of Haggard et al. (2002). In a series of trials, participants attended to a clock (diameter = 2 cm) with a clock hand (2 mm) rotating clockwise with a period of 2,560 ms. The clock face (presented on the computer screen) was marked with conventional intervals (5, 10, 15, etc.). Each trial started with a blank screen for 1 s, after which the clock hand started moving from a random position. Depending on the trial type, participants freely pressed a key to cause a tone to occur (1000 Hz, presented for 100 ms on a headphone), pressed the key and heard no tone, or only heard the tone. At the end of each trial, participants reported the position of the clock hand at the moment they pressed the key or heard the tone, using the numbers 0 through 60 in intervals of 1.

The task consisted of four types of trials. In one trial type, participants made a voluntary key press with their index finger, at a time of their own free choice during the second cycle

of the minute hand's rotation. Pressing the key caused the auditory tone to occur 250 ms later. After the tone, participants judged the onset of their key press. In a second trial type, participants also pressed the key that produced the tone, but in this case, they were asked to judge the onset of the tone. We refer to these first two types of trials as agency trials. In a third trial type, key presses were performed, but a tone did not follow, and participants judged the onset of their action. In a fourth trial type, no key presses were made, and a tone sounded at a random time during the display of the running clock; on these trials, participants judged the onset of the tone. We refer to these last two types of trials as single-event trials. The task was divided into four blocks, each corresponding to a separate condition in a 2 (judgment: key press vs. tone) × 2 (agency: single event vs. agency) within-subjects design. Each block contained 40 trials. The order of blocks was counterbalanced.

For each trial, judgment error (in milliseconds) was calculated as the difference between the perceived time of an event and its actual time of occurrence. A positive judgment error corresponds to delayed awareness of the event, and a negative judgment error corresponds to anticipatory awareness.

After the task, participants completed the Free Will (FW) scale (Paulhus & Carey, in press). An example item from this scale is, "People have complete control over the decisions they make" (response scale for all items: 1 = *not at all*, 5 = *to a great extent*). Participants also responded to two questions asking how important the task was to them and how carefully they had used the clock (1 = *not at all*, 5 = *to a great extent*).

Results

The mean judgment errors were subjected to a general linear model analysis, with judgment (key press vs. tone) and agency (single event vs. agency) as within-subjects variables and FW score as a continuous variable. This analysis revealed a significant interaction between judgment and agency, $F(1, 42) = 33.64$, $p < .001$, $\eta_p^2 = .45$. We replicated the standard intentional binding effect (Haggard et al., 2002): Judging the onset of the action when it was followed by the tone (vs. not followed by the tone) produced a positive judgment error (mean shift = +32.24 ms). In addition, judging the onset of the tone when it was preceded by the action (vs. not preceded by the action) produced an even stronger negative judgment error (mean shift = −48.02 ms). This interaction effect was qualified by a significant three-way interaction involving FW score, $F(1, 42) = 4.16$, $p < .05$, $\eta_p^2 = .09$.

To examine this three-way interaction, we estimated the interaction between judgment and agency for participants with weak free-will beliefs (1 *SD* below the mean FW score) and for participants with strong free-will beliefs (1 *SD* above the mean FW score; see Aiken & West, 1991). These analyses showed that the interaction effect was significant for participants with weak beliefs in free will, $F(1, 42) = 6.91$, $p < .01$, $\eta_p^2 = .14$. However, the interaction effect was much stronger for participants with strong free-will beliefs, $F(1, 42) = 30.56$, $p < .001$, $\eta_p^2 = .42$. Figure 1 displays mean error as a function of judgment, agency, and belief in free will. Note that the significant difference in intentional binding between participants with weak versus strong free-will beliefs was driven mainly by enhanced anticipatory awareness of the effect (tone) among participants with strong free-will beliefs. This stronger shift for the outcome than for the action (resulting from predictive signals of the sensory outcome of action) is a typical finding in intentional binding studies, and in the present case suggests that stronger beliefs in free will correspond to a stronger focus on the outcomes of actions.

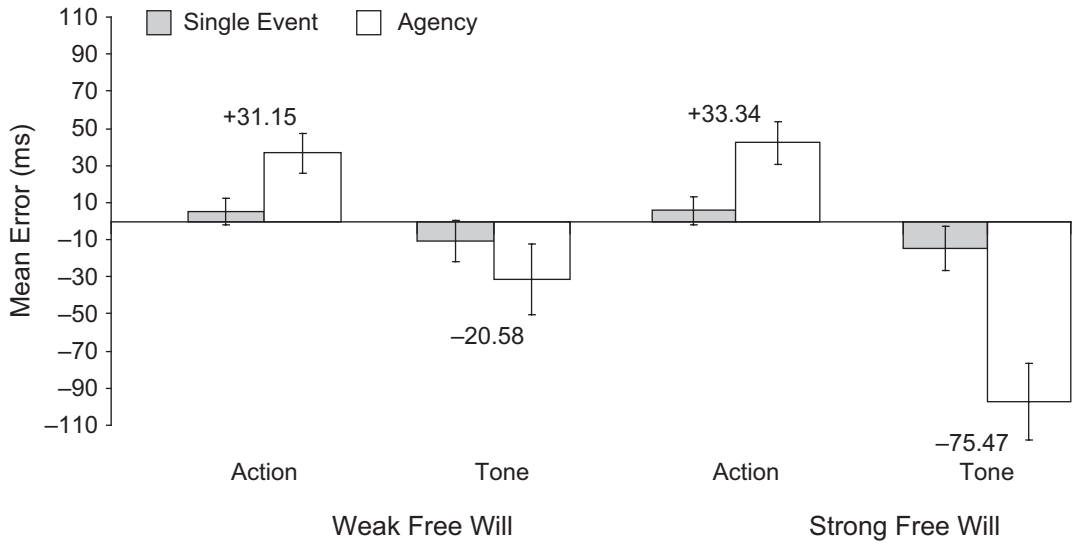

Fig. 1. Mean error in Experiment 1 as a function of the event judged (action vs. tone), whether the event took place in a single-event or agency trial, and belief in free will (1 *SD* below vs. above the mean score). The numbers above and below the bars indicate the mean shifts (in milliseconds) between single-event and agency trials. Error bars represent standard errors.

Pearson correlations showed that FW score did not correlate significantly with task importance, $r = -.05$, $p = .74$, or with carefulness in using the clock, $r = .08$, $p = .61$. Thus, task importance and carefulness in clock use do not explain the observed relation between intentional binding and beliefs in free will.

Experiment 2

Results of Experiment 1 showed that the perceived times of action and outcome shift toward each other to a greater degree when beliefs in free will are stronger. This binding process reflects the extent to which goal-directed behavior is experienced as intentional and self-caused, thus offering a conscious route by which beliefs in free will are associated with self-agency.

In Experiment 2, we took this idea of an association between free-will beliefs and experience of self-agency one step further. As noted earlier, the unconscious route to beliefs in free will may arise from inferred experiences of self-agency resulting from matches between unconsciously preactivated and actual outcomes (Wegner, 2002). Building on this notion, we tested the hypothesis that unconsciously priming the outcome of an action before the outcome occurs augments the experience of self-agency, but that this outcome-priming effect is more pronounced when free-will beliefs are stronger.

Method

Participants. Fifty-five undergraduates participated in Experiment 2 in return for a small payment.

Procedure. The agency priming task was taken from Aarts et al. (2005). Participants were seated behind a computer. They were instructed to press and hold down the "S" key on the keyboard to cause a gray square to rapidly traverse a rectangular path, consisting of eight white tiles, in a counterclockwise direction. The computer independently moved another gray square along the path at the same speed, but in the opposite direction (clockwise). The positions of the participants' and computer's gray squares were shown in rapid alternation. At a certain point in time, participants had to press the "Enter" key. This action turned one of the eight white tiles black, and this tile was said to represent the position of either participants' own square or the computer's square at the time of the key press. Thus, the stop (represented by the black tile) at that specific position could have been caused by the participants' key press or by the computer. Each time the movement was stopped, they were asked to indicate whether they had caused the square in the display to stop at that position (0 = *not me*, 1 = *me*). Each of the eight tiles on the path was presented as the stopping location four times, for a total of 32 trials.

Each trial began with a warning signal. Next, the message "Start" appeared in the center of the display until the participant pressed the "S" key. The participant's and the computer's squares then began to move along the path. Squares were displayed for 60 ms at each position. Thus, the speed of one lap was 960 ms. The number of laps that occurred in a trial was programmed to vary randomly between 8 and 10. When the message "Stop" appeared in the center of the computer screen, only the eight white empty tiles were shown, until the participant pressed the "Enter" key. A black square was presented 100 ms after the key press. The placement of this square was always four positions farther than the last position of the participant's square before the "Stop" message appeared. Thus, participants did not have actual control of where the black square was. Cues for responding were displayed in the middle of the rectangular path. Participants were instructed to keep focused on the cues during the task.

In 16 of the 32 trials, a black square was flashed on the pathway before "Stop" appeared. This primed location was always the same as the subsequently presented position of the black square. The prime occurred 40 ms after the last presentation of the participant's square. The prime was presented for 34 ms and was followed 46 ms later by the "Stop" message (thus, the total priming period was 120 ms). In the no-prime condition, the position of the black square was not flashed (the position was presented in white for 34 ms). Every possible location was primed twice. Trials were presented in random order. The average of the self-agency ratings (0 = *no*, 1 = *yes*) served as the main dependent variable.

After the task, participants completed the FW scale. Finally, two questions measured how important participants perceived the task to be and the extent to which they carefully attended to the task (1 = *not at all*, 10 = *to a great extent*).

Debriefing. As in our earlier work (e.g., Aarts et al., 2005), debriefing showed that none of the participants had seen the primes, indicating that outcome priming occurred outside of awareness. Furthermore, none of the participants realized the true nature of the study. One participant misunderstood the task instructions and was omitted from the analyses.

Results and discussion

The average ratings of self-agency were subjected to a general linear model analysis with priming condition (no prime vs. prime) as a within-subjects variable and FW score as a continuous variable. This analysis yielded a main effect of priming, $F(1, 52) = 17.45$, $p < .01$, $\eta_p^2 = .25$, and a marginally significant effect of FW score, $F(1, 52) = 2.85$, $p = .10$, $\eta_p^2 = .05$. These effects were qualified by a significant interaction between priming and FW score, $F(1, 52) = 4.13$, $p < .05$, $\eta_p^2 = .07$.

To examine this interaction in more detail, we estimated the effect of priming on self-agency for participants with a low FW score (1 *SD* below the mean) and for participants with a high FW score (1 *SD* above the mean). These analyses revealed a substantial priming effect among participants with a high FW score. Priming strongly augmented these participants' experiences of self-agency, $F(1, 52) = 19.23$, $p < .001$, $\eta_p^2 = .27$.

Furthermore, there was a nonsignificant tendency for priming to enhance the experienced self-agency in participants with a low FW score, $F(1, 52) = 2.23$, $p = .14$, $\eta_p^2 = .04$ (see Fig. 2 for means).

There were no reliable effects of priming condition, FW score, or the interaction between the two on participants' speed of pressing the key in response to the stop signal. Thus, these variables did not affect participants' behavior.

Pearson correlations showed that FW score did not correlate with perceived task importance, $r = .02$, $p = .88$, or with carefulness in attending to the task, $r = -.06$, $p = .69$. Thus, task importance and attention to the task cannot explain the relation between outcome-priming effects on self-agency and beliefs in free will.

General Discussion

The present research was motivated by two observations. First, people can have strong beliefs in free will: They think they are able to cause their own actions and outcomes. Second, people's behavior can have both conscious and unconscious sources: People engage in goal-directed action by consciously intending to realize action outcomes and after being unconsciously primed with action outcomes. These observations raise an important and fundamental question: Are free-will beliefs associated with conscious and unconscious processing of information involved in goal-directed behavior and self-agency?. We have reported two experiments to examine this issue. Specifically, we have shown that beliefs in free will are especially strong when (a) conscious intentions to produce action outcomes bind the perception of action and outcome together in time and (b) unconscious priming of action outcomes creates experiences of self-agency when the primed outcomes occur.

Our experiments do not allow us to draw conclusions about the causal status of free-will beliefs in the conscious and unconscious processing of action-outcome information, but the established association between free-will beliefs and self-agency offers new and important evidence of how the mind may create and bolster beliefs in free will. For example, the difference in intentional binding between participants with weak versus strong free-will beliefs indicates that the mind can be differentially tuned to deal with predictive signals of the sensory effects of actions. People who establish stronger beliefs in free will seem to more strongly process predictive signals of effects that result from their intentional actions. Researchers have proposed that the processing of these predictive signals relies on the parietal-frontal circuit involved in intentional behavior (e.g., Anderson & Cui, 2009; Brass & Haggard, 2008), and such processing has been implicated in the development of psychiatric disorders such as obsessive-compulsive disorder and schizophrenia (e.g., Blakemore, Wolpert, & Frith, 2002; Kim, Ha, & Kwan, 2004). Furthermore, it also seems likely that mesolimbic reward pathways play a role and that incentives alter the processing of predictive signals of action effects (Aarts, Dogge, & Deelder, 2010; Gottlieb, 2007). Thus, differences in cortical functioning and motivation may underlie the association between beliefs in free will and intentional binding.

Fig. 2. Mean experienced self-agency (0 = *no*, 1 = *yes*) in Experiment 2 as a function of priming condition (no prime vs. prime) and belief in free will (1 *SD* below vs. above the mean score). Error bars represent standard errors.

Furthermore, the observed relation between unconscious outcome-priming effects on self-agency and beliefs in free will suggests that people's view of their ability to cause their own behavior (i.e., that outcomes are caused by their own actions) relies on an unconscious authorship process. This process is susceptible to primes that render the representation of action outcomes active before one performs an action and observes the corresponding outcome; such primes lead people to infer that their behavior was self-caused when in fact it was influenced by the environment. The authorship process has been shown to be independent of culture (Aarts, Oikawa, & Oikawa, 2010), but a recent study suggests that it can be modulated by attention (Van der Weiden, Aarts, & Ruys, 2010). This opens the possibility that beliefs in free will differ between people as a result of differences in attending to and mentally representing behavior in terms of outcomes. Combining these insights with the findings of Experiment 1 suggests that beliefs in free will modulate and are reinforced by the way people process predictive signals of intended action outcomes and draw causal inferences when outcomes occur in the external world.

It is important to note that in our priming study, participants were not the actual cause of the primed outcomes, and, hence, the self-agency experiences were illusive. This demonstration of an illusion of self-causation is informative, as it demonstrates that feelings of control do not always correspond with actual control (Dijksterhuis & Aarts, in press). Beliefs in free will can be related to actually causing one's own actions and outcomes, and thus can carry veracity. But these beliefs can also reflect an inaccurate assessment of actual causes and a rather deceptive view on the faculty of the human mind.

Finally, the present studies raise the issue of where beliefs in free will actually come from. Given the correlational nature of our experiments, we are not in a position to make strong claims about this issue, but we can offer some speculative thoughts. A recent study has shown that people from different

cultures believe that human beings have a special power of free will (Sarkissian et al., 2010). This suggests that there must be some more fundamental basis for the fact that people—whatever culture they happen to grow up in—believe themselves to be the agents of their own behavior. We examined two basic phenomena (intentional binding and unconscious outcome priming in self-agency) to shed new light on this matter. It is clear that the religious and ethical systems to which people subscribe shape their understanding and expression of free-will beliefs (e.g., Kymlicka, 1991; Lessig, 2004). Apart from this link between social context and beliefs in free will, though, our experiments offer important evidence concerning how conscious and unconscious mental processes may contribute to these beliefs (Gilbert, 1991). We therefore hope that future research will not only address the societal contribution to and merits of beliefs in free will, but also take up the challenge to illuminate how these beliefs may shape and derive from the workings of the mind.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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References

Aarts, H., Custers, R., & Marien, H. (2009). Priming and authorship ascription: When nonconscious goals turn into conscious experiences of self-agency. *Journal of Personality and Social Psychology*, *96*, 967–979.

Aarts, H., Custers, R., & Wegner, D.M. (2005). On the inference of personal authorship: Enhancing experienced agency by priming effect information. *Consciousness and Cognition*, *14*, 439–458.

Aarts, H., Dogge, M., & Deelder, M. (2010). *Motivation and the sense of self-agency: Positive reward signals modulate the intentional binding between action and outcome*. Unpublished manuscript, Utrecht University, Utrecht, The Netherlands.

Aarts, H., Oikawa, M., & Oikawa, H. (2010). Cultural and universal routes to authorship ascription: Effects of outcome priming on experienced self-agency in The Netherlands and Japan. *Journal of Cross-Cultural Psychology*, *41*, 87–98.

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.

Anderson, R.A., & Cui, H. (2009). Intention, action-planning, and decision making in parietal-frontal circuits. *Neuron*, *63*, 568–583.

Bargh, J.A. (2008). Free will is un-natural. In J. Baer, J. Kaufman, & R. Baumeister (Eds.), *Are we free? The psychology of free will* (pp. 128–154). New York, NY: Oxford University Press.

Blakemore, S.J., & Frith, C. (2003). Self-awareness and action. *Current Opinion in Neurobiology*, *13*, 219–224.

Blakemore, S.J., Wolpert, D.M., & Frith, C.D. (2002). Abnormalities in the awareness of action. *Trends in Cognitive Sciences*, *6*, 237–242.

Brass, M., & Haggard, P. (2008). The what, when, whether model of intentional action. *The Neuroscientist*, *14*, 319–325.

Custers, R., & Aarts, H. (2010). The unconscious will: How the pursuit of goals operates outside of conscious awareness. *Science*, *329*, 47–50.

Dijksterhuis, A., & Aarts, H. (in press). Control, consciousness and agency. In H. Aarts & A.J. Elliot (Eds.), *Goal-directed behavior.* New York, NY: Psychology Press.

Gilbert, D.T. (1991). How mental systems believe. *American Psychologist*, *46*, 107–119.

Gottlieb, J. (2007). From thought to action: The parietal cortex as a bridge between perception, action, and cognition. *Neuron*, *53*, 9–16.

Haggard, P., Clark, S., & Kalogeras, J. (2002). Voluntary action and conscious awareness. *Nature Neuroscience*, *5*, 382–385.

Kim, M.-S., Ha, T.H., & Kwan, J.S. (2004). Neurological abnormalities in schizophrenia and obsessive-compulsive disorder. *Current Opinion in Psychiatry*, *17*, 215–220.

Kymlicka, W. (1991). *Liberalism, community and culture*. New York, NY: Oxford University Press.

Lessig, L. (2004). *Free culture: The nature and future of creativity*. New York, NY: Penguin.

Libet, B. (2004). *Mind time: The temporal factor in consciousness*. Cambridge, MA: Harvard University Press.

Nichols, S. (2004). The folk psychology of free will: Fits and starts. *Mind & Language*, *19*, 473–502.

Paulhus, D.L., & Carey, J. (in press). Measuring beliefs in free will and related constructs. *Journal of Personality Assessment*.

Sarkissian, H., Chatterjee, A., De Brigard, F., Knobe, J., Nichols, S., & Sirker, S. (2010). Is believe in free will a cultural universal? *Mind & Language*, *25*, 346–358.

Van der Weiden, A., Aarts, H., & Ruys, K.I. (2010). Reflecting on the action or its outcome: Behavior representation level modulates outcome priming effects on self-agency experiences. *Consciousness and Cognition*, *19*, 21–32.

Vohs, K.D., & Schooler, J. (2008). The value of believing in free will: Encouraging a belief in scientific determinism increases cheating. *Psychological Science*, *19*, 49–54.

Waldman, D.A., Viney, W., Bell, P.A., Bennett, J.B., & Hess, S. (1983). Internal and external locus of control in relation to beliefs in free will and determinism. *Psychological Reports*, *53*, 631–635.

Wegner, D.M. (2002). *The illusion of conscious will*. Cambridge, MA: MIT Press.

Wegner, D.M., & Wheatley, T. (1999). Apparent mental causation: Sources of the experience of will. *American Psychologist*, *54*, 480–492.