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Vicarious Agency: Experiencing Control Over the Movements of Others

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Participants watched themselves in a mirror while another person behind them, hidden from view, extended hands forward on each side where participants' hands would normally appear. The hands performed a series of movements. When participants could hear instructions previewing each movement, they reported an enhanced feeling of controlling the hands. Hearing instructions for the movements also enhanced skin conductance responses when a rubber band was snapped on the other's wrist after the movements. Such vicarious agency was not felt when the instructions followed the movements, and participants' own covert movement mimicry was not essential to the influence of previews on reported control.

When you wave your hand in the air, how do you know you're the one who did it? And when someone else's hand waves, how do you know you're not the source of the movement? These questions seem absurd to the normal human, of course, but their very absurdity suggests that each of us has in place an efficient system of mind that gives us an immediate sense of authorship for some actions and not for others. This system seems likely to draw on the fact that we usually know what we are going to do before we do it, and we thus experience a sense of conscious will for actions we know in advance. The present studies explored the role of such prior knowledge of action by examining whether knowing what another person's hands will do can enhance the sense that we are vicariously controlling the other's hand movements—even when such control is objectively impossible.

Authorship Processing

Most people can readily sort many events in the world into those they have authored and those they have not. This observation suggests that each person has a system for *authorship processing* (Wegner & Sparrow, in press), a set of mental processes that monitors indications of authorship to judge whether an event, action, or thought should be ascribed to self as a causal agent. Authorship processing is distinct from causal attribution more generally, because authorship processing is a form of causal inference in which events are attributed to agents. Fritz Heider (1958; Heider & Simmel, 1944) emphasized that the perception of agency or authorship in animate objects is quite unlike the perception of causation that occurs for physical events or inanimate objects. Agents are seen as first causes or uncaused causes, origins of action to which authorship can be ascribed because they appear to cause events through self-movement (Johnson, 2003). Because human agents have access to a variety of sources of information about authorship that would be irrelevant to the attribution of causality for physical events (e.g., one's own thoughts and interoceptive sensations), authorship processing needs to be understood apart from causal attribution.

In an analysis of authorship processing, Wegner and Sparrow (in press) have suggested that a set of *authorship indicators* is consulted when people make judgments of their own agency. Of the many such indicators illustrated in the literatures on social attribution (e.g., Gilbert, 1998; E. E. Jones et al., 1972; Kruglanski, 1975), agent perception (e.g., Baron-Cohen, 1995; Dennett, 1987; Johnson, 2003; Malle, 1999), self-perception (e.g., Bem, 1972; Nisbett & Wilson, 1977; Wegner, 2002; Wilson, 2002), and interoception (Craig, 2003; Frith, Blakemore, & Wolpert, 2000; Gandevia & Burke, 1992; Jeannerod, 1997), the elemental indicators appear to include the following:

Body and environment orientation cues. Knowing where the body is and what tools or environmental opportunities are available in its current orientation helps to determine what the person could have authored (Dijksterhuis & Bargh, 2001; Goldman, 1970; Vallacher & Wegner, 1985). Actions are afforded a person by a setting (Gibson, 1977), so information about the interrelation of person and setting is a first step in understanding authorship.

Direct bodily feedback. Sensory feedback from body to brain includes proprioceptive and kinesthetic sensations from muscles, skin, joints, and tendons as well as from the vestibular system (Gandevia & Burke, 1992; Georgieff & Jeannerod, 1998). This feedback can influence perceptions of authorship for actions that cannot even be seen (L. A. Jones, 1988).

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Direct bodily feed forward. Signals from brain to body can influence the experience of authorship, as when the predicted sensory consequences of action are incorrect (Blakemore & Frith, 2003; Blakemore, Wolpert, & Frith, 2002). Delusions of control, when actions are thought to be controlled by alien forces, may result from a breakdown of this forward loop (Blakemore, Smith, Steel, Johnstone, & Frith, 2000).

Visual and other indirect sensory feedback. Viewing, hearing, or otherwise indirectly sensing movements can influence authorship judgments, as suggested by studies of false visual action feedback (Nielson, 1963). Daprati et al. (1997), for example, found that people presented with false video representations of the movements of their own hands were sometimes influenced to experience the videos as authentic.

Social cues. Indications that an action imitates the action of another or obeys the command of another can influence perceived authorship (Kelley, 1972). Milgram (1974) remarked on the loss of the feeling of responsibility for action that occurs during obedience, for example, describing this sensation as an "agentic shift." Similar reductions of experienced authorship of action are reported by people in hypnosis (Lynn, Rhue, & Weekes, 1990) and by those induced to imitate others' actions (Sparrow & Wegner, 2004).

Action consequences. Inferences of authorship arise when actions have consequences for agents, such as satisfying or thwarting their goal achievement (E. E. Jones & Davis, 1965; Langer & Roth, 1975). People are more likely to locate causality in the self when they have succeeded in performing an action, for example, and are less likely to do so when they have failed.

Action-relevant thought. Authorship is likely to be inferred when the agent has action-relevant thoughts that occur prior to the action (Wegner & Wheatley, 1999). For example, when participants attempted to stop a square moving on a computer screen, a movement that could also have been stopped by the computer, they judged themselves to have more authorship for the movement when the stop position had been primed (Aarts, Custers, & Wegner, 2004).

The sense that you are the one who waved your arm, in other words, is the result of input from a remarkably wide array of information sources. Research has focused on each of these authorship indicators to some degree, but has examined the role of action-relevant thought only rarely. It is clear, however, that one of the most telling differences between self and other is that we usually know what we are going to do, whereas we do not have such cognitive previews for actions performed by others. The previews our minds provide, in the form of intentions, plans, or other conscious thoughts, may often be responsible for the experience of authorship we possess for our own actions. How can the influence of such prior thought be understood?

Conscious Will and Authorship

Processing one's own authorship is a subset of the general problem of processing the authorship of any agent. However, there is an important difference. When we ascribe an act to another person, we often do so dispassionately, noting merely that this is something they have done ("she ran the stoplight"). Part of authorship processing involves just such judgments pertaining to ourselves. However, when we sense our own authorship of an action, there is an additional quality present, a feeling of doing, that marks the event uniquely. The feeling of consciously willing the action adds a psychological exclamation point ("I ran the stoplight!").

The experience of consciously willing an action has been described as an *authorship emotion* (Wegner, 2002), a feeling that ties the basic fact of the causal event to a bodily response and lends it a sense of "embodiment" (Barsalou, Niedenthal, Barbey, & Ruppert, in press). The experience of conscious will need not be a veridical expression of how the action came about (although people tend to interpret it this way), but it does serve to authenticate the action as something done by the self. Authorship seems to be a self-recognition of agency, then, that has both a rational component (knowledge that one was the agent causing the action) and an experiential component (the feeling of consciously willing the action).

The development of the experiential component of one's own action authorship is the focus of the theory of apparent mental causation. According to this theory, the feeling that we consciously will our own actions is traceable to an inference we make from the match between our conscious thoughts and observed action (Wegner, 2002, 2003, in press; Wegner & Wheatley, 1999). When a thought appears in consciousness just prior to an action, is consistent with the action, and is not accompanied by salient alternative causes of the action, we experience conscious will and ascribe authorship to ourselves for the action. Thoughts occurring with such priority, consistency, and exclusivity do not arise as regularly for the actions of others, and this absence may often prevent us from adopting others' actions as our own.

Illusions of authorship can arise when these sources of information are unclear. Problems of exclusivity that arise when someone is coacting with another, for example, yield venerable illusions such as Ouija board spelling. In research modeled on the Ouija situation, Wegner and Wheatley (1999) found that supplying participants with a thought consistent with and prior to an action they were forced by their partner to perform was sufficient to give participants the sense that they had intentionally performed the action. Pronin and Wegner (2004) studied the operation of the consistency principle in another way, finding that participants who were led to have malevolent thoughts about a person were more likely than others to claim responsibility for harming the person. Wegner, Fuller, and Sparrow (2003) found that when people helping another person to communicate were told that the cause of the communication was not exclusively their own thoughts, the helpers often lost track of the authorship of their own actions and ascribed authorship instead to the person they were helping. These findings suggest that the presence of information that prompts consistent, prior, and exclusive thoughts of another's actions might influence people to experience the sense that they have exerted control over those actions.

Vicarious Agency

Prior studies of authorship processing have focused on actions the person could plausibly understand as belonging to self. The

principles of apparent mental causation should still operate to influence the experience of authorship, however, even when objective circumstances mitigate against a rational judgment that the action is one's own. When the action is clearly occurring to another person's body, for example, apparent mental causation might still prompt some experience of agency. The role of prior consistent thoughts about action in determining authorship should be particularly acute, for example, when other sources of authorship information (such as visually discernible separation of self and other in space, visual feedback, proprioceptive feedback, etc.) are unavailable or unclear. Some prior studies have examined authorship illusions that occur under such information-impoverished conditions, thereby pointing to instances of what might be called *vicarious agency*—feelings of authorship for the actions of others.

An experience of vicarious agency of one sort, for example, was documented by Nielson (1963). He had participants insert a gloved hand in a viewing box and then on a signal draw a line down a piece of paper. Unknown to them, the hand they viewed in the box was actually a mirror reflection of an experimenter's hand, also gloved and holding a pen, which appeared in the spot where they would expect their own hand to be. When the experimenter's hand deviated from the line by tracing to the right, participants did not discover the deception, and instead "corrected" the tracing by moving their own hand to the left.

Contemporary studies using variations of this paradigm have examined the relative strength of various authorship indicators (e.g., vision vs. proprioception) in normal and special populations. Among normal individuals, visual information about one's actions can often override direct proprioception in this way (Fourneret & Jeannerod, 1998; Pavani, Spence, & Driver, 2000). In special groups, the experience of vicarious agency can be even more profound. Ramachandran and Rogers-Ramachandran (1996) found that arm amputees who experience voluntary movement of a phantom limb reported that visual presentation of an arm in position of the phantom (either their own contralateral arm in a mirror or the experimenter's arm) prompted a dramatic experience of voluntary movement of the visually presented arm. When the fingers wiggled or the hand waved, they sensed themselves doing this.

According to the apparent mental causation theory, vicarious agency should be particularly strong when prior thoughts occur that are consistent with an observed action. Evidence for this possibility was found in a study of patients with apraxia, which disrupts the ability to produced skilled voluntary movements (Sirigu, Daprati, Pradat-Diehl, Franck, & Jeannerod, 1999). These patients were asked to make finger movements, such as crossing the middle over the index finger, and to discriminate whether video presentations showed their own fingers or those of an experimenter. When the observed movement matched the instructed movement, they often claimed that the movement was their own—even when their motor disturbance generally prevented them from moving their fingers in the observed manner. Apparently, thinking of the correct action and observing it yielded an illusion of mental causation even when direct sensation of disturbed movement contradicted this experience.

The importance of consistent prior thoughts for the experience of vicarious agency is also shown by research in which these thoughts are absent. Such deficits in knowledge of action are characteristic of people with schizophrenia who are hallucinating, and frequent authorship confusions are reported in this group as a result. People with schizophrenia experience hearing voices, for example, apparently because they have thoughts that do not follow consistently from prior thinking. These inconsistent thoughts are difficult to attribute to their own authorship and are instead ascribed to imaginary agents (Hoffman, 1986). In line with this interpretation, a study in which participants viewed video of the movements of own and others' gloved hands found that failures to identify the authorship of own hand movements were particularly pronounced among participants with schizophrenia (Daprati et al., 1997).

The present experiments tested the influence of foreknowledge of action on vicarious agency in normal participants. Participants watched themselves in a mirror as another person hidden immediately behind them extended arms forward on each side of them. This is a pantomime sometimes known as *helping hands*. The person behind the participant then followed instructions delivered over headphones for hand movements. The main prediction was that when participants heard these instructions, they would experience a greater sense that they were controlling these movements than when they saw the movements without such previews.

Experiment 1

Method

Undergraduates fulfilling a psychology course requirement at the University of Virginia arrived at the lab in previously unacquainted pairs (24 female pairs, 9 male pairs). One member of each pair was randomly designated the participant and the other was designated the hand helper. The participant faced a full-length mirror and donned first a pair of gloves, then a smock that had a cardboard back extending above his or her head, and then a pair of headphones. Participants' arms remained at their sides, out of view under the smock. The hand helper put on headphones and a similar pair of gloves, stood immediately behind the participant such that smock and cardboard obscured his or her face and shoulders, and reached arms forward through sleeves attached to the shoulders of the smock (see Figure 1). The hand helper's arms thus extended on each side of the participant, appearing in the position of the participant's own arms both from the participant's normal viewpoint and in the participant's mirror reflection. Participants were asked to watch in the mirror and not move their own arms.

Hand helpers were told that they would hear a sequence of instructions over the headphones. Participants were told that they might or might not hear anything over their headphones and that whatever was heard might or might not relate to the actions of the helper. A tape of action instructions lasting 3.5 min was played, giving a series of 26 instructions (e.g., "wave hello with your right hand," "give the OK sign with both hands," "hold up your left hand and spread the fingers apart," etc.). Participants in the preview group ($n = 16$) heard these instructions as the hand helper followed them, whereas those in a no-preview comparison group ($n = 17$) heard nothing through the headphones.

After the participants finished this exercise and extricated themselves from the paraphernalia, they made several ratings of their experience (on 7-point scales from 1 = *not at all* to 7 = *very much*). One question was included to check the success of the manipulations ("To what degree did you feel you could anticipate the movements of the arms?"). The key questions called for ratings of the degree of authorship elicited by the manipulations ("How much control did you feel that you had over the arms' movements?"; "To what degree did you feel you were consciously willing the arms to move?"). Questions were also asked to tap participants'

Figure 1. A participant viewed from the front, as she would see herself in the mirror (on left), and participant with hand helper as viewed from the side (on right).

other feelings regarding the experience ("To what degree did the arms look like they belonged to you?"; "To what degree did the arms feel like they belonged to you?"; "Did the arms bother or annoy you?"). When they finished their ratings, participants were debriefed and dismissed.

Results and Discussion

The manipulation was checked with the item, "To what degree did you feel you could anticipate the movements of the arms?" Participants who heard previews of the actions reported significantly greater anticipation ($M = 4.50$, $SD = 0.97$) than those who did not ($M = 2.71$, $SD = 1.61$), $t(31) = 3.85$, $p < .001$, $\eta^2 = .32$. The two questions regarding aspects of authorship of the arms' movements ("How much control did you feel that you had over the arm's movements?" and "To what degree did you feel that you were consciously willing the arms to move?") were correlated with one another, $r(31) = .44$, $p < .05$, so the mean of these item ratings was used as an index of vicarious agency. In line with our hypothesis, the participants receiving previews expressed an enhanced feeling that they were able to control and will the arms' movements. Mean vicarious control ratings were significantly greater with previews ($M = 3.00$, $SD = 1.09$) than without ($M = 2.05$, $SD = 1.61$), $t(31) = 2.68$, $p < .02$, $\eta^2 = .19$.

Ratings of other variables did not differ between conditions. Previews did not significantly influence ratings of "To what degree did the arms look like they belonged to you?" (preview, $M = 4.25$, $SD = 1.53$; no preview, $M = 3.82$, $SD = 1.33$), $t(31) = .86$, $p = .40$; or "To what degree did the arms feel like they belonged to you?" (preview, $M = 3.25$, $SD = 1.52$; no preview, $M = 2.76$, $SD = 1.33$), $t(31) = 1.02$, $p = .32$; or "Did the arms bother or annoy you?" (preview, $M = 2.81$, $SD = 1.38$; no preview, $M = 2.82$, $SD = 1.63$), $t(31) = .02$, $p = .98$. Overall, then, the previews did not yield a radical sense of transformation—only the predicted increment in the experience of control.

These findings are suggestive, but they depend on self-report and might conceivably be explained as resulting from participants' guessing the hypothesis and attempting to please the experimenter. Postexperimental questioning (i.e., "Do you have any guesses about what was being studied in this experiment?") indicated that no participant was able to articulate the hypothesis, but further evidence is desirable on the potential role of experimental demand. For a second study, therefore, measurement of the influence of previews was extended beyond self-reports of the experience of control to include a psychophysiological measure.

Experiment 2

This study amplified the prior experiment in two ways. First, participants' electrodermal responses to an insult to the other's hands (a rubber band snap on the wrist) were assessed to learn whether vicarious control might be associated with an empathic bodily response to the hands. Second, the no-preview and preview conditions of the prior experiment were supplemented with an inconsistent-preview condition. This condition gave participants an incorrect instruction for each hand movement to discern whether such previews might undermine vicarious control compared with no preview and to rule out the converse possibility that any instruction, even an inconsistent one, might have the effect of enhancing vicarious control.

Method

Undergraduates at Harvard University (95 women and 42 men) participated for credit in an introductory psychology course. Data for 13 other participants were not included because of equipment failure in measuring skin conductance or because they moved in response to the hand helper's instructions. The procedure was like that of Experiment 1, but here two experimenters were present at each session and one (of the same sex as the

participant) was the hand helper for the participant. A total of 32 hand-movement instructions were given in this study.

Also for this experiment, the hand helper wore a rubber band on one wrist some 4 cm above the glove. It was explained that the hand helper would snap the band against the wrist both just before and just after the hand movement session. For the snap, the hand helper lifted the band 8–10 cm and let it go sharply against the inner wrist. The participant's skin conductance was measured, with resting periods of 15 s included before and after each snap. Skin conductance was measured with finger electrode placement as recommended by Fowles et al. (1981). The participant's fingers were cleaned, conductivity gel was applied, and Ag/AgCl electrodes were affixed with Velcro fasteners to the medial phalanges of the first and second fingers of the nondominant hand. Measurements were made with an IG-3 preamp and Model T-68 amplifier (J & J Enterprises, Poulsbo, WA), and a video camera recorded the digital readout. As in the first study, participants wore gloves like those of the hand helper.

Participants were randomly assigned to one of three conditions. In addition to consistent preview and no-preview conditions like those of Experiment 1, an inconsistent preview condition was included in which participants heard instructions timed to coincide with the hand helper's instructions but not matching what the hand helper heard and enacted. These inconsistent instructions were a reordering of the instructions given the hand helper, and four instructions were replaced with entirely new ones the hand helper never enacted. Both participant and experimenter donned headphones, plugged into the same channel for consistent instructions and separate channels for inconsistent instructions. Participants in the no-instruction condition heard nothing through the headphones. No preview instruction was given in any condition for the rubber band snaps.

Results and Discussion

Responses to the manipulation check question of whether participants could anticipate the arms' movements varied significantly across conditions, $F(2, 134) = 57.70$, $p < .001$, $\eta^2 = .46$. The consistent-preview group reported greater ability to anticipate ($M = 4.93$, $SD = 1.36$) than either the no-preview group ($M = 2.46$, $SD = 1.33$) or the inconsistent-preview group ($M = 2.29$, $SD = 1.27$), $p < .05$ in each case (Newman-Keuls), and the latter groups did not differ.

A vicarious control index was computed as in Experiment 1, the mean of the control and will items, which were again significantly correlated, $r(135) = .38$, $p < .001$. The conditions varied significantly in vicarious control experience by this index, $F(2, 134) = 6.50$, $p < .005$, $\eta^2 = .09$. Consistent previews prompted greater feeling of control ($M = 2.46$, $SD = 1.28$) than either no previews ($M = 1.74$, $SD = 0.87$) or inconsistent previews ($M = 1.77$, $SD = 0.87$), $p < .05$ in each case (Newman-Keuls), and the latter groups did not differ. These results replicated those of Experiment 1 and show that inconsistent previews, rather than undermining the experience of vicarious control, leave it at the same reduced level produced by no preview. Apparently, the basic low level of vicarious control yielded by not knowing actions in advance is not further reduced when available knowledge of the action is actually spurious. This result also provides assurance that the enhanced vicarious control observed in Experiment 1 was due to consistent previews and not merely to hearing any instruction, because the inconsistent previews did not inflate vicarious control in comparison with no previews.

One self-report difference that had not been found in the prior experiment was observed among conditions. The conditions produced differing reports of whether the arms "bothered or annoyed" the participant, $F(2, 134) = 3.70$, $p < .01$, $\eta^2 = .10$. The group who heard the inconsistent preview found the arms more annoying ($M = 3.31$, $SD = 1.72$) than the no-preview group ($M = 2.07$, $SD = 1.30$), $p < .05$, with the consistent-preview group between ($M = 2.70$, $SD = 1.63$) and not significantly different from either (by Newman-Keuls). Hearing inconsistent previews influenced the emotional feel of the experience, even as it did not reduce what were already low feelings of control. Hearing instructions for the arms to do one thing and then finding them repeatedly doing another was apparently enough to make them annoying.

The skin conductance measure revealed a pattern suggesting that vicarious control was accompanied by a sense of empathy with the arms. An index of skin conductance response (SCR) was computed for each participant for each rubber band snap. Skin conductance (in μSiemens) was measured at each of five 1-s intervals following the snap as the ratio to the baseline skin conductance measured at the moment of the snap. The SCR index, then, was the area between the skin conductance curve for the 5 s following the snap and a line with intercept at 1.00 and slope equal to the increment in skin conductance ratio per second over the 15 s following the snap (cf. Decety & Chaminade, 2003). Separate analyses were performed for the SCR index for the first snap (before participants experienced the series of arm movements) and for the second snap (which occurred when the arm movements were over).

The three conditions showed equal and large SCRs to the first snap (see Figure 2). The conditions did not differ, $F(2, 134) = 1.12$, $p < .5$, and the mean SCR across conditions ($M = .040$) was substantially greater than zero, $F(1, 134) = 44.15$, $p < .001$, $\eta^2 = .25$. This is the similarity one would expect prior to the experimental manipulation, and the overall response suggests that everyone found the first snap of the rubber band to be arousing. However, this response varied across conditions at the second snap of the rubber band, $F(2, 134) = 3.72$, $p < .03$, $\eta^2 = .05$ (see Figure 3). The consistent-preview participants showed a continued SCR ($M = .043$), which was greater than that of the combined inconsistent-preview ($M = .002$) and no-preview ($M = .018$) participants, $t(134) = 2.52$, $p < .02$, whereas the latter two groups did not differ, $t(89) = 1.33$, $p > .15$. Only the participants in the consistent condition responded to the reappearance of the rubber band snap with the same response they had shown for the first snap. Also, the correlation between SCR for first and second snaps

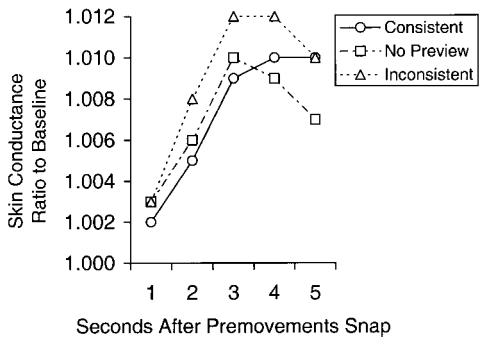

Figure 2. Skin conductance ratio to baseline by second following the premovements snap of the rubber band, for each of the preview conditions in Experiment 2.

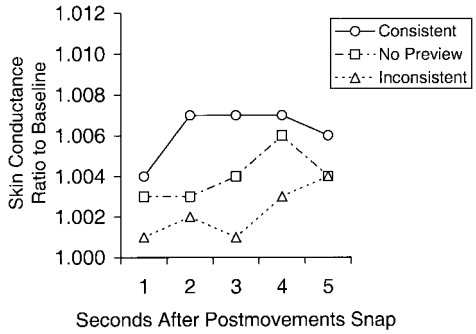

Figure 3. Skin conductance ratio to baseline by second following the postmovements snap of the rubber band, for each of the preview conditions in Experiment 2.

was only significant for consistent-preview participants, $r(135) = .76$, $p < .001$, suggesting that individual variations in the response to the first snap were played out again in responses to the second snap in that condition.

One way to conceptualize these findings is to say that the first SCR for all groups was an indication of an orienting response to a novel stimulus. This response may have been empathic in origin, or it may merely have been a startle to an aversive stimulus. The maintenance of this SCR after the movements in the consistent-preview group, however, represents a continued orienting response arising from a failure to habituate and may be attributable to the development of an empathic experience of the arms. The absence of this SCR in the groups with no preview and inconsistent preview, it follows, may be due to habituation of orienting to the snap stimulus following from a failure to generate an empathic experience of the arms. Other than through differential empathy, it is unclear why the consistent-preview group would not habituate whereas the other two groups apparently did so.

Evidence for the role of the experience of vicarious control in the production of this empathic effect was suggestive but not conclusive. A correlation analysis revealed that SCR at the second snap was significantly correlated with the manipulation check item—the report that the participant could anticipate the arms' movements, $r(135) = .25$, $p < .03$, and that SCR was not significantly correlated with the vicarious control index, $r(135) = .05$. However, an analysis of covariance showed that the effect of preview condition on SCR at the second snap was nonsignificant once the influence of these two ratings was removed, $F(2, 132) < 1$—although neither covariate in this analysis reached significance. These effects are not inconsistent with the idea that previews led to the SCR effect by enhancing vicarious control, but they do not establish it. Research using a more detailed array of self-report measures in this setting might be effective in assessing such mediation.

Experiment 3

This experiment tested the role of the timing of previews and the occurrence of the participants' own movements in the vicarious agency effect. Regarding timing, the priority principle of the theory of apparent mental causation suggests that previews must occur appropriately just before an action or they will not enhance apparent mental causation and give rise to an experience of will (Wegner, 2002; Wegner & Wheatley, 1999). To test this principle for vicarious agency, this study compared the effects of hearing movement instructions 3 s before the movements, hearing them simultaneously with the instruction to the hand helper, or hearing them 3 s following the movements. In a different paradigm, Wegner and Wheatley (1999) found that thought primes occurring 1 s or 5 s prior to action both produced enhanced feelings of authorship as compared with primes appearing 30 s early or 1 s late. On the basis of this finding, it was expected that the 3-s-late instruction in this setting would reduce vicarious control compared with the simultaneous instruction and 3-s-early instruction conditions in which the instructions served to preview the movements.

The second focus of this study was the role of participants' own movements in vicarious control. We had observed in the prior experiments that some participants made small movements under the smock in response to the instructions, and we found on post-experimental questioning that a number of people reported such covert mimicry. It could be that such movement, albeit at a very subtle level for most participants, might have been a standard response to the instructions and might have played a role in the experience of vicarious control. Proprioception for such movements might have contributed to the experience of vicarious control in some way, perhaps even serving as a requisite for any such experience. This potential influence would suggest that previews have an indirect influence on the experience of control rather than a direct one—via own movement production and proprioception—so the role of own movements deserves analysis.

Two unique experimental conditions were included here to explore the contribution of own movements to vicarious control. In one condition, participants were given the usual previews and also were explicitly instructed to perform subtle movements mimicking the instructed movement in response to each instruction. In another condition, participants were also given previews but were instructed to perform a distracting movement inconsistent with the instructed movements (tapping their hands against their legs at each instruction). If own movements consistent with previews are the pathway whereby previews enhance vicarious control, mimicry of the instructed movements should enhance preview effects, and distracting movements should undermine them.

Method

Harvard University undergraduates (69 women and 54 men) participated in return for credit in psychology classes. The procedure was much like that of Experiment 2, although here only one experimenter was involved per participant, matched for sex. Each participant was randomly assigned to one of six conditions, as follows:

No instruction. Participants heard no instructions for the hand movements and merely observed them as they occurred (as in Experiments 1 and 2).

Simultaneous instruction. Participants heard the instructions given to the hand helper as they occurred and observed the movements (as in the consistent-instruction conditions in Experiments 1 and 2).

Early instruction. Participants heard each instruction 3 s prior to the time at which the hand helper heard it. The movements were separated by an interval of 8 s, so these instructions occurred 5 s following the prior movement.

Late instruction. Participants heard each instruction 3 s after the time at which the hand helper heard it. The hand helper acted on instructions

immediately, so the movement was typically complete when the instruction was heard.

Simultaneous instruction with mimicry. Participants heard the instructions as they were given to the hand helper, as in the simultaneous-instruction condition, but also were asked to mimic the movement in a small way while their hands remained at their sides.

Simultaneous instruction with distraction. Participants heard the instructions as they were given to the hand helper, as in the simultaneous-instruction condition, but were also asked to tap their hands lightly against their legs at their sides each time they heard an instruction.

In the last two conditions, the experimenter was able to detect and verify the occurrence of the instructed mimicries and leg taps.

Results

Responses to the manipulation check were similar to those of Experiment 2. The question of whether participants could anticipate the arms' movements varied significantly across conditions, $F(5, 117) = 19.48$, $p < .001$, $\eta^2 = .45$. Participants who received either no instruction or late instruction, the two conditions without a preview, reported a reduced ability to anticipate the arms' actions compared with every other condition, all of which included a preview ($p < .05$ in each case, Newman-Keuls); means are displayed in Table 1. In addition, participants who received early instruction reported significantly greater ability to anticipate the movements ($M = 5.77$) than participants whose instruction arrived simultaneous to the arm movement ($M = 4.48$, $p < .05$). No other preview comparisons were significant.

The items measuring vicarious control in the prior studies ("How much control did you feel that you had over the arms' movements?" and "To what degree did you feel that you were consciously willing the arms to move?") were augmented in this experiment to improve scale reliability with an additional item ("Did it feel as though you consciously caused the arms' movements?"). The three items were correlated with one another, mean inter-item $r(117) = .41$, $p < .001$ (Cronbach's $\alpha = .67$), and their mean was used to assess vicarious control.

A one-way analysis of variance revealed a significant main effect of condition on this index of vicarious control, $F(5, 117) = 3.40$, $p < .008$, $\eta^2 = .13$; see Table 1 for means. This result was examined further in a series of planned contrasts arranged to explore specific patterns of theoretical interest.

Effects of instruction timing. The first planned contrast compared all preview conditions with all no-preview conditions. Weights of +1 (simultaneous instruction), +1 (early instruction), +1 (simultaneous instruction and mimicry), and +1 (simultaneous instruction and distraction) for preview conditions and −2 (no instruction) and −2 (late instruction) for no-preview conditions were assigned. This contrast was significant for preview ($M = 2.47$) versus no preview ($M = 1.76$), $F(1, 117) = 10.69$, $p < .002$. The finding that having a preview of action increases feelings of vicarious control was thus replicated from the prior experiments.

To examine effects of priority in more detail, two additional planned contrasts were performed. To see whether late instructions undermined vicarious control as compared with early or simultaneous instruction, a contrast was made with weights of −4 (late), +1 (simultaneous), +1 (early), +1 (simultaneous with mimicry), +1 (simultaneous with distraction), and 0 (no instruction). This contrast was significant, $F(1, 117) = 7.56$, $p < .008$, showing that late instructions reduced vicarious control ($M = 1.71$) compared with simultaneous or early instructions ($M = 2.44$). A contrast between late instruction ($M = 1.71$) and no instruction ($M = 1.82$) was not significant, $F(1, 117) < 1$. Thus, it appears that hearing instructions after the fact of the arms' movement does not enhance vicarious control. Late instruction operates the same as having no instruction at all, because there is no preview in either case.

Early instruction, in turn, did not change vicarious agency ($M = 2.55$) relative to all simultaneous instruction conditions ($M = 2.40$). The contrast between the early instruction condition and all the simultaneous instruction conditions was not significant (weights were +3 for early instruction, −1 for simultaneous instruction, −1 for simultaneous with mimicry, and −1 for simultaneous with distraction), $F(1, 117) < 1$.

Effect of own movements. Contrasts were performed to focus on the effects of own movement on participants' feelings of vicarious control over the movements of the arms. The first contrast tested whether mimicry ($M = 2.87$), when added to instruction, increased reports of vicarious control over instruction alone ($M = 2.29$). This contrast used weights of +3 (simultaneous instruction with mimicry), −1 (simultaneous instruction), −1 (early instruction), −1 (simultaneous instruction with distraction), 0 (late instruction), and 0 (no instruction) and was significant, $F(1, 117) = 4.06$, $p < .05$. Adding movement consistent with the preview provided through the instruction, then, enhanced feelings of vicarious control above the level produced by previews alone. Perhaps the visual feedback provided when a consistent arm movement was viewed in the mirror led people to misinterpret the feedback from their own muscle movement and so to amplify the experience of control over the others' arms. Alternatively, it might be that the feed-forward processes occurring in producing muscle

Table 1
Mean Movement Anticipation and Vicarious Control by Condition in Experiment 3

	Movement anticipation		Vicarious control	
Condition (*n*)	*M*	*SD*	*M*	*SD*
No instruction (21)	2.38	1.50	1.82	0.96
Simultaneous instruction (21)	4.48	1.47	2.02	1.02
Early instruction (22)	5.77	1.48	2.55	1.03
Late instruction (21)	2.48	2.06	1.71	1.02
Simultaneous instruction with mimicry (18)	5.17	1.34	2.87	1.30
Simultaneous instruction with distraction (20)	5.45	1.32	2.32	1.11

movements consistent with previews are involved as an amplifier of vicarious control.

In either event, given this apparent amplification effect, a key question is whether one's own imitative movement is in fact necessary for the experience of vicarious control. Perhaps the participants in the preview conditions in this and the prior experiments were spontaneously following the instructions they heard in the previews, albeit in a very subtle way not perceptible to the hand helper, and this consistent movement was essential to the creation of vicarious control. To test this possibility, contrasts were conducted to examine the effects of own movement that is inconsistent with the instruction, what we have termed the "simultaneous instruction with distraction" condition (in which participants tapped their hands against their legs during each hand helper arm movement).

If own muscle feedback consistent with the preview is necessary for previews to increase the experience of vicarious control, then inconsistent feedback from the distracting action should render the preview ineffective in producing enhanced vicarious control. The contrast between simultaneous instruction with distraction ($M = 2.32$) and no preview ($M = 1.76$), with weights of $+2$ for distraction and -1 for late and no preview, however, was marginally significant, $F(1, 117) = 3.52$, $p = .06$, indicating that the elimination of consistent movements by the participant was not sufficient to nullify the effect of the preview. A contrast to see if distraction ($M = 2.32$) was a detriment to previews occurring without distraction ($M = 2.48$), with weights of $+3$ for simultaneous instruction with distraction and -1 for each other preview condition (simultaneous instruction, simultaneous instruction with mimicry, and early instruction), was not significant, $F(1, 117) < 1$. Thus it appears that even with the distraction of inconsistent self-produced movement, having a preview tends to increase vicarious control over no preview. Moreover, such distraction also does not decrease vicarious control below that provided by the preview. Mimicry may help to enhance vicarious control experience by adding the sensation of own muscle movement to visual feedback of the other's arms, but own muscle movement consistent with the action is not essential for the influence of previews on vicarious control.

General Discussion

These studies examined some conditions under which people experienced a feeling that they could control another person's hands. In all three experiments, this experience of vicarious agency was enhanced significantly by the presence of a preview that allowed the anticipation of the action. Hearing instructions consistent with the action prompted reports of greater control of the action than did hearing no previews in all studies, hearing consistent instructions prompted reports of greater control than did an inconsistent preview in the second study, and hearing consistent instructions prior to the action yielded reports of greater control than did instructions following the actions in the third study.

The experiments also examined some physiological consequences and conditions of this effect. In the second study, when one of the observed hands snapped a rubber band on the other, participants who had previews of prior actions of the hands showed a sustained SCR to the snap, whereas those without previews showed a lessened SCR to the snap that followed the movements. Beyond the self-reported experience of control, then, exposure to previews of the action had an influence on electrodermal responses. These responses are not easily attributable to participants' potentially strategic responses to perceived experimental demand.

The third experiment explored the role of participants' own movements in the influence of previews on vicarious control experience. It was found that participants instructed to make their own subtle movements consistent with the instructions showed an enhanced level of vicarious agency but that these movements were not necessary for previews to enhance such agency. Participants who were instructed to make distracting movements inconsistent with the previews still tended to report a vicarious control experience. The feeling of moving another person's hands, in sum, was not dependent on participants' ability to move their own hands in the same way.

Experiences of Will

This research examined the experience of controlling another person's arms as a way of exploring what might be involved in the experience of controlling one's own arms. The curious implication of the research is that the experience of control over one's own movements is potentially open to extension to an experience of control over anything at all. Perhaps all that is needed for the development of a sense of agency is a preview that allows the person to establish a sense of mental causation over the previewed event. Admittedly, the events over which participants gained a sense of control in these studies were carefully orchestrated to be easily confused with own movement. The observed effects may depend to a large degree on the relative weakness of proprioceptive feedback and on the compelling quality of the visual display of another person's arms in place of one's own.

Indeed, there is evidence that corticospinal excitability associated with hand action is modulated by observed hand position (Maeda, Chang, Mazziotta, & Iacoboni, 2001; Maeda, Kleiner-Fisman, & Pascual-Leone, 2002). It may be that hands placed facing toward the participant in these studies might have weakened the observed effects and that the experience of vicarious agency is dependent on sensitivities to the visual perception of actions that were serendipitously engineered in these studies through the selection of the helping hands configuration. Yet the previews of action in these studies did not enhance the simple feeling of identification with the arms: In Experiment 1, consistent previews produced no significant increment in the experience that the arms were indeed one's own but rather yielded only an enhanced sense that one could control them. Participants here were not mistaking one object for another (others' hands for their own) but rather experiencing a transformation in the extent of their own conscious will.

This transformation conforms to the theory of apparent mental causation. To the degree that there is a parallel between externally generated action previews (like those that the participants heard over headphones) and mentally generated previews of voluntary action that occur in everyday life for one's own action (such as natural thoughts about intentions or goals), these results suggest that the experience of consciously willing one's own actions may arise from the causal inferences drawn from one's own spontaneous preview processes. The feeling that one's thoughts have

caused one's actions may not necessarily come as a direct indication of the causal process; instead, it may be a reflection of the fact that we have observed our thoughts and actions coincide and so have traced agency to ourselves (cf. Wegner, 2002).

These findings are relevant to the consistency principle of the theory of apparent mental causation, which has not been tested previously in research. The results indicate that thoughts consistent with action induce the sense that one has caused the action (Experiment 1) and that thoughts inconsistent with action yield no different experience of such causation than no preview of the action at all (Experiment 2). The priority principle of apparent mental causation, in turn, was tested in Experiment 3. Participants in one condition were given consistent action instructions that followed each action onset by 3 s, and they experienced no increment in vicarious control compared with having no instructions at all. As in the research of Wegner and Wheatley (1999), then, the occurrence of consistent thoughts following action does not enhance feelings of authorship. Only when consistent previews occurred appropriately prior to each action did such vicarious agency arise.

These experiments did not test the exclusivity principle of apparent mental causation, because they were conducted in a paradigm that explored the limits of the principle. Participants in these studies were asked to consider actions that clearly were authored by an agent other than themselves. Indeed, the owner of the arms was standing just behind them and could not plausibly be ignored. A clear cause of the arms' movements other than one's own thoughts was thus regularly salient in this setting. The generally low levels of overall vicarious control observed in these studies suggest that the exclusivity principle is indeed powerful, but the significant and predictable increments in vicarious control that accrued from the variations in consistency and priority suggest that these principles, too, have important influences on the experience of conscious will.

Overall, the vicarious control experiences participants reported in these studies must be understood as more indicative of feelings than of rational judgments. As we noted earlier, the sense of agency is likely to have an experiential component, particularly when it comes to reports of own agency, a component that may lead to experiences that depart from the results of a sober analysis of causality. People in these experiments overlooked the absurdity of the judgments they were asked to make, because they no doubt knew that they could not control the arms of another person. To answer questions tapping the experience of control, they seem to have adopted an "as if" stance to the questions. Their answers show a variety of regularities suggesting that the realm of the experience of agency can be mapped even when physical causation is not in question.

Vicarious Agency in the Brain

The occurrence of vicarious agency highlights the possible connections that may exist between the neural and cognitive systems involved in producing one's own action and the systems involved in perceiving the actions of others. This link has been the topic of research for some time (e.g., Prinz & Hommel, 2002) but has been emphasized recently by the discovery of mirror neurons in monkeys—neurons that respond both to own movement and to similar movements by others (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). The existence of such dual-focus structures at the neural level suggests that the ability to "mind read" may be reflected in anatomically direct connections between own and other's movements (Gallese & Goldman, 1998). In fact, a version of an authorship illusion has even been observed at the level of the neuron: Graziano (1999) found that same neurons in the monkey (*Macaca fascicularis*) respond to both felt position of own arm covered from view and to the seen position of a false arm. The role of mirror neurons in human authorship processing is as yet unknown, but the present findings suggest that previews of others' actions may activate such neural connections.

The phenomenon of vicarious agency serves as an important reminder for any future studies of the functional neuroanatomy of willed action. Research to date has examined the brain activations associated with willed action by comparing self-initiated movement with externally triggered action (Cunnington, Windischberger, Deecke, & Moser, 2002; Hunter et al., 2003), by comparing perception of own movement and others' movement (Farrer & Frith, 2001), or by comparing normal voluntary movements with movements conducted by patients who have limited experience of voluntariness for the same actions (Spence, Crimlisk, Cope, Ron, & Grasby, 2000). These various studies often failed to distinguish the experience of agency from the operation of agency (Wegner, 2002) and so have not yet yielded an entirely clear picture of what the brain does during consciously willed action. The possibility that people may experience vicarious agency for the actions of others prompts the realization that brain activations associated with experiences of agency need not parallel those linked with the exertion of control. No actual agency need take place for the person to experience control, and this observation should be acknowledged in the pursuit of the neural correlates of consciously willed action.

Vicarious Agency in Everyday Life

Beyond their implications for the experience of conscious will and perceptions of own agency, these findings also relate to the way people experience others' actions more generally. In particular, they illustrate some common features of the empathic experience of others' actions. The empathic extension of self—to movie characters, to imagined figures from books or stories, or, most profoundly, to close relationship partners—might be a form of the vicarious agency observed in this research. Perhaps the emotional sensitivity we gain for others in certain circumstances might be due to our ability to construct foreknowledge of their actions and so to gain a sense that these actions belong to us and are even somewhat under our control. The SCR results of Experiment 2 point to such sensitivity, produced here merely by previews of the earlier movements of a pair of hands. When the actions of another person are predictable—from our knowledge of their situation or personality, perhaps, or from our own experience with the actions—we may come to experience the actions not at a distance but as though we ourselves are causing them to happen.

The results are also reminiscent of the experience of sports fans mimicking the movements of their favored player in a forlorn attempt to "help along." Experiences of vicarious agency often seem to accompany such sympathetic movement or "body English" as we watch others performing actions. Indeed, it would be intriguing in the present paradigm to measure participants' own

muscle potentials as they watch the arms move to learn if previews that induce experienced control of another's actions are typically attended by the participant's own sympathetic movements. Jacobson's (1932) classic finding of electromyograph (EMG) perturbations in people who were merely instructed to think about movements suggests this possibility. People asked to think about rowing a boat while only sitting quietly in the lab were still found to produce muscle potentials like those of someone with both oars in the water. Although sympathetic movements were not assessed in the present studies, we do know from Experiment 3 that such movements, even played out most subtly, can enhance the experience of vicarious agency. Perhaps empathic entrainment with specific others could be induced more generally through manipulations that encourage people to mimic others' actions when previews are available of what the others will do.

The phenomenon of vicarious agency may be most evident in everyday life when we are placed in conditions that invite us to confuse our actions with those of others. As noted earlier, the most readily apparent cases of such confusion exist in psychopathologies such as schizophrenia and in classic automatisms such as Ouija board movement. However, the present results serve as a reminder that more pervasive confusions of authorship may arise in a variety of everyday contexts. Whenever we are led to think about others' actions—because we are performing the same or complementary actions, because we have an interest in the goal or outcome, or even because the action simply occurs in our presence, there is the potential for an experience of vicarious agency. We might feel a twinge of authorship when our child wins an award, for example, not because we actually did it, but because our anticipatory thoughts of the glory made us vicarious agents in the action. We could also feel slight pangs of authorship when we see a cartoon figure run off a cliff and plummet to the valley below—again, not because of any deep empathy with the figure, but merely because of our ability to anticipate the action. Agency may be experienced beyond its normal bounds whenever we think about what will be done. We may be less likely to share feelings of agency, then, when we see someone behave in an unexpectedly cruel, meaningless, or dangerous way. Actions we did not think about in advance will be dissociated from our selves and experienced as the doings of outside agents. Our rational judgments of our own authorship, in sum, seem to be accompanied by a more ephemeral sense of controlling our worlds—a feeling of vicarious agency that comes and goes depending on whether we have merely contemplated the action.

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