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A new spin on the Wheel of Fortune: Priming of action-authorship judgements and relation to psychosis-like experiences

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Abstract

The proposal that there is an illusion of conscious will has been supported by findings that priming of stimulus location in a task requiring judgements of action-authorship can enhance participants' experience of agency. We attempted to replicate findings from the 'Wheel of Fortune' task [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]. We also examined participants' performance on this task in relation to self-reported passivity experiences and hallucination-proneness. We found a significant effect of priming, with primes being found to increase the experience of agency. An interaction between gender and priming was also found, with priming enhancing feelings of agency in women but not in men. There were no significant correlations between levels of self-reported passivity experiences or hallucination-proneness and participants' susceptibility to the priming effect on ratings of agency. Implications of these findings are discussed with regard to a prominent model of passivity experiences.

Keywords: Agency; Conscious will; Delusions of control; Forward model; Hallucinations; Passivity

1. Introduction

The feeling of having consciously willed something to happen is a fundamental human experience. Wegner (2002, 2004) has proposed that this experience of action-authorship could be a result of the same mental processes we use in the perception of causality more generally. As Hume (1739) noted, the constant conjunction of x followed by y leads us to infer that x caused y. Wegner (2004) translates this argument, typically used to explain causality for mechanistic events (the paradigmatic example being the collision of billiard balls), into the realm of mental phenomena. In essence Wegner proposes that, just as we experience a moving billiard ball as causing the movement of a stationary ball with which it collides, we experience ourselves as causal when an action is preceded

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by a relevant forethought about the action. This leads us to experience ourselves as causal agents when "we have experienced relevant thoughts about the act at an appropriate interval in advance, and so can infer that our own mental processes have set the act in motion" (p. 654). Wegner terms this the theory of apparent mental causation: "people experience conscious will when they interpret their own thought as the cause of their action" (Wegner & Wheatley, 1999, p. 480). Wegner describes three aspects of thought–action contiguity that determine the extent to which mental causation is felt. These are the priority, consistency, and exclusivity of the thought about the action (Wegner & Wheatley, 1999). For the perception of apparent mental causation, the thought should occur before the action, be consistent with the action, and not be accompanied by other potential causes.

An important implication of this theory is that people may experience the feeling of doing something when there is actually no causal connection between their thoughts and their actions. Indeed, as Wegner notes, there may be a third factor causing both the thought and the action, with no causal linkage from the thought to the action. It is this that has led Wegner (2002, 2004) to talk of the "illusion" of conscious will.

1.1. Priming and the artificial enhancement of conscious will

The potential for our feeling of conscious will to be illusory, and show no relation to the actual mechanisms by which our actions have been generated, has been empirically demonstrated by Wegner and colleagues (e.g., Aarts, Custers, & Wegner, 2005; Wegner & Wheatley, 1999). At the heart of such experiments is the idea that briefly priming an effect of an action (by priming a thought/representation of an action's consequences just before it occurs) increases the probability that one will experience that effect as due to one's own volition.

One methodology created to investigate this phenomenon is the 'Wheel of Fortune' task (Aarts et al., 2005). In this task, participants are told that they control the motion of a grey square rapidly traversing a rectangular grid whilst a computer independently moves another square in the opposite direction at the same speed. At a certain point participants are instructed to press a key to stop the motion of their square. They are then shown a new grid with one square highlighted and they must judge whether their key-press caused their square to land there, or whether that was where the computer had caused its square to stop. The high velocity at which the squares traverse the grid results in this decision being ambiguous. This ambiguity regarding who caused the square to land on the final highlighted position (i.e., whether it was the participant's button press that stopped their square there, or whether it was where the computer's square finished) allows the participant's experience of authorship over the observed stops to be experimentally manipulated. In primed trials, the position of the final square is briefly presented to participants (for 34 ms) before they see the final square's position, which is in fact predetermined. This is termed an 'effect-prime', as it primes the judgement about the apparent effect of the participant's button press (Aarts et al., 2005). Wegner's theory of apparent mental causation leads to the prediction that, in effect-primed trials, the occurrence of the thought/representation of the square's position, followed by the perception of it being there, will increase participants' feeling of conscious volition of stopping the square, compared to a control condition where no prime is present.

Aarts and colleagues have published three papers demonstrating that the provision of an effect-prime does increase the experience of conscious will (Aarts, 2007; Aarts, Wegner, & Dijksterhuis, 2006; Aarts et al., 2005). However, this methodology has yet to be replicated by other research groups. The first aim of the current study was therefore to provide an independent replication of Aarts et al.'s findings. We were also interested in examining whether the magnitude of this effect was similar in both genders as, unusually, Aarts and colleagues have neither reported the gender compositions of their samples, nor analysed the effect of effect-primes by gender. Given that Wegner (2004) implies that the mechanism that generates the "illusion of conscious will" (p. 649) is likely to be a universal, non-gender-specific, human phenomenon, foregoing an analysis by gender is understandable. We proposed to investigate empirically this implied absence of gender specificity of priming on authorship judgements. Additionally, we wished to determine whether the Wheel of Fortune task is robust to minor deviations from Aarts et al.'s original methodology.

1.2. Applying the Wheel of Fortune task to questions of psychopathology

In addition to explaining typical judgements of action-authorship, Wegner and colleagues' theory of apparent mental causation has been used to account for disturbances in action-authorship judgements associated with various forms of psychopathology (e.g., Frith, 2002; Jones & Fernyhough, 2007a). For example, patients with schizophrenia often suffer from what are termed passivity experiences. In such experiences patients feel as if their actions have been caused by, or are under the control of, another agency. For example, a patient reported by Mellor (1970) describes how his "fingers pick up the pen, but I don't control them. What they do is nothing to do with me" (p. 18). Frith and colleagues (Blakemore, 2003; Frith, 2002; Frith, Blakemore, & Wolpert, 2000) have attempted to explain such experiences as resulting from a breakdown in the mechanism responsible for generating the emotion of authorship. In their model, the issuing of a motor command is accompanied by the production of a parallel efference copy of the motor command which is then used by a predictor mechanism to create a prediction (the 'predicted state') of what the movement will result in. Awareness of starting a movement appears to be based on this predicted state and not on sensory feedback from movements themselves. In experiments investigating the time at which a self-generated movement is perceived as starting, it is found that individuals experience their movement as starting ~50–80 ms before their actual movement begins (Haggard, Newman, & Magno, 1999).

Frith (2002) draws on Wegner's (2002) concept of apparent mental causation to explain how the emotion of self-authorship is created when awareness that an action is about to occur (based on the predicted state, which is available 50–80 ms before we move), is promptly followed by the actual action (see Jones & Fernyhough, 2007a). If the predicted state mechanism malfunctions, then Wegner's mechanism of apparent mental causation cannot work, meaning that the actor does not feel the authorship emotion. It is this malfunction of the predicted state that has been proposed to be the source of passivity experiences (Frith et al., 2000). In addition to its involvement in the generation of passivity experiences, a malfunction of the predicted state has been proposed to play a causal role in the genesis of auditory verbal hallucinations (AVHs). In such models, a failure in the predicted state has been proposed to cause self-produced speech to be experienced as not produced by the self, resulting in an AVH (e.g., Jones & Fernyhough, 2007a; Seal, Aleman, & McGuire, 2004).

Although Frith and colleagues are not clear on this point, there are at least two potential ways in which the predicted state mechanism could lead to a breakdown in the feeling of authorship. Firstly, there may be a problem upstream of the predicted state, resulting in a complete or partial failure to generate a predicted state. Secondly, there may be a problem downstream of the predicted state. In this latter case, the creation of the predicted state may be normal, but the individual may be unable to use this information to generate the feeling of agency. The Wheel of Fortune procedure offers a potential method of distinguishing which of the above possibilities is the best explanation of passivity experiences and AVHs. We propose that effect-primes may be seen as proxy predicted states, in that they give a preview of what is about to occur. If there were indeed a problem downstream of the predicted state, meaning that individuals could generate it but not use it, then individuals with passivity experiences or AVHs should be impaired in their ability to use the effect-primes on the Wheel of Fortune task to increase their feeling of authorship. This would result in a negative correlation between susceptibility to both passivity experiences and AVHs, and the increase in the feeling of authorship on effect-primed trials. A failure to find a correlation would be in line with the prediction of the upstream explanation, namely that such experiences result from a lack/breakdown of the predicted state, and the ability to use the predicted state (prime) should hence not be related to levels of such experiences.

One obvious way of testing these potential explanations would be to employ the Wheel of Fortune procedure in examining action-authorship judgements in patients with schizophrenia who have passivity experiences, or in patients who experience AVHs. Another strategy, which we adopt here, is to use measures of susceptibility to passivity experiences and AVHs in a non-clinical sample. Measures of general delusionality in the healthy population often include items relating to passivity experiences. For example, the Peters et al. Delusions Inventory (PDI-21; Peters, Joseph, Day, & Garety, 2004) includes items relating to passivity experiences such as "Do you ever feel as if you are a robot or zombie with no will of your own?" (item #21). This item was found to be endorsed by 6.3% of a student sample by Jones and Fernyhough (2007b). This provides evidence that, just as hallucinations and persecutory delusions have been found to exist on a continuum stretching into the healthy population (Johns & van Os, 2001), passivity experiences may also exist on a continuum. In order to test the specificity of any observed relation, we also set out to examine associations between Wheel of Fortune performance and susceptibility to another form of delusional ideation, not linked to problems with the predicted state and feelings of authorship, namely persecutory delusions.

In summary, this study set out to investigate the following hypotheses. Firstly, we hypothesized that authorship ratings on the Wheel of Fortune task would be higher on effect-primed trials than non-effect primed trials. We made a second hypothesis that there would be no interaction between priming and gender. Thirdly, we hypothesized that the effect of priming on authorship judgements would be robust to minor variations to Aarts et al. (2005) experimental methodology. Specifically we proposed that the effect of priming on authorship judgements would still be found when participants performed the task on laptop computers (compared to desktop computers) and completed a range of questionnaires before (rather than after) performance of the Wheel of Fortune task. Fourthly, we hypothesized that self-reported susceptibility to both passivity experiences and AVHs would correlate negatively with increases in the feeling of action-authorship resulting from exposure to effect-primes. Our final hypothesis was that self-reported persecutory delusion-like beliefs would not correlate with increases in the feeling of action-authorship resulting from exposure to effect-primes.

2. Method

2.1. Participants and design

A convenience sample of 144 students (62 men, 82 women) with mean age of 21.5 yrs ($SD = 3.91$) participated in the experiment. Participants were tested in two groups in order to assess whether there was an effect of order of testing. In Group 1, 92 participants (40 men, 52 women) first completed the three questionnaires described in Section 2.2, recorded their basic demographic data, including their gender, and then undertook the Wheel of Fortune task, using laptop computers in a quiet room. Participants were not paid for their participation. In a within-participants design, participants experienced trials on which they were primed with effect information (the final location of the square) and trials in which they were not primed. In Group 2, the remaining 52 participants (22 men, 30 women) firstly undertook the Wheel of Fortune task, using desktop computers in isolated cubicles, and then completed the questionnaire portion of the study and recorded their demographic details including gender. Again, in a within-participants design, participants experienced trials on which they were primed with effect information (the final location of the square) and trials in which they were not primed.

2.2. Measures

2.2.1. Passivity experiences

A new 5-item questionnaire was developed for the purpose of assessing levels of passivity experiences in a healthy population sample (see Appendix 1), as there is no existing tool that attempts to measure these specific experiences in non-clinical samples. This was termed the Scale for Assessment of Passivity Experiences in the General Population (SAPE-GP). The items constituting this were taken in part from the Peters et al. Delusions Inventory (Peters et al., 2004) and in part adapted from the Scale for the Assessment of Positive Symptoms (Andreasen, 1984). Items were scored on a five-point Likert scale with potential responses being: "always" (4), "very often" (3), "fairly many times" (2), "occasionally" (1), "never" (0). Total scores could hence range from 0 to 20, with higher scores indicating more passivity experiences.

2.2.2. LSHS-R

The revised Launay–Slade hallucination scale (Launay & Slade, 1981 as modified by Bentall & Slade, 1985) is a 12-item instrument designed to measure predisposition to hallucination-like experiences. Each item is scored on a five-point Likert scale consisting of: "certainly applies to me" (4), "possibly applies to me" (3), "unsure (2), "possibly does not apply to me" (1), "certain does not apply to me" (0). Total scores can range from 0 to 48. Higher scores indicate a greater predisposition to hallucination-like experiences.

2.2.3. Persecutory delusion-like beliefs

These were assessed using the persecutory ideation questionnaire (PIQ; McKay, Langdon, & Coltheart, 2006), a 10-item questionnaire designed to measure persecutory ideation in both clinical and non-clinical samples. Items are rated on a five-point Likert scale ranging from Very True (4) to Very Untrue (0), with higher scores meaning that individuals experienced greater levels of persecutory ideation. This measure has been shown to have good reliability and validity (McKay et al., 2006).

2.3. Experimental task and procedure

The Wheel of Fortune task was programmed in C+ using the Borland builder environment. Precise control of timing was ensured with the use of Direct X. Administration and scoring of the task was exactly as reported in Aarts et al. (2005). Participants were informed that the study was designed to examine feelings of control. The participants had to press and hold the S-key on the keyboard to cause a grey square rapidly to traverse a rectangular path, consisting of eight white squares, in a counter-clockwise direction. At the same time, another grey square (under the computer's control) moved along the same path but in a clockwise direction. At a random point in time (between 8 and 10 laps of the screen) the grid went blank and participants had to stop the motion of the squares, which they were told continued to rotate invisibly, by pressing the Enter-key. This resulted in one of the white squares of the grid turning black, which was said to represent the position of either their own square, or the computer's, at the time they pressed stop. After each stop, participants were asked to indicate whether they had caused the square to stop on that position or whether the computer had. The authorship judgement was measured on a 10-point Likert scale, running from 'not me at all' (1) to 'absolutely me' (10). The stop location was presented twice on each of the eight tiles of the path. The experimental task thus consisted of 16 trials. The order of primed and unprimed trails was randomly specified for each participant. Before the experimental phase proper, participants were given two practice trials to familiarize themselves with the procedure. These data were not used in the analyses reported here.

2.4. Events in a trial

Each trial began with a warning signal (the word 'Warning' appeared on the screen). Next the message 'Start' appeared in the centre of the grid until the participant pressed (and held) the S-key. The participant's and the computer's squares then began to move along the path in alternate steps (the squares were presented one after the other). Squares were displayed for 67 ms on each position. It hence took 1072 ms for one complete lap to occur (67 ms $\times$ 8 positions $\times$ 2 [participant's and computer's] squares; Aarts et al., 2005). The number of laps that occurred in a trial was programmed to vary randomly between 8 and 10 laps. When the message 'Stop' appeared in the centre of the grid, only the eight white empty tiles were shown, until the participant pressed the Enter-key. At the press of this button a black square was presented after 101 ms. The placement of this square was always four positions farther than that of the last position of the participant's square before the stop message had appeared. Thus, participants did not have actual control of where the black square landed.

2.5. Effect-priming

In 8 of the 16 trials the black square that was to be displayed was flashed on the screen before the message 'Stop' appeared. The primed location was always the same as the subsequently presented position of the black square. The prime occurred 33 ms after the last presentation of the participant's square. Primes were presented for 33 ms and were followed 51 ms later by the message 'Stop' (the total priming period hence being 117 ms). In the no-priming condition, the position of the black square was not flashed (the position was presented in white for 33 ms). The priming event was employed for every possible location on the 8 square grid, resulting in eight trials of the priming condition, and 8 of the no-priming condition.

2.6. Measurement of potential control

Participants' potential control over producing the effects was also measured. The computer measured participants' reaction times (in ms) between the word 'Stop' appearing on screen, and their press of the Enter-key. As Aarts (2007) notes, if the participants press the Enter-key 330 ms (equivalent to 369 ms using our timings) after the presentation of the stop message, then they will have pressed it at the same time that their square was actually in the position indicated by the black square. A measure of potential control was hence calculated as the absolute difference between the participant's reaction time (time of Enter-key press less time of presentation of the word 'Stop') and 369 ms. Most participants on most trials stopped the motion of the squares before one lap of the squares could be completed. For slower responses the response times first had the time of the completed laps (1072 ms for each lap) subtracted from it, then the absolute difference between this figure and 369 ms was calculated (Aarts et al., 2005). The smaller the absolute difference in these numbers, the more likely it was that participants could actually have caused the square to land on that position. If there are no differences in this figure between primed and non-primed trials, it rules out the possibility that participants may have rated their authorship higher on primed trials due to them actually landing their square closer to the final position of the black square on such trials.

A number of individual trials resulted in participants showing high reaction times. This was interpreted as the participant losing concentration on the task or hitting the wrong button to stop the motion of the squares. As such, any trials on which participants' reaction times were greater than 2144 ms (two laps of the invisible squares) were removed from the data. This eventually led to the removal of a total of 104 individual trials (Group 1: 90 removed, Group 2: 14 removed) representing 5% (Group 1: 6%, Group 2: 2%) of the total trials performed by participants.

2.7. Debriefing

At the end of the session participants were debriefed. The debriefing indicated that none of participants realized the true nature of the study. Previous studies utilising this task (e.g., Aarts, 2007) with a 34 ms prime duration have noted that none of their participants reported having seen the primes. In our replication, one participant confidently reported having seen a black square flash on around half of the trials and further noted that the position of this square was identical to the location of the final square. This participant's data were excluded from the analysis, as their experience of the task was clearly not comparable to the other participants. A minority of participants (<10%) reported having seen a flash on the screen on a few trials, but they were unaware that the position of this square matched the position of the final black square.

3. Results

3.1. Authorship ratings and effect-priming

Descriptive statistics are presented in Table 1. The average ratings of experienced authorship across the 16 trials were analysed using a 2 (Prime: present, absent) × 2 (Order of testing: Group 1, Group 2) × 2 (Gender: male, female) mixed-design ANOVA. A Kolmogorov–Smirnov test indicated that the ratings of experienced authorship on both primed and non-primed trials did not deviate significantly from a normal distribution, $D(143) = .05$, $p > .05$ for both. The main effect of priming was significant, $F(1,139) = 7.44$, $p < .01$, $\eta^2 = .05$. This effect size is small to medium by Cohen's (1988) criteria, and is comparable to the effect size for effect-priming of $\eta^2 = .09$ found by Aarts (2006). The interaction between priming and gender was also found to be significant, $F(1,139) = 16.96$, $p < .001$, $\eta^2 = .11$. By Cohen (1988) criteria, this is a medium to large

Table 1
Descriptive statistics for variables under investigation

	Overall ($N = 143$)	Men ($n = 61$)	Women ($n = 82$)
Authorship rating (effect-prime)	5.35 (1.52)	4.92 (1.41)**	5.67 (1.52)**
Authorship rating (no effect-prime)	4.74 (1.53)	5.17 (1.67)**	4.42 (1.33)**
Passivity experiences	2.00 (2.74)	2.60 (3.78)*	1.61 (1.68)*
Hallucination-proneness	18.09 (7.39)	16.90 (7.04)	18.86 (7.56)
Persecutory ideation questionnaire	7.85 (5.70)	7.54 (4.57)	8.05 (6.36)

Note. Passivity experience and persecutory ideation questionnaire data were unavailable for 11 participants.
* $p < .05$.
** $p < .01$.

Table 2
Correlations between delusions and effects on authorship of priming

	Passivity experiences	Hallucination-proneness	Persecutory ideation
Overall effect of priming ($N = 132$)	−.02	−.09	.10
Effect of priming in men ($n = 52$)	.09	−.08	.01
Effect of priming in women ($n = 80$)	−.04	−.19*	.13

Note. Passivity experience and persecutory ideation questionnaire data were unavailable for 11 participants.

effect. There was no interaction between priming and group, $F(1,139) = .49$, $p = .49$, nor between priming, group, and gender, $F(1,139) = 1.01$, $p = .32$. Finally, there was no main effect of gender, $F(1,139) = .03$, $p = .87$, or group, $F(1,139) = .01$, $p = .94$.

To investigate the interaction between priming and gender, paired t-tests were first performed separately for each gender on the authorship ratings for primed and non-primed trials. For men, authorship ratings for the primed and non-primed trials did not differ significantly, $t(60) = -.85$, $p = .40$. For women, authorship ratings were significantly higher for the primed than the non-primed trials, $t(81) = 5.37$, $p < .001$, Cohen's $d = .59$. This is a large effect size as defined by Cohen (1988) criteria for paired t-test effect sizes. Secondly, t-tests were performed comparing ratings on the primed and non-primed trails across genders. Men scored significantly lower than women on primed trials, $t(141) = -3.02$, $p < .01$, Cohen's $d = .52$, and significantly higher than women on non-primed trials, $t(141) = 3.00$, $p < .01$, Cohen's $d = .52$.

3.2. Potential control

The mean absolute differences between the response time after the Stop message and the time required to land exactly halfway through the presentation of the black square (see Section 2.5) were compared for the eight primed trials and the eight non-primed trials using a 2 (Prime: present, absent) × 2 (Order of testing: Group 1, Group 2) × 2 (Gender: male, female) mixed-design ANOVA. It was found that there was no effect of priming, $F(1,139) = .08$, $p = .77$, indicating that priming did not affect participants' potential control over causing the effects. Furthermore, there was also no interaction between either gender, $F(1,139) = .13$, $p = .72$, or group, $F(1,139) = .26$, $p = .61$, with priming, and no three-way interaction between priming, group, and gender, $F(1,139) = .17$, $p = .68$. There was no main effect of gender, $F(1,139) = 1.73$, $p = .19$, although there was a main effect of group, $F(1,139) = 7.49$, $p = .01$, $\eta^2 = .05$, with reaction times significantly quicker in Group 2. Overall the mean absolute difference score was 94 ms ($SD = 83$).

3.3. Passivity experiences, persecutory ideation, and effect-priming

Cronbach's alpha for the SAPE-GP was 0.73, indicating satisfactory internal reliability. Levels of passivity experiences reported were exceedingly low. Only 13 participants scored five or over on the SAPE-GP. As shown in Table 1, men had significantly higher levels of passivity experiences than women.

Correlations among passivity experiences, hallucination-proneness, persecutory delusion-like beliefs, and the difference in authorship between primed and non-primed trials (average primed authorship rating less average non-primed authorship ratings for each participant) are reported in Table 2. There were no significant correlations among the variables on either the entire data set or when analysed by gender. There was a trend towards females (but not males) showing a correlation between hallucination-proneness and effect-priming ($p = .09$). Greater hallucination-proneness was associated with lower susceptibility to effect-primes in women. However, due to the number of correlations performed, concluding that there is a relation between hallucination-proneness and effect-priming in women would risk making a Type I error.

4. Discussion

This study aimed to replicate the Wheel of Fortune methodology as devised by Aarts et al. (2005). In concordance with our first hypothesis we found a significant main effect of priming on this task. Participants reported greater feelings of authorship on primed compared to non-primed trials. Our second hypothesis, that there would be no interaction between gender and priming, was falsified, with women, but not men, showing an effect of priming on authorship judgements. Our third hypothesis was that the effect of priming would be robust to minor changes in Aarts et al. (2005) methodology. This hypothesis was supported with no effect of experimental methodology being found. Fourthly, we hypothesized that levels of passivity experiences and AVH-proneness would correlate with participants' susceptibility to primes. There was no correlation between participants' (of either gender) susceptibility to primes and either levels of self-reported passivity experiences or AVH-proneness. Finally, as predicted, no correlation was found between participants' susceptibility to primes and their levels of persecutory delusion-like beliefs.

4.1. Gender effects

Men gave higher authorship ratings than women on non-primed trials. This might be explained by the greater perceived self-efficacy on computer-based tasks experienced by men (Busch, 1995; Durndell, Haag, & Laithwaite, 2000). Our finding that effect-primes increased women's, but not men's, authorship ratings (resulting in women producing higher authorship ratings than men on primed trials) is an intriguing finding that requires some discussion.

One possibility is that we found an effect of priming in women but not in men due to the smaller number of men than women used in the present study, and the subsequent lower power of the study when examining men. However, if the effect size of priming in men had been equivalent to that found in women in the present study ($d = .59$), then the sample size of men would have resulted in a power in excess of $\beta = .80$, ample to detect an effect.

If our finding is not due to a lack of power, it raises the question as to whether our data can be reconciled with the previous Wheel of Fortune experiments by Aarts and colleagues. All of these previous studies which reported a main effect of effect-primes on the Wheel of Fortune task (Aarts, 2007; Aarts et al., 2005; Aarts et al., 2006) failed to report splits of their data by gender or include gender in their ANOVAs as a between-subjects variable. It is possible that these studies would have found a gender effect had they analysed their data in this way. Furthermore, we may speculate that, as the series of studies by Aarts and colleagues have all used student populations, these potentially consisted of a large number of psychology students. In many western countries, females make up a majority of psychology students: for example, 81% of students accepted onto a Psychology degree in the United Kingdom in 2006 were women (UCAS, 2007), and similar gender compositions are seen in studies that report gender splits on samples drawn from psychology departments in other European countries (e.g., Bohne et al., 2002). Since Aarts (2007) drew his Wheel of Fortune sample from Dutch undergraduates, it is probable that there was a preponderance of women in this sample. Thus it may be the case that the overall effect of effect-priming Aarts et al. reported is due to the effect of priming in women offsetting the lack of a priming effect in men. This would be consistent with our findings.

If this gender effect turns out to be robust (and we would call for replications of this) then possible explanations for why women, but not men, showed an effect of priming on authorship judgements must be addressed. At this time such explanations are necessarily speculative, and will need to be experimentally tested in future studies. One potential explanation arises from Wegner and Wheatley (1999) observation that the experience of conscious will is an expression of our tendency to take what Dennett (1987) terms the 'intentional stance'. This, as Wegner and Wheatley state, involves viewing "psychological causation not in terms of causal mechanism but rather in terms of agents who have beliefs and desires that cause their acts. Conscious will is part of taking an intentional stance towards oneself" (p. 490). However, Baron-Cohen (2002, 2003, 2005) has argued that the "drive to identify another's mental states" (2005, p. 820), which he terms of the skill of empathizing, is greater in women than men. This argument has received substantial empirical support (e.g., Davis, 1994; Hall, 1978; Happé, 1995; Tannen, 1990). It hence seems plausible that the greater propensity in women to take the intentional stance towards others may lead to an equivalent propensity to overrate the role of thoughts in causing their own actions, contributing to our finding that women were more likely to overrate the role of thoughts induced by effect-primes in causing the observed event.

Alternative explanations are also possible. It could be argued that gender differences in perceptual abilities could be the cause of the present findings. For example, in an experiment examining the impact of odor priming on the ability to recognize a target word, only women (and not men) were found to show an effect of priming (Hermans, Baeyens, & Eelen, 2004). The authors of the study ascribed this gender effect to the superior olfactory perceptual abilities of women (Doty, 1991). Given that the Wheel of Fortune task involves a significant spatial component, and a prime which varies in its spatial location, it could be argued that a difference between men and women in susceptibility to spatial primes could have caused the present pattern of results. However, the findings of a study by Koshino, Boese, and Ferraro (2000) on the efficacy of spatial primes suggest that such a differential susceptibility is not likely to exist. In this study the letter *O* was presented on a screen in one of four possible locations. Once it appeared on screen participants had to identify its location as quickly as possible. Brief priming of the target's location decreased participants' reaction times for identifying its position, but with no gender difference in the magnitude of the priming effects.

We would hence call for our findings to be replicated by other studies using the Wheel of Fortune methodology, perhaps including independent measures of propensity to take the intentional stance (de-Wit, Fernyhough, & Jones, 2006). Although we have argued that differential sensitivity to spatial primes is unlikely to be a cause of the current findings, it would also prove interesting to investigate the artificial enhancement of conscious will using experimental methods that do not use spatial primes. One potential method for this is the I-Spy methodology of Wegner and Wheatley (1999), which involves auditory rather than spatial priming. If the gender differences reported here were also obtained on the I-Spy paradigm, it would be a clue that our findings are due to gender differences in general susceptibility to primes in action-authorship paradigms, rather than to any specific susceptibility to spatial primes. However, the only existing study utilising the I-Spy paradigm (Wegner & Wheatley, 1999) has not reported on gender effects within the data. It would hence be desirable for any replication of the I-Spy experiment to analyse the data by gender to investigate possible interactions between gender and priming.

We also note here that, whereas Aarts and colleagues (e.g., Aarts, 2007; Aarts et al., 2005) reported none of their participants consciously saw their 34 ms prime, approximately 10% of our participants reported being aware at some level of seeing our comparable 33 ms prime. However, we do not anticipate this will affect the nature of our conclusions because Aarts et al. (2005: experiment 2) have previously demonstrated that priming is effective whether it is induced by brief (34 ms) primes which participants do not report being aware of, or longer (68 ms) primes (visible to 44% of participants).

4.2. Passivity experiences, AVH-proneness, and effect-priming

The finding that susceptibility to priming on this task was unrelated to self-reported passivity experiences provides preliminary evidence that it is not an inability to use the predicted state that leads to passivity experiences, but rather its absence altogether. One alternative explanation might be that the passivity experiences scale devised for this study was not sensitive or reliable enough to detect relevant differences in a non-clinical sample, and we would call for further work in developing such scales. Another alternative might be that passivity experiences are not sufficiently common and/or intense in such a sample for any such relations to obtain. Given the low endorsement rates of items on the SAPE-GP, this appears a likely explanation. Only the replication of the present findings with a clinical sample, and clinically proven assessments of passivity experiences, would allow any firm conclusions on this issue to be drawn.

Similar arguments apply to the finding that susceptibility to priming was unrelated to AVH-proneness. As items measuring hallucination-proneness were endorsed to a wider extent than those assessing passivity experiences, this offers firmer evidence for an upstream impairment in the predicted state than the passivity data. However, again we would call for the replication of these findings with both clinical and non-clinical samples in order to allow any firm conclusions to be drawn.

4.3. Conclusions and future directions

In summary the present study was able to replicate the finding that brief priming is able to increase judgements of authorship. Furthermore, the effect was found to be robust to minor deviations from the experimental methodology of Aarts et al. (2005). Our finding of a gender effect points to the need for further examination of potential gender effects in the artificial enhancement of the experience of action-authorship. We have speculated that gender differences in the tendency to take the intentional stance may extend to the generation of our feeling of volition. This also supports the more general idea that the generation of our own feeling of conscious will involves taking the intentional stance towards our own minds (de-Wit et al., 2006; Frith, 2002). We have also suggested that it is possible to use brief effect-primes to mimic the predicted state proposed as part of Frith et al. (2000) forward model. Such a methodology should potentially allow a range of future experiments to explore further the mechanisms behind passivity experiences and hallucination in clinical populations.

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Appendix 1. Scale for assessment of passivity experiences in the general population (SAPE-GP)

1. Do you ever feel as if you are under the control of some force or power other than yourself?
2. Do you ever feel as if you are possessed by someone or something else?
3. When making movements (such as reaching for something) do you ever feel as if someone else inside you caused you to move?
4. Do you ever feel as if you are a robot or zombie without a will of your own?
5. Do you ever feel as if your feelings or actions are not under your control?

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