Journal of Personality

WILEY

ORIGINAL ARTICLE

Do Locus of Control and Big Five Personality Traits Account for Individual Differences in Social Influence on Agency Judgments?

Mark Wulff Carstensen[1,2] | Pierre Jacquet[3,4,5] | David Cohen[6,7] | Marlène Jan[4,8] | Mario Speranza[4,8] | Axel Baptista[4,8] | Valerian Chambon[1,2,9]

[1]Département d'Études Cognitives, Institut Jean Nicod, ENS, CNRS, PSL University, Paris, France | [2]Department d'Etudes Cognitives, École Normale Supérieure, Paris, France | [3]Conseil Départemental Yvelines et Hauts-de-Seine, Centre Hospitalier des Versailles, Institut du Psychotraumatisme de l'Enfant et de l'Adolescent (IPEA), Versailles, France | [4]UVSQ, Inserm, Centre de Recherche en Epidémiologie et Santé des Populations (CESP), Université Paris-Saclay, Versailles, France | [5]LNC2, Département d'Études Cognitives, École Normale Supérieure, INSERM, PSL Research University, Paris, France | [6]Service de Psychiatrie de l'Enfant et de l'Adolescent, GH Pitié-Salpêtrère Charles Foix, APHP, Paris, France | [7]Institut des Systèmes Intelligents et de Robotique, ISIR CNRS UMR 7222, Sorbonne Université, Paris, France | [8]Centre Hospitalier de Versailles, Le Chesnay, France | [9]Centre National de la Recherche Scientifique, Paris, France

Correspondence: Mark Wulff Carstensen (markwcarstensen@gmail.com)

Received: 8 June 2024 | **Revised:** 13 May 2025 | **Accepted:** 22 May 2025

Funding: This study was supported by Fondation de France (grant no. 00112563) and Fondation pour la Recherche Médicale (grant no. SPF202209015876).

Keywords: advice taking | locus of control | sense of agency | social cognition | social influence

ABSTRACT

Objective: The sense of agency might be jointly affected by situational and interindividual factors. In this study, we examined whether personality traits and control beliefs can explain individual differences in both (1) sense of agency and (2) susceptibility of agency judgments to social influence.

Method: To do so, we used measures of the Big Five Personality Traits and Levenson's Locus of Control in combination with a task based on an interactive computer game, which we submitted to a large cohort of online participants ($N = 562$). We manipulated sensorimotor agency cues related to action control as well as social information communicated to participants.

Results: Our results show that while locus of control beliefs are related to differences in sense of agency, neither Big Five personality traits nor locus of control beliefs can account for differences in susceptibility to social influence.

Conclusion: Locus of control and Big Five personality traits can account for some differences in sense of agency, but not for differences in belief alignment.

1 | Introduction

One of the key components of the phenomenology of voluntary actions is the sense of agency, that is, the feeling that we are in control of our actions and through them external events in the world (Beck et al. 2017; Bonicalzi and Haggard 2019; Moore 2016). A functional sense of agency is a crucial internal marker for correct estimations of one's control and is closely related to feelings of moral responsibility (Bigenwald and Chambon 2019). It is commonly thought that the sense of agency depends on actively monitoring two types of information (Moore 2016; Moore and Haggard 2008): (1) Internal information, such as signals relating

Axel Baptista and Valerian Chambon jointly supervised this work.

to motor commands (Blakemore et al. 2002) or action fluency signals (Sidarus et al. 2017; Chambon, Moore, et al. 2014), and (2) external information such as sensory feedback and social cues (Wegner et al. 2004; Wegner and Sparrow 2004). Traditionally, the sense of agency and its underlying processes have been studied in nonsocial contexts (Sidarus et al. 2020; Haggard and Eitam 2015) where participants sit in isolation and freely decide *when* to act or *what* to do (Ras et al. 2019; Schultze-Kraft et al. 2020; Soon et al. 2013). However, in everyday life, actions are often carried out in a social context. In such contexts, both social and nonsocial external information can feed into the processes of the sense of agency.

Recent studies have sought to characterize the way in which social contexts and social cognition processes can affect individuals' sense of agency. For instance, the mere presence of other people reduces the sense of agency over negative outcomes (Beyer et al. 2017, 2018) and that mentalizing during the execution of an action can influence how much agency a person feels over the outcome (Sidarus et al. 2020). In addition, it has been shown that the sense of agency is reduced when participants are coerced to execute their actions (Caspar et al. 2016), that sharing control in joint actions can both increase and decrease judgments of agency depending on the type of sensory feedback provided (Cho et al. 2020; Dewey et al. 2014), and that explicit social feedback from others can affect judgments of agency to closely align with disagreeing feedback (Baptista et al. 2022). Thus, the presence of other agents can have either passive effects as in the case of audience effects (Hamilton and Lind 2016) or active effects as in cases of coercion or explicit feedback (Baptista et al. 2022; Caspar et al. 2016).

Although some studies have examined the effects of social influences on sense of agency, less is known about the underlying factors that have an impact on this influence. It has been suggested that sense of agency is jointly affected by both situational and interindividual factors (Tapal et al. 2017; Schwarz et al. 2022; Dewez et al. 2019; Jeunet et al. 2018). In this paper, we suggest that two types of trait-like constructs can explain part of the interindividual differences: (1) in the sense of agency itself and (2) in the subjects' propensity to modulate this experience through explicit feedback from unfamiliar peers.

The 1st trait of interest is the locus of control. Locus of control captures the degree to which people believe that they themselves, in contrast to external forces, are in control of the outcomes in their lives (Rotter 1954; Levenson 1981). People with high internal locus of control believe that what happens to them is the result of their own (internal) abilities or actions, whereas people with an external locus of control believe that what happens to them is due to external factors. The Levenson locus of control scale is particularly useful for our purpose, as it captures not only the internal/external distinction but also captures distinct social and nonsocial aspects of external influence. Thus, the "powerful others" construct captures the extent to which people believe that events in their lives are affected by powerful other agents, whereas the "chance" construct expresses the extent to which people believe that events in their lives are affected by natural (non-agentive) randomness in the external world. Previous studies connecting locus of control with sense of agency have shown that internal locus of control correlates with higher sense of agency (Dewez et al. 2019; Jeunet et al. 2018). It should be noted that these effects are observed in studies focusing on virtual reality contexts, with small-to-medium effect sizes or with sample sizes that are questionable for testing this particular relationship (e.g., Jeunet et al. include only 24 participants). Here, we aim to investigate in more detail and more generally how locus of control relates to sense of agency and how differences in locus of control affect the integration of social information in relation to agency judgments.

The 2nd set of traits we are interested in here are the Big Five personality traits. The Big Five personality traits have been shown to be linked to some extent to susceptibility to social influence on the one hand (Oyibo and Vassileva 2019; Caldwell and Burger 1997; Oyibo et al. 2017; Anagnostopoulou et al. 2017), and to sense of agency on the other hand (Schwarz et al. 2022). The Big Five personality traits compose a model of personality traits with wide application across different domains due to its empirical validity (Roccas et al. 2002; McCrae and John 1997). The five traits measured by the Big Five personality questionnaire are (1) *Agreeableness*, which characterizes people who are friendly, sympathetic, approachable, modest, nonconfrontational and less competitive. (2) *Conscientiousness*, which characterizes people who are self-disciplined, goal-oriented and well-organized. (3) *Neuroticism*, which characterizes those who are anxious, nervous, and fearful. People in this category tend to be emotionally unstable, feel less confident and insecure about themselves. (4) *Extraversion*, which characterizes individuals who tend to socialize and interact with others, and (5) *Openness*, which characterizes people who are curious, imaginative, and open to new ideas and experiences. Of these, neuroticism and openness have been shown to be significantly related to sense of agency in a negative and positive way, respectively (Schwarz et al. 2022). However, these associations have rather small effect sizes, with the largest effect being the link between neuroticism and sense of agency ($r = 0.13$) (Schwarz et al. 2022). The traits neuroticism, conscientiousness, and Openness have been shown to relate to social influence of the type "social proof", which is prototypically captured by the phrase "I often rely on other people to know what to do". These results show that conscientiousness and neuroticism are positively correlated with "social proof"-type influence, and that Openness is negatively correlated with susceptibility to this type of social influence (Oyibo and Vassileva 2019). To the best of our knowledge, this relationship between the Big Five traits and "social proof"-type influence is supported by only one study (i.e., Oyibo and Vassileva 2019).

In the present study, we examined how individual personality traits and locus of control beliefs may affect the integration of social feedback into the agency judgments produced during a "space invader" game (see Section 2.1.3–2.1.5, see Figures 1 and 2) where participants' control over the motor component of the gameplay was modulated without their knowledge (Metcalfe et al. 2010). Our main hypotheses concerned the relationships between locus of control, sense of agency, and susceptibility to social influence. We expected that high internal locus of control would be associated with a greater sense of agency and a lower likelihood of aligning with social feedback, that is, feedback provided by unfamiliar peers about the agency judgment reported

FIGURE 1 | Participants move the white square called the "Catcher" horizontally to try to catch the stars and avoid hitting the circles.

by the participant—or, in other words, with a lower susceptibility to social influence. Based on a previous pilot study ($N = 112$), we also expected that people with a higher *social-external* locus of control, that is, those with a higher "powerful others" locus of control, would be more likely to align with social feedback. Furthermore, based on pilot results, we hypothesized that the Big Five personality trait "agreeableness" would be linked to a greater susceptibility to social feedback.

2 | Present Study

In a preregistered experimental study (https://osf.io/ex5a6), we explored how trait-like constructs captured by the Levenson locus of control scale and the big five personality traits relate to sense of agency as well as to the integration of social feedback into agency judgments. In the present study, we aim to test our preregistered hypotheses on 562 typical adults recruited online, as well as to replicate previous findings in the literature, using a series of linear-mixed models.

Our hypotheses are that (H1) internal locus of control is related to higher sense of agency. (H2) The Big Five personality traits "agreeableness," "conscientiousness," "extraversion," and "openness" are related to a higher sense of agency while (H3) the trait "neuroticism" is related to a lower sense of agency. In addition, we hypothesize that (H4) people with higher internal locus of control are less likely to revise their agency judgments based on social feedback, and that (H5) people with more social-external locus of control are more likely to revise their agency judgments based on social feedback. Finally, we expect that (H6) people with higher scores on the Big Five traits "agreeableness," "conscientiousness," and "neuroticism" are more likely to revise their agency judgments based on social feedback, and that (H7) people with higher scores on the "openness" trait are less likely to revise their agency judgments based on social feedback.

The experiment was designed and run using JavaScript and presented digitally online. Ethics approval was granted by Comité d'Éthique de la Recherche-Sorbonne Université (N° 2019—CER 2 SOTIPAD).

2.1 | Materials & Methods

2.1.1 | Sample Size Calculation

Linear mixed-models were used to analyze the data. For such models, conventional power calculations are notoriously difficult to perform (Westfall et al. 2014; Kumle et al. 2021; Maxwell 2000). In the absence of existing data or an a priori hypothesis about the exact values of effect sizes, sample sizes are commonly based on previous studies. On this basis, and in line with more recent sample size recommendations, a sample of 40–60 participants would be appropriate (Brysbaert and Stevens 2018; Baptista et al. 2022; Olsen et al. 2019; Pescetelli and Yeung 2020; Metcalfe and Greene 2007). However, it has been suggested that many studies in psychology with fewer than 100 participants are at risk of being underpowered (Brysbaert 2019; Brooks and Barcikowski 2012; Knofczynski and Mundfrom 2008). As we also wanted to use the dataset to do exploratory analysis to investigate relationships for which we had no a priori hypotheses, we opted for a target sample size of 500 participants. According to the sample size recommendations from Knofczynski & Mundfrom, models with 8 predictor variables (such as our M3 and M4 models) are sensitive to small effect sizes (p2 = 0.15–0.20) with a sample size of 500 participants.

In addition, we used the r-package "pwr" to conduct an a priori power analysis using the effect sizes from previous studies in a Pearson correlation test that resulted in a suggested sample size of 461–541 ($r = 0.12$ & 0.13, sig = 0.05, power = 0.80).

2.1.2 | Participants

Participants were recruited online via the recruitment service Prolific Academic (PA). In order to maximize power, we included as many participants at each level of analysis as possible, taking into account the exclusion criteria we detail below. Of 900 recruited participants: 7 participants (14 entries) were removed for being duplicate participants; 17 were removed for not completing all the task trials; 38 participants, representing less than 5% of the total sample, were excluded due to a technical error where their data were not saved to the online database; 8 participants were excluded for having more than one no-play trial (see Section 2.1.8). This left us with 823 participants for M1 analysis (see Section 2.2). An additional 42 participants were excluded because they did not complete the questionnaires (see Measurement) resulting in a total of 781 participants (372 Female and 409 Male) for M3 analysis (see Section 2.2). For M2 and M4 analysis, 269 participants were removed because they suspected that the "advisors" in the task were actually bots (see

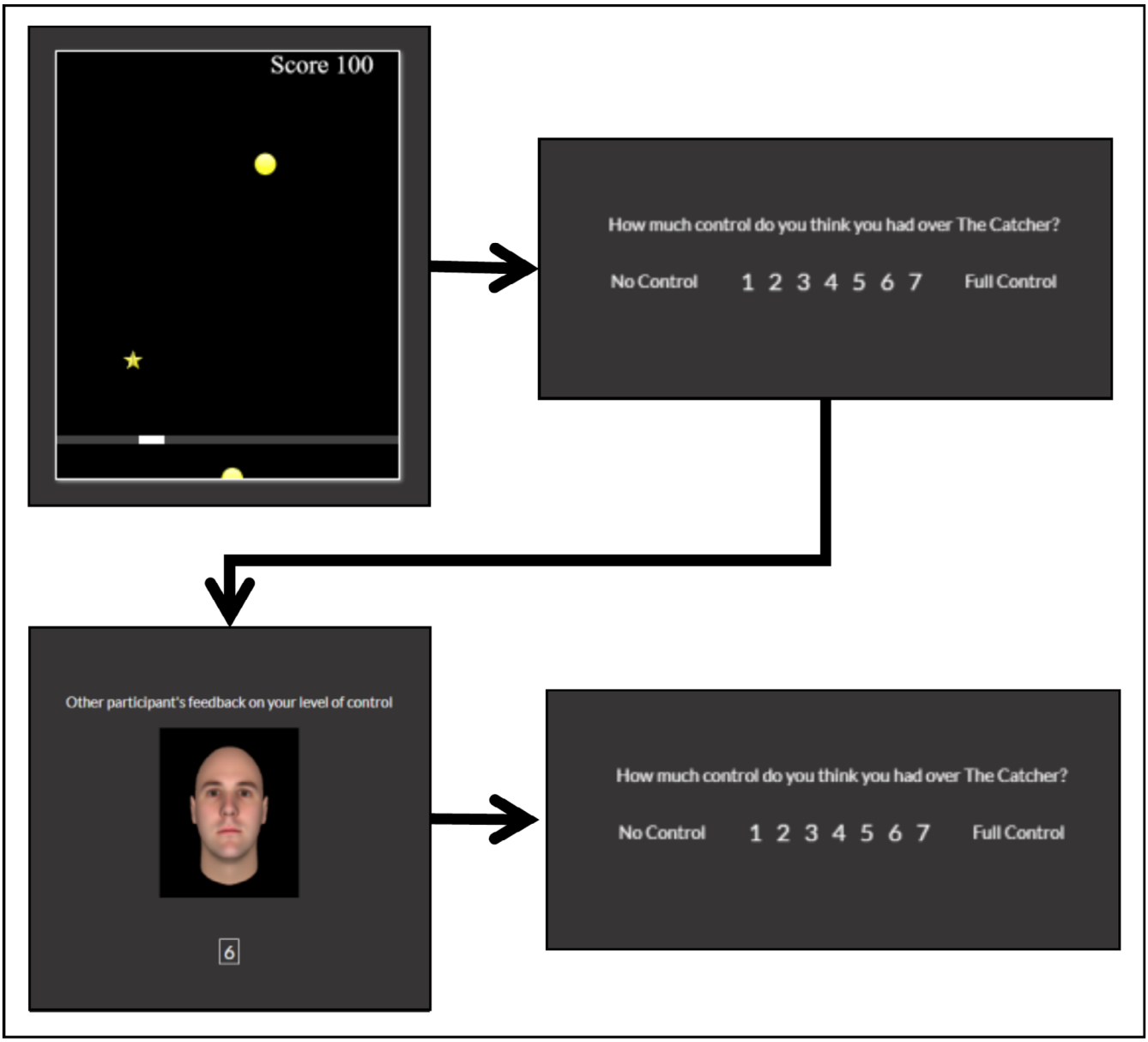

FIGURE 2 | Typical trial: (1) Participants play the game, then (2) provide their first agency rating (JoA #1), then (3) receive feedback from the advisor, and finally (4) provide their second agency rating (JoA #2). Belief alignment is measured by comparing the first JoA (JoA #1) and second JoA (JoA #2).

Section 2.1.3) or other types of nonhuman feedback. This left us with 558 participants for M2 analysis, of which 33 were excluded because they did not complete the questionnaires, resulting in a total of 525 participants (275 Female and 250 Male) for M4 analysis. Participants were between 18 and 74 years of age, with a median age of 27. Participants were paid approximately 9£/H for their participation.

2.1.3 | Experiment

The primary task of the experiment was a game where participants tried to catch downward scrolling stars and avoid touching circles (Figure 1). Participants were instructed to use a computer mouse for the duration of the experiment. Using their mouse, participants could move a small white box called "The Catcher" back and forth across a horizontal track as 20 stimuli, 10 stars and 10 circles randomly generated and distributed across the play area, fell through the play area from the top of the screen. Participants were instructed to use The Catcher to "catch" stars and avoid catching the circles. If a hit occurred, the target would disappear, accompanied by a sound (either a "pling"-sound for catching a star or a "bzz"-sound for hitting a circle). If a target was not hit, it would continue traveling downward until it disappeared through the bottom of the screen. The game also included a score-counter in the top right corner. Participants were awarded 100 points for every star they caught and lost 50 points for every circle they hit. Participants played the game for 10 s on each trial, after which they were asked to indicate how much control they thought they had over the catcher ("How much control do you think you had over The Catcher?") on a 7-point Likert scale ranging from 1, "No control," to 7, "Full Control."

The scale remained on screen until participants selected a value. After giving their first judgment of agency (JoA #1), participants received feedback from an "online player" (the "advisor") about the degree of control they had during the game. The feedback from advisors wasalso given on a 7-point Likert scale. Then, participants were asked again to evaluate how much control they thought they had over The Catcher (JoA #2) (Figure 2). In reality, advisors were bogus agents designed to randomly agree or disagree with the participant's initial judgment (see *Manipulation of Social Feedback*).

Participants carried out 100 trials. Of these, 8 trials were nonsocial training trials, where participants did not receive any advisor feedback and were not asked to judge their level of a control a second time. Every 40th trial, the participants were asked to take a break. This break lasted a minimum of 30 s before participants were able to proceed. As part of the instructions, participants had been informed that they would have more or less control over the Catcher, that they would be asked to indicate their degree of control on a scale from 1 to 7, and that they would receive feedback about their control from other players. Though the advisors were in reality bogus agents, several steps were taken to strengthen the illusion that they were real players. When participants first entered the experiment, they were met with a loading-screen and the text "waiting for other players" to simulate the process of connecting different players online. Participants themselves were also tasked with occasionally playing the role of the advisor, observing trials of "other players," and giving them feedback on how much control they thought the observed players had. The trials observed were in reality prerecorded trials. In addition, the avatars of the advisors would randomly change to simulate the experience that different players were advising them on different trials. At the end of the experiment participants were asked about how they thought the feedback they received was given ("How do you think feedback was provided?") and what they thought of their advisors ("What did you think of your advisors?"). The aim was to ascertain whether participants believed the advisors were real players or whether they suspected them of being bots. Participants who indicated that they suspected the advisors of being bots (or other nonhuman mechanisms) were excluded from the analysis.

After completing all 100 game trials, the participants were presented with a selection of questionnaires to fill out.

2.1.4 | Manipulation of Sensorimotor Cues

Three game conditions were designed to manipulate internal sensorimotor agency cues by altering the control the participants had over the Catcher. In the CONTROL condition, the objective control of the Catcher was undisturbed (full control). In the TURBULENCE condition, objective control was impaired by turbulences (random noise) intervening between the mouse input and the position of the Catcher. In the MAGIC condition, the Catcher's radius was enlarged with an invisible extension that could catch the target stars but not the distractor circles. In this condition, the participant was sometimes credited with catching a star even though they had not visibly touched it with the Catcher.

2.1.5 | Manipulation of Social Feedback

The advisor would agree with the participant in one third of the trials (agreement trials) and disagree in two thirds of the trials (disagreement trials). In half of the disagreement trials (i.e., one third of the total trials), the advisor would disagree by indicating that the participant had less control than they had initially estimated (negative valence disagreement) and in the other half of the disagreement trials, the advisor would disagree by indicating that the participant had more control than they had initially estimated (positive valence disagreement). Positive and negatively directed disagreements came in three different strengths: small (+1/−1), medium (+2/−2) or large (+3/−3). Thus, social feedback varied by type (agree/disagree), disagreement direction (negative/positive), and disagreement strength (small, moderate, large). In cases where the strength of disagreement would extend beyond the ends of the scale (i.e., less than 1 or more than 7), the direction of the feedback was inversed (i.e., −3 would become +3, and +3 would become −3, etc.). Advisors were always shown with an avatar that was an emotionally neutral face (Oosterhof and Todorov 2008).

2.1.6 | Randomization Procedure

Condition, disagreement type, disagreement direction, and disagreement strength were all randomized such that participants would go through a near-identical number of all three conditions with a near-identical number of type-direction-strength configurations for each condition. Randomization was done on a trial-by-trial basis.

2.1.7 | Questionnaires

To measure the personality traits and locus of control of participants, we used the Levenson locus of control questionnaire (Levenson 1972) and the Big Five Inventory 10 questionnaire, which is a validated and shorter 10-item version of the traditional Big Five questionnaire (Courtois et al. 2020).

2.1.8 | Attention Checks

To ensure that only trials where participants actually played the game were included, mouse movement was tracked during each individual trial. If no movement was detected for a given trial, the trial was marked as a no-play trial and was discarded from the analysis. If a participant had multiple no-play trials, the participant was excluded from analysis. A total of 43 no-play trials were observed across 32 participants.

2.2 | Results

We tested (1) the effects of game condition and performance on sense of agency (M1), (2) social and nonsocial predictors of belief alignment (M2), (3) trait-like predictors of sense of agency (M3), and (4) trait-like predictors of belief alignment (M4).

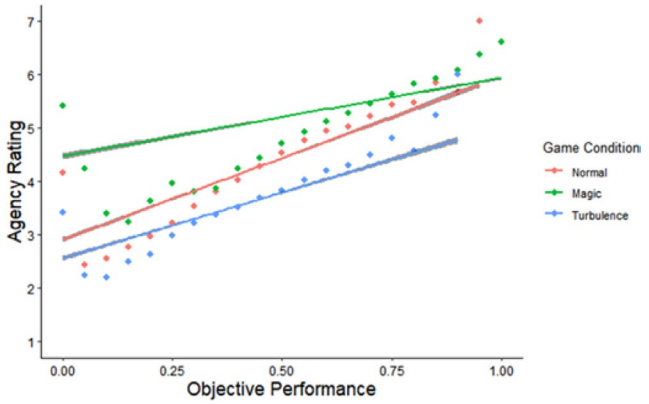

FIGURE 3 | Predictors of JoA #1 (M1): Average JoA #1 across participants for the relation between effects of game condition on JoA #1 and the effect of the participant's performance on JoA #1. The widths of the lines represent the 95% confidence interval.

M1 and M2 were conducted as proof of concept and to replicate previous findings in the literature. M3 tested our Hypothesis 1–3, and M4 tested our Hypothesis 4–7.

For M2, the game condition variable was deviation coded, and scaling was applied to all continuous predictors.

Data were analyzed in R version 3.4.1 using the lme4 and BayesFactor packages (R Core Team 2014; Bates et al. 2015; Morey and Rouder 2014). Graphs were produced using the ggplot2 package (Wickham 2016).

The raw data and the scripts used to run analysis are publicly available on the Open Science Framework at https://osf.io/katx4/.

2.2.1 | Model M1, Game Condition and Performance Predictors of Sense of Agency

Model Specifications

Model M1 Where *initial judgment of agency* (JoA#1) is the dependent variable, *turbulence* and *magic* represent the game conditions, *performance* represents the hit rate, *turbulence*performance* and *magic*performance* represent interaction terms between game condition and performance during the game, and *y.Z* is the random term. The game condition "Normal" serves as the dummy variable (the baseline that the others are compared to).

To test whether our experimental conditions independently affected sense of agency judgments, we conducted a logistic mixed model regression ($N = 823$, see Section 2.1.2). The model included a by-subject random intercept, and all independent variables were treated as by-subject random effects. Results showed that performance had a significant positive effect on JoA#1 ($b = 0.09$, SE = 0.002, $t(784.226) = 37.63$, $p < 0.001$, 95% CI [0.09, 0.10]; see Figure 3). In addition, it showed that the turbulence condition had a significant negative effect on JoA#1 ($b = -0.08$, SE = 0.004, $t(869.261) = -21.96$, $p < 0.001$, 95% CI [−0.09, −0.07]). We also found that the magic condition had a significant positive effect on JoA#1 ($b = 0.12$, SE = 0.003, $t(907.744) = 36.34$, $p < 0.001$, 95% CI [0.11, 0.13]). Surprisingly, we also discovered that the effect of performance was modulated by the magic condition ($b = -0.06$, SE = 0.002, $t(765.767) = -22.18$, $p < 0.001$, 95% CI [−0.06, −0.05]), as well as by turbulence ($b = 0.005$, SE = 0.003, $t(807.627) = 2.00$, $p = 0.045$, 95% CI [−0.001, 0.01]).

2.2.2 | Model M2, Effect of Independent Task Variables on Belief Alignment

Model Specifications

Model M2 Where *Belief Alignment* is the dependent variable, *turbulence* and *magic* represent the game conditions, *performance* represents the hit rate, *JoA#1* represents the first agency judgment, *DisagreementStrength* represents the strength of disagreement, *DisagreementDirection* represents the direction of disagreement, *turbulence*DisagreementDirection* and *magic*DisagreementDirection* represent interaction terms between game condition and disagreement direction during the game, and *y.Z* is the random term.

Belief alignment was assessed during the blocks where participants received feedback from advisors on their level of control over the Catcher. Trials where participants updated their agency judgment to align with the feedback they received were coded as alignment trials. On average, participants aligned their judgment of agency 27% (SE = 0.23) of the time, which is similar to previous studies that used the same paradigm (Baptista et al. 2022). To test whether our social manipulations affected belief alignment, we ran a logistic mixed effects model ($N = 558$ see Section 2.1.2). The model included a by-subject random intercept, and all independent variables were treated as by-subject random effects.

We found effects from the game conditions Magic ($b = 0.24$, SE = 0.04, $z = 5.640$, $p < 0.001$, 95% CI [0.16, 0.32]) and Turbulence ($b = -0.20$, SE = 0.04, $z = -5.724$, $p < 0.001$, 95% CI [−0.27, 0.13]). Furthermore, we found that performance significantly affected the probability of belief alignment ($b = -0.06$, SE = 0.02, $z = -2.786$, $p = 0.005$, 95% CI [−0.10, 0.02]), and that disagreement strength affected belief alignment ($b = 0.42$, SE = 0.03, $z = 15.023$, $p < 0.001$, 95% CI [0.37, 0.48]), that is, stronger disagreements lead to a higher probability of belief alignment. In addition, we found that disagreement direction affected belief alignment ($b = -0.22$, SE = 0.05, $z = -4.236$, $p < 0.001$, 95% CI [−0.32, −0.12]), meaning participants were more likely to align their judgment when receiving positive directed feedback (more control) than negative directed feedback (less control). Furthermore, we found interaction effects between the magic game condition and the disagreement direction ($b = -0.50$, SE = 0.05, $z = -9.578$, $p < 0.001$, 95% CI [−0.61, −0.40]) and between the turbulence game condition and the disagreement

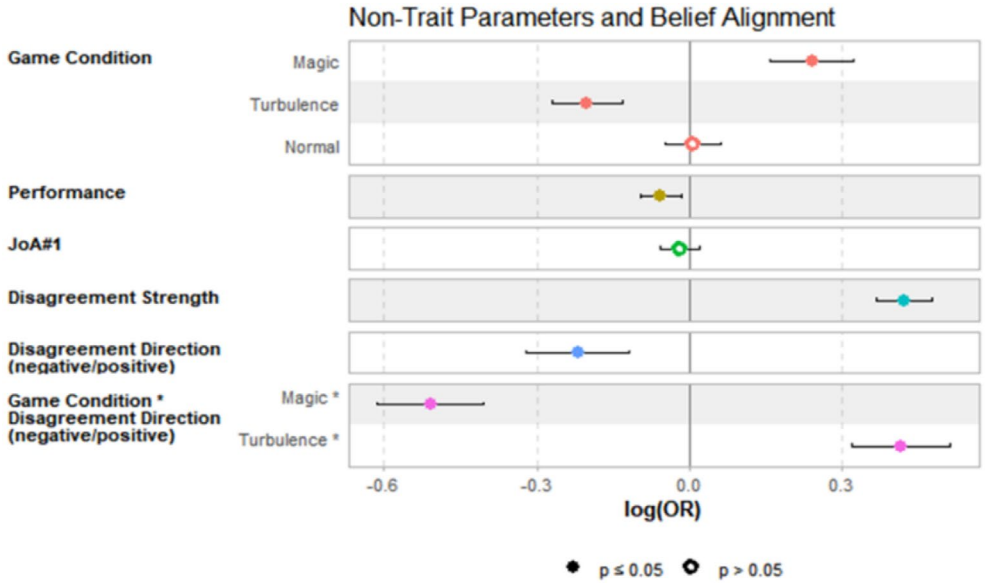

FIGURE 4 | Parameter estimates with 95% confidence interval from the logistic model of belief alignment.

direction ($b = 0.42$, SE = 0.05, $z = 8.414$, $p < 001$, 95% CI [−0.32, 0.51]) (Figure 4).

2.2.3 | Model M3, Locus of Control and Big Five Predictors of Sense of Agency

Model Specifications

Model M3 Where *initial judgment of agency* (JoA#1) is the dependent variable, *InternalLoC, PowerfulOthersLoC*, and *ChanceLoC* represent the three locus of control dimensions; *Extraversion, agreeableness, conscientiousness, neuroticism*, and *openness* represent the big five personality traits, and *y.Z* is the random term.

To test whether our trait-like constructs of interest were related to differences in sense of agency, we ran a logistic mixed model regression ($N = 781$ see Section 2.1.2) (Figure 5). The model included a by-subject random intercept.

Hypothesis 1. *Our findings show that internal locus of control is related to higher sense of agency (*b = *0.002, SE < 0.001*, t*(771.702) = 3.045*, p = *0.02, 95% CI [0.0007, 0.003]). In addition, we also found that the "chance" locus of control is related to a higher sense of agency (*b = *0.002, SE < 0.0007*, t*(771.460) = 2.276*, p = *0.02, 95% CI [0.0002, 0.003]).*

Hypothesis 2. *Interestingly, most of the Big Five traits were not related to a higher sense of agency. Unlike previous findings in the literature, we only found a significant effect from conscientiousness (*b = *−0.005, SE < 0.002*, t*(772.047) = −2.034*, p = *0.04, 95% CI [0.009, 0.0001]).*

Hypothesis 3. *Our findings also did not replicate previous findings that the Big Five trait "neuroticism" was related to a higher sense of agency (*p = 0.23*).*

2.2.4 | Model M4, Locus of Control and Big Five Predictors of Belief Alignment

Model Specifications

Model M4 Where *belief alignment* is the dependent variable, *Internal LoC, Powerful Others LoC*, and *Chance LoC* represent the three locus of control dimensions; *Extraversion*, *agreeableness*, *conscientiousness*, *neuroticism*, and *openness* represent the Big Five personality traits, and *y.Z* is the random term.

To test whether our trait-like constructs of interest were related to differences in belief alignment, we ran a logistic mixed model regression ($N = 525$ see Section 2.1.2) (Figure 6). The model included a by-subject random intercept.

Hypothesis 4. *We found no evidence that higher internal locus of control was related to a lower proportion of belief alignment (*p = 0.60*) (Figure 6).*

Hypothesis 5. *Contrary to our hypothesis #5, we found no evidence that a higher social-external locus of control (i.e., "powerful other") was related to a greater propensity to align with social feedback (*p = *0.11).*

Hypothesis 6. *Our hypothesis #6, which predicted that the Big Five trait "agreeableness", "conscientiousness", and "neuroticism" was linked to a greater likelihood of aligning with social feedback, was also not corroborated by the evidence (*p = *0.56*, p = *94*, p = *74*).*

Hypothesis 7. *At last, our hypothesis #7, which predicted that the Big Five trait "openness" was related to a reduced likelihood of aligning with social feedback, was also not corroborated by the evidence (*p = *49*).

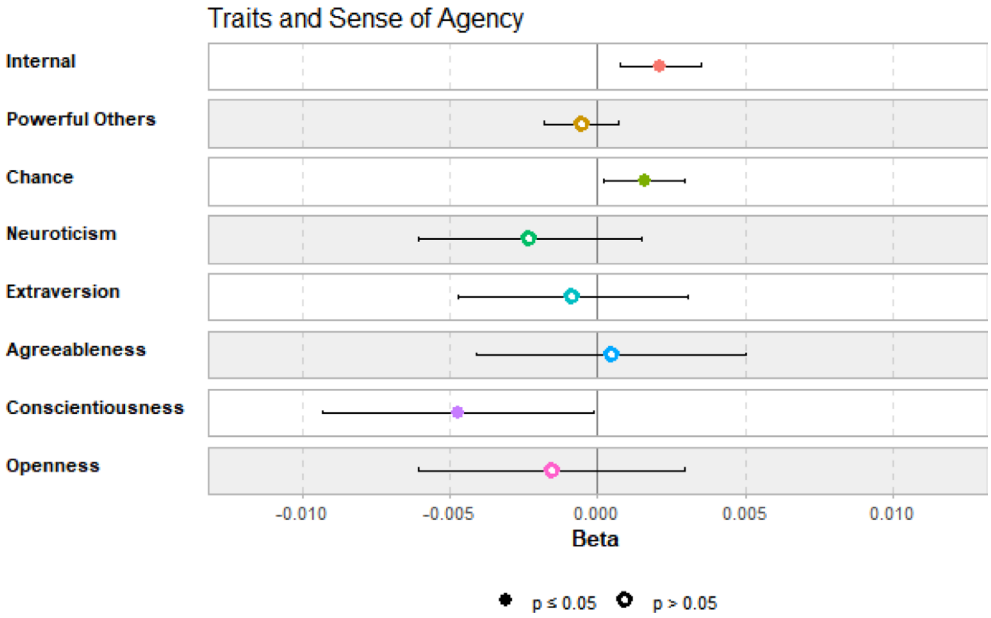

FIGURE 5 | Predictors of JoA#1 (M3). Parameters with 95% confidence intervals from the logistic model of JoA #1.

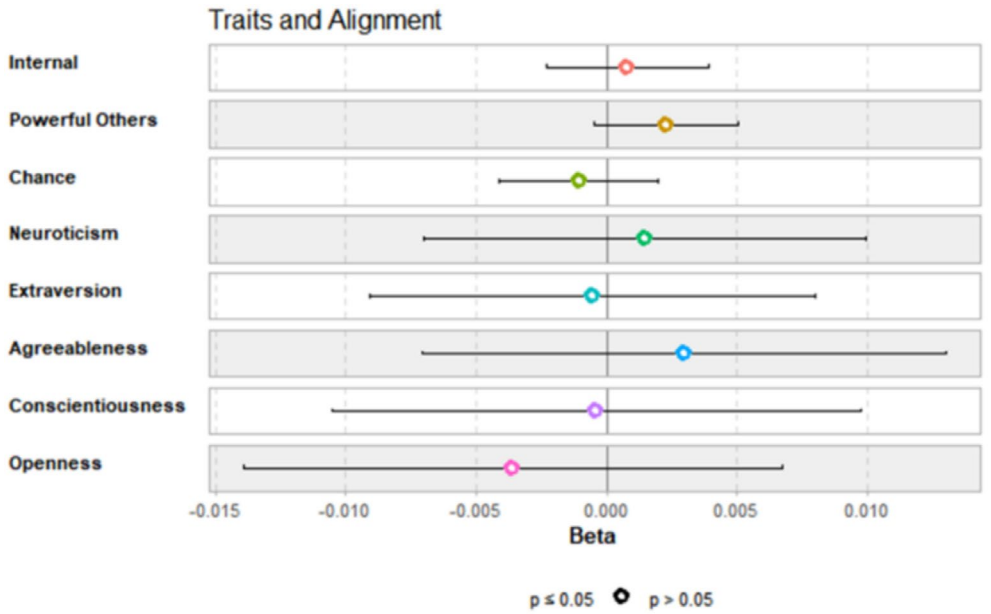

FIGURE 6 | Predictors of belief alignment (M4). Parameters with 95% confidence intervals.

Bayes factor analysis was used to interpret the nonsignificant results of M4 (Dienes 2014), which showed substantial evidence in favor of the null hypothesis ($BF10 < 0.33$, $BF = 0.000001$).

2.3 | Discussion

The primary aim of this study was to determine whether personality traits can help explain individual differences in reported sense of agency and in how people integrate peer feedback into their agency judgments.

Our results (M3) show that some trait-like constructs capture a portion of interindividual variability in sense of agency. Although our effect sizes are small and should be interpreted with caution, we found that internal locus of control is related to a higher sense of agency. This result is consistent with previous findings (e.g., Dewez et al. 2019) and goes further in several respects. Although previous studies have shown this effect in the context of body ownership in virtual reality settings, here we demonstrate the existence of a relationship between internal locus of control and sense of agency in a more abstract, less bodily context, with repeated measures for each participant. Crucially, we observed this effect on a much larger sample than those previously tested in the literature, which attests to its robustness.

Our results also show a relationship between the "chance" locus of control and sense of agency. Surprisingly, we find that the

"chance" locus of control is related to a *higher* sense of agency. We would have expected the "chance" locus of control to be related to a *lower* sense of agency, since this external locus consists of seeing the occurrence of life events as the result of chance. One possible explanation for this counterintuitive association is that the "chance" locus captures beliefs about larger-scale events in the agent's life ("To a great extent my life is controlled by accidental happenings"), whereas our experimental paradigm here measures agency by asking the participant about a small-scale object in the agent's vicinity ("How much control do you think you had over the Catcher?"). It remains possible that people who score high on the "chance" locus feel an exacerbated control over small-scale events because they can exert a direct physical influence on them, an influence they would no longer feel with distant large-scale life events, which would in turn be explained more parsimoniously by chance or random factors. In contrast, the internal locus of control might instead capture a more general increase in sense of agency that can potentially be seen in response to both small-scale and large-scale events.

Unlike recent findings by Schwarz et al. (2022), we did not observe a significant relationship between sense of agency and the Big Five personality traits "neuroticism" or "openness". We did, however, find a relationship between conscientiousness and sense of agency, but contrary to previous findings and our own hypothesis (H2), the results here show an inverse relationship between conscientiousness and sense of agency, that is, people who score high on conscientiousness tend to have a lower sense of agency. It should be noted that our results, as well as previous findings linking Big Five traits to sense of agency, have a small effect size, suggesting caution in generalizing these effects. These effects may also be inherently difficult to detect and require a larger sample size than in the present study (>700). We also cannot rule out the possibility that these effects are generally false positives.

One notable difference between the Schwarz et al.'s study and ours is that we collected agency judgments on a trial-by-trial basis, whereas Schwarz and colleagues collected agency judgments once every 25th trial. On the one hand, it has been shown that there is an interaction between personality traits and environmental uncertainty (Schwarz et al. 2022). This can be explained by the fact that people rely less on environmental cues and more on internal (personality-related) cues when producing their agency judgments in uncertain environments (Moore and Fletcher 2012; Synofzik et al. 2013). Since our trial-by-trial manipulation introduces a level of uncertainty for participants (the task environment changes from trial to trial), we might expect our paradigm to be more sensitive to trait-related effects. On the other hand, it is possible that while we capture a "state-dependent" sense of agency, Schwarz and colleagues capture a "state-independent" sense of agency. The very nature of a state-independent measure would therefore make it more likely to correlate with the Big Five traits, which are thought to capture stable constructs relatively independent of the current state of the measurement context. Surprisingly, previous research suggests that there is no overarching "trait" of perceived agency, and that the sense of agency is better described as a "state-sensitive" construct. For instance, when participants are given more control by virtue of a veto-power, this does not lead to a generally higher sense of agency, as would be expected if there was an overarching "trait" of perceived agency. On the contrary, a higher sense of agency is only observed in trials where the veto-power is used (Schwarz et al. 2023), which supports the idea that the sense of agency is better described as a "state-sensitive" construct. If sense of agency is indeed better characterized as a state-dependent construct, this would also explain why the effect sizes associated with the link between Big Five traits and the sense of agency are, in our study as in others, generally so small. As with any other psychological variable of interest (e.g., Safra et al. 2022), research on the experience of agency would benefit from future research programs that specifically attempt to capture its state–trait component and understand how these components relate to real-life or task behaviors. Only then will it be possible to reduce the noise that currently affects the measurement of individual differences in this experience.

Regarding the integration of social information into agency judgments, we found that both the direction of the disagreement as well as the strength of the disagreement affected the frequency with which participants updated their initial judgment of agency (M2) (We obtained the same results when using the full sample without exclusions, see Appendix S1). Participants were thus more likely to align with feedback that told them they had *more* control than they had initially estimated, and more likely to align on trials where the advisors more strongly disagreed with participants' initial judgment. These results replicate the findings on the integration of social information reported in Baptista et al. (2022). However, our additional result (M4) did not confirm any of our hypotheses about the relationship between personality traits and belief alignment. In contrast to our hypotheses H4 and H5, we found no evidence that the "internal" locus or the "powerful others" locus of control were related to belief alignment. Nor did we find any evidence that the Big Five traits were related to belief alignment (H6 and H7). Instead, Bayes factor analysis showed substantial evidence in favor of the null hypothesis, that is, evidence in favor of the hypothesis that none of the personality traits played a role in explaining susceptibility to social influence in the context of agency judgments. However, when we run the analysis on the full sample, without exclusions, we do see belief alignment in the expected direction (Appendix S2, $N=811$), namely that the traits "powerful others" and "agreeableness" is related to more frequent belief alignment, although also these effects are also small in size. This could hint at the view that these traits explain differences in how participants integrate information from nonhuman sources such as AI. This would be of interest for research investigating human-AI interactions; however, in our current design, we cannot discern whether these traits predict belief alignment behavior when interacting with nonhuman agents or simply predict how suspicious participants are about their advisors not being human. Further research is necessary to untangle this conflation.

Our null findings are particularly noteworthy, as they contrast with studies that have previously shown a connection between various types of personality traits and susceptibility to social influence (Jacquet et al. 2018; Oyibo and Vassileva 2019). One possible explanation for this contrast might lie in the type of judgment that is the target of social feedback. In our study, the target of social feedback is the subjects' agency judgments. In the studies by Oyibo & Vassileva and Jacquet et al., on the other

hand, the judgments targeted by social feedback are initial decisions on how to act or to assess other people's trustworthiness from facial cues. Agency judgments are perhaps a special case of judgments that are not subject to the same processes underlying social susceptibility as other kinds of judgments. Specifically, it might be the case that the susceptibility to social influence in the context of agency judgments is not affected by traits such as the Big Five personality traits or Locus of Control beliefs. Instead, it seems that the characteristics of the social feedback, that is, strength of disagreement and disagreement direction, matter more than any trait-related influence. What is it that makes agency judgments so special? It is possible that human participants are aware that the accuracy of their agency judgments cannot be easily inferred externally (Chambon, Filevich, et al. 2014). Something similar might be at play in our task, which implicitly assumes that the observer is able to infer the accuracy of the participant's agency judgments from the simple visual cues of their actions in the game. In this particular context, this may have two consequences. First, subjects might be more reluctant to revise their agency judgments in light of the observer's feedback. However, our data suggest that this is unlikely, as our participants align their agency judgments with social feedback as frequently as in other studies of the same type, but which used different judgments as targets (Jacquet et al. 2018). Secondly, participants' alignment may be driven by a different type of motivation than in other studies, and this alternative motivation may not be related to personality traits. In addition, comparing participants who believed the advisor-illusion (i.e., that advisors were real people) with participants who were excluded because they suspected nonhuman feedback, we find that the illusion-believing group was more likely to align with the feedback they received (Appendix S3). Whether this is because participants align for epistemic reasons (they believe the information provided by the advisor is useful) or because of social desirability reasons (they wish to be accommodating in order to be more likeable) is an important question that cannot be addressed in our current paradigm. Addressing these questions will require further research. First, to clarify whether susceptibility to social influence is a general or a domain-specific phenomenon and, secondly, to distinguish with a degree of precision the various motives that may lead an individual to align or not align their own agency judgments with the opinion of a third party.

2.4 | Conclusion

Together, our findings shed light on the relationship between sense of agency and personality traits, particularly with respect to the relationship between locus of control and sense of agency. Our results also shed light on the link between personality traits and change-of-mind processes in the context of agency judgments. Specifically, our results show that none of the traits tested here appear to play a significant role in explaining the interindividual variance in change-of-mind behavior regarding one's own agency judgments. Overall, the discrepancies between our results and previous findings in the literature invite further investigations to explain these conflicting results. We have suggested several directions for future research that might shed light on the link between the personality traits tested here, agency, and social susceptibility, in ways that might help to unravel their ambiguous relationships.

Author Contributions

The experimental design, data collection, and data analysis was conducted by Mark Wulff Carstensen, Valerian Chambon, Pierre Jacquet, Marlène Jan, and Axel Baptista. Discussion and interpretation, as well as presentation of the data, was conducted by Mark Wulff Carstensen, Pierre Jacquet, David Cohen, Marlène Jan, Mario Speranza, Axel Baptista, and Valerian Chambon.

Acknowledgments

M.C., D.C., A.B., and V.C. were supported by the Fondation de France grant N°00112563. A.B. was supported by a fellowship from the Fondation pour la Recherche Médicale (grant SPF202209015876). We are grateful to Marius Fouquerand, Tristan Jeanne, and Vincent Nguyen Van Nguyen for helping us program the experiment.

References

Anagnostopoulou, E., B. Magoutas, E. Bothos, J. Schrammel, R. Orji, and G. Mentzas. 2017. "Exploring the Links Between Persuasion, Personality and Mobility Types in Personalized Mobility Applications." https://doi.org/10.1007/978-3-319-55134-0_9.

Baptista, A., P. O. Jacquet, D. Cohen, and V. Chambon. 2022. "Susceptibility of Agency Judgments to Social Influence." *Cognition* 266: 105173.

Bates, D., M. Mächler, B. Bolker, and s. Walker. 2015. "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software* 67, no. 1: 1–48.

Beck, B., D. S. Costa, and P. Haggard. 2017. "Having Control Over the External World Increasese the Implicit Sense of Agency." *Cognition* 162: 54–60.

Beyer, F., N. Sidarus, S. Bonicalzi, and P. Haggard. 2017. "Beyond Self-Serving Bias: Diffusion of Responsibility Reduces Sense of Agency and Outcome Monitoring." *Social Cognitive and Affective Neuroscience* 12, no. 1: 138–145.

Beyer, F., N. Sidarus, S. Fleming, and P. Haggard. 2018. "Losing Control in Social Situations: How the Presence of Others Affects Neural Processes Related to Sense of Agency." *ENeuro* 5, no. 1: ENEURO.0336.

Bigenwald, A., and V. Chambon. 2019. "Criminal Responsibility and Neuroscience: No Revolution Yet." *Frontiers in Psychology* 10: 1406.

Blakemore, S. J., D. M. Wolpert, and C. D. Frith. 2002. "Abnormalities in the Awareness of Action." *Trends in Cognitive Sciences* 6, no. 6: 237–242.

Bonicalzi, S., and P. Haggard. 2019. "From Freedom From to Freedom to: New Perspectives on Intentional Action." *Fronties in Psychology* 10: 1193.

Brooks, G. P., and R. S. Barcikowski. 2012. "The PEAR Method for Sample Sizes in Multiple Linear Regression." *Multiple Linear Regression Viewpoints* 38, no. 2: 1–16.

Brysbaert, M. 2019. "How Many Participants Do we Have to Include in Properly Powered Experiments? A Tutorial of Power Analysis With Reference Tables." *Journal of Cognition* 2, no. 1: 16.

Brysbaert, M., and M. Stevens. 2018. "Power Analysis and Effect Size in Mixed Effects Models: A Tutorial." *Journal of Cognition* 1, no. 1: 9.

Caldwell, D. F., and J. M. Burger. 1997. "Personality and Social Influence Strategies in the Workplace." *Personality and Social Psychology Bulletin* 23, no. 10: 1003–1012.

Caspar, E. A., J. F. Christensen, A. Cleeremans, and P. Haggard. 2016. "Coercion Changes Sense of Agency in the Human Brain." *Current Biology* 26, no. 5: 585–592.

Chambon, V., E. Filevich, and P. Haggard. 2014. "What Is the Human Sense of Agency, and Is It Metacognitive?" In *The Cognitive Neuroscience of Metacognition*, edited by S. M. Fleming and C. D. Frith. Springer.

Chambon, V., J. W. Moore, and P. Haggard. 2014. "TMS Stimulation Over the Inferior Parietal Cortex Disrupts Prospective Sense of Agency." *Brain Structure and Function* 220, no. 6: 3627–3639.

Cho, P. S., N. Escoffier, Y. Mao, C. Green, and R. C. Davis. 2020. "Beyond Physical Entrainment: Competitive and Cooperative Mental Stances During Identical Joint-Action Tasks Differently Affect Inter-Subjective Neural Synchrony and Judgments of Agency." *Social Neuroscience* 15, no. 3: 368–379.

Courtois, R., J.-M. Petot, O. Plaisant, et al. 2020. "Validation of the French Version of the 10-Item Big Five Inventory." *Encephale* 46, no. 6: 455–462.

Dewey, J. A., E. Pacherie, and G. Knoblich. 2014. "The Phenomenology of Controlling a Moving Object With Another Person." *Cognition* 132: 383–397.

Dewez, D., R. Fribourg, F. A. Sanz, et al. 2019. "Influence of Personality Traits and Body Awareness of the Sense of Embodiment in Virtual Reality." *IEEE International Symposium on Mixed and Augmented Reality (Ismar), Beijing, China*, 123–134. IEEE.

Dienes, Z. 2014. "Using Bayes to Get the Most out of Non-Significant Results." *Frontiers in Psychology* 5, no. 781: 781.

Haggard, P., and B. Eitam. 2015. *The Sense of Agency*. Oxford University Press.

Hamilton, A. F. C., and F. Lind. 2016. "Audience Effects: What Can They Tell Us About Social Neuroscience, Theory of Mind and Autism?" *Culture and Brain* 4, no. 2: 159–177.

Jacquet, P. O., V. Wyart, and A. Desantis. 2018. "Human Susceptibility to Social Influence and Its Neural Correlates Are Related to Perceived Vulnerability to Extrinsic Morbidity Risks." *Scientific Reports* 8: 13347.

Jeunet, C., F. Argelaguet, and A. Lecuyer. 2018. ""Do You Feel in Control?": Towards Novel Approaches to Characterise, Manipulate and Measure the Sense of Agency in Virtual Environments." *IEEE Transactions on Visualization and Computer Graphics* 24, no. 4: 1486–1495. https://doi.org/10.1109/TVCG.2018.2794598.

Knofczynski, G. T., and D. Mundfrom. 2008. "Sample Sizes When Using Multiple Linear Regression for Prediction." *Educational and Psychological Measurement* 68, no. 3: 431–442.

Kumle, L., M. L.-H. Vö, and D. Draschkow. 2021. "Estimating Power in (Generalized) Linear Mixed Models: An Open Introduction and Tutorial in R." *Behavior Research Methods* 53, no. 6: 2528–2543.

Levenson, H. 1972. "Distinctions Within the Concept of Internal-External Control: Development of a New Scale." In *Proceedings of the Annual Convention of the American Psychological Association*, 261–262. American Psychological Association.

Levenson, H. 1981. "Differentiating Among Internality, Powerful Others, and Chance." In *Research With the Locus of Control Construct*, edited by H. M. Lefcourt. Academic Press.

Maxwell, S. E. 2000. "Sample Size and Multiple Regression Analysis." *Psychological Methods* 5, no. 4: 434–458.

McCrae, R. R., and O. John. 1997. "An Introduction to the Five-Factor Model and Its Application." *Journal of Personality* 60: 175–215.

Metcalfe, J., and M. J. Greene. 2007. "Metacognition of Agency." *Journal of Experimental Psychology* 136, no. 2: 184–199.

Metcalfe, J., T. S. Eich, and A. D. Castel. 2010. "Metacognition of Agency Across the Lifespan." *Cognition* 116, no. 2: 267–282.

Moore, J., and P. Haggard. 2008. "Awareness of Action: Inference and Prediction." *Consciousness and Cognition* 17: 136–144.

Moore, J. W. 2016. "What Is the Sense of Agency and Why Does It Matter?" *Frontiers in Psychology* 7: 1272.

Moore, J. W., and P. C. Fletcher. 2012. "Sense of Agency in Health and Disease: A Review of Cue Integration Approaches." *Consciousness and Cognition* 21, no. 1: 59–68. https://doi.org/10.1016/j.concog.2011.08.010.

Morey, R. D., and J. N. Rouder. 2014. "BayesFactor Version 0.9.9: An R Package for Computing Bayes Factor for a Variety of Psychological Research Designs." Software. http://bayesfactorpcl.r-forge.r-project.org/.

Olsen, K., A. Roepstorff, and D. Bang. 2019. "Knowing Whom to Learn From: Individual Differences in Metacognition and Weighting of Social Information." *PsyArXiv*.

Oosterhof, N. N., and A. Todorov. 2008. "The Functional Basis of Face Evaluation." *Proceedings of the National Academy of Sciences of the United States of America* 105: 11087–11092.

Oyibo, K., R. Orji, and J. Vassileva. 2017. "Investigation of the Influence of Personality Traits on Cialdini's Persuasive Strategies." International Workshop on Personalizaing in Persuasive Technologies (PPT17).

Oyibo, K., and J. Vassileva. 2019. "The Relationship Between Personality Traits and Susceptibility to Social Influence." *Computers in Human Behavior* 98, no. 6: 174–188.

Pescetelli, N., and N. Yeung. 2020. "The Role of Decision Confidence in Advice-Taking and Trust Formation." *Journal of Experimental Psychology* 150, no. 3: 507–526.

R Core Team. 2014. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing.

Ras, M., A. M. Nowik, A. Klawiter, and G. Króliczak. 2019. "When Is the Brain Ready for Mental Actions? Readiness Potential for Mental Calculations." *Acta Neurobiologiae Experimentalis* 79, no. 4: 386–398.

Roccas, S., L. Sagiv, S. H. Schwartz, and A. Knafo. 2002. "The Big Five Personality Factors and Personal Values." *Personality and Social Psychology Bulletin* 28, no. 6: 789–801.

Rotter, J. B. 1954. *Social Learning and Clinical Psychology*. Prentice-Hall.

Safra, L., N. Lettinga, P. O. Jacquet, and C. Chevallier. 2022. "Variability in Repeated Economic Games: Comparing Trust Game Decisions to Other Social Trust Measures." *Royal Society Open Science* 9: 2054–5703.

Schultze-Kraft, M., E. Parés-Pujolrás, K. Mati'c, P. Haggard, and J.-D. Haynes. 2020. "Preperation and Execution of Voluntary Action Both Contribute to Awareness of Intention." *Proceedings of the Royal Society* 287: 20192928.

Schwarz, K. A., A. L. Klaffehn, N. Hauke-Forman, F. V. Muth, and R. Pfister. 2022. "Never Run a Changing System: Action-Effect Contingency Shapes Prospective Agency." *Cognition* 229: 105250.

Schwarz, K. A., S. Tonn, J. Büttner, W. Kunde, and R. Pfeister. 2023. "Sense of Agency in Social Hierarchies." *Journal of Experimental Psychology: General* 152, no. 10: 2957–2976.

Sidarus, N., E. Travers, P. Haggard, and F. Beyer. 2020. "How Social Contexts Affect Cognition: Mentalizing Interferes With Sense of Agency During Voluntary Action." *Journal of Experimental Social Psychology* 89: 103994.

Sidarus, N., M. Vuorre, and P. Haggard. 2017. "How Action Selection Influences the Sense of Agency: An ERP Study." *NeuroImage* 150: 1–13.

Soon, C. S., A. H. He, S. Bode, and J.-D. Haynes. 2013. "Predicting Free Choices for Abstract Intentions." *Proceedings of the National Academy of Sciences of the United States of America* 15: 6217–6222.

Synofzik, M., G. Vosgerau, and M. Voss. 2013. "The Experience of Agency: An Interplay Between Prediction and Postdiction." *Frontiers in Psychology* 4: 127. https://doi.org/10.3389/fpsyg.2013.00127.

Tapal, A., E. Oren, R. Dar, and B. Eitam. 2017. "The Sense of Agency Scale: A Measure of Consciously Perceived Control Over One's Mind, Body, and the Immediate Environment." *Frontiers in Psychology* 8, no. 1552.

Wegner, D. M., and B. Sparrow. 2004. "Authorship Processing." In *The Cognitive Neurosciences*, edited by M. S. Gazzaniga, 1201–1209. Boston Review.

Wegner, D. M., B. Sparrow, and L. Winerman. 2004. "Vicarious Agency: Experiencing Control Over the Movements of Others." *Journal of Personality and Social Psychology* 86: 838–848.

Westfall, J., D. A. Kenny, and C. M. Judd. 2014. "Statistical Power and Optimal Design in Experiments in Samples of Participants Respond to Samples of Stimuli." *Journal of Experimental Psychology* 143, no. 5: 2020–20245.

Wickham, H. 2016. *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.