Ask the Pendulum: Personality Predictors of Ideomotor Performance

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Abstract

For centuries, people have asked questions to hand-held pendulums and interpreted their movements as responses from the divine. These movements occur due to the ideomotor effect, wherein priming or thinking of a motion causes muscle movements that end up swinging the pendulum. By associating particular swinging movements with *yes* and *no* responses, we investigated whether pendulums can aid decision-making and which personality traits correlate with this performance. Participants ($N = 80$) completed a visual detection task in which they searched for a target letter among rapidly presented characters. In the verbal condition, participants stated whether they saw the target in each trial. In the pendulum condition, participants instead mentally "asked" a hand-held pendulum whether the target was present; particular motions signified *yes* and *no*. We measured the accuracy of their responses as well as their sensitivity and bias using signal detection theory. We also assessed four personality measures: locus of control (feelings of control over one's life), transliminality (sensitivity to subtle stimuli), need for cognition (preference for analytical thinking), and faith in intuition (preference for intuitive thinking). Overall, locus of control predicted verbal performance and transliminality predicted pendulum performance. Accuracy was low in both conditions (verbal: 57%, pendulum:

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53%), but bias was higher in the verbal condition ($d = 1.10$). We confirmed this bias difference in a second study ($d = 0.47$, $N = 40$). Our results suggest that people have different decision strategies when using a pendulum compared to conscious guessing. These findings may help explain why some people can answer questions more accurately with pendulums and Ouija boards. More broadly, identifying the differences between ideomotor and verbal responses could lead to practical ways to improve decision-making.

1 Introduction

Pendulums magnify subtle movements. If one holds a pendulum and thinks of a particular motion, subtle muscle movements will initiate the swinging of the pendulum in that direction. These movements usually occur without perceived conscious control (Easton & Shor, 1976; Gordon & Rosenbaum, 1984). As a result, for centuries people have interpreted these movements as responses from the unconscious — or the divine. In some cases, people can answer questions more accurately with muscle movements than they can with conscious guessing (Gauchou, Rensink, & Fels, 2012). The personality traits that predict this accuracy, however, remain unknown. The present study thus explores several traits and their relation to ideomotor performance.

Hand-held pendulums swing seemingly on their own due to *ideomotor movements*, subtle muscle movements caused by thinking of a motion. Similar mechanisms likely underlie Ouija boards, automatic writing, dowsing rods, and other ideomotor tools intended to bypass conscious analysis and reduce bias (Spitz, 1997; Wegner, 2003). Hypnotherapists have used pendulums clinically to probe unconscious material (Ewin, 2009); magicians have used them to retrieve information from people such as the location of hidden objects (Banachek, 2002; Spitz, 1997). Others use pendulums in an attempt to aid decision-making — from choosing which vegetables are fresh to deciding which house to buy or even who to marry (Lundstrom, 2010).

Fortunately for those making drastic decisions this way, ideomotor responses can be more accurate than chance alone. For example, Gauchou and colleagues (2012) tested whether ideomotor responses can reflect implicit knowledge when using a Ouija board. Participants held a small pointer or *planchette* on a board ascribed with *yes* and *no* responses. The experimenter asked various questions that participants earlier claimed not to know (e.g., "Did Operation Desert Storm occur in the 1980s?"). Without the participants' perceived control, they moved the planchette towards the *yes* or *no* areas of the board, answering the questions. Their responses were more accurate when using the Ouija board (65%) than when responding verbally (50%). By following their involuntary muscle movements, it seemed that participants could express their implicit knowledge.

These ideomotor phenomena vary from person to person. For some, pendulums barely move; for others, they immediately swing in a consistent direction (Karlin, Hill, & Messer, 2007). During our pilot testing, some participants found the pendulum movement mundane while others found it mystical: one even stayed behind to privately ask the pendulum questions about her life. Nevertheless, we know of only two individual factors that may underlie ideomotor differences: gender and hypnotic suggestibility. Women produce larger ideomotor movements than men in some studies (Easton & Shor, 1976) but not in others (Wegner, Ansfield, & Pilloff, 1998). Hypnotic suggestibility — how easily one follows suggestions under hypnosis — also positively correlates with pendulum movement (Eysenck & Furneaux, 1945; Karlin et al., 2007). To uncover more of these factors, we explored four personality measures that may predict ideomotor response:

- *Locus of control* measures feelings of control over one's life (Duttweiler, 1984). People with an internal locus tend to take responsibility for their actions; those with an external locus tend to believe that situational forces or luck determine their life events. We predicted that people with a more external locus of control would perform better, since they may be more likely to let the pendulum swing without consciously interfering with it (cf. Lundstrom, 2010; Gauchou et al., 2012). Similarly, people with an external locus of control may be more suggestible (Burger, 1981) which should promote pendulum movement (Eysenck & Furneaux, 1945; Karlin et al., 2007).

- *Transliminality* measures the threshold at which stimuli reach conscious awareness, as measured by a self-report questionnaire (Lange, Thalbourne, Houran, & Storm, 2000). People with higher transliminality can detect subtle internal or external stimuli such as briefly presented images (Crawley, French, & Yesson, 2002; Olson, Amlani, Raz, & Rensink, 2015). Transliminality also correlates with absorption, mysticism, and paranormal beliefs (Lange et al., 2000). Since pendulum users claim that people need to be sensitive to their thoughts and muscle movements (Lundstrom, 2010; Nielsen & Polansky, 1987), we predicted that those higher in transliminality would show more accurate ideomotor responses. In addition, since transliminality correlates with paranormal beliefs, high transliminality people may be more open to the atypical activity of asking questions to a pendulum.

- *Need for cognition* measures the tendency to engage in and enjoy thinking (Cacioppo & Petty, 1982). We expected that these analytical people would perform worse with the pendulum since they may try to consciously interfere with the ideomotor responses (cf. Lundstrom, 2010).

- *Faith in intuition* measures reliance on intuitive decision-making (Cacioppo & Petty, 1982). If ideomotor responses can express implicit knowledge (Gauchou et al., 2012), those who trust their intuition may perform better with the pendulum.

In this paper, we explore how these personality traits relate to ideomotor response. Participants completed two conditions of a task in which they searched for a target letter among rapidly presented characters. In the verbal condition, participants stated whether they saw the target in each trial. In the pendulum condition, they instead mentally "asked" a pendulum whether the target was present; we told them particular motions signified *yes* and *no*. Study 1 compares these verbal and pendulum responses; Study 2 tests whether these differences remain in a more difficult task. Combined, these studies explore whether people can use pendulums to access the mechanisms involved in unconscious decision-making.

2 Study 1

2.1 Methods

2.1.1 Participants

Eighty undergraduate students from McGill University completed the study for course credit. After excluding those who deviated from the task instructions (see Section 2.1.5), 63 participants remained. They were on average 20.3 years old (*SD* = 1.4) and 87% were female. Most studied psychology (65%), commonly in the second year of their studies (40%). Few had held a pendulum before (33%) or had done so only for a physics class (25%); few had used a Ouija board either (29%). Most of the participants were right-handed (86%). We chose our sample size in advance based on a power analysis (see Section 2.1.5).

2.1.2 Materials

2.1.2.1 Questionnaires

To begin the study, participants completed paper-and-pencil questionnaires testing four personality traits. To measure locus of control, we used the 28-item Internal Control Index. An example item is: "If I want something, I work hard to get it". Each item uses a 5-point Likert scale ranging from "rarely" (1) to "usually" (5). Higher scores on the questionnaire (up to 140) suggest an internal locus of control and lower scores (down to 28) suggest an external one. The scale has high internal consistency (Cronbach's $\alpha = .84$; Duttweiler, 1984); it was similar in our sample ($\alpha = .81$). Participants had an average score of 102.78 (*SD* = 11.07, range = 79 to 126), which is expected given their age and education level (Duttweiler, 1984).

We then measured transliminality using the 17-item true–false Revised Transliminality Scale. An example item is: "... I have had such a heightened awareness of sights and sounds that I cannot shut them out". Agreeing with such items implies greater sensitivity — that more near-threshold material enters conscious awareness. The scale ranges from 0 to 17 reflecting how many items were labelled as true. It has a test–retest reliability of .82 and good convergent validity (Houran, Thalbourne, & Lange, 2003). The scale also has high internal consistency (Cronbach's $\alpha = .82$; Lange et al., 2000); it was similar in our sample ($\alpha = .77$). After a Rasch transformation (see Lange et al., 2000), participants had an average score of 22.9 (*SD* = 3.49) and a range of 13.7 to 32.5, close to the expected values (Thalbourne, Crawley, & Houran, 2003).

Finally, participants completed the 40-item Rational–Experiential Inventory which measures one's information processing style (Epstein, Pacini, Denes-Raj, & Heier, 1996). It has two subscales: need for cognition and faith in intuition. An example item measuring need for cognition is: "I prefer complex problems to simple problems"; for faith in intuition, an example is: "I trust my initial feelings about people". Each item ranges from "definitely not true" (1) to "definitely true of myself" (5), making each subscale range from 20 to 100. The internal consistency of both subscales is high ($\alpha = .81$ and .90); the values were similar in our sample ($\alpha = .80$ and .89). Participants had an average need for cognition score of 76.74 (*SD* = 10.18, range = 50 to 96) and a faith in intuition score of 63.99 (*SD* = 12.62, range = 33 to 96). The need for cognition score correlated with locus of control ($r(60) = .620$, 95% CI [.450, .760]).

2.1.2.2 Equipment

After completing the questionnaires, participants entered the testing room which contained a glass table in front of a computer monitor (1920 $\times$ 1080 resolution, 24-inch BenQ, Taipei, Taiwan). Stimuli were presented using PsychoPy (version 1.83.04; Peirce, 2009) at 60 Hz. On the table sat a brass pendulum with a 20 cm string (Adermark, Vancouver, Canada). A video camera (GoPro 4, San Mateo, CA) was placed 6 cm underneath the glass surface of the table to record the pendulum's movement.

2.1.3 Procedure

2.1.3.1 Instructions

The experimenter explained that pendulums magnify unconscious muscle movements and can therefore reflect implicit knowledge. Based on advice from hypnotherapists and magicians, we used suggestion to associate pendulum movements with particular responses (D. Ewin, personal communication, 2014; Banachek, 2002; cf. Eysenck & Furneaux, 1945). In particular, the experimenter stated:

> What researchers have found is that if you hold a pendulum and think of *yes*, it will swing up and down as if nodding its head.[1] If you think of *no*, it will swing side to side as if shaking its head *no*. You don't even have to consciously move your hand: it will just move unconsciously and the pendulum will begin to swing.[2]

While giving these instructions, the experimenter demonstrated the movement with the pendulum. Next, the participant held the pendulum in her right hand above the video camera, so that the tip of the pendulum was 2 cm above the table. The participant thought of the word *yes* and waited for vertical movement. The experimenter promoted this movement by waving her finger beside the pendulum then slowly increasing the speed (cf. pacing and leading; Easton & Shor, 1977; Nash & Barnier, 2012). Using suggestions common in hypnosis, the experimenter verbally reinforced the pendulum's movement ("just like that", "that's right") before repeating this procedure for the horizontal movement representing *no*.

2.1.3.2 Detection task

[1]Some pendulum users recommend calibrating the movements to the individual (Lundstrom, 2010). They suggest asking the pendulum to "show yes" and "show no" rather than choosing vertical and horizontal movements in advance. In pilot testing, these *yes* and *no* movements indeed varied across participants. Alas, to reduce individual variation, we decided to keep the movements constant.

[2]If the pendulum did not swing, the experimenter would state: "Sometimes it takes a bit of time — just visualise the pendulum swinging side to side, side to side." If it still did not swing or showed little movement: "It's okay, sometimes it takes a bit of practice."

Participants then completed the task, which consisted of two conditions with 24 trials each. In each trial, participants would see a rapidly presented series of numbers and punctuation marks while they attempted to detect a target letter. The experimenter explained that the letter would appear in half of the trials. The stimuli were white on a 50% grey screen and measured 3 cm in height (4.3 degrees of visual angle).

Each trial began with a fixation cross followed by 6 distractors (numbers or punctuation marks) at 17 ms each to serve as masks (see Figure 1). Next, 24 distractors appeared for 33 ms each with no inter-stimulus interval. In half of the trials, one of the distractors was replaced with the target: a random capital letter. The target never appeared in the first 6 nor last 6 positions of the stream to reduce serial position effects (Potter, 1976). The stream concluded with another 6 masks at 17 ms each.

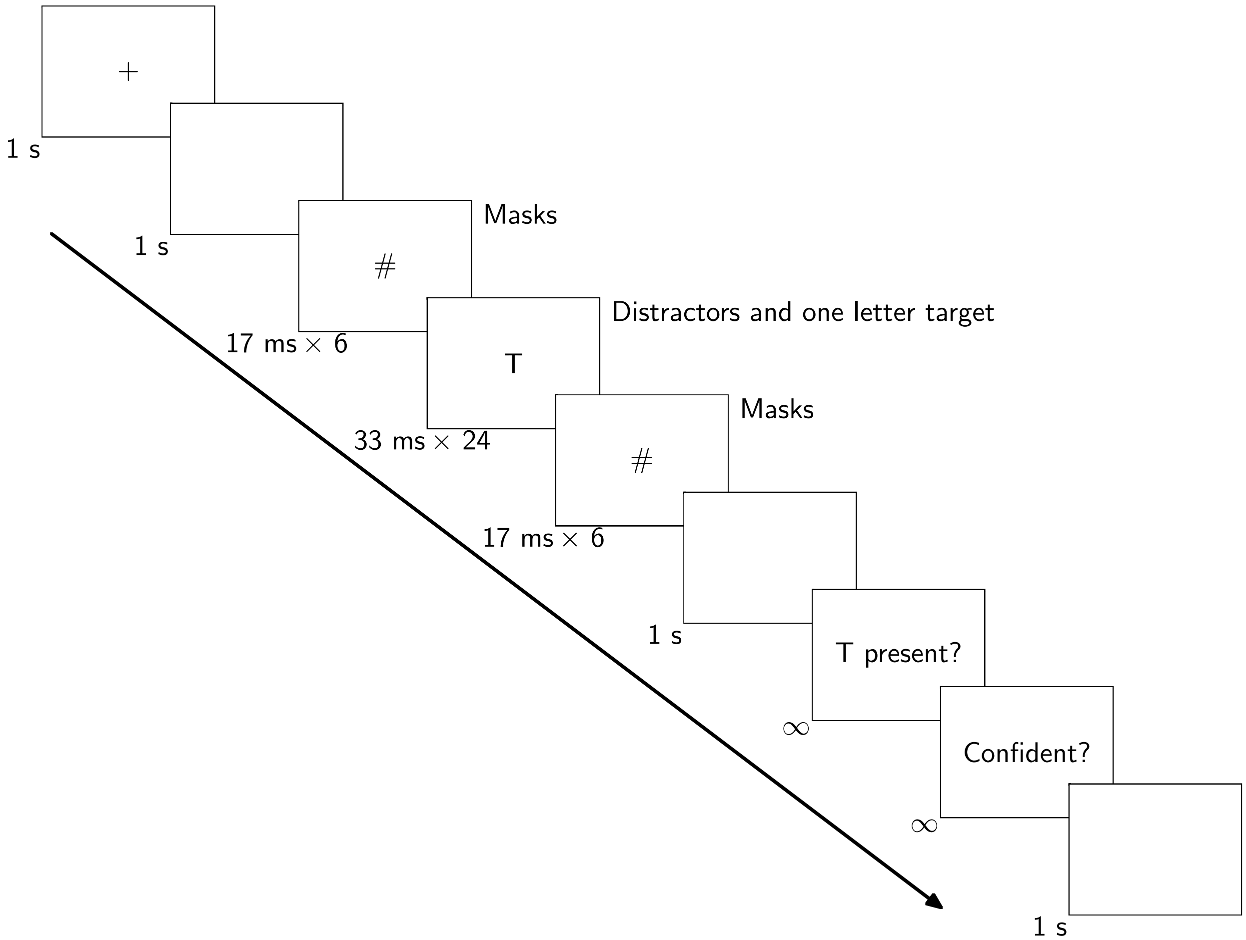
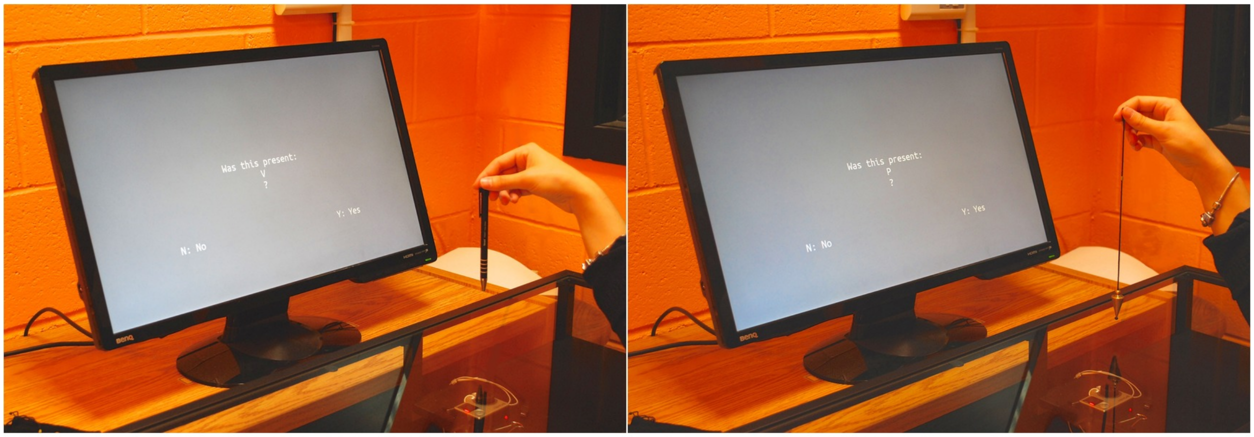


Figure 1: Task design. Participants searched for the target letter among distractors (numbers and punctuation). They then stated the target's presence either verbally or by asking a pendulum and responding based on its movements. In the verbal task, participants stated their confidence (certain or uncertain); in the pendulum task, they stated their agreement with the pendulum's response (agree, disagree, or uncertain).

2.1.3.2.1 Verbal condition

After viewing the stream, participants stated whether the target was present, then the experimenter typed this response. The median response time was 5.53 s (*SD* = 3.01) and there was no time limit. Participants then indicated their confidence by stating whether they were certain or uncertain about their response. Throughout this verbal condition, participants held a pen above the video camera to maintain a similar posture as in the pendulum condition (Figure 2). We counter-balanced the order of these conditions across participants.



A B

Figure 2: Setup. In the verbal condition, participants answered verbally while holding a pen (A); in the pendulum condition, they mentally asked a pendulum then watched its movement (B).

2.1.3.2.2 Pendulum condition

In the pendulum condition, after each character stream, participants mentally asked the pendulum whether the target was present. As instructed, vertical movement meant *yes* and horizontal movement meant *no*. The participants watched the pendulum's movement then verbally classified it as *yes* or *no*. The video camera recorded the movement and the experimenter noted any discrepancies between the participants' classifications and the actual swinging. Overall, there were few discrepancies so we deferred to the participants' judgements.[3] The median response time was 20.64 s (SD = 14.81), considerably longer than in the verbal condition ($Mdn = 5.53$ s, SD = 3.01). Participants then indicated their confidence by stating whether they agreed with, disagreed with, or were uncertain about the pendulum's response. For example, sometimes the pendulum swung in a vertical *yes* pattern, but the participant disagreed with it and thought the correct answer should have been *no*. Measuring confidence in this way allowed us to make coarse comparisons between the two conditions.

If the pendulum was not moving in a consistent pattern, the experimenter suggested to

[3]We hope to analyse the pendulum movement based on the video data in a future article (Olson & Raz, in progress).

continue focusing on its movement before stating the response. The pendulum eventually moved in every trial. After the study, we fully debriefed participants. The protocol was approved by the McGill Faculty of Medicine Institutional Review Board.

2.1.4 Dependent variables

In each trial, we measured accuracy: whether participants were correct about the target's presence. We then used signal detection theory to calculate sensitivity and bias (Green & Swets, 1966). *Sensitivity* (d') refers to how well people could detect the target; higher values mean better detection and zero values mean chance-level performance. *Bias* (or *criterion*, c) refers to the overall bias in declaring the target present or absent. Higher bias values mean a higher probability of declaring the target absent and zero values mean no bias towards either response.

2.1.5 Analysis

We had two sets of hypotheses. First, we expected that personality measures would predict performance. For each condition, we used mixed-effect logistic regression to predict the accuracy of each trial given the four personality measures. We chose a family-wise Type I error rate of .10, giving Bonferroni-corrected α values of .025 for each of the four predictors. Next, we tested two analogous linear models predicting average (not per-trial) sensitivity then average bias as response variables. Each of these three models constituted separate families for error control. All regressions were forced-entry. Their assumptions were reasonable besides the lack of specification error: as an exploratory study, we could not measure all (and only) relevant variables. Our logistic model for accuracy had high statistical power; our linear models for sensitivity and bias did not. For overall model fit statistics, see Table A2.

Second, we assessed how participants' confidence in their responses related to performance between the conditions. We had five pre-specified hypotheses based on the Ouija board findings (see Appendix A; Gauchou et al., 2012). We compared per-trial accuracy using chi-square tests as well as average sensitivity and bias using t tests. Hypotheses about each of these dependent variables constituted a family. A family-wise α of .10 gave Bonferroni-corrected α values of .02 for each test. With our intended sample size ($N = 80$) and assuming a 10% exclusion rate, we had 90% power to detect medium-sized effects (Cohen's $d = 0.43$). All assumptions were reasonable for these tests.

We excluded participants who gave the same response to over 80% of the trials in either condition. For example, if a participant responded "present" to 85% of the verbal trials, we omitted the data from *both* conditions. This exclusion criterion omitted participants who deviated from the task instructions by giving near-constant responses; it also allowed us to calculate signal detection theory values. Beyond these considerations, the 80% criterion was chosen arbitrarily. This criterion excluded 16 participants in the verbal condition and 3 in the pendulum condition (2 of whom were already excluded), leaving 63 remaining in total. In addition, 2 participants did not complete all of the questionnaires and so were excluded only from the personality analyses. Our exclusion criteria, variables, hypotheses, and analyses were pre-registered online.[4]

There was one difference between our pre-registered procedure and our analysis here. We initially intended to see how personality measures correlated with differences in condition performance within *each participant*. However, given the low performance in both conditions, we instead decided to analyse how personality measures predicted performance within *each condition*. This only changed the dependent variables in the personality models (from difference scores to raw scores). All other deviations from our pre-register procedure are explicitly labelled as exploratory and do not use significance testing.

Our analysis focuses on effect sizes (Cumming, 2014). For mean differences, we report a robust version of Cohen's d — symbolised as d_R — which measures condition differences in standard deviations. It equals the 20% trimmed mean divided by the 20% Winsorised

[4]See https://osf.io/w4qra/register/565fb3678c5e4a66b5582f67.

standard deviation (Algina, Keselman, & Penfield, 2005). Square brackets throughout denote bootstrapped 95% confidence intervals (Kirby & Gerlanc, 2013).

The analyses used R 3.3.3 (R Core Team, 2016), with packages lme4 1.1-12 for mixed-effects logistic regression, bootES 1.2 for bootstrapped effect sizes (Kirby & Gerlanc, 2013), Hmisc 4.0-2 for bootstrapped confidence intervals, MuMIn 1.15.6 for logistic regression R^2, and ggplot2 2.2.1 (Wickham, 2009) for graphs.

2.2 Results

Overall, accuracy and sensitivity were low in both the verbal (57% $[55\%, 60\%]$, $d' = 0.26$ $[0.15, 0.37]$) and pendulum conditions (53% $[51\%, 56\%]$, $d' = 0.12$ $[0.04, 0.21]$, Figure 3A). Bias, however, was higher in the verbal condition ($c = 0.2$ $[0.15, 0.24]$) than in the pendulum condition ($c = 0$ $[-0.05, 0.06]$, $t(62) = 6.7$, $p < .001$, Figure 3B). Thus, participants were more likely to declare the target absent in the verbal condition, yet they showed little bias in the pendulum condition. The difference was 1.096 $[0.76, 1.54]$ standard deviations (d_R) — a large effect. Within each participant, exploratory analyses showed that bias correlated between the conditions ($r = .323$ $[.010, .600]$) but we did not see a similar correlation for sensitivity ($r = .199$ $[-.040, .420]$).

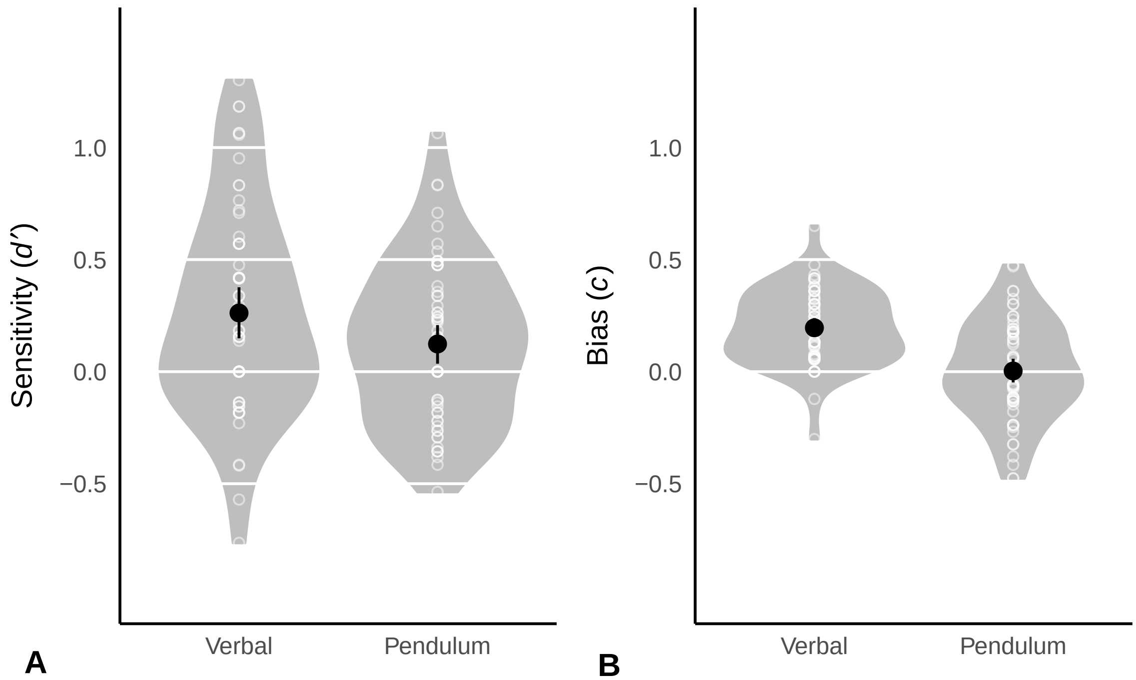


Figure 3: Sensitivity (A) and bias (B) by task. Bias was higher in the verbal task. Dots show means, errors bars show 95% bootstrapped confidence intervals, circles show data points, and width estimates underlying distribution.

Several personality measures predicted performance. In the verbal condition, locus of control predicted sensitivity: people who reported feeling more control over their lives performed better than those who reported less control (Figure 4A). For every one-point increase in locus of control, sensitivity (d') increased by 0.02 units ($p = .008$). Need for cognition also predicted verbal performance: people with higher need for cognition scores performed less accurately (odds ratio = 0.982, $p = .023$).

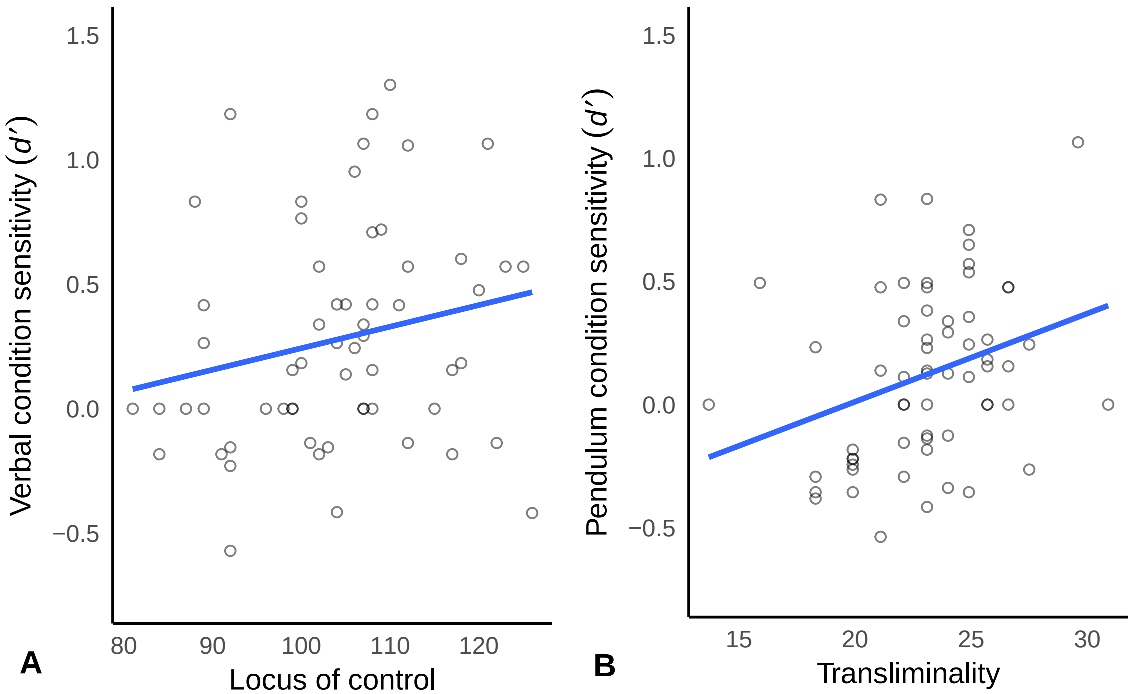


Figure 4: Sensitivity in the verbal condition given locus of control (A; $r = .183$) and sensitivity in the pendulum condition given transliminality (B; $r = .310$), ignoring all other predictors. Each circle shows data from one participant.

In the pendulum condition, transliminality predicted performance. People with higher transliminality scores — those more sensitive to subtle stimuli — performed better than those with lower scores (Figure 4B). For every one-point increase in transliminality, sensitivity increased by 0.044 units ($p = .009$). See Table 1 for full statistics.

Table 1: Personality predictors of verbal and pendulum performance. Locus of control and need for cognition predicted verbal performance while transliminality predicted pendulum performance. Bonferroni-corrected α values were .025.

DV	Task	Predictor	*B*	*SE*	*z*	*p*
Accuracy	Verbal	Locus of control	0.017	0.007	2.593	.010*
		Transliminality	0.004	0.020	0.184	.854
		Need for cognition	-0.018	0.008	-2.268	.023*
		Faith in intuition	0.005	0.005	1.124	.261
	Pendulum	Locus of control	0.010	0.006	1.610	.107
		Transliminality	0.052	0.020	2.649	.008*

DV	Task	Predictor	*B*	*SE*	*z*	*p*
		Need for cognition	-0.005	0.008	-0.605	.545
		Faith in intuition	0.000	0.004	0.092	.927
Sensitivity	Verbal	Locus of control	0.020	0.007	2.761	.008*
		Transliminality	0.005	0.021	0.232	.818
		Need for cognition	-0.019	0.008	-2.226	.030
		Faith in intuition	0.005	0.005	1.037	.304
	Pendulum	Locus of control	0.008	0.005	1.569	.122
		Transliminality	0.044	0.016	2.710	.009*
		Need for cognition	-0.002	0.006	-0.311	.757
		Faith in intuition	0.000	0.004	-0.045	.964
Bias	Verbal	Locus of control	0.000	0.002	0.127	.900
		Transliminality	-0.011	0.007	-1.428	.159
		Need for cognition	0.000	0.003	0.005	.996
		Faith in intuition	-0.003	0.002	-1.768	.082
	Pendulum	Locus of control	-0.002	0.003	-0.625	.534
		Transliminality	0.007	0.010	0.730	.468
		Need for cognition	0.005	0.004	1.192	.238
		Faith in intuition	-0.005	0.002	-2.252	.028

Beyond these personality measures, we also found gender differences in an exploratory analysis. Women and men differed in their sensitivity: women outperformed men in the verbal condition ($d_R = 1.24$ $[0.64, 2.06]$, Figure 5A) but not in the pendulum condition ($d_R = -0.03$ $[-0.99, 0.99]$, Figure 5B). We did not see similarly strong gender differences in bias (verbal: $d_R = -0.31$ $[-1.49, 0.74]$; pendulum: $d_R = 0.16$ $[-0.87, 0.9]$).

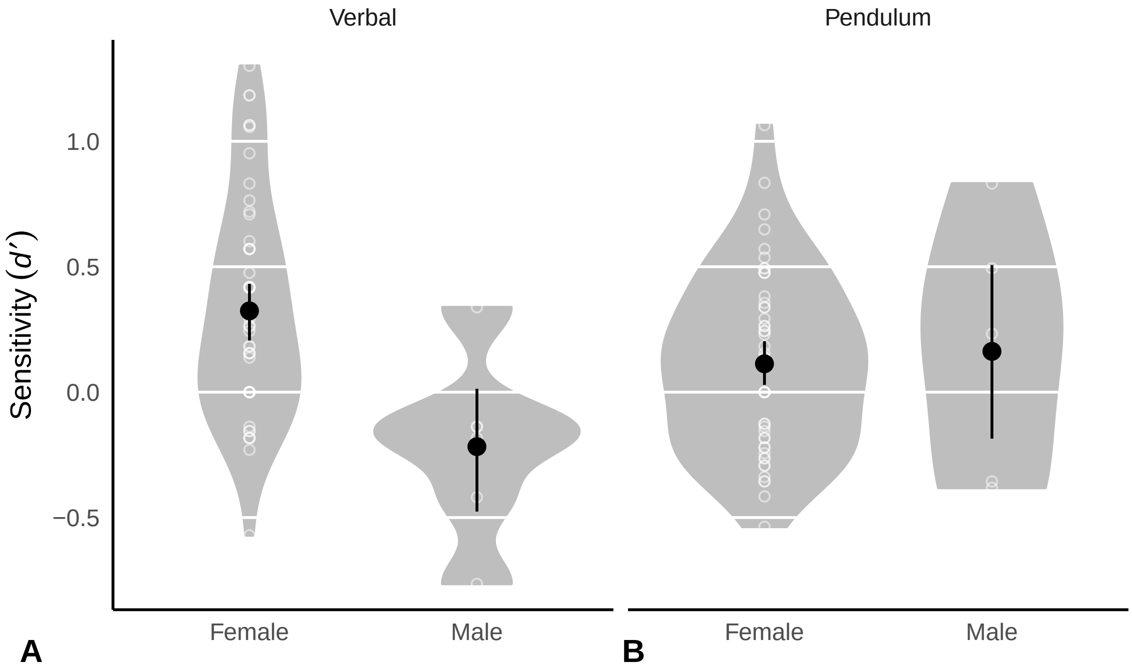


Figure 5: Sensitivity by condition and gender. Women outperformed men in the verbal condition (A) but not the pendulum condition (B). Dots show means, errors bars show 95% bootstrapped confidence intervals, circles show data points, and width estimates underlying distribution.

For confidence, performance was highest when participants felt certain about their answers (see Table A1 and Figure A1). Ideomotor response always underperformed verbal guessing, unlike the Ouija board findings (Gauchou et al., 2012). We next conducted a follow-up study to examine this discrepancy.

3 Study 2

Gauchou and colleagues (2012) found the largest difference between verbal and ideomotor performance when participants felt least certain about their responses. Namely, when guessing, participants performed best when responding with a Ouija board. To increase the uncertainty (and difficulty) of our task, we doubled the stimulus presentation speed. We then tested whether this increase in uncertainty would give results comparable to those with a Ouija board. This study also allowed us to replicate some of the findings of Study 1 (cf. Open Science Collaboration, 2015).

3.1 Methods

We recruited 40 additional undergraduate students to participate. After exclusions, 34 participants remained, 59% of whom were female (compared to 87% in Study 1). Besides gender, the samples of the two studies were similar. The participants were on average 20.2 years old (*SD* = 0.9); many studied psychology (44%), commonly in the second (32%) or fourth year (35%) of their degree. Few had held a pendulum before (24%) and most were right-handed (85%). The rest of the methodology was identical to Study 1 except that the stimulus timing was 17 ms rather than 33 ms (see Figure 1).

Our sample size was limited by feasibility constraints. We did not have high statistical power to predict performance based on personality, but we did have the power to test some of the large effects seen in Study 1.

3.2 Results

Accuracy was at chance level for both the verbal (51% [47%, 54%]) and pendulum conditions (50% [47%, 54%], Figure 6A). The lower accuracy was likely due to the relatively brief stimulus presentation time (17 ms) which reduced visibility and caused a floor effect. As in Study 1, bias was higher in the verbal condition ($c = 0.18$ [0.11, 0.24]) than in the pendulum condition ($c = 0.04$ [−0.04, 0.12], $t(32) = 2.59$, $p = .014$, Figure 6B). Thus, people again showed almost no bias in the pendulum condition. The difference between the conditions was 0.466 [0.14, 0.9] standard deviations (d_R).

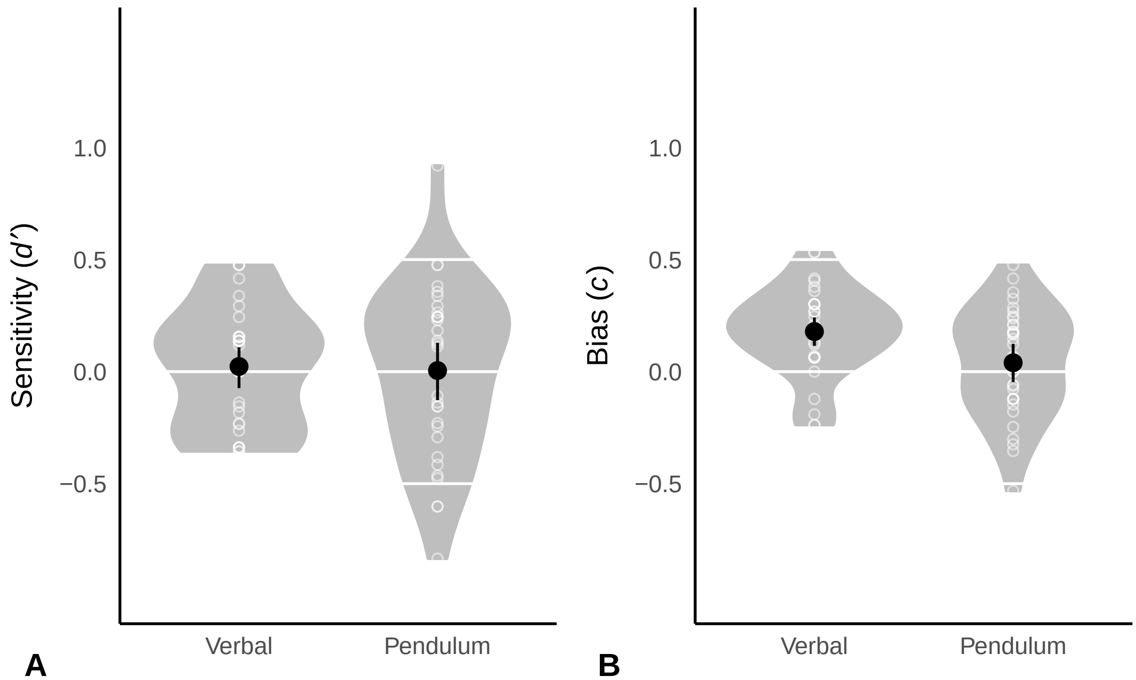


Figure 6: Sensitivity (A) and bias (B) by condition. As in Study 1, bias was higher in the verbal condition. Dots show means, errors bars show 95% bootstrapped confidence intervals, circles show data points, and width estimates underlying distribution.

Unlike in Study 1, personality measures did not predict performance (see Table B1), possibly due to the floor effects and reduced power. Further, exploratory analyses showed that sensitivity in the verbal condition negatively correlated with sensitivity in the pendulum condition ($r = -0.364$ $[-.630, -.000]$). We did not see a similar correlation for bias ($r = 0.081$ $[-.270, .440]$). Thus, using a more difficult task we were only able to partly reproduce the pattern of results found in Study 1.

4 Discussion

For centuries, people have consulted hand-held pendulums in an attempt to aid decision-making. We examined which personality measures predict performance when deciding about the presence of visual stimuli. Participants either responded verbally or by "asking" a pendulum and watching its motion after we paired particular movements with different answers.

Several personality measures predicted performance. In the verbal condition, people who felt more control over their lives (locus of control) performed better than those who felt less control. In the pendulum condition, people high in transliminality — those sensitive to subtle stimuli — performed better than those low in transliminality. Indeed, transliminality may capture some important aspects of pendulum use. Pendulum users would ideally be sensitive to their subtle movements; transliminality correlates with detection of subtle internal and external stimuli (e.g., Thalbourne & Houran, 2000). Pendulum users should also be open to the idea of consulting a pendulum (Lundstrom, 2010); similarly, transliminality correlates with openness to experience and paranormal beliefs (Lange et al., 2000).

Although accuracy was comparable in both conditions, pendulum responses showed relatively little bias. Both conditions of the task were difficult, which usually increases uncertainty and bias, making people more likely to declare the target absent (Green & Swets, 1966). In both studies, however, bias was higher in the verbal condition but lower — around 0 — in the pendulum condition. Thus, consistent with the views of some pendulum users (e.g., Lundstrom, 2010), decisions made with pendulums may be less biased — though not more accurate.

Given this difference in bias, our findings suggest that people employ a different decision strategy when using a pendulum versus responding verbally. In other words, unconscious pendulum movements are not equivalent to conscious responses; instead, something changes in the process of decision-making. These results are consistent with other studies finding different decision strategies in ideomotor versus verbal responses (e.g., Marcel, 1993; Gauchou et al., 2012). Nevertheless, the largest limitation of our study is that we cannot isolate this mechanism or the cause of the differences between the conditions. Perhaps focusing attention away from the decision itself (cf. Dijksterhuis & Strick, 2016), using a more introspective mindset (Wilson & Schooler, 1991; Tordesillas & Chaiken, 1999), or taking more time to ponder the questions could explain these differences. Or, as one reviewer suggested, merely giving the suggestion that pendulums reflect unconscious knowledge could have affected their bias. Alas, in our study, we chose a more natural method of pendulum use at the expense of causal precision.

Our results somewhat differed from those found with Ouija boards. In particular, Gauchou and colleagues (2012) found that ideomotor performance can exceed verbal performance; we did not see this relationship with pendulums. This could have been due to several factors, such as the difference in ideomotor tool (Ouija board versus pendulum) or type of question asked (memory versus visual detection). Indeed, given that we only examined perceptual decisions, it is unclear how far our findings can generalise. Future studies could explore what other types of decisions people can accurately answer through ideomotor response (Olson & Raz, in progress). Such studies could help determine the mechanisms and boundaries of unconscious decision-making.

Still, many questions remain. If people use a different decision-making strategy with a pendulum, what is its mechanism and phenomenology? Do the dynamics of the pendulum movement, such as speed or direction, predict accuracy? Will our finding of a reduced decision bias when using a pendulum generalise to real-world decisions? Answering these questions will help understand the puzzling practice of consulting a pendulum, and it may even help improve decision-making.

Supplementary data

Supplementary data sets, including personality measures, reaction time, and all other dependent variables, are available online at https://osf.io/xe9mk/.

Authors' contribution

J.O. designed the study and analysed the data, E.J. helped collect the data, and A.R. provided feedback. All contributed to the manuscript.

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Conflict of interest statement. None declared.

APPENDICES

A Study 1 supplementary results

We had several pre-specified hypotheses about the relationship between performance and confidence (based on Gauchou et al., 2012):

1. Performance would differ between the verbal and pendulum conditions.
2. Performance would differ in the verbal condition when participants are uncertain compared to the pendulum condition overall.
3. Performance would differ in the verbal condition when participants are uncertain compared to the pendulum condition when participants are uncertain.
4. In the pendulum condition, performance would differ when participants agree or disagree with the pendulum's response compared to when they are uncertain about it.
5. In the pendulum condition, performance would differ based on whether participants agree or disagree with the pendulum's response.

See Table A1 and Figure A1 for tests of these hypotheses.

Table A1: Statistics for overall performance comparisons. Bias (c) differed between verbal and pendulum conditions and sensitivity (d') differed in the pendulum condition based on agreement. Each test had a Bonferroni-corrected α of .02.

Hypothesis	Measure	Test statistic	p
1. Verbal $\neq$ Pendulum	Accuracy	$\chi^2(_1) = 3.9$	.048
	Sensitivity	$t(60) = 1.988$	.051
	Bias	$t(62) = 6.7$	<.001*
2. Verbal uncertain $\neq$ Pendulum	Accuracy	$\chi^2(1) = 0.048$	.827
	Sensitivity	$t(94) = 1.94$	.055

Hypothesis	Measure	Test statistic	p
	Bias	$t(107)$ = -4.009	<.001*
3. Verbal uncertain $\neq$ Pendulum uncertain	Accuracy	$\chi^2(1)$ = 2.3	.129
	Sensitivity	$t(78)$ = 0.055	.956
	Bias	$t(59)$ = -3.4	.001*
4. Pend. agree or disagree $\neq$ Pend. uncertain	Accuracy	$\chi^2(1)$ = 4.083	.043
	Sensitivity	$t(83)$ = -2.435	.017*
	Bias	$t(61)$ = -1.016	.314
5. Pendulum agree $\neq$ Pendulum disagree	Accuracy	$\chi^2(1)$ = 23.462	<.001*
	Sensitivity	$t(69)$ = -5.739	<.001*
	Bias	$t(48)$ = -1.087	.282

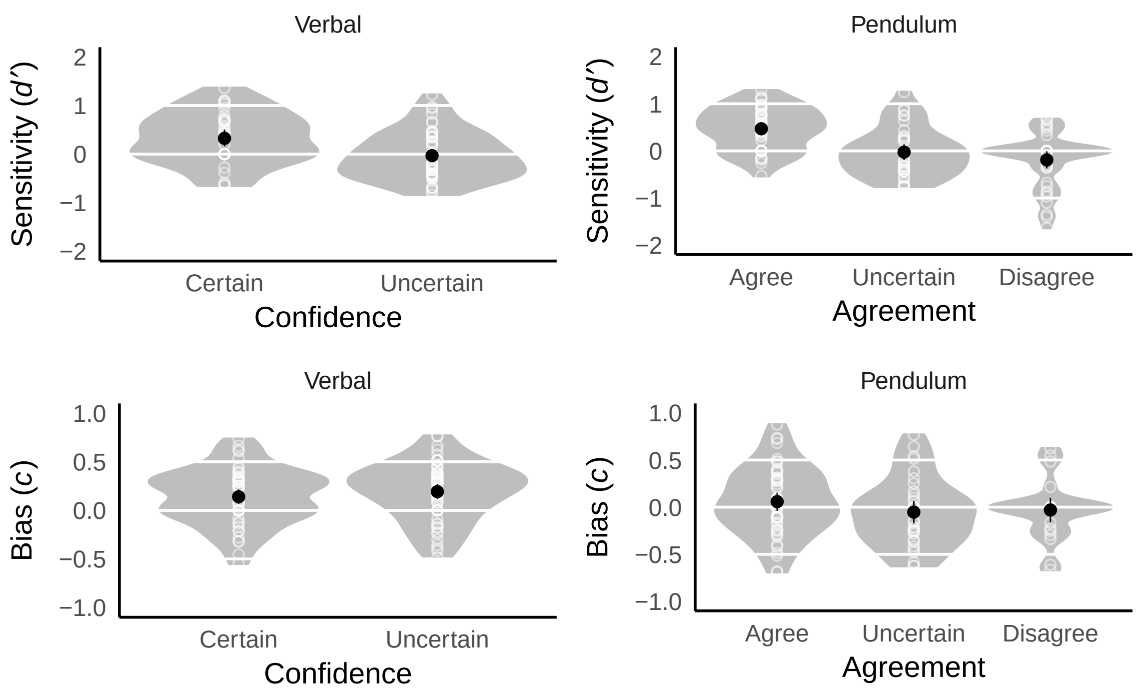

Figure A1: Performance by confidence. Sensitivity was highest when participants felt confident in their verbal response or agreed with the pendulum response. Bias showed relatively little difference. Dots show means, errors bars show 95% bootstrapped confidence intervals, circles show data points, and width estimates underlying distribution.

For the fit statistics of the personality models, see Table A2.

Table A2: Personality model fit statistics. Accuracy uses a mixed-effect logistic model and sensitivity and bias use linear models. R^2 values for accuracy account for both fixed and random factors (Nakagawa & Schielzeth, 2013).

Condition	Measure	Test statistic	p	R^2
Verbal	Accuracy	$\chi^2(6) = 8.519$	.074	.009
	Sensitivity	$F(4, 54) = 2.399$	.061	.151
	Bias	$F(4, 56) = 2.531$	.050	.153
Pendulum	Accuracy	$\chi^2(6) = 9.515$	.049	.008
	Sensitivity	$F(4, 56) = 1.772$	.147	.112
	Bias	$F(4, 56) = 1.711$	.160	.109

B Study 2 supplementary results

Table B1 shows the personality predictors (cf. Table 1) and Table B2 shows the performance differences (cf. Table A1).

Table B1: Personality predictors of verbal and pendulum performance. Bonferroni-corrected α values were .025.

DV	Task	Predictor	B	SE	z	p
Accuracy	Verbal	Locus of control	-0.006	0.008	-0.782	.434
		Transliminality	0.002	0.022	0.096	.923
		Need for cognition	0.007	0.007	0.978	.328
		Faith in intuition	0.002	0.006	0.381	.703
	Pendulum	Locus of control	0.003	0.008	0.327	.744
		Transliminality	-0.029	0.022	-1.308	.191
		Need for cognition	-0.008	0.007	-1.090	.276
		Faith in intuition	0.004	0.006	0.735	.462
Sensitivity	Verbal	Locus of control	-0.005	0.005	-0.897	.378
		Transliminality	0.013	0.016	0.818	.421

DV	Task	Predictor	*B*	*SE*	*z*	*p*
		Need for cognition	0.005	0.005	1.046	.305
		Faith in intuition	0.002	0.004	0.422	.677
	Pendulum	Locus of control	0.001	0.007	0.200	.843
		Transliminality	-0.025	0.020	-1.230	.229
		Need for cognition	-0.008	0.007	-1.227	.230
		Faith in intuition	0.002	0.006	0.439	.664
Bias	Verbal	Locus of control	-0.006	0.004	-1.592	.123
		Transliminality	-0.009	0.010	-0.902	.375
		Need for cognition	-0.003	0.003	-0.944	.354
		Faith in intuition	0.000	0.003	0.034	.973
	Pendulum	Locus of control	-0.005	0.004	-1.245	.223
		Transliminality	-0.003	0.011	-0.261	.796
		Need for cognition	-0.008	0.004	-2.169	.039
		Faith in intuition	0.000	0.003	-0.091	.928

Table B2: Statistics for overall performance comparisons. Bias (c) differed between verbal and pendulum conditions and accuracy differed in the pendulum condition based on agreement. Each test had a Bonferroni-corrected α of .02.

Hypothesis	Measure	Test statistic	*p*
1. Verbal $\neq$ Pendulum	Accuracy	$\chi^2(1) = 3.9$	.048
	Sensitivity	$t(31) = 0.232$	.818
	Bias	$t(32) = 2.59$	.014*
2. Verbal uncertain $\neq$ Pendulum	Accuracy	$\chi^2(1) = 0.048$	.827
	Sensitivity	$t(52) = -0.341$	.735
	Bias	$t(59) = -2.179$	.033
3. Verbal uncertain $\neq$ Pendulum uncertain	Accuracy	$\chi^2(1) = 2.3$	.129
	Sensitivity	$t(27) = -1.649$	.111
	Bias	$t(35) = -0.382$	.705
4. Pend. agree or disagree $\neq$ Pend. uncertain	Accuracy	$\chi^2(1) = 4.083$	.043
	Sensitivity	$t(30) = -2.437$	.021

Hypothesis	Measure	Test statistic	p
	Bias	$t(44)$ = 1.372	.177
5. Pendulum agree $\neq$ Pendulum disagree	Accuracy	$\chi^2(1)$ = 23.462	<.001*
	Sensitivity	$t(18)$ = -0.545	.592
	Bias	$t(18)$ = -1.492	.153

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