Short Research Article

Metacognitive Sensitivity on the Iowa Gambling Task Reveals Awareness as a Necessary Condition for Advantageous Performance

Julieta M. Zapata[1,2], Nicolás A. Comay[3], Gaspar Taricco[3], Pablo Barttfeld[3], Guillermo Solovey[4], Aarón Saal[1,2], and José V. Ahumada[1,2]

[1]Facultad de Psicología, SeCyT – Universidad Nacional de Córdoba, Argentina
[2]Centro de Investigaciones Maria Saleme Burnichon (CIFFyH), Facultad de Filosofía y Humanidades, Universidad Nacional de Córdoba, Argentina
[3]Cognitive Science Group, Instituto de Investigaciones Psicológicas (IIPsi, CONICET-UNC), Facultad de Psicología, Universidad Nacional de Córdoba, Argentina
[4]Instituto de Cálculo, Facultad de Ciencias Exactas y Naturales, UBA-CONICET, Buenos Aires, Argentina

Abstract: The Somatic Marker Hypothesis (SHM) proposes that human decision-making under uncertainty is advantageously guided by affective signals before developing awareness of which courses of action are better. However, this claim has been questioned due to the limitations of the methods used to measure awareness, with alternative measures yielding conflicting results. To address this issue, we apply metacognitive sensitivity, a reliable method based on confidence ratings that outperform previous awareness measures, in an online nonclinical sample ($N = 44$) to assess awareness in the Iowa Gambling Task (IGT). Using this approach, we found that awareness and advantageous decision-making are not independent processes; an increase in metacognitive sensitivity strongly predicted an improvement in task performance in nearly all blocks of the task. A lab-based preregistered replication ($N = 47$) confirmed these findings. Interestingly, some participants demonstrated awareness without advantageous decision-making, suggesting that awareness is a necessary – but not sufficient – condition for optimal performance. Overall, this study highlights the challenges of measuring awareness in the IGT and introduces a novel alternative method that questions a key postulate of the SMH.

Keywords: decision-making, metacognition, metacognitive sensitivity, Iowa Gambling Task, Somatic Marker Hypothesis, awareness

The Somatic Marker Hypothesis (SMH) proposes that human decision-making under uncertainty is beneficially guided by bodily affective signals, which anticipate whether a course of action will be favorable or unfavorable (Damasio, 1994). A controversial aspect of this hypothesis is that somatic markers operate not only consciously (as in gut feelings, for example) but also outside awareness, allowing people to make good decisions before they become aware of them (Bechara et al., 1997). Supporting evidence comes from studies comparing the performance of patients with ventromedial (VM) damage and healthy participants in the Iowa Gambling Task (IGT; Bechara et al., 1994), a card game designed to assess real-world decision-making ability under uncertainty and risk by offering decks with different monetary outcomes. In these studies, healthy participants develop somatic markers that guide their decisions advantageously before consciously knowing decks' payoffs, whereas VM patients neither develop somatic markers nor make advantageous decisions, even when they are aware of the payoff structure (Bechara et al., 1994, 1997).

The extent to which the advantageous behavior of healthy participants on IGT depends on implicit somatic signals has been questioned, primarily for the weakness of the method used to assess participants' knowledge (Konstantinidis & Shanks, 2014; Simonovic et al., 2019). The original method involved asking two open-ended questions every 10 trials: (i) "Tell me all you know about what is going on in this game" and (ii) "Tell me how you feel about this game" (Bechara et al., 1997). Such broad and open-ended questions are not always able to identify all the conscious knowledge that participants may have (Maia & McClelland, 2004; Persaud et al., 2007). Additionally, these types of questions

https://doi.org/10.1027/1618-3169/a000636

pose challenges for researchers when classifying participants' responses. Indeed, Fernie and Tunney (2013) demonstrated that the knowledge attributed to participants varied depending on how their responses were classified. Moreover, by using more specific questionnaires, other studies demonstrated that most healthy participants already possessed knowledge when they began to behave advantageously (Bowman et al., 2005; Cella et al., 2007; Evans et al., 2005; Maia & McClelland, 2004), questioning the role of somatic markers in guiding decisions outside awareness. However, counter-arguments suggest that exhaustive and specific questionnaires are not entirely reliable, as they might facilitate knowledge acquisition during the task (Bechara et al., 2005). Persaud et al. (2007) supported this view by showing that when using the Bechara et al. (1997) questionnaire, participants performed well before becoming aware of the advantageous strategy. By contrast, with Maia and McClelland's (2004) more detailed questionnaire, participants reported good performance and awareness simultaneously during the task.

To avoid the complications associated with verbal reports on IGT, quantitative nonverbal methods have been proposed, such as post-decision wagering (PDW). In this method, a high bet on a correct decision and a low bet on an incorrect one indicates knowledge. Interestingly, using PDW Persaud et al. (2007) found that participants behave advantageously before becoming consciously aware of it, aligning with the SMH. However, PDW has its own limitations, such as the challenge of defining an optimal wagering strategy and the influence of the loss aversion phenomenon (Dienes & Seth, 2010; Fleming & Dolan, 2010; Konstantinidis & Shanks, 2014). Another nonverbal measure, which has proven to be more reliable than PDW (Konstantinidis & Shanks, 2013), is metacognitive sensitivity – the ability of a decision-maker to distinguish correct from incorrect decisions. The rationale is similar to PDW but with confidence ratings instead of wages: high confidence in correct choices and low confidence in incorrect choices indicate awareness. However, a critical advantage of metacognitive sensitivity is that it assesses the ability to distinguish between correct and incorrect decisions independently of the participant's tendency to give high or low confidence ratings (known as "metacognitive bias;" Fleming & Lau, 2014). For instance, a highly self-confident person may tend to have a liberal bias thus mostly reporting high confidence levels, while others may have a conservative bias, using mostly the low part of a confidence scale. This suggests that bias and conscious perception can vary independently (Michel, 2023), and in this regard, metacognitive sensitivity is considered a bias-free method (Fleming & Lau, 2014).

Despite appealing, little attention has been given to using metacognitive sensitivity to assess awareness on the IGT. To our knowledge, only one study (Konstantinidis & Shanks, 2014) has applied this measure, but it did not measure awareness on a block-by-block basis to track the learning process over time. Building on this evidence, here we propose metacognitive sensitivity as a more effective measure of awareness on the IGT, highlighting its virtues over other methods: (1) people may find it more intuitive to report confidence in their decision rather than providing detailed verbal responses; (2) it is a nonintrusive method that does not promote knowledge acquisition during the task; (3) it is a nonparametric, quantitative measure, enabling precise estimation and quantitative analysis of the participant's awareness throughout the task, thus avoiding the bias introduced when experimenters classify the participants' responses (Fernie & Tunney, 2013); (4) it is unaffected by loss aversion phenomenon or by metacognitive bias (Dienes & Seth, 2010; Fleming & Dolan, 2010).

In the present study, we incorporated confidence ratings into the classic IGT and examined the relationship between metacognitive sensitivity and performance on a block-by-block basis. In an initial online experiment, we found a strong relationship between metacognition and performance across most blocks of the task. This finding was replicated in a second preregistered lab-based experiment. Interestingly, very few participants demonstrated a behavioral pattern consistent with the SMH – high performance with low or chance-level metacognition – while many more exhibited low or chance-level performance alongside high metacognition. Overall, this pattern of results suggests that awareness is necessary but not a sufficient condition for advantageous decision-making in the IGT.

Materials and Methods

Two studies were carried out to assess participants' knowledge in the IGT using metacognitive sensitivity. Experiment 1 involved the online administration of the IGT with confidence ratings after each choice. Experiment 2 is a preregistered lab-based replication of Experiment 1. The preregistration of Experiment 2 can be found at https://doi.org/10.17605/OSF.IO/3RWUN.

Participants

In Experiment 1, 63 students from the National University of Córdoba (Argentina) completed the experiment online. Overall, 18 participants were discarded for reporting the same confidence level on more than 85% of the trials (see Embon et al., 2023, for a list of studies using similar exclusion criteria), and two additional participants were dismissed for not exploring all decks. Therefore, 33% of the original sample was excluded from the analysis, which aligns with the typical exclusion rate of 3% to 37% usually found in online studies (Chandler et al., 2014). Consequently, the final sample consisted of 44 participants (31 females; 70.45%) between 18 and 58 years (*M* = 27.18; *SD* = 10.38). We report in the Electronic Supplementary Materials, ESM 1, the same analyses performed here but without excluding any subject; results do not change.

In Experiment 2, 50 participants completed the experiment in dedicated experimental rooms in the laboratory, at the National University of Córdoba. Three participants were discarded from the analysis because they reported the same confidence level on more than 85% of the trials and were subsequently replaced to meet the preregistered targeted sample of 47 participants. The exclusion criteria and the replacement of the participants were preregistered in Experiment 2.

Both experiments were approved by the ethical committee of the Instituto de Investigaciones Psicológicas (CONICET-UNC). Participants read and accepted informed consent before the experiment and reported no history of psychiatric and/or neurological conditions or illegal drug use. To encourage commitment to the task, prizes were awarded to the top performers in both studies: the three participants with the highest scores at the end of data collection received gift vouchers for a local bookstore: $15 for first place, $10 for second place, and $5 for third place.

Iowa Gambling Task With Confidence Ratings

A computerized version of the IGT was administered using JATOS (Lange et al., 2015). We employed the traditional payoff scheme (Bechara et al., 1994; see also ESM 1). The task was adapted to include (1) an informed consent and information sheet, (2) instructions, and (3) confidence reports. After reading the instructions, participants were presented with four decks of cards labeled "A," "B," "C", and "D" on the screen. They had to choose one deck and then report their confidence in having made a good choice on a scale from 1 (= *not sure at all*) to 4 (= *completely sure*). Then, participants received feedback that included: 1) the amount of money earned and lost and the net outcome and 2) the total amount of money they had accumulated by that trial (Figure 1). The task consisted of 100 trials, and participants started the game with an initial amount of $2,000. The objective was to win as much money as possible.

Throughout the game, participants had to learn that decks A and B are "bad" decks, offering high rewards but also significant penalties, which result in a long-term net loss. Specifically, while both bad decks provide a reward of $100 in every trial, they differ in the frequency and magnitude of the losses. Deck A incurs losses of $150, $200, $250, $300, or $350 in five out of 10 trials, while Deck B results in a loss of $1,250 in one out of 10 trials. Consequently, the net result for both decks (A and B) is −$250 over 10 trials. In contrast, decks C and D are considered "good" decks because they yield a net gain of $250 over 10 trials. Both decks provide a reward of $50 in every trial, but they differ in the amount and frequency of losses. Deck C incurs losses of $25, $50, or $75 in five out of 10 trials, while deck D incurs a single loss of $250 in 10 trials. Learning involves giving up the temptation to choose the bad decks, which offer short-term gains, to ensure a long-term profit by choosing the good decks.

In Experiment 2, we also randomized decks' payoffs across participants. Specifically, the outcomes originally associated with each deck were randomly assigned to any of the four decks. This manipulation was preregistered and it was not included in Experiment 1.

Metacognitive Sensitivity Assessment

The area under a "Type 2" receiver operating characteristic curve (ROC) was calculated for each block to compute metacognitive sensitivity (Fleming & Lau, 2014). This metric takes into account all possible confidence criteria that divide confidence levels into high and low confidence. On a four-point confidence scale, the first criterion classifies a confidence level of 1 as low and Levels 2, 3, and 4 as high. The next criterion will classify Levels 1 and 2 as low

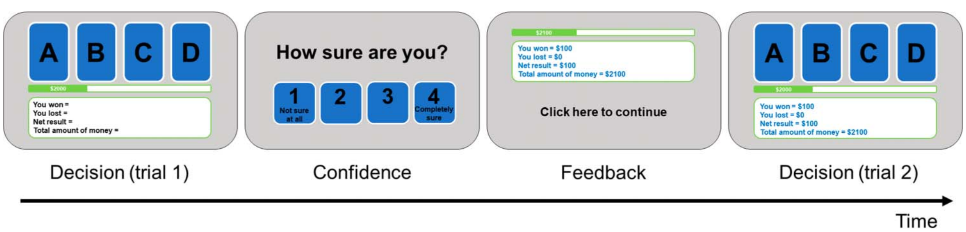

Figure 1. Iowa Gambling Task with confidence ratings. Four decks were shown on the screen. The green horizontal bar indicates the participant's total money for each trial. The text in the white block indicated how much money the participant won and lost on the previous trial, the net score, and the total amount of money up to the current trial. After each deck selection, participants rated their confidence in their decision and then they received the outcome feedback of their choice.

Levels 3 and 4 as high, and so on. The next step is to compute the proportion of "Type 2" hits (high confidence in a correct response) and "Type 2" false alarms (high confidence in an incorrect response) for each division of the data done by the confidence criteria. Finally, the inverse cumulative Type 2 hits rate is plotted on the y-axis, and the inverse cumulative Type 2 false alarm rate is plotted on the x-axis. The curve that crosses these points is the ROC curve, and the area under this curve indexes the metacognitive ability of the participant. We computed the area under the ROC curve using an adaptation to R from Fleming and Lau's (2014) code. Note that a response was considered correct when the participant picked deck C or D.

Examples of participants with different metacognitive sensitivities are depicted in Figure 2.

Data Analysis

Task performance was assessed by calculating the proportion of advantageous choices by blocks of 20 trials

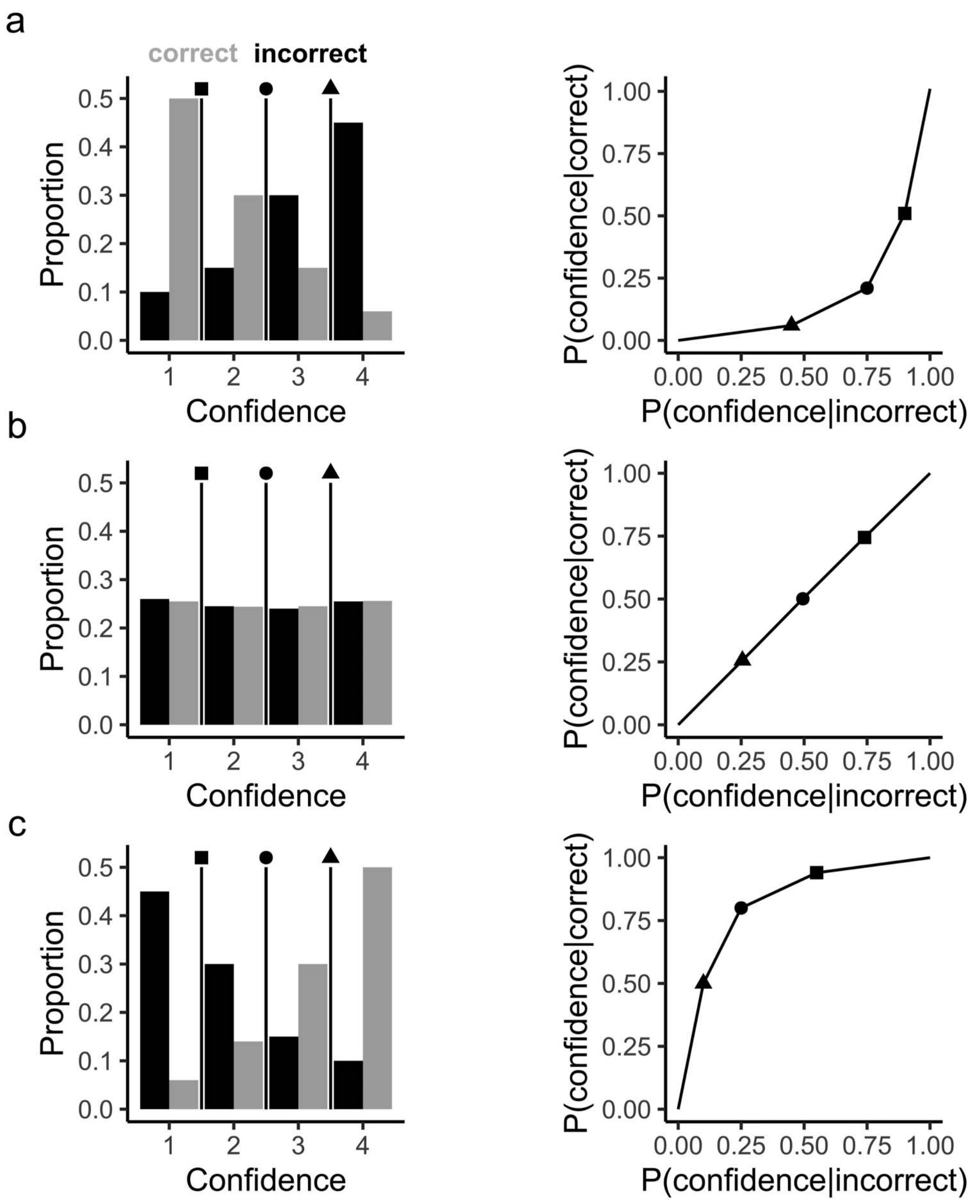

Figure 2. Example of participants with different metacognitive abilities as measured by the AUROC-2 curve. (a) A participant that gives a higher confidence rating to incorrect alternatives (black) and low confidence to correct alternatives (gray) will result in an area under the ROC curve that is less than 0.5. (b) A participant who does not distinguish between correct and incorrect responses using the confidence scale results in chance-level metacognition. This is represented by an area under the ROC curve of 0.5. (c) A participant with high metacognitive ability gives high-confidence responses to correct decisions and low-confidence responses to incorrect decisions, resulting in a higher area under the ROC curve.

(Bechara et al., 1994). Metacognitive sensibility was used as an indicator of awareness and was assessed by computing the area under a ROC curve for each of the five blocks of the IGT (Fleming & Lau, 2014). A linear regression was computed predicting performance from metacognition on the five blocks of the task. Additionally, we used t-tests to determine whether performance and metacognition were above chance levels.

In ESM 1, we also report: (1) the same analysis reported above but applied to all the participants from Experiment 1 (i.e., not excluding any subjects); (2) analyses regarding the proportion of each deck choice and the confidence level on each deck in both studies. The standard p-value < .05 was used to address if any statistical analysis results were significantly different from those expected if the null hypothesis was correct. All analyses were performed using the software R. For Experiment 2, linear regression analyses were preregistered.

Results

Experiment 1. Online Study

Figure 3a and 3b show the mean performance and metacognition scores of the participants throughout the task. Performance analysis by blocks indicates that performance did not exceed chance level in any of the blocks (Block 1: $t_{43} = -1.58$, $p = .94$, $d = 0.24$; Block 2: $t_{43} = -1.48$, $p = .93$, $d = 0.22$; Block 3: $t_{43} = -0.26$, $p = .6$, $d = 0.04$; Block 4: $t_{43} = 0.55$, $p = .29$, $d = 0.08$; Block 5: $t_{43} = -0.46$, $p = .68$, $d = 0.07$; Figure 3 left panel). The mean proportion of advantageous choices and the mean proportion of selections from each deck – both for the entire task and for each block – are detailed in ESM, Table E1. Metacognitive sensitivity was significantly above chance level starting from Block 3 onwards (Block 1: $t_{43} = -0.28$, $p = .61$, $d = 0.04$; Block 2: $t_{43} = 0.55$, $p = .29$, $d = 0.08$; Block 3: $t_{43} = 4.86$, $p < .001$, $d = 0.73$; Block 4: $t_{43} = 2.73$, $p = .005$, $d = 0.41$; Block 5: $t_{43} = 1.84$, $p = .036$, $d = 0.28$; Figure 3 right panel).

When examining the relationship between the two variables in each block, we found a significant association in all blocks except for Block 2 (Block 1: β = 1.07, $p < .001$; Block 2: β = 0.01, $p = .96$; Block 3: β = 0.62, $p = .043$; Block 4: β = 0.85, $p < .001$; Block 5: $p < .001$; Figure 4).

Experiment 2. Preregistered Lab-Based Replication

To enhance the reliability of the findings, we conducted a preregistered lab-based replication of Experiment 1. We initially examined the overall performance and metacognition across blocks. We found that performance did not differ from chance level in any of the blocks except for Block 1, where performance was significantly below chance (Block 1: $t_{46} = -2.50$, $p = .02$, $d = 0.36$; Block 2: $t_{46} = -0.97$, $p = .34$, $d = 0.14$; Block 3: $t_{46} = -0.67$, $p = .51$, $d = 0.10$; Block 4: $t_{46} = 1.08$, $p = .28$, $d = 0.16$.; Block 5: $t_{46} = 1.36$, $p = .18$, $d = 0.20$; see Figure 5, left panel). The mean proportion of advantageous choices and the mean proportion of selections from each deck – both for the entire task and for each block – are detailed in ESM 1, Table E2. Regarding metacognition, we found the same pattern: metacognitive sensitivity did not differ from chance level in any of the blocks except Block 1, where it was significantly below chance level (Block 1: $t_{46} = -4.33$, $p < .001$, $d = 0.63$; Block 2: $t_{46} = -0.18$, $p = .86$, $d = 0.03$; Block 3: $t_{46} = 1.47$, $p = .15$, $d = 0.21$; Block 4: $t_{46} = 0.29$, $p = .77$, $d = 0.04$; Block 5: $t_{46} = 1.28$, $p = .21$, $d = 0.19$; Figure 5 right).

When relating the two variables, we again found a close association between metacognition and performance in all blocks except for Block 2, although this time a marginally significant relationship for this particular block was observed (Block 1: β = 0.79, $p < .001$; Block 2: β = 0.27, $p = .053$; Block 3: β = 0.42, $p = .015$; Block 4: β = 0.66, $p < .001$; Block 5: β = 0.76, $p < .001$ Figure 6).

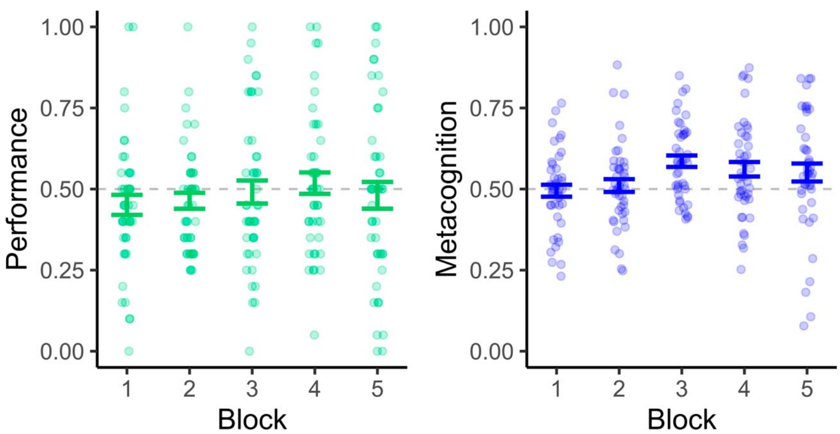

Figure 3. Performance and metacognition across blocks (Study 1). Participants' performance did not exceed the chance level in any of the blocks (dashed horizontal line at 0.5; left panel). Metacognitive sensitivity was above the chance level (dashed horizontal line at 0.5) starting from Block 3 onwards (right panel). In both panels, jittered dots represent each participant's mean score per block. Vertical bars in this figure represent the standard error of the mean.

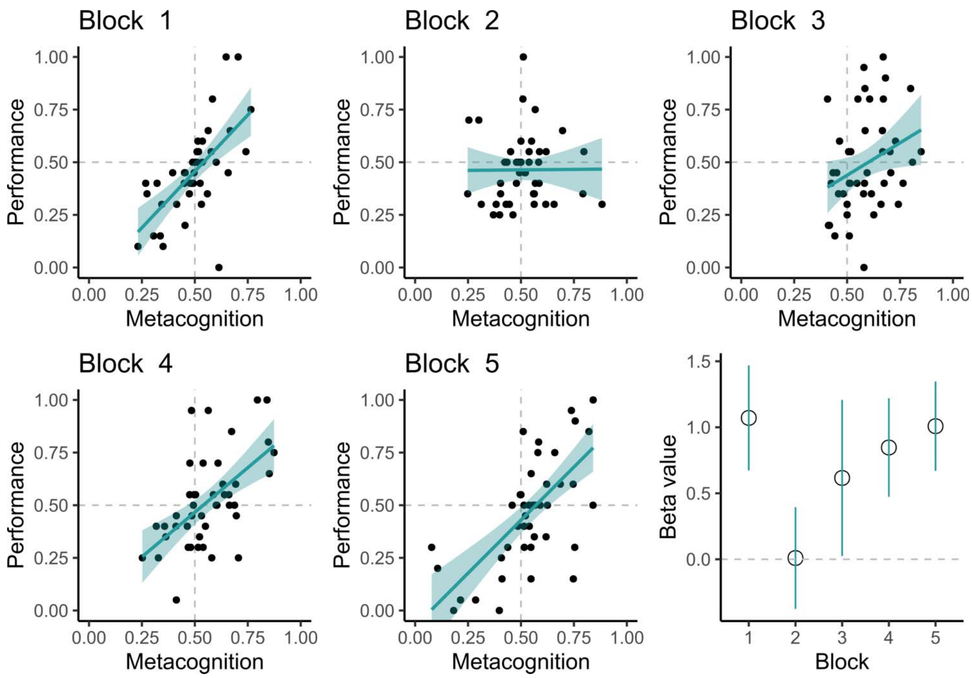

Figure 4. Relationship between performance and metacognition across blocks (Study 1). Metacognitive sensitivity significantly predicted performance across all blocks except Block 2. In most blocks, either no participants or only a small minority exhibited advantageous performance without corresponding metacognitive awareness (top-left quadrants). In comparison, more participants presented the opposite dissociation: high metacognitive ability with low or chance-level performance (bottom-right quadrants). The last panel indicates the β values of the regressions along with their 95% confidence intervals.

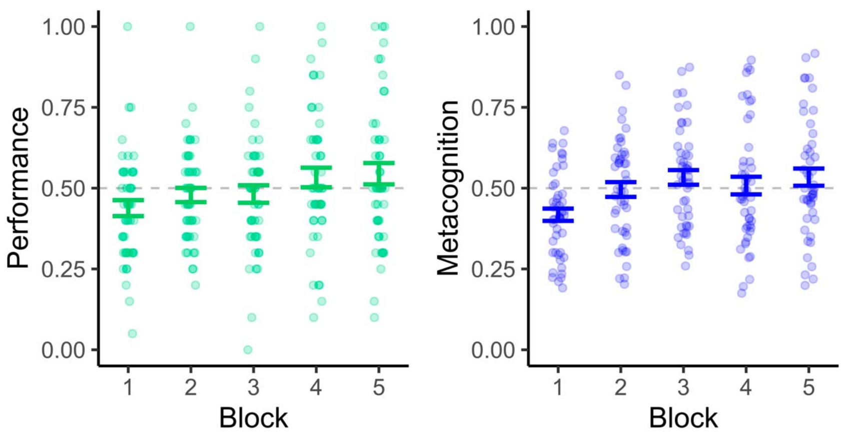

Figure 5. Performance and metacognition across blocks (Study 2). The participants' performance never exceeded the chance level throughout the task (left panel). The same is found in the metacognitive domain (right panel). Vertical bars in this figure represent the standard error of the mean.

Discussion

Inconsistent findings regarding the relationship between performance and awareness on the IGT can largely be attributed to the limitations of the methods used to assess awareness. After conducting a comprehensive review of awareness measurement in the IGT, we advocate for metacognitive sensitivity – computed as the area under a ROC curve – as a more reliable method for assessing knowledge in the task. To investigate this relationship, we conducted two experiments. In Experiment 1, we found that metacognitive sensitivity significantly predicted performance (*N* = 44) in almost all blocks, indicating a close link between awareness and performance on the IGT. Experiment 2, a preregistered lab-based replication (*N* = 47), yielded similar results, reinforcing the robustness of our findings.

The SMH posits that decision-making under uncertainty is advantageously guided by somatic makers before individuals acquire knowledge of the situation. This assertion is supported by evidence showing that healthy participants achieved good performance in the initial blocks of the IGT, without being aware of which decks were better (Bechara

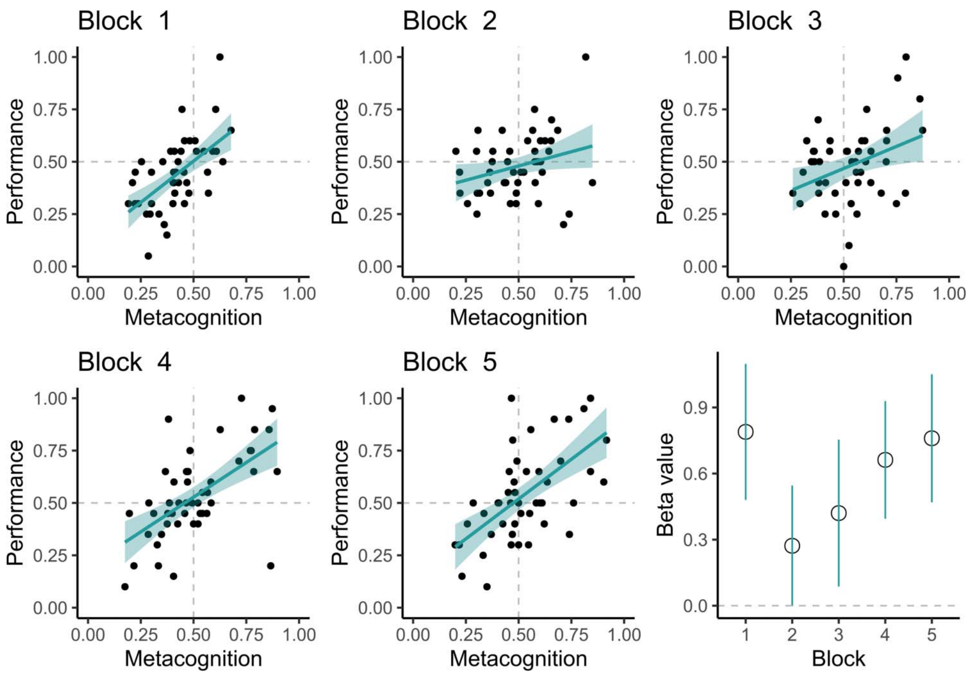

Figure 6. Relating performance and metacognition across blocks (Study 2). Similar to Study 1, metacognitive sensitivity significantly predicted performance across all blocks except Block 2, although this time we found a marginally significant relationship. As in the online study, in all blocks, only a small minority exhibited advantageous performance without corresponding metacognitive awareness (top-left quadrants). The last panel indicates the β values of the regressions along with their 95% confidence intervals.

et al., 1997). However, our study challenges this notion. First, we observed a general positive relationship between awareness and performance across blocks, suggesting interdependence between these two processes. Second, although this relationship weakened in Block 2, the participants who displayed advantageous behavior without metacognition were a clear minority in both experiments, a pattern consistent across all blocks. This aligns with previous studies indicating that participants possess more knowledge than Iowa group states (Bowman et al., 2005; Cella et al., 2007; Evans et al., 2005; Maia & McClelland, 2004).

On the other hand, in line with the SMH, especially in Experiment 1, several participants presented metacognitive sensitivity without demonstrating advantageous performance, akin to VM patients. This suggests that knowledge alone is insufficient to guide behavior effectively (Bechara et al., 1994, 1997). Nevertheless, our results show that awareness is a *necessary* condition for the emergence of advantageous performance. Future research should explore why some participants do not use their knowledge to make advantageous decisions.

While we cannot rule out the role of somatic markers in the current study, as we did not measure somatic activity, our findings challenge the idea that somatic markers guide decision-making advantageously before awareness (Bechara et al., 1997). Consistent with our results, Dong et al. (2016) found that appropriate somatic markers were only formed when participants acquired conceptual knowledge, suggesting that awareness influences their development.

Another important question is whether the mere presence of somatic markers and explicit knowledge is enough to achieve advantageous performance on the IGT. In this sense, Yip et al. (2020) showed that emotional intelligence (EI) may mediate the relationship between somatic markers' activity and advantageous behavior. Participants with low EI misinterpreted somatic activity as arousal, leading them to engage in risk-seeking rather than risk-avoidant behavior. Thus, proper interpretation of somatic activity also seems to be necessary for good performance.

In conclusion, there is limited compelling evidence supporting the dissociation of IGT performance from conscious awareness. However, the relationship between somatic markers and knowledge remains complex and still unclear (Konstantinidis & Shanks, 2014). Further research is needed to determine why certain participants develop awareness and how this knowledge is related to somatic markers activity and advantageous performance on the IGT.

Limitations

Based on our findings, we cannot assert that somatic markers are not involved at all in the development of advantageous behavior on IGT, as we did not directly measure somatic markers. Our claim is therefore limited to that they do not appear to guide behavior advantageously before awareness, as suggested by our data.

It has been shown that task performance can impact measures of metacognition, such as the area under a ROC curve (Fleming & Lau, 2014). Further research is necessary to determine whether the IGT suffers from this same issue. If it does, one interesting possibility would be to develop a model-based approach to metacognition (Fleming & Lau, 2014) in the IGT, given that controlling task performance is not feasible in this task.

Electronic Supplementary Materials

The electronic supplementary materials are available with the online version of the article at https://doi.org/10.1027/1618-3169/a000626

ESM 1. The document contains extra analysis and results.

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History

Received January 31, 2024
Revision received October 26, 2024
Accepted January 6, 2025
Published online March 5, 2025

Acknowledgments

Julieta M. Zapata has a scholarship from the Secretaría de Ciencia y Técnica, Universidad Nacional de Córdoba, Argentina. Nicolás A. Comay has a scholarship from the Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina).

Authorship

Julieta M. Zapata and Nicolás A. Comay share first authorship. Julieta M. Zapata: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. Nicolas A. Comay: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. Gaspar Taricco: Methodology, Investigation. Pablo Barttfeld: Methodology, Software, Writing – review & editing, Supervision, Funding acquisition, Project administration. Guillermo Solovey: Methodology, Software, Writing – review & editing, Supervision, Funding acquisition, Project administration. Aaron Saal: Methodology, Writing – review & editing, Supervision, Funding acquisition, Project administration. José V. Ahumada: Methodology, Writing – review & editing, Supervision, Funding acquisition, Project administration.

Open Science

Open Code: The task code (which is a modification of an openly available version https://github.com/bdm4/Iowa-Gambling-Task) is available at https://github.com/JulietaZapata/IGTandMetacognition (Comay & Zapata, 2024).

Open Data: The data and the scripts for performing the data analysis and reproducing the main figures of this study are available at https://github.com/JulietaZapata/IGTandMetacognition (Comay & Zapata, 2024).

Preregistration: The preregistration of Experiment 2 can be found at: https://doi.org/10.17605/OSF.IO/3RWUN (Zapata et al., 2024).

Funding

This research was supported by two grants from Agencia Nacional de Promoción Científica y Tecnológica (Argentina) PICT (Grant #2018-03614 and Grant #2021-0083) to Pablo Barttfeld, one grant from Universidad de Buenos Aires (UBACyT 20020170100330BA) to Guillermo Solovey, and one grant from the Secretaría de Ciencia y Técnica, Universidad Nacional de Córdoba (SeCyT UNC 33620180101048CB) to José Victor Ahumada.

ORCID

Julieta M. Zapata
https://orcid.org/0009-0000-4454-1173
Guillermo Solovey
https://orcid.org/0000-0003-4093-2649
José V. Ahumada
https://orcid.org/0000-0002-1915-2173

Julieta M. Zapata
Facultad de Psicología
Universidad Nacional de Córdoba
Boulevard de la reforma esq Enfermera Grodillo Gomez
5000 Córdoba
Argentina
julieta.m.zapata@gmail.com

