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Artigo Original

Body image perception and sense of agency: notes from the alien hand experiment

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Abstract

Body image perception comprises stable and dynamic representational features. Here, we examined whether a stable body image (BI) measure correlates to a dynamic sense of agency (SoA) score. Moreover, we tested whether differential BI perception scores predicts SoA performance under sensory conflict conditions. A total of 21 university students (age *M*=25.9, *SD*=9.29) completed the Brazilian version of the Silhouette Figures Scale (SFS) and participated in The Alien Hand Experiment (TAHE). TAHE is a task that manipulates participants' hand movement SoA. A Bayesian correlation matrix revealed substantial negative correlation probability between BI perception and SoA confidence in accuracy responses, specifically in experimental conditions where agency was manipulated. Based on the SFS scores, participants were divided into groups with and without evidences of BI distortion. Bayesian Independent Samples T-Tests evidenced substantial differential probability between groups. Analyzes confirmed lower SoA confidence among subjects with BI distortion greater than ±3 kg/m².

Keywords: Body image; Agency; Body awareness; Statistical probability; Self-perception.

Percepção de imagem corporal e senso de agência: notas do experimento da mão alienígena

Resumo

A percepção da imagem corporal compreende características representacionais estáveis e dinâmicas. Aqui, examinamos se uma medida estável da imagem corporal (IC) correlaciona com o senso de agência (SA) de movimentos corporais. Um total de 21 estudantes universitários (*M*=25,9, *DP*=9,29) completaram a versão brasileira da Escala de Figuras de Silhuetas (EFS) e participaram do Experimento da Mão Alienígena. Uma matriz de correlação bayesiana revelou uma probabilidade de correlação negativa substancial entre a percepção de IC e a confiança em SA, especificamente nas condições experimentais onde o SA foi manipulado pelo experimento. Com base nos escores da EFS, os participantes foram divididos em grupos com e sem evidências de distorção de IC. Testes de comparação de grupos evidenciaram uma diferença substancial entre os grupos de IC. As análises confirmaram uma menor confiança em SA entre indivíduos com distorção de IC maior que ±3 kg/m².

Palavras-chave: Imagem corporal; Agência; Consciência corporal; Estatística probabilística; Autopercepção.

Percepción de imagem corporal y senso de agencia: notas del experimento de la mano alienígena

Resumen

La percepción de la imagen corporal comprende características representativas estables y dinámicas. Aquí examinamos si una medida estable de la imagen corporal (IC) correlaciona con el senso de agencia (SA) de movimientos corporales. Un total de 21 estudiantes universitarios (*M*=25,9, *DP*=9,29) completaron la versión brasileña de la Escala de Figuras de Siluetas (EFS) y participaran en el Experimento de la Mano Alienígena. Una matriz de correlación bayesiana reveló una probabilidad de correlación negativa sustancial entre IC y la confianza en SA, específicamente en las condiciones experimentales donde el SA fue manipulado. Con base en los escores de la EFS, los participantes se dividieron en grupos con y sin evidencias de distorsión de IC. Las comparaciónés de grupos evidenciaron una diferencia sustancial entre los grupos. Los análisis confirmaron una menor confianza en SA entre individuos con distorsión de IC mayor que ±3 kg/m².

Palabras clave: Imagen corporal; Agencia; Conciencia corporal; Estadística probabilística; Autopercepción.

Introduction

The visual analysis of body shape has been emphasized in recent literature on attentional bias towards biological motion and joint action perception (Klüver, Hecht, & Troje, 2016; Meagher & Marsh, 2014). However, research on the association between stable body shape perception and self-generated movement has not progressed at the same rate as the former. With the advance of technology, new models of body perception representation have emerged in action-perception research, including movement perception as a new feature in the scope of body image judgment (Mahlo & Tiggemann, 2016).

Literature on body image (BI) has traditionally emphasized the evaluation of attitudinal dimensions of judgment towards the body, for example, by associating the satisfaction with the own body to the level of physical activity or marital status (Nikniaz, Mahdavi, Amiri, Ostadrahimi, & Nikniaz, 2016). In parallel to BI satisfaction research, BI perception investigations have explored, for example, the association between overweight and tendencies to distort the real size perception of the own body (Ettarh, Van de Vijver, Oti, & Kyobutungi, 2013). Nevertheless, few studies have delved into the relationship between BI perception/satisfaction and perception of body agency during action. Although BI perception and movement perception refer to differential cognitive processes, both are related to body perception. Studies have addressed this relationship with similar questions, such as: 1) how body shape and size estimation skills predict biological motion pattern recognition (Phillipou et al., 2015); 2) how a stable human figure self-consciousness effects human action recognition (Muñoz, Carballido, & Romero, 2015); or 3) how body ownership manipulation during action influences body self-identification (Heed et al., 2011).

In the search of a variable related to body movement perception, sense of agency (SoA) has become a reasonable measure of discriminant action perception. SoA is defined as the ability to correctly discriminate a self-generated action from actions controlled by an external source (Chambon & Haggard, 2011). SoA is disturbed, for example, in rare disorders such as the alien hand syndrome, when a patient presents involuntary limb movements together with a sense of loss of limb ownership (Hassan & Josephs, 2016). It has been suggested that an adequate SoA is the result of a coherent interaction between stable visual and proprioceptive signals (Van den Bos & Jeannerod, 2002), indicating an association to body shape self-identification. This process has been investigated through different sets of measures (Dewey & Knoblich, 2014). Nevertheless, the assessment of SoA poses methodological difficulties because of its dynamic nature. One way of testing it is by perceptual illusions such as The Alien-Hand Experiment (TAHE). Introduced by Nielsen (1963), TAHE has been replicated in multiple clinical settings (Belayachi & Van der Linden, 2009; Daprati et al., 1997; Rosenbaum et al., 2011; Sorensen, 2005) and non-clinical groups (DeCastro & Gomes, 2011; Van den Bos & Jeannerod, 2002).

Considering that both BI and SoA share aspects of body perception but are usually investigated separately, the aim of the present study was to evaluate whether a standard BI perception/satisfaction measure correlates to a SoA measure in a non-clinical group. The study set out to understand whether a static body image representation measure is associated to a dynamic movement perception score of the same body under sensory conflict conditions. Our hypothesis was that subjects with distorted BI perception would present worse performance in SoA under sensory conflict conditions.

Method

Participants

The participants consisted of 21 undergraduate students (13 women) recruited from a local University. They ranged in age from 18 to 35 years (M=25.9, SD=9.29). Stature and weight were measured to compute the Body Mass Index, which ranged from 18.50 to 29.99 kg/m² (M=26.10, SD=4.73), comprehending normal and overweight BMI indexes according to World Health Organization (2003). The original group comprised 30 participants. However, to avoid eventual motor performance noise, eight participants who reported use of psychiatric medication were excluded. Another participant was excluded because he did not respond adequately to TAHE instructions protocol provided in the pre-test phase. The final 21-person sample size approximates to other non-clinical studies using TAHE (DeCastro & Gomes, 2011; Van den Bos & Jeannerod, 2002). The study protocol was approved by the university's Ethics Committee (Registered ethics No. 39574314.6.0000.5334).

Materials

Silhouette Figures Scale (SFS – Brazilian version: Kakeshita, Silva, Zanatta, & Almeida, 2009). SFS evaluates BI perception and satisfaction. The Brazilian version consists of 15 silhouette figure cards for each sex that range from extremely thin (Silhouette 1 –

BMI = 17.5 kg/m²) to extremely obese (Silhouette 15 – BMI = 47.5 kg/m²). Participants are asked: 1) to identify the figure that best represents their current body shape, and 2) to identify the figure that best represents their desired body shape. BI perception score is obtained by subtracting the correspondent BMI from the chosen actual silhouette figure from the participant's real BMI. BI satisfaction score is measured by subtracting the corresponding BMI of the chosen desired silhouette figure from the corresponding BMI of the actual silhouette figure chosen by the participant. Scores are treated as continuous variables, as the original scale does not provide specific cut points to classify a distorted or dissatisfaction BI score. Psychometric properties of the Brazilian version indicated a high reliability for the actual body measure (α=.92) and for the desired body measure (α=.86) (Griep, Aquino, Chor, Kakeshita, Gomes, & Nunes, 2012).

The Alien Hand Experiment (TAHE) is an experimental task that manipulates the participant's visualization of his or her own hand movement (**Figure 1A**). Participants are instructed to draw a vertical line over a pre-printed line inside a box with their non-dominant hand as fast as they can while wearing a glove. In the current study, three different action visualization conditions were defined. In the first condition, participants could see their own hand movement inside the box (Control condition). For the following conditions, without participants' knowledge, a mirror inside the box is tilted in a 45° angle so that the reflection presents the participant with a similar hand (alien-hand) wearing the same glove as theirs and performing a similar action. In the second condition, the alien-hand, which is performed by an experimenter, seeks to mimic the participant's movement (Convergent Movement condition – CM – **Figure 1B**). In the third condition, the alien-hand purposely deviates the drawing from the pre-printed line at 30° at the end of the movement (Divergent Movement condition – DM – **Figure 1C**). The 30° value is based on a previous TAHE study that demonstrated consciousness of alien agency in a non-clinical group in inclinations beginning at 15° (Daprati et al., 1997). Thus, 30° inclination was selected to purposely create divergence consciousness between visualized action and proprioceptive action. All three conditions summed 18 trials randomly distributed between the conditions, with six trials for each condition. Participant responses were evaluated in two measures: 1) SoA Accuracy by experimental condition (0-6 pts) and in total (0-18 pts), and 2) SoA Confidence in accuracy responses by experimental condition (5-30 pts) and in total (5-90 pts).

Procedures

All participants provided informed consent upon arriving to the laboratory. The informed consent described detailed information regarding the research purpose and participant's rights according to resolution 466/12 of the Brazilian National Health Council. After taking weight and stature measures, they responded the SFS and then proceeded to TAHE. The experiment took place in a room with reduced lights and in the presence of two experimenters (one female and one male). In front of TAHE apparatus, participants received instructions about the task and practiced four trials inside the box (pre-test phase). Looking through a coupled display, participants could see inside the box only when an internal light was triggered. One of the experimenters had control of internal light activation via remote control. The go signal to initiate the movement

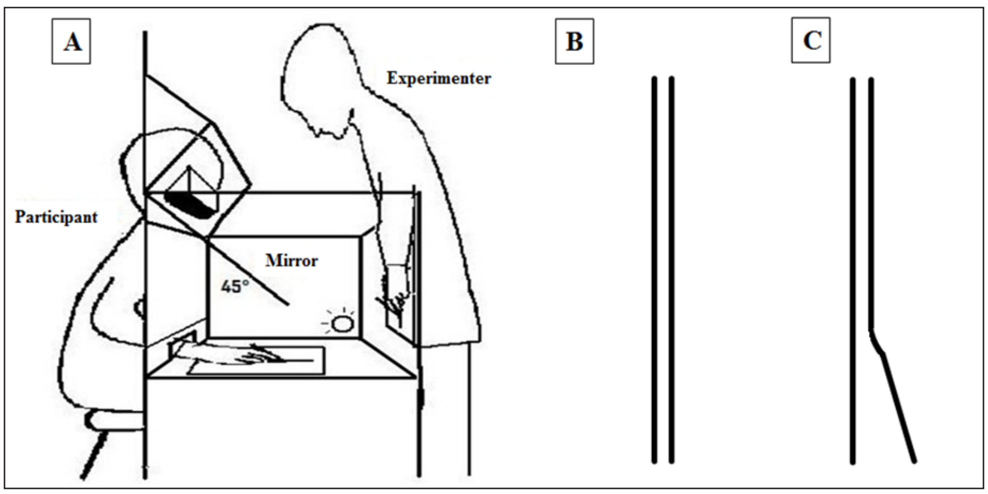

Figure 1. (A) General setting of TAHE; **(B)** Convergent Movement experimental condition; **(C)** Divergent Movement experimental condition.

was the light activation. Time interval visualization by trial was fixated at 300 ms by a pre-programmed digital timer (©CLIP-CLI Model). This interval was selected based on a previous study that found a 150-200 ms interval for visual self-agency consciousness, after the actual performance (Yokosaka, Kuroki, Nishida, & Watanabe, 2015). Thus, upper intervals, such as the applied 300 ms, should allow adequate time to discriminate delays between visualized action and proprioceptive action but may produce noise in decision making on SoA. The second experimenter was located in the opposite side of the box, performing the manipulation of the mirror and imitating participants' movement in CM and DM conditions. After each trial, participants were asked: 1) *was it you that drew the line?* and 2) *how much do you trust your previous statement in a one to five scale? Consider one to be very little confidence and five to be much confidence.*

Data Analysis

The research data analysis approach was based on the Bayesian criteria of hypothesis testing. To compare SoA performances in the different TAHE experimental conditions a within-subject analysis was first tested through a Bayesian Repeated Measures ANOVA. A Bayesian Correlation Estimation was tested between BI and SoA scores, applying Kendall's tau-b coefficient. Based on the correlation results, Bayesian Independent Samples T-Tests were estimated by comparing two groups of participants divided by their BI perception scores. All analyzes were examined by estimating a Bayes Factor (*BF10*) using Bayesian Information Criteria (Wagenmakers, 2007), which compares the fit of the data under the null hypothesis as compared to the alternative hypothesis. Analyzes were run by *JASP* (Version 0.8.0.0). The Bayesian Correlation Matrix applied a stretched beta prior parameter width of 1 and Bayesian T-Tests were estimated by applying a Cauchy prior parameter width of 0.707. To interpret Bayes Factors as evidence for the alternative or null hypothesis we adopted Jeffreys (1961) language classification of probability: *BF10* = 1 = no evidence, *BF10* = 1-3 = anecdotal evidence for H1, *BF10* = 3-10 = substantial evidence for H1, *BF10* = 10-30 = strong evidence for H1, *BF10* = 1/3-1 = anecdotal evidence for H0, *BF10* = 1/10-1/3 = substantial evidence for H0, *BF10* = 1/30-1/10 = strong evidence for H0.

Results

Bayesian Repeated Measures ANOVA

The tested model to compare SoA confidence in accuracy responses between the three experimental conditions suggested a decisive difference (*BF10* = 941.6) in favor of the alternative hypothesis. In a level by level simulation, the biggest probability difference was attested between the Control condition and CM condition (*BF10* = 413.6), while a simulation considering only the comparison between CM and DM conditions did not prove sufficient differential probability (*BF10* = 0.38), suggesting anecdotal evidence in favor of the null hypothesis. In general, participants had greater scores for SoA confidence in accuracy responses in the Control condition.

Similarly, a comparison model between the three conditions was estimated for SoA accuracy. The model suggested a decisive differential probability between these conditions (*BF10* = 315183.3). Again, the strongest probability of difference was observed between Control and CM conditions (*BF10* = 95801.5). The simulation comparing CM and DM conditions was repeated and did not provide evidences of differential probability (*BF10* = 0.35), suggesting once again anecdotal evidences in favor of H0. Participants had greater scores for SoA accuracy in Control condition.

Bayesian Correlation Estimation

The model tested the theoretical hypothesis for negative correlation between BI and SoA. The results evidenced substantial negative correlation probability between BI perception and total SoA confidence in accuracy responses (τ = -.35, *BF10* = 6.02). Specifically, BI perception had a substantial negative correlation probability with SoA confidence in CM condition (τ = -.39, *BF10* = 9.74) and with SoA confidence in DM condition (τ = -.38, *BF10* = 8.40) but not with the Control condition (τ = .09, *BF10* = 0.47). Considering SoA accuracy, only an anecdotal negative correlation probability was observed between BI perception and SoA accuracy in DM condition (τ = -.26, *BF10* = 1.90). **Table 1** displays the correlations between BI perception and SoA confidence/accuracy under negative hypothesis correlation.

The Bayesian model predicted a strong positive correlational probability between BI perception and BI satisfaction (τ = .43, *BF10* = 19.16) in favor of the alternative hypothesis. On the other hand, the model suggested anecdotal evidences in favor of the null hypothesis for the correlation between total SoA accuracy and total SoA confidence in accuracy responses (*BF10* = 0.38). Within SoA, the only probable correlation was evidenced between accuracy and confidence in accuracy during the Control condition (τ = .63, *BF10* = 1056.6).

TABLE 1
Bayesian Correlation Matrix for BI Perception × SoA Confidence/Accuracy

		BI Perc.	*General Conf.*	*General Acc.*	*Control Conf.*	*Control Acc.*	*CM Conf.*	*CM Acc.*	*DM Conf.*	*DM Acc.*
BI Perception	Kendall's tau	–	-0.35	-0.11	-0.09	-0.06	-0.39	0.17	-0.38	-0.26
	BF_{-0}	–	6.02	0.55	0.47	0.39	9.74	0.13	8.40	1.90

Note: For all tests, the alternative hypothesis specifies that the correlation is negative.

Bayesian Independent Samples T-Test

No differences between female and male participants were found. Also, no differences between normal BMI participants and overweight BMI participants were evidenced. Suggested probability correlations between BI perception and SoA confidence in accuracy responses gave rise to a hypothesis test between different BI perception groups. Based on the SFS scores, participants were divided into one group without evidences of BI distortion (Actual Perceived Silhouette <±3 kg/m² regarding real BMI, Deviation Mean = 0.83 kg/m², *N* = 9) and another group with evidences of BI distortion (Actual Perceived Silhouette > ±3 kg/m² regarding real BMI, Deviation Mean = 6.65 kg/m², *N* = 12). No evidences in favor of real BMI differences between the two groups were observed (*BF10* = 0.46).

Under the hypothesis of differences between groups, substantial evidences of difference were observed in favor of the alternative hypothesis for total SoA confidence in accuracy responses (*BF10* = 9.18), SoA confidence in accuracy under the CM condition (*BF10* = 8.28), and SoA confidence in accuracy under the DM condition (*BF10* = 7.89). Altogether, these results suggest superior SoA confidence in accuracy for the group without evidences of BI perception distortion when compared to the BI distorted perception group. **Figure 2** draws a comparison between a variable favored by the alternative hypothesis (SoA general confidence) and a variable with a tendency to the null hypothesis (SoA general accuracy) when comparing the BI's groups.

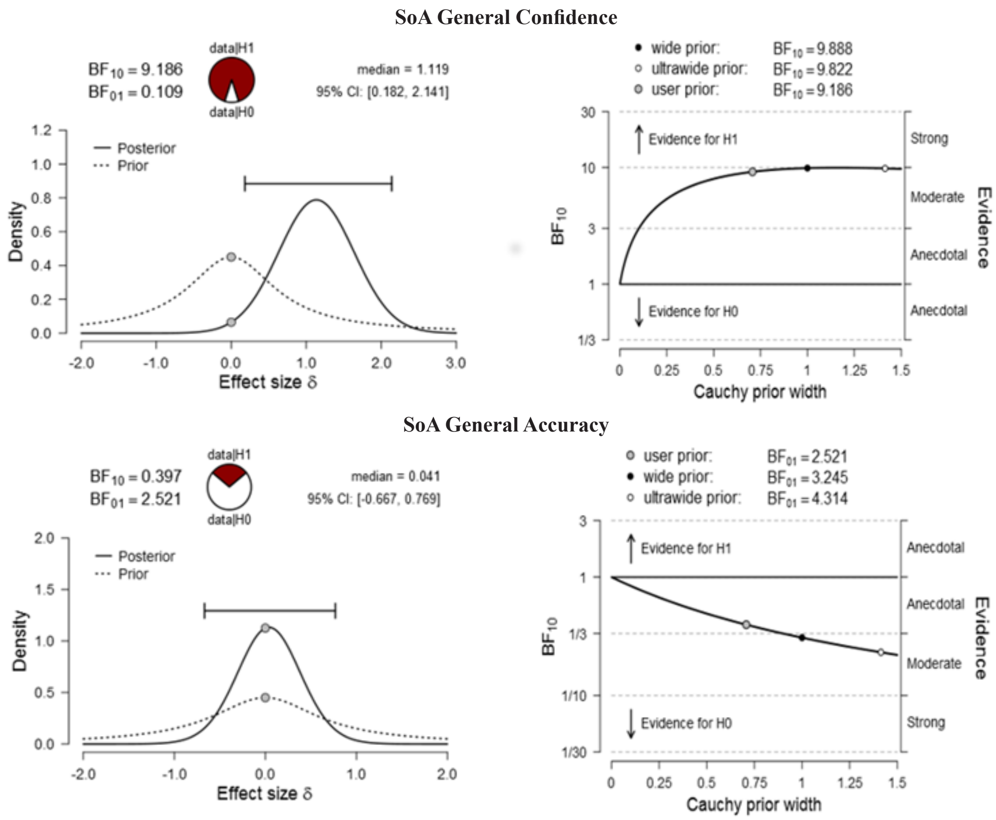

Figure 2. Comparison between an H1 probability tendency and an H0 probability tendency. Left charts show prior and posterior curves/right charts show Bayes factor robustness check.

Discussion

The results partially corroborated our initial hypothesis that subjects presenting distorted BI perception would show worse performance in SoA during TAHE. Analyzes confirmed lower SoA confidence in accuracy responses among subjects with BI perception deviation greater than ±3 kg/m². SoA confidence was specifically affected for this group during the conditions under experimental manipulation. Our results are consistent with the work of Daprati et al. (1997) who found in a similar group of non-clinical respondents consciousness of alien agency beginning at 15° drawing deviations from the pre-printed target in TAHE. This was evidenced in our study by the high index of accurate responses during the DM condition. However, SoA confidence in the accuracy responses presented itself as a distinct variable, varying according to the level of BI distortion. A selective lack of correlation between SoA accuracy and SoA confidence in accuracy was evidenced in the experimental conditions in which agency noise was present, but not in control condition. Accordingly, it is interesting to note that unsure SoA participants under experimental conditions were those that had BI distorted perception scores.

In this perspective, it is worth asking whether the reduction in SoA confidence, as observed in these subjects, can be attributed to a metacognitive impairment, such as an insight inability (Maniscalco & Lau, 2012), or a distress in the fluency of action selection (Sidarus, Vuorre, Metcalfe, & Haggard, 2017), or even due to a negative emotional processing, as studied in bulimic patients (Sorensen, 2005). Applying a different version of TAHE, Sorensen showed that bulimic patients tended to incorrectly self-attribute the manipulations purposely caused by the alien-hand and charged themselves for doing the pseudo-mistakes in the task. Such finding was not replicated in our study, as SoA accuracy was relatively stable along conditions. However, SoA levels of confidence were affected according to the BI perception group. Even though clinical groups have not been included in our study, deviations greater than ±3 kg/m² in BI perception may be associated to a sub-clinical manifestation of SoA confidence disturbance. Such hypothesis report back to Belayachi and Van der Linden (2009) research in which a sub-clinical checking group presented signs of low-level agency manifestation.

Considering BI variables alone, one possible interpretation for the positive correlation between BI satisfaction and BI perception is that dissatisfaction with the own body generates an attentional bias towards body size idealization and may consequently lead to a distorted BI perception (Moussally, Brosch, & Van der Linden, 2016). Still, in the present study, BI satisfaction did not evidence any probable sign of correlation with SoA measures, contrary to the BI perception scores. However, it must be noted that the choice to use the Silhouette Figures Scale to evaluate BI imposes a self-report bias towards participants' conceptual body experience in an extremely narrowed interval of time. In this sense, the results must be taken carefully once other measurement approaches for BI can shed light on different aspects of BI-SoA association or disassociation.

Regarding the option to use Bayesian analysis it is important to lay emphasis on the continuous increase of psychological research applying such statistical approach, as recent attested in a systematic review (van de Schoot, Winter, Ryan, Zondervan-Zwijnenburg, & Deapoli, 2017). We have applied in the present study a Bayesian trend of hypothesis testing, which proved interesting to observe not only effects regarding the alternative hypothesis under evaluation but also the size effect of the null hypothesis results. Especially important in experimental research is to quantify the probability of hypothesis results even when the results are negative and tending to the null hypothesis. Our sample size could represent a strong limitation for the results interpretation. However, considering the use of Bayesian analysis, the interpretation of the results is directly linked to the observed data. In this case, the probabilities do not follow null hypothesis logic, where the increase of sample size could lead to complete acceptance or refutation of this hypothesis.

Considering the results on the present research, it must be noted that even if we had applied a frequentist statistical approach similar effects would have been found. For example, if we had runned non-parametric spearman rho correlation tests between BI perception and SoA confidence in accuracy, statistical effects would have been obtained for the same pairs observed in the Bayesian analysis. Namely, BI perception with total SoA confidence in accuracy (rho = -.51, $p < .01$), BI perception with SoA confidence during CM condition (rho = -.53, $p < .01$), and BI perception with SoA confidence during DM condition (rho = -.54, $p < .01$). Even the reported anecdotal negative probability correlation observed between BI perception and strict SoA accuracy during DM condition could have been replied in the frequentist analysis (rho = -.37, $p < .05$). The same would have been found for the independent samples t-tests. Namely, difference between BI groups for total SoA confidence in accuracy

($t(19)=3.21$, $p<.01$, $d=1.41$, 95% CI [3.4, 16.3]), SoA confidence during CM condition ($t(19)=3.14$, $p<.01$, $d=1.38$, 95% CI [1.2, 6.1]), and SoA confidence during DM condition ($t(19)=3.12$, $p<.01$, $d=1.37$, 95% CI [1.5, 7.6]).

Our results are partially limited by the lack of a contrasting clinical group, but the initial experimental purpose was fully addressed by the participants' group composition. Considering the initial aim of the study to understand if a static body image representation measure could correlate to a dynamic SoA perception in an experimental task, the results are promising. Our main result matched this purpose by evidencing superior SoA confidence in accuracy for participants' without evidences of BI perception distortion when compared to BI distorted perception subjects. These results support continuous research exploring the relation between BI perception and SoA in experimental settings. Future studies applying TAHE should focus on the variation of experimental conditions and instructions to produce differential agency manipulations. Temporal control may be improved in TAHE by the use of delayed-video displays or computerized interfaces. Further experimental investigations in the field could lead to promising perspectives for understanding the interaction between stable body image perception and associated action-perception processes.

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