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Can you Feel the Body that you See? On the Relationship Between Interoceptive Accuracy and Body-Image

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Abstract

Interoception and exteroception for body signals are two different ways of perceiving the self: the first from within, the second from outside. We investigated the relationship between Interoceptive Accuracy (IAcc) and external perception of the body and we tested if seeing the body from an external perspective can affect IAcc. Fifty-two healthy female subjects performed a standard heartbeat perception task to assess the IAcc, before and after the Body Image Revealer (BIR), which is a body perception task designed to assess the different aspects of body-image. The performance of the lower IAcc group in the heartbeat perception task significantly improved after the exteroceptive task. These findings highlight the relations between interoceptive and exteroceptive body-representations, supporting the view that these two kinds of awareness are linked and interact with each other.

Keywords: Interoception; Interoceptive accuracy; Interoceptive awareness; Body-image; Body-awareness; Self-awareness.

Introduction

Perception of one's own body depends on the integration of bodily signals from the outside (exteroception; Blanke, Slater, & Serino, 2015; Tsakiris, 2010) and the inside (interoception; Herbert & Pollatos, 2012; Tsakiris, Tajadura-Jiménez, & Costantini, 2011). These signals contribute to one's body image, that is, "the picture we have in our minds of the size, shape, and form of our bodies and to our feelings concerning these characteristics and our constituent body parts" (Slade, 1988 cited in Skrzypek, Wehmeier, & Remschmidt, 2001, p. 216). Body image can be described as the multidimensional psychological experience of embodiment, in particular the physical appearance of one's own body (Cash, 1990), also including one's self-perceptions and self-attitudes towards the body, namely, thoughts, beliefs, feelings and behaviours (Cash, 2004). Skrzypek et al. (2001) state that the concept of body image can be divided into two different aspects: one component relates mainly to the perception of body size, and the other to the affective disposition towards one's body appearance. Therefore, body image disturbances may include perceptual distortions or feelings of dissatisfaction towards one's appearance (Thompson, 2004). In this light, it is worth taking into consideration both components of body image, since there might be a dissociation between problems related to the perception of one's own body or affect towards one's own body (Cash, 2002).

Recent studies investigated how interoceptive and exteroceptive bodily processes interact with each other to modulate body experience. For instance, individuals with lower interoceptive accuracy have been shown to experience a stronger Rubber Hand Illusion (RHI, Tsakiris et al., 2011). Intriguingly, a similar but inverse relationship holds between interoception and attitudes towards one's body. For example, Ainley and Tsakiris (2013) showed that the degree to which individuals are aware of their inner body signals (i.e., Interoceptive Accuracy, IAcc) is inversely correlated with self-objectification, which is the tendency to experience one's body as an object (Fredrickson & Roberts, 1997). Others have found an inverse relationship with body-image satisfaction (Emanuelsen, Drew, & Köteles, 2014): in two samples of healthy participants, results showed that lower interoceptive accuracy, measured using the heartbeat perception task, is associated with higher body dissatisfaction, as evaluated using the Body Image Ideals Questionnaire by Cash and Szymanski (1995). These observations suggest that interoceptive processing extends from the basic levels of multisensory integration to the conscious (affective) attitudes that we hold about our body, highlighting the role of interoception in different hierarchical levels of body-representations.

Notably, eating disorders (ED) are characterized by low IAcc (Blascovich et al., 1992; Harver, Katkin, & Bloch, 1993; Fassino, Pierò, Gramaglia, & Abbate-Daga, 2004) and a high tendency for self-objectification (Calogero, Davis, & Thompson, 2005). For instance, Pollatos et al. (2008) showed that interoception, as measured by using a heartbeat perception task, is decreased in patients with anorexia nervosa compared to healthy participants. Eshkevari, Rieger, Longo, Haggard, and Treasure (2012) further showed a stronger RHI in participants with ED, significantly predicted by lower self-reported interoception and self-objectification. These findings have been interpreted as reflecting greater visual capture and greater sensitivity towards the external visual body perception in ED patients. Lastly, an alteration in the anterior insula activity, a key area for processing and integrating interoceptive information (Kaye, Fudge, & Paulus, 2009) which is activated during interoceptive tasks (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004), has been found in people with anorexia nervosa, confirming the link between ED and interoception, as mediated by altered insular processing.

To summarize, existing findings from ED and healthy adults suggest that the processing and interaction of interoception and exteroception bodily signals play a key role in the construction of one's own body image. However, the extent to which different levels of interoceptive accuracy are linked to differences in the perceptual or affective components of body-image remains unknown. To address this question, here we measured interoceptive accuracy in healthy participants with a heartbeat perception task. Although heartbeat awareness is not the only component of interoception, we focused on this dimension, as it is the one most commonly investigated by the current literature (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015) and which can be reliably measured by well-validated tasks (Schandry, 1981). Then, in the same participants we assessed body image with the Body Image Revealer (BIR) software (Mian & Gerbino, 2009), a digital method aimed at quantifying individuals' perception of their body from the outside. BIR presents participants with a modified picture of their own body and then allows them to adapt it until the picture matches their cognitive (i.e., the perception of their own body size), affective (i.e., the way they feel about their own body), metacognitive (i.e., the way they think that other people see their body) and optative (i.e., the way they would like their body to be) components of their body image.

We first investigated whether there is a relationship between levels of IAcc and performance on the different tasks of the BIR (cognitive, affective, metacognitive and optative). In line with previous findings, we predicted that people with higher IAcc would be more accurate in body perception task, whereas subjects with lower IAcc might show difficulties in perceiving their external body image, predicting a positive relationship between accuracy in the heartbeat counting task and BIR ratings. Since differences in body size and shape might affect the ability to perceive one's own body from the inside and the outside (Bruch, 1962; Herbert & Pollatos, 2014; Pollatos et al., 2008), body mass index (BMI) was also considered as a covariate. Indeed, under- and overweight individuals have been shown to misperceive their own bodies (Garner, Garfinkel, Stancer, & Moldofsky, 1976), resulting in lower IAcc and worse performance at the BIR. The second question we addressed is whether the two tasks can directly influence each other. It might be the case that focusing on one's own body image might alter IAcc, and in particular, in line with Ainley, Tajadura-Jiménez, Fotopoulou, and Tsakiris (2012), self-observation might enhance the ability to feel the body from the inside. To test this hypothesis, the heartbeat counting task was administered twice, once before and once after the BIR task (pre- and post- conditions) to measure if the exteroceptive awareness task could influence performance on the interoceptive task.

Method

Participants

Fifty-two young (M_{age} = 22.21, *SD* = 4.04), healthy females students at Royal Holloway, University of London, were recruited using the Psychology Department's experiment management system. The study was approved by the Department of Psychology Ethics Committee, Royal Holloway.

Participants signed an informed consent form and at the end of the experiment they received a debriefing form that explained the aim of the study. The experiment lasted 30 minutes and participants received £5 each for their participation.

For each subject, height and weight were assessed using a measuring tape and a scale in order to calculate their BMI. BMI was calculated using the following formula: mass in kg/height in m^2. A BMI range from 16 to 18.5 is considered to be underweight, from 18.5 to 25 is considered to be normal weight and a range from 25 to 30 is considered to be overweight. Thirty-six participants were normal weight (M = 20.63, SD = 1.87), six participants were underweight (M = 17.00, SD = 1.10) and nine were overweight (M = 28.40, SD = 3.20). The average BMI of the sample was 21.56 (SD = 3.96).

One participant was excluded because she performed the BIR task randomly (i.e., higher percentage of body distortion), without paying attention to the different tasks. Therefore, the data analysis was performed with 51 results. Table 1 reports the descriptive statistics of all participants.

Table 1: Descriptive statistics for all the variables.

Variable	**All participants (*N* = 51)**	**Higher IAcc group (*N* = 26)**	**Lower IAcc group (*N* = 25)**
Mean age years (*SD*)	22.10 (4.04)	22.35 (4.28)	21.84 (3.84)
Mean BMI[1] (*SD*)	21.60 (4.00)	21.86 (4.06)	21.32 (3.92)
N participants BMI < 18	6	4	2
N participants BMI > 25	9	6	3
Mean IAcc[2] pre (*SD*)	0.62 (0.16)	0.75 (0.10)	0.47 (0.07)
Mean IAcc post (*SD*)	0.66 (0.18)	0.74 (0.14)	0.56 (0.16)
Mean Cognitive (*SD*)	-0.76 (9.77)	-2.43 (8.45)	0.97 (10.87)
Mean Affective (*SD*)	1.28 (10.11)	-1.87 (7.40)	4.55 (11.58)
Mean Metacognitive (*SD*)	-0.90 (10.82)	-1.83 (9.13)	0.07 (12.46)
Mean Optative (*SD*)	-6.23 (9.73)	-8.61 (9.42)	-3.75 (9.61)

[1] Body Mass Index

[2] Interoceptive Accuracy

Note: a BMI < 18 stands for underweight and a BMI > 25 represents overweight.

Procedure

Heartbeat counting task. Participant's heart rate was assessed using the POLAR Watch RS800CX heart monitor. POLAR products have been shown to have excellent validity and reliability in measuring heart rate and R-R interval data (e.g., Kingsley, Lewis, & Marson, 2005; Nunan et al., 2008; Quintana, Heathers, & Kemp, 2012; Weippert et al., 2010). Following the well-validated Mental Tracking Method by Schandry (1981), data were recorded for three time intervals (35s, 25s, 45s), each separated by a pause of 20s. The software Polar ProTrainer5 was used to extract the actual number of heartbeats. The procedure consisted of moistening the electrode areas of the belt (in order to facilitate heart rate transmission) and asking participants to place their wrists on the electrode areas. Participants were asked to stay still during the task and to look at a fixation cross shown on a computer screen. One acoustic start cue was presented at the beginning of each time interval and another acoustic stop cue indicated the end of the interval. Throughout the experiment, participants were instructed to count their own heartbeats silently without taking their pulse. At the end of each time interval, participants were asked to verbally report how many heartbeats they counted. No feedback on the length of the counting phases or the quality of their performance was given.

Body Image Revealer (BIR) task. The BIR uses a technique that allows a picture of the participant's body to be distorted without the subject's awareness of this change. In fact, the transformation is made without the participant looking at the computer screen, so that he/she is not aware of the percentage of distortion or the real size of the original body. Moreover, the BIR uses an algorithm of two-dimensional modelling with a morphing/warping technique that reflects the real pattern of weight loss and gain in women and men. This method is useful and precise because takes into account the body image (whole body or parts of it) and its proportions, giving an extremely realistic visualisation. To this purpose, anthropometric data and simulative/emulative curves of about 40 Caucasian and African-American males and females were originally sampled, obtaining a standard distortion curve. This technique, which provides an extremely realistic image, is preferable to existing techniques such as video-distortion using anamorphic lenses, in which the morphing is based on the division into frames of images or other software that examines the whole picture, and which does not take into account the body shape (entire or its parts), which is taken into account by the BIR. To test the validity and reliability of the BIR software, data from a large sample of 540 individuals were analysed. The BIR allows different aspects of the body image (cognitive, affective, metacognitive and optative) to be evaluated, and correlates with self-report measures of body image disturbances. The data of healthy participants have been compared with data those collected on patients with eating disorders ($N = 67$), confirming good psychometric properties.

The BIR software uses real pictures of the participant with the aim of measuring the discrepancy between the dimensions of the real image and the sizes attributed by the participant during the task. Pictures of the participant were taken with a digital camera, which were then uploaded into the software that modified them simulating the overweight and the underweight versions of the participant.

The range of the distortion can vary between +75% - which makes the image appear heavier than the original picture - to -75% - which makes the image appear lighter than the original. These limits were set up during the design phase of the software in order to avoid the image having an unnatural and artificial appearance. Participants were shown the images from a frontal perspective and were asked to enlarge or shrink the image until they achieved the sizes that they thought were the right ones according to the BIR's task requests.

In order to take the pictures, participants were firstly provided with long black leggings and black t-shirts and they were asked to change their clothes behind a curtain. Then they were asked to stand against a white background with their arms wide open at the height of the shoulders and their legs hip-width apart. A picture of their whole body was taken using a Konica Minolta camera and then the photo was uploaded onto a computer. The modified picture was shown to participants only after the first assessment of IAcc with the heartbeat counting task, in order to not influence the performance at the baseline. Before the start of the BIR test, the picture was modified using Paint: it was rotated 270 degrees and reduced by 50% on both the horizontal and vertical axes. Once modified, it was opened in the software and the experimenter selected the parts that would be modified, from the neck to the feet. After this step, the start condition was chosen (lighter vs. heavier) which was administered in a counterbalanced order between participants. In the Minus condition the test started with the picture reduced by 75%, while in the Plus one the picture was enlarged by 75%. The decision of having two different starting conditions was taken in order to control for the "anchoring effect", in which individuals that start with the larger picture tend to overestimate their sizes, while people that see their thinner picture as first one have a tendency to underestimation (Gardner, 1996).

The BIR included four questions:

(1) How do you *think* you really look like? (Cognitive task);

(2) How do you *feel* you look like? (Affective task)

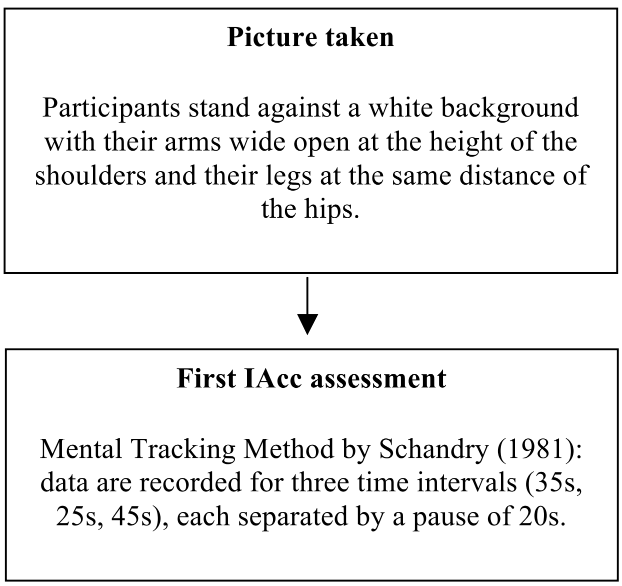
(3) How do you *think others think* you look like? (Metacognitive task)

(4) How do you *want* to look like? (Optative task)

Each question was repeated 6 times, 3 times with the image starting in the Minus condition (lighter image) and 3 times in the Plus condition (heavier image). The order of the questions was randomized for each participant and the same pictures was presented throughout the experiment. During the test the lighter and heavier pictures were presented 24 times in an alternating order.

To answer the different questions, the participants were requested to modify their images using the “+” or “-” keys until they achieved the desired sizes, according to the specific question asked. After each trial they pressed the space bar and switched to the next picture. Participants could not go back to the previous trial once they had responded. The test was administered twice, with 12 questions each (3 times Minus/Plus x 4 questions). The discrepancy between the real picture and the body size perception of the participant was calculated. A value of zero represents the most accurate performance (i.e., when the real picture and the perceived sizes are exactly the same), whereas values above zero indicate overestimation of the body sizes and values below zero indicates underestimation. Results can vary between +50 (overestimation) and -50 (underestimation). The whole procedure is displayed in Figure 1.

Figure 1: Schema of the procedure.



BIR task

The picture is uploaded into the software and modified simulating the overweight and the underweight conditions. Participants are asked to enlarge or shrink the image until they achieve the sizes that they think are the right ones according to BIR's task questions:

1) How do you think you really look like? (Cognitive task)

2) How do you feel you look like? (Affective task)

3) How do you think the others think you look like? (Metacognitive task)

4) How do you want to look like? (Optative task)

Each question is repeated 6 times, 3 in Minus and 3 in Plus condition (total of 24 questions randomized for each participant).

Second IAcc assessment

Mental Tracking Method by Schandry (1981): data are recorded for three time intervals (35s, 25s, 45s), each separated by a pause of 20s.

Data Analysis

In order to quantify the IAcc from the heartbeat perception task, the following formula was used:

$$1/3 \sum (1-(|\text{recorded heartbeats} - \text{counted heartbeats}|)/\text{recorded heartbeats})$$

for both Pre- and Post-condition. Thus, the interoceptive accuracy score can vary between 0 and 1, with higher scores indicating small differences between recorded and counted heartbeats, which means higher IAcc, and lower scores indicating bigger discrepancies and lower IAcc.

In order to assess the accuracy in body perception with BIR, we averaged the mean perceptual error for each task (Cognitive, Affective, Metacognitive and Optative), i.e., the difference between the participant's actual image and the one they chose across the 6 repetitions. The data were normalized and then analysed using the statistic software IBM SPSS Statistics 19.

The Body Image Revealer scores were analysed using a Mixed ANOVA with "Start condition" (Minus or Plus) as a between-subjects factor and "Type of question" on the BIR as a within-subjects factor, which is composed of four levels (cognitive, affective, metacognitive and optative).

To test the first hypothesis, a median split analysis was performed, based on the results from the first IAcc assessment (*Mdn* Pre = 0.59). The higher IAcc group consisted of 26 participants, while 25 participants were in the lower IAcc group. One MANCOVA was conducted with group (higher, lower IAcc) as a between-subjects factor, and the BIR performance at the cognitive, affective, metacognitive and optative tasks as dependent variables, and participants' BMI as covariates.

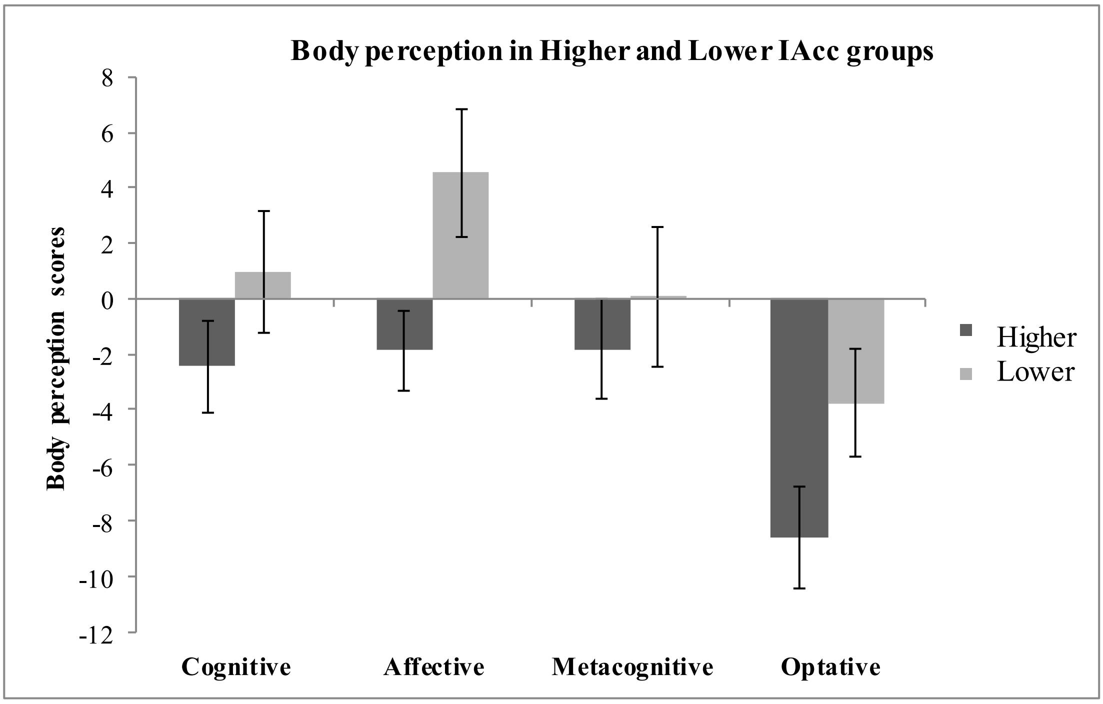
To test the second hypothesis and to check whether exposure to one's own body image improved IAcc results, a paired-sample *t* test was conducted to compare the Pre- and Post-condition.

Results

The effect of the Type of question was significant, $F(3, 147) = 18.87$; $p < .001$, $\eta_p^2 = .27$, whereas the effect of the Start condition and the interaction Type of questions*Start condition were not significant, $F(1, 49) = 1.05$; $p = .31$; $F(3, 147) = 1.31$; $p = .27$. These results highlight that people answered the questions in a different way according to the instruction, regardless of the condition they started the BIR with. In general participants showed accurate body perception at the cognitive (M = -0.76, SD = 9.77), affective (M = 1.28, SD = 10.11), and the metacognitive (M = -0.89, SD = 10.82) tasks, whereas showed a strong desire to be thinner on the optative task (M = -6.23, SD = 9.73). Paired-samples *t* tests comparing the results at the BIR showed that responses on the optative task significantly differed from the ones on the cognitive, $t(50) = 4.89$, $p < .001$, 95% CI [3.22, 7.71], d = 0.56, affective, $t(50) = 7.16$, $p < .001$; 95% CI [5.40, 9.61], d = 0.74, and metacognitive tasks, $t(50) = 4.28$, $p < .001$, 95% CI [2.83, 7.83], d = 0.49 (all p values corrected with Bonferroni $p < .008$). Differently from previous reports, in our sample we did not find an "anchoring effect". It can be hypothesized that this is due to the randomization of the questions' order.

As a second step, we tested whether there were differences in the performance of the higher and lower IAcc groups at the BIR task. Results of the MANCOVA showed a nonsignificant group effect on the BIR task, $F(4, 45) = 2.23$, $p = .08$ and a nonsignificant effect of BMI on performance on the BIR, $F(4, 45) = 2.42$, $p = .06$. Figure 2 displays the performance on the BIR task in higher and lower IAcc groups.

Figure 2: Performance at the BIR task in higher and lower IAcc groups.

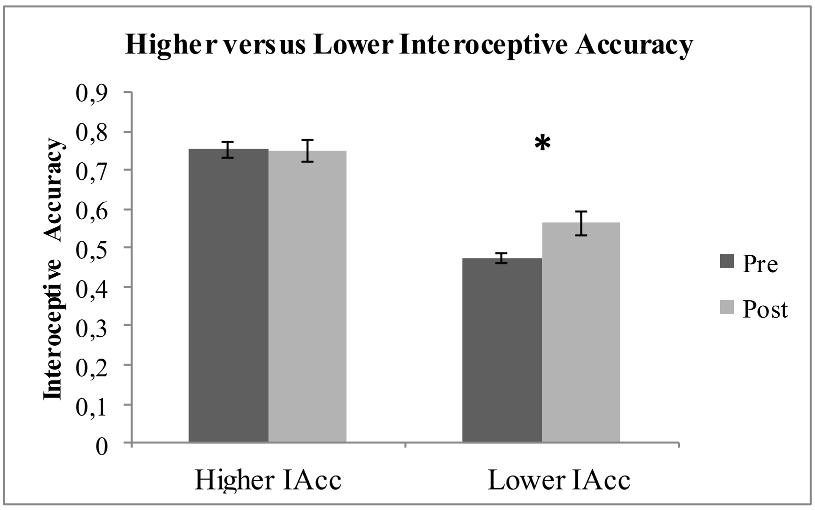


To better understand the interaction between BMI and performance at the BIR, four linear regression analyses were performed with BMI as a predictor and the Body Image Revealer results as outcomes to see if BMI influenced BIR responses. Results revealed that BMI significantly predicted the performance on the cognitive, $R^2 = .11$; $F(1, 49) = 6.16$, $p = .02$, and metacognitive, $R^2 = .14$; $F(1, 49) = 7.89$, $p = .01$ tasks. People with higher BMI show overestimation of their actual sizes when answering the questions "How do you *think you really* look like?" and "How do you *think others think* you look like?". No significant relationships with BMI were found for affective and optative responses (both p-values > .07).

The second hypothesis test showed a significant difference between responses on the second ($M = 0.66$, $SD = 0.18$) and the first ($M = 0.62$, $SD = 0.16$) IAcc assessments, $t(50) = 2.01$, $p = .04$, 95% CI

[-0.08, -0.01], *d* = 0.25, suggesting that participants' IAcc improved in the second assessment. To further investigate this effect, a 2 x 2 mixed ANOVA was performed with "Group" (Higher vs Lower IAcc) as a between-subjects factor and "Time of IAcc assessment" (pre- vs post-condition) as a within-subjects factor. A significant effect of Group, $F(1, 49) = 68.34$, $p < .001$, $\eta_p^2 = .58$, and a significant effect of Time of IAcc assessment were found, $F(1, 49) = 4.67$, $p = .04$, $\eta_p^2 = .09$. Results also showed a significant two-way interaction, $F(1, 49) = 6.01$, $p = .02$, $\eta_p^2 = .11$. Two paired-sample *t* tests were conducted to better evaluate the difference in the performance of the two groups (higher and lower IAcc) between the two conditions (pre and post BIR). A significant difference was found in the performance of the lower IAcc group between the first assessment ($M = 0.48$, $SD = 0.07$) and the second one ($M = 0.56$, $SD = 0.16$; $t(24) = -2.93$, $p =. 01$, 95% CI [-0.15, -0.03], $d = 0.58$). There were no differences in the higher IAcc group's performance between the first measure ($M = 0.75$, $SD = 0.10$) and the second one ($M = 0.75$, $SD = 0.15$; $p = .82$). These results underline that people with lower IAcc in the Pre-condition improve in the Post- one, while people with higher IAcc do not change their performance after the exteroceptive task. Figure 3 shows the improvement of the lower IAcc group in the post condition.

Figure 3: Differences between higher IAcc and lower IAcc group. Participants with lower IAcc improved their performance in the Post condition ($p = .01$).



An alternative interpretation to our results it that the improvement in IAcc performance was due to a test-retest factor and regression to the mean. To examine this possibility, we analysed the IAcc test-retest on a sample of healthy subjects ($N = 7$) who performed the heartbeat perception task twice, without any manipulation in between, and we conducted the same median split analyses to check if the lower IAcc group improved in the Post condition. Results showed that neither the higher and lower IAcc groups improved their performance in the second assessment (both $p > .71$).

Lastly, given that some participants were underweight (BMI < 18, $n = 6$), analyses were re-run excluding these individuals and the pattern of results remained unchanged. More specifically, the difference in the affective task between higher and lower IAcc groups remained significant ($p = .04$), as well as the improvement in the post condition for the lower IAcc group ($p = .008$).

Discussion

The aim of the present research was to study the interaction between interoception, i.e., the way we perceive our body from the inside, and exteroception, i.e., the way we see ourselves from the outside. To examine this relationship, two techniques were used: the heartbeat perception task and the Body Image Revealer. The first one provides a measure of interoceptive accuracy, whereas the second one evaluates the accuracy of external body perception.

First of all, the results of the BIR task showed a significant effect of the "Type of question" on performance. Participants' responses varied as a function of the body image dimension they were asked about. More precisely, participants from the present sample showed an accurate body perception in the cognitive, affective and metacognitive tasks, whereas they preferred to have a thinner body size in the optative task. This could be explained in the light of the well-known effect of "normative discontent", a weight dissatisfaction that most women experience as result of an emerging societal stereotype (Rodin, Silberstein, & Striegel-Moore, 1984; Tantleff-Dunn, Barnes, & Larose, 2011).

Interestingly, the modulation of responses on the BIR depending on body image dimension was related to the participants' real body size. Indeed, women with higher BMI overestimated their body sizes on the cognitive and metacognitive tasks. This means that overweight participants thought that they were larger than they actually were and they thought that other people perceived them as being bigger than their actual size. This body image distortion could be the consequence of their weight: the social pressure to be thin may have affected the way participants saw themselves and the way they thought that other people saw or judged them. This result has been found also in other studies (e.g., Arciszewski, Berjot, & Finez, 2012), suggesting that women with higher BMI have greater body image self-discrepancies.

Additionally, we compared the lower and higher IAcc groups on the BIR task and we found no significant differences between the performances of the two groups. Future studies should consider a larger sample of individuals to make sure that this result is not due to lack of statistical power. Moreover, other techniques for body perception assessment might be used, for example, the silhouettes method, or other computer based image distortion techniques, in order to explore the potential link between interoception and exteroception and extend these preliminary findings.

Lastly, we found that IAcc increases with the repetition of the heartbeat perception task, specifically in people with lower IAcc at baseline. Indeed, two different groups were created on the basis of their ability in the heartbeat counting task, namely higher IAcc and lower IAcc. By comparing the performance of these two groups, we found a significant improvement of IAcc only in the lower IAcc group the second time the task was performed.

There are two possible explanations for the increase in IAcc amongst those with lower IAcc accuracy: the improvement could be due to a testing effect and/or to self-observation. Regarding the first explanation, it is well known that people, after repeating the same task, improve their performance because they already know how it works and they are more experienced on the task. Panayiotou and Vrana (1998) found that self-focus provoked a reduction of the processing resources useful to complete a secondary task: instead of improvement, participants showed an impairment in the performance. Lastly, since these results might be explained as a regression to the mean, we performed the same analysis on a control group of healthy subjects, albeit a low sample size, showing that neither the higher nor the lower IAcc groups improved in the second assessment.

These findings suggest that IAcc can increase and a change in interoceptive accuracy can occur by either externally-triggered social events, such as social exclusion (Durlik & Tsakiris, 2015) or self-directed attention such as observation of one's face (Ainley et al., 2012) or, as in the case of the present research, the view of one's own body.

The BIR task makes participants more aware of their internal states leading to an improvement in their interoceptive accuracy. In line with this hypothesis, other studies (e.g., Ainley et al., 2012) have highlighted that self-observation through a mirror enhances self-awareness and, as result, the ability to count the own heartbeats in the IAcc task. The same effect can be observed in this experiment, as participants were asked to look at their own picture for around ten minutes and to think about their body image. Moreover, the questions asked were intended to make the subjects think about their body representation and the related feelings.

This finding opens new avenues on the link between interoception and exteroception and the way these two aspects of the body can communicate and influence each other. Given that eating disorders and overweight/obese individuals are characterized by poor interoception (Herbert, Blechert, Hautzinger, Matthias, & Herbert, 2013; Herbert & Pollatos, 2014; Pollatos et al., 2008), training that focuses on self-observation might be considered in the future to increase people’s awareness of their internal signals and improve their eating behaviour. Obese patients, for instance, usually report the inability to know when start and stop eating, i.e., to feel the internal signals of hunger and satiety, resulting in an eating behaviour led by external signals (Schachter & Rodin, 1974). Enhancing their interoception might, eventually, help them to adopt a healthier eating style.

One limitation of the study was that the sample mainly consisted of participants with normal BMI and only a few under- or overweight participants. Moreover, we did not check for eating disorders with a diagnostic interview or questionnaire. Nevertheless, the BIR performance was in the normal range and the analyses with the exclusion of underweight participants led to the same results. We can, therefore, assume that, even if under -or overweight, participants did not show body image concerns or disorders. Another limitation, as stated above, is the absence of a control condition where participants are exposed to neutral stimuli in order to confirm that the improvement in the post condition is a result of self-observation and not a test effect. It will be interesting in future studies to include such a control condition and further investigate how IAcc can be modified according to different manipulations and conditions.

Future research should also consider equal groups of underweight, normal range and overweight people in order to compare their performance. It could also be interesting to test patients affected by eating disorders or body perception distortions with the aim of comparing their results with the normative ones obtained in this study. Lastly, the focus of the present research was IAcc, but other components of interoception can be affected e.g., hunger sensation, therefore future studies might investigate whether changes in IAcc corresponds to changes in other bodily perceptions, combining the heartbeat perception task with other techniques to examine changes in gastric functioning and hunger-related feelings.

Conclusion

In summary, we showed that external self-observation - in this case using a body perception task - improves the ability to monitor one's own heartbeat, especially in people with poor IAcc. This finding might be important for understanding the complex interaction between interoception and the perception of one's own body, an issue which appears to be promising for identifying the potential mechanisms underlying eating disorders.

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