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Interoception and gender: What aspects should we pay attention to?

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ABSTRACT

Interoception is involved in both somatic and mental disorders with different prevalence between genders; however, gender differences are often neglected. To examine the potential gender differences in interoceptive awareness, we recruited 376 healthy subjects (51% males, aged 17–30 years), to fill in the Multidimensional Assessment of Interoceptive Awareness (MAIA). Of that sample, in a subgroup of 40 subjects (50% males), interoceptive accuracy was assessed by heartbeat counting task (HCT).

The results on interroceptive awareness suggest that females tend to notice bodily sensations more often, better understand relations between bodily sensations and emotional states, worry or experience more emotional distress with sensations of pain or discomfort and see body as less safe. The results of interoceptive accuracy further suggest that females are less efficient in consciously detecting heartbeats. Therefore, gender should be considered when interoceptive evaluation is performed in disorders associated to bodily sensations and to the emotional/mood states.

1. Introduction

Interoception is a group of senses for perception of physiological state of the body that aids in maintenance of homeostasis, allowing a better connectedness to the world and a better adaptation to the changing environment (Barrett & Simmons, 2015; Critchley & Harrison, 2013; Häfner, 2013). Being related to human self-consciousness (Seth, 2013), decision-making (Dunn et al., 2010), also being a part of popular *mindfulness* practices (Arthington, 2016; Farb, Segal, & Anderson, 2013; Haase et al., 2016), and an important aspect of several mental and physical disorders (Barrett & Simmons, 2015; Ehlers & Breuer, 1996; Flink, Nicholas, Boersma, & Linton, 2009; Pollatos et al., 2008; Verdejo-Garcia, Clark, & Dunn, 2012; Weiss, Sack, Henningsen, & Pollatos, 2014), interoception is deserving increasing amount of attention from the scientific community.

Apart from the well-known involvement of interoception in pain sensitivity (Simons, Elman, & Borsook, 2014), impaired interoception has been proposed as a vulnerability or maintaining factor in anorexia nervosa (Pollatos et al., 2008), depression (Terhaar, Viola, Bär, & Debener, 2012), alexithymia (Herbert & Pollatos, 2012). An important aspect of these conditions is related to the different prevalence rates between genders: anorexia nervosa (Nagl et al., 2016), depression (Ferrari et al., 2013), sensitivity to pain (Bartley & Fillingim, 2013; Weiss et al., 2014) are more prevalent in females, and

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alexithymia – in males (Salminen, Saarijärvi, Aärelä, Toikka, & Kauhanen, 1999). All the above mentioned suggest that gender might be an important confound in interoception-related studies.

The multifaceted view of interoception has emerged in recent years (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015; Forkmann et al., 2016; Mehling et al., 2012). It is suggested to distinguish between *interoceptive accuracy* (the objective accuracy to detect bodily sensations (Garfinkel et al., 2015)) and *interoceptive awareness* (a set of a person's beliefs on the aspects of his/her own abilities and tendencies to consciously sense signals originating from the inside of the body (Mehling et al., 2012)). Few decades ago, Franzoi, Kessenich, and Sugrue (1989) concluded that there were no differences between males and females in a subconstruct of *interoceptive awareness* and more recent studies on the subjective aspect of interoception tended to ignore gender as a factor. The assessment with the *Multidimensional Assessment of Interoceptive Awareness* questionnaire (Mehling et al., 2012) was heavily biased towards samples dominated by females: in the original MAIA validation study, the sample consisted of 79% females. Similarly, Chilean MAIA study sample consisted of 77% females (Valenzuela-Moguillansky & Reyes-Reyes, 2015), German – 68% (Bornemann, Herbert, Mehling, & Singer, 2015), Italian – 91% (Calì, Ambrosini, Picconi, Mehling, & Committeri, 2015) and Polish – 100% (Brytek-Matera & Kozieł, 2015). None of these studies compared results between genders. Several studies considering *interoceptive accuracy* reported that males were more accurate while detecting their heartbeats in comparison to females (Ludwick-Rosenthal & Neufeld, 1985; Montoya, Schandry, & Müller, 1993). However, Mussgay, Klinkenberg, and Rüddel (1999) and Pollatos and Schandry (2004) failed to show gender differences in heartbeat counting task (HCT). It would seem, therefore, that further investigations are needed in order to clarify what aspects of interoception are sensitive to gender and what is the relationship between the interoceptive aspects within genders.

This paper reports on the gender differences in a sample of young healthy subjects related to the *interoceptive awareness* (as measured with *Multidimensional Assessment of Interoceptive Awareness* questionnaire) and the *interoceptive accuracy* (as measured with heartbeat counting task).

2. Methods

2.1. Participants

The sample consisted of 376 (51% male) volunteers aged 17–30 years (M = 21.19, SD = 2.31). The mean age did not differ between genders (Mann-Whitney test, $p = 0.202$). The majority of the participants were university students. The years of their education ranged from 10 to 24 years (M = 14.9, SD = 1.9). The research was approved by Lithuanian Bioethics Committee and all of the participants gave their informed consents.

After the completion of MAIA, subjects were asked to participate in the psychophysiological experiment. Those who expressed interest and provided contact details were invited to complete heartbeat counting task (N = 40). No monetary or course-credit payment was provided. The data of five participants, i.e. two males and three females, were excluded: there were extrasystoles in EKG of 1 participant; 1 participant reported guessing the number of heartbeats; 3 participants detected less than two beats during the tasks. Further analysis was performed on the data of 35 participants (18 males and 17 females). The mean age of the experimental subsample was 24.03 years (no age difference between males and females, Mann-Whitney test, $p = 0.319$). All of the experimental subsample participants met the following criteria: were able to participate in all of the experimental procedures without having a break for smoking, had normal or corrected-to-normal visual acuity and good general health, were not using psychotropic substances or any drugs and slept for 6 or more hours at night before an experiment. Additionally subjects were asked about the signs of chronic fatigue and the experience of strong emotions at the time. The information was collected in the form of self-reported questionnaire.

2.2. MAIA questionnaire

All subjects were volunteers agreeing to fill in a paper version of the Lithuanian version of MAIA questionnaire. The detailed description of MAIA questionnaire is provided in Mehling et al. (2012) and psychometric characteristics of Lithuanian MAIA version are presented in Baranauskas, Grabauskaitė, and Griškova-Bulanova (2016). The MAIA has 32 questions that are grouped into 8 scales aiming at the following aspects: (1) *Noticing* – awareness of uncomfortable, comfortable, and neutral body sensations; (2) *Not-Distracting* – tendency not to ignore or distract oneself from sensations of pain or discomfort; (3) *Not-Worrying* – tendency not to worry or experience emotional distress with sensations of pain or discomfort; (4) *Attention Regulation* – ability to sustain and control attention to body sensations; (5) *Emotional Awareness* – awareness of the connection between body sensations and emotional states; (6) *Self-Regulation* – ability to regulate distress by attention to body sensations; (7) *Body Listening* – active listening to the body for insight; (8) *Trusting* – experience of one's body as safe and trustworthy. The subjects had to evaluate each of statements on a 6-point scale (i.e. from 0 – "Never" to 5 – "Always") indicating how often each statement could be applied to them generally in their daily life.

2.3. Heartbeat counting task

For the evaluation of interoceptive accuracy, the modified version of Schandry (1981) heartbeat counting task (HCT) was used: participants of the experimental subsample were instructed to focus their attention to the area of the heart and try to feel the heartbeats. Subjects were asked *not* to take their own pulse or try any other physical manipulations which might facilitate the detection of heartbeats; they were asked to count only the heartbeats which they were sure to sense and not to guess. Participants counted their heartbeats from the moment of appearance of the fixation cross until the moment it disappeared. At that point participants had to write down the number of heartbeats counted. Each participant had four trials, which lasted 25, 35, 45 and 55 s. The order of trials was randomly altered between participants. Breaks between trials were randomly selected within the interval from 20 to 40 s. After the HCT, participants reported if they counted only truly sensed heartbeats or they were guessing.

2.4. Experimental procedure

Participants were asked to refrain from caffeine consumption and not to have any intense physical activity an hour before the experiment. Upon arrival to the laboratory, subjects filled in the informed consent and a questionnaire on the demographic data. Subjects were seated in a chair facing a computer screen (eyes ≈80 cm away from it). For EKG recording (in order to track the actual number of heartbeats occurring during the HCT), two Ag/AgCl electrodes were placed on the forearms, near the wrists. EKG was recorded using *ASALAB* (*ANT Neuro*, the Netherlands) system with 1024 Hz sampling rate, referenced to Cz electrode.

2.5. Data analysis

To determine interoceptive accuracy, the number of actual heartbeats was estimated offline by identifying R peaks in a 1–35 Hz band-pass filtered EKG with modified Pan-Tompkins algorithm (Pan & Tompkins, 1985). After this automatic procedure, the identified R peaks were re-viewed and a custom written script was employed for counting R peaks reflecting the number of the heartbeats which have occurred during each trial of the HCT.

Interoceptive accuracy (IA) was estimated using the following formula (Ehlers & Breuer, 1992):

$$IA = \frac{1}{N} \cdot \sum_{i=1}^{N} \left(1 - \frac{|R_i - C_i|}{R_i}\right)$$

Here, R – real number of heartbeats, C – number of counted (i.e. reported by participant) heartbeats, i – number of trial, N – total number of trials.

2.6. Statistical evaluation

For the statistical evaluation, *IBM SPSS Statistics*, *R statistics* and *MATLAB* softwares were used. The significance level α was set at 0.05. Bonferroni correction was used to correct significance level for multiple tests (Curtin & Schulz, 1998). The majority of ratings of the MAIA scales were non-normally distributed as indicated by Shapiro-Wilk test (whole sample $p < 0.05$; experimental subsample $p < 0.005$). The distribution of HCT results was non-normal (Shapiro-Wilk test, p = 0034). The non-parametric statistical tests were applied to assess gender differences (Mann-Whitney test) and to evaluate correlations (Spearman's correlation test).

3. Results

3.1. MAIA results

The results of the larger sample (N = 376) showed that females had significantly higher scores on *Noticing* and *Emotional Awareness* scales of MAIA, whereas males had higher scores on *Not-Worrying* and *Trusting* scales (see Table 1). For the *Not-Distracting*, *Attention Regulation* and *Self-Regulation* scales we did not find any gender differences in a large sample (Table 1).

Differences between genders in two out of eight MAIA scales in an experimental subsample (N = 35) were detected: females had higher scores on *Emotional Awareness* scale (p = 0.003, in line with results of a larger sample) and on *Body Listening* scale (p = 0.003; this was on the trend level in a larger sample). No differences were found in a subsample for other scales. The medians and quartiles of the scores from the experimental sample are shown in Table 2.

3.2. Heartbeat counting task

The accuracy of detecting heartbeats in the experimental subsample varied between 29% and 98%. Since 85% accuracy is considered as a borderline between good and bad heartbeat perceivers (Montoya et al., 1993; Pollatos, Kirsch, & Schandry, 2005; Pollatos & Schandry, 2004), 11 subjects of the experimental sample can be treated as good perceivers, among them 10 males. Overall, males statistically significantly outperformed females ($p < 0.001$). The median accuracy while counting the heartbeats was 87.2% for males and 64.1% for females.

Table 1
Medians and quartiles (in parentheses) of MAIA scores in a sample of 376 participants. P values obtained using Mann-Whitney test; significant differences marked in Bold.

Scale	Median (Quartile range)			p value
	Both genders	Males	Females	
Noticing	3.50 (3.00–4.00)	3.25 (2.75–3.75)	3.50 (3.00–4.00)	**0.021**
Not-Distracting	2.00 (1.67–2.67)	2.00 (1.33–2.67)	2.00 (1.67–2.67)	0.251
Not-Worrying	2.33 (1.67–3.00)	2.50 (1.67–3.33)	2.00 (1.33–2.67)	**<0.001**
Attention Regulation	2.86 (2.29–3.43)	3.00 (2.39–3.43)	2.86 (2.29–3.43)	0.303
Emotional Awareness	3.40 (2.80–4.00)	3.20 (2.60–3.80)	3.40 (3.00–4.00)	**0.003**
Self-Regulation	2.50 (1.75–3.25)	2.63 (1.75–3.31)	2.50 (1.75–3.25)	0.536
Body Listening	2.33 (1.33–3.00)	2.00 (1.00–3.00)	2.33 (1.67–3.00)	0.053
Trusting	4.00 (3.00–4.67)	4.00 (3.33–4.67)	3.67 (3.00–4.33)	**<0.001**

Table 2
Medians and quartiles (in parentheses) of MAIA scores in experimental sample of 35 participants. P values obtained using Mann-Whitney test; significant differences marked in Bold.

Scale	Median (Quartile range)			p value
	Both genders	Males	Females	
Noticing	3.50 (3.00–3.88)	3.38 (3.00–3.50)	3.50 (3.00–4.00)	0.232
Not-Distracting	2.00 (1.83–2.67)	2.00 (2.00–2.67)	2.33 (1.33–2.33)	0.590
Not-Worrying	2.33 (1.50–2.84)	2.17 (1.67–2.67)	2.33 (1.33–3.33)	0.935
Attention Regulation	2.86 (2.64–3.43)	2.93 (2.11–3.43)	2.86 (2.71–3.43)	0.613
Emotional Awareness	3.40 (3.00–3.80)	3.00 (2.80–3.55)	3.60 (3.40–4.20)	**0.003**
Self-Regulation	3.00 (1.87–3.50)	3.00 (1.25–3.44)	3.00 (2.25–3.50)	0.568
Body Listening	2.33 (1.33–3.00)	1.50 (1.00–2.33)	3.00 (2.00–3.33)	**0.003**
Trusting	3.67 (3.33–4.33)	3.67 (3.33–4.33)	4.00 (3.33–4.33)	0.684

3.3. Relations between MAIA and HCT

Interoceptive accuracy (as measured with HCT) was related to interoceptive awareness (eight MAIA scales) using Spearman's correlation test. Bonferroni correction for the computations of the multiple variable correlations was applied with a new level of significance set at $\alpha = 0.006$ (i.e. 0.05/8). The correlation coefficients and corresponding p-values for the experimental subsample, males and females separately are presented in Table 3.

A negative moderate correlation ($r = -0.621$, $p < 0.001$) between interoceptive accuracy and the *Body Listening* scale scores of MAIA was observed for the whole subsample (see Fig. 1), suggesting that participants, who were more accurate when counting heartbeats, tended to less "actively listen to the body for insight" (scale description as defined by Mehling et al. (2012)). The similar trend was seen in the female subsample, though the correlation was smaller and failed to reach significance after Bonferroni correction ($r = -0.499$, $p = 0.042$). No correlation was observed in the male subsample.

4. Discussion

We aimed to assess the role of gender on the two aspects of interoception – a sense of physiological state of the body – *interoceptive awareness* as measured with subjective self-evaluation questionnaire and *interoceptive accuracy* as measured with heartbeat counting task (HCT). We also evaluated the association between the two subconstructs of interoception.

4.1. Interoceptive awareness

Interoceptive awareness is described as a set of a person's beliefs on the aspects of his/her own abilities and tendencies to consciously sense signals originating from the inside of the body (Mehling et al., 2012). For the evaluation of interoceptive awareness, we used *Multidimensional Assessment of Interoceptive Awareness* questionnaire and included approximately the equal amount of males and females in contrast to earlier studies where no comparison of MAIA scores between genders was performed. We found differences in the following scales when comparing males and females in a sample of 376 subjects: females obtained higher MAIA scores on the *Noticing* and *Emotional Awareness* scales, but lower scores on *Not-Worrying* and *Trusting* scales. In the experimental subsample (N = 35), the lower scores on *Emotional Awareness* scale in males were observed and a trend of higher *Body Listening scores* in females became significant; however, we did not show gender differences between the *Noticing, Not-Worrying* and *Trusting* scales, in contrast to the larger sample. Our data suggests that self-evaluation of *Not-Distracting*, *Attention Regulation* and *Self-Regulation* do not differ between genders when young healthy subjects are investigated.

Table 3
Correlation coefficients (r) and corresponding p-values between MAIA scores and accuracy on the heartbeat counting task. Significant correlations marked in Bold.

Scale (Questions)	Both genders		Males		Females	
	r	p	r	p	r	p
Noticing	−0.040	0.819	−0.119	0.637	0.348	0.171
Not-Distracting	−0.057	0.744	−0.369	0.132	0.127	0.626
Not-Worrying	−0.034	0.847	−0.105	0.678	0.002	0.993
Attention Regulation	−0.245	0.156	−0.445	0.064	0.072	0.785
Emotional Awareness	−0.342	0.044	−0.266	0.286	0.219	0.398
Self-Regulation	−0.285	0.097	−0.282	0.257	−0.145	0.580
Body Listening	**−0.621**	**<0.001**	−0.355	0.149	−0.499	0.042
Trusting	0.143	0.413	−0.115	0.024	−0.146	0.576

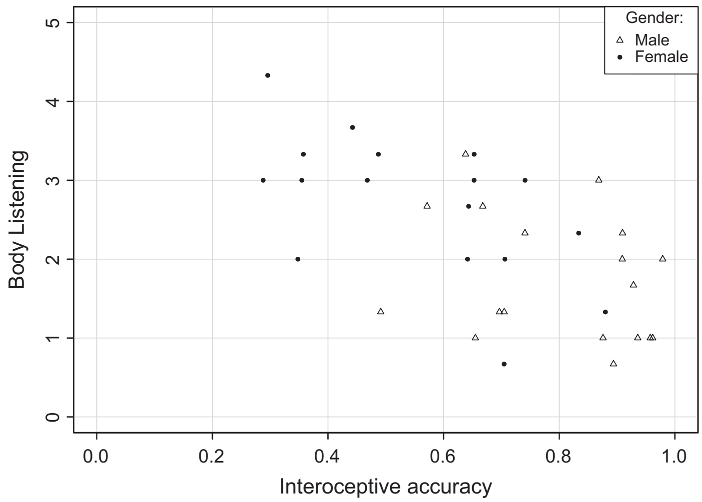

Fig. 1. A scatterplot of individual scores on Body Listening against individual interoceptive accuracy (N = 35).

The better *Noticing* (the ability to notice and focus on interoceptive stimuli), a trend for higher scores on *Body Listening* (the tendency to actively listen to the body for insight) and lower scores on *Trusting* (the experience of one's body as safe and trustworthy) and *Not-Worrying* (the tendency *not* to experience emotional distress with physical discomfort) in females are in line with Whitaker, Scott, and Wardle (2015). Authors in their review paper conclude that females have better health literacy and more medical knowledge, are more likely to engage in actions to detect possible symptoms of diseases, interpret sensations as warning, discus bodily sensations with others.

Better *Emotional Awareness* (the ability to attribute specific physical sensations to physiological manifestations of emotions) in females corresponds to the empirical evidence on gender differences in psychology as reviewed by Meyers-Levy and Loken (2015). Authors state that females possess more elaborated emotional intelligence, are more reactive to negative stimuli in their environment than males, report negative events as less controllable and show more powerless emotions like fear or sadness. Meyers-Levy and Loken (2015) show that females use more detailed processing when they are in a sad mood, and this rumination potentially increases depression and anxiety – conditions known to be more prevailed in females (McLean, Asnaani, Litz, & Hofmann, 2011; Van de Velde, Bracke, & Levecque, 2010). Following this line, alexithymia – inability to report one's emotions – is more prevalent in males (Salminen et al., 1999). Thus, our results give support for the view of Hausmann, Rutz, and Benke (2008), who argued that depression is not really "a female disease": although females are more often diagnosed, it might be that males tend not to complain or share their negative feelings with others due to their lower *Emotional Awareness*.

Some of the differences in a smaller subsample might have not been detected due to the less statistical power and due to the characteristics of participants: in the smaller experimental sample, subjects were motivated to participate in a long experiment and were interested to gain additional knowledge and experience without reimbursement, while the remaining group only had to fill the questionnaire. This would suggest that personal characteristics of the participants might be important when evaluating interoceptive awareness. However, the question whether personality traits and interoception are connected, remains unresolved. For example, Fassino, Pierò, Gramaglia, and Abbate-Daga (2004) showed that some disorder-related personality characteristics in a sample of subjects with eating disorders correlated to interoceptive awareness. Further, Pollatos, Schandry, Auer, and Kaufmann (2007) found that interoceptive accuracy correlated with neuroticism and anxiety. In contrast, Barrett, Quigley, Bliss-Moreau, and Aronson (2004) did not find correaltions between interoceptive accuracy to extraversion and neuroticism.

Our results advise that gender be accounted for when subjective evaluation of the manifestations of the disorders associated to bodily sensations (like somatoform disorders (Liu et al., 2012) or pain sensitivity (Wiesenfeld-Hallin, 2005)) and to the emotional/mood states (like depression (Van de Velde et al., 2010), anxiety (McLean et al., 2011), alexithymia (Salminen et al., 1999)) is performed.

4.2. Interoceptive accuracy

Interoceptive accuracy is defined as the objective accuracy to detect bodily sensations (Garfinkel et al., 2015). 31% of our experimental subsample were rated as "good perceivers"; this is comparable to previous studies where 34–46% were reported to have a good perception of the heart beats (Herbert, Muth, Pollatos, & Herbert, 2012; Herbert, Pollatos, & Schandry, 2007; Matthias, Schandry, Duschek, & Pollatos, 2009; Montoya et al., 1993). In our sample, 10 out of 11 good perceivers were males and males were significantly better on the interoceptive accuracy. This is in line with some earlier studies (Ludwick-Rosenthal & Neufeld, 1985; Montoya et al., 1993). One of the possible explanations for males being more accurate on the heartbeat perception tasks (at least, when they are required to track their beats for less than one minute) might be related to the biomechanical characteristics of the heart. Males on average have greater heart volume and stronger contraction of heart muscle (Shepherd & Miller, 1998), thus it may be easier for them to sense the heartbeats as the "stimuli". This is supported by the correlation between cardiac perception accuracy and stroke volume ($r = 0.69$) as reported by Schandry, Bestler, and Montoya (1993).

However, several authors failed to find the difference between genders in HCT performance (Mussgay et al., 1999; Pollatos & Schandry, 2004). The discrepancy between the results might be due to the methodological differences. Mussgay et al. (1999) studied subjects diagnosed with depressive, somatoform or personality disorders, whereas we studied healthy young participants. In a study of Pollatos and Schandry (2004) only 12 of 44 participants were males, thus gender groups were unequal in size and subjects performed longer task in their study.

We suggest that gender should be accounted for when *interoceptive accuracy* is assessed by means of heartbeat counting approach with careful attention being paid to methodological aspects.

4.3. Association between interoceptive accuracy and interoceptive awareness

We showed a moderate negative correlation between the accuracy of heartbeat perception and "active listening to the body for insight" (the description of the *Body Listening* scale (Mehling et al., 2012)) in a whole subsample including both males and females. Other scales of MAIA were unrelated to HCT. A trend for more accurate performance on HCT in females who scored lower on *Body Listening* scale was observed; however, the correlation did not survive Bonferroni correction ($r = -0.499$, $p = 0.042$). These was not evident in a male group ($r = -0.355$, $p = 0.149$).

It may be initially surprising to see that the more subjects listen to their bodies, the less accurate they are in detecting bodily sensations. Interoceptive experience is influenced by predictions (Barrett & Simmons, 2015), and the more subtle or ambiguous the bodily sensations are, the more subjects rely on common sense beliefs about what they think their bodies must be doing (Pennebaker & Epstein, 1983). Overall, our observation fits well with the theory of Yerkes-Dodson on the inverted U-shape relationship: the growing motivation enhances performance till an optimal point, and after reaching it, the growing motivation starts to interrupt the quality of performance due to the increase of emotional arousal (Frijda, 1986). However, Weitkunat and Schandry (1990) showed that, despite the increasing motivation by paying money for better HCT results, the "poor perceivers" did not manage to score higher on this task, although Canales-Johnson et al. (2015) reported that interoceptive accuracy might be improved by HCT training.

Up to date only three studies evaluated relationships between MAIA questionnaire scores and interoceptive accuracy and none of them evaluated gender effect for the scales. Calì et al. (2015) used all eight MAIA scales and, in contrast to our findings, showed a weak positive correlation between HCT results and *Attention Regulation* scale in a sample of females (males were not included in their study). The discrepancy between results might be related to the methodological aspects – authors asked to "report the count or estimated number of heartbeats" whereas we asked for the precisely counted number. Results of two remaining studies assessing relationship between MAIA and interoceptive accuracy cannot be directly compared to our observations due to methodological differences. Meessen et al. (2016) used only two MAIA scales – *Noticing* and *Attention Regulation,* though, in line with our results, they did not find any significant associations with HCT results in a sample of 24 participants (79.2% females). Unlike other mentioned studies, Dudley and Stevenson (2016) evaluated HCT by the absolute difference between the self-reported number of heartbeats and the actual heart rate; however they also did not find any association between HCT results and MAIA scores.

Overall, the negative association between *Body Listening* and HCT results points to the need to make a distinction between the objective sensory abilities and the awareness of sensations (Garfinkel et al., 2015; Forkmann et al., 2016). Ceunen, Van Diest, and Vlaeyen (2013) warned: "[Interoceptive] accuracy and awareness of perception [are] related, yet distinct". The authors noted that subjects with higher interoceptive awareness might not necessarily have higher interoceptive accuracy. This is further supported by the studies in patients with somatoform disorders (i.e. paying too much attention to their bodily sensations) that have lower heartbeat perception accuracy in comparison to healthy controls (Mussgay et al., 1999; Schaefer, Egloff, & Witthöft, 2012). Similarly, several studies failed to find relationship between body awareness (measured as one's beliefs about one's sensitivity to normal non-emotive bodily processes, and the ability to anticipate bodily reaction) and interoceptive measures (including heartbeat detection) (Ainley & Tsakiris, 2013; Dunn, Dalgleish, Ogilvie, & Lawrence, 2007; Emanuelsen, Drew, & Köteles, 2015; Ferentzi et al., 2017). Additionally, it was shown that meditation training enhanced interoceptive awareness only (Bornemann et al., 2015) but not the ability to accurately count heartbeats which we refer to as "interoceptive accuracy" (Khalsa et al., 2008).

Although our results imply that interoceptive awareness and interoceptive accuracy are distinct (the lack of correlations between MAIA scales and results of HCT), we do not provide firm evidence on the presence of gender differences in associations between subjective and objective interoception aspects. This question should be addressed in future studies.

5. Conclusions

Our study prompts the importance of encountering gender effect in interoception studies and stresses out the multidimensionality of the construct of interoception. The results on *interroceptive awareness* suggest that females tend to notice bodily sensations more often, better understand relations between bodily sensations and emotional states, worry or experience more emotional distress with sensations of pain or discomfort and see body as less safe. Therefore, gender should be considered when subjective evaluation is performed in disorders associated to bodily sensations (like somatoform disorders or pain sensitivity) and to the emotional/mood states (depression or anxiety). The results of *interoceptive accuracy* further suggest that females are less efficient in consciously detecting heartbeats, thus gender should be accounted for when *interoceptive accuracy* is assessed by means of heartbeat counting approach.

Conflict of interest

The authors declare that they have no conflict of interest.

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