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Interoceptive sensitivity predicts sensitivity to the emotions of others

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Some theories of emotion emphasise a close relationship between interoception and subjective experiences of emotion. In this study, we used facial expressions to examine whether interoceptive sensibility modulated emotional experience in a social context. Interoceptive sensibility was measured using the heartbeat detection task. To estimate individual emotional sensitivity, we made morphed photos that ranged between a neutral and an emotional facial expression (i.e., anger, sadness, disgust and happy). Recognition rates of particular emotions from these photos were calculated and considered as emotional sensitivity thresholds. Our results indicate that participants with accurate interoceptive awareness are sensitive to the emotions of others, especially for expressions of sadness and happy. We also found that false responses to sad faces were closely related with an individual's degree of social anxiety. These results suggest that interoceptive awareness modulates the intensity of the subjective experience of emotion and affects individual traits related to emotion processing.

Keywords: Interoception; Emotion; Facial expression; Anxiety.

The relationship between subjective emotion and the associated somatic responses has long been a subject of interest for psychologists. William James (1884) claimed that our feeling of bodily changes as they occur is the emotion and emphasised the importance of actually feeling bodily changes for the fulfilment of emotional experience. The theory of emotion proposed by James (1884) and Lange (1885/1992) is commonly known as the peripheral theory of emotion. Numerous studies have used it

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as a basis to examine the mechanisms of emotional experience, and the validity of its hypothesis has been tested often over the past several decades (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004; Damasio, 1994; Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990; Plutchik & Ax, 1967; Rainville, Bechara, Naqvi, & Damasio, 2006; Schachter & Singer, 1962).

Researchers have identified both psychological and neural correlates of the subjective experience of emotion, leading to influential models such as the somatic marker hypothesis (Damasio, 1994). The findings of psychological and brain-imaging studies have indicated that we refer to our internal bodily state when we are aware of our emotional state, and that our internal state modulates our emotional experience (Bechara, Tranel, Damasio, & Damasio, 1996; Dunn et al., 2010; Lane, 2008; Pollatos, Kirsch, & Schandry, 2005; Terasawa, Fukushima, & Umeda, 2013; Terasawa, Shibata, Moriguchi, & Umeda, 2013).

The perception of afferent information arising from within the body has been termed "interoception" (Cameron, 2001; Sherrington, 1906). Several methods have been established to measure the interoceptive ability of an individual. These include the heartbeat detection task (HDT) (Schandry, 1981) and the water load test (Herbert, Muth, Pollatos, & Herbert, 2012). In addition, there are several questionnaires for evaluating interoceptive awareness (Mehling et al., 2009) such as the Autonomic Perception Questionnaire (Mandler, Mandler, & Uviller, 1958), the Body Perception Questionnaire (Porges, 1993) and the Modified Somatic Perceptions Questionnaire (Main, Wood, Hollis, Spanswick, & Waddell, 1992).

Although we feel our heartbeat and body temperature increase when engaging in cardiovascular exercise, we do not usually have a vivid awareness of our internal bodily state when at rest. However, researchers have found that when people are asked to attend to their internal organs (such as the heart and stomach) clear individual differences appear in the perception of internal states, even when at rest. The effects of interoceptive awareness on regulating negative emotional responses have been shown in a series of studies using methods incorporating mindfulness or meditation (Farb, Segal, & Anderson, 2013; Kirk, Downar, & Montague, 2011). Conversely, individuals with high levels of interoceptive sensitivity have been shown to feel salient emotions (Wiens, Mezzacappa, & Katkin, 2000) and focus on the arousal aspects of emotional experiences (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004). Studies in the fields of psychiatry and cognitive neuroscience have consistently reported on the coexistence of high levels of interoceptive sensitivity and high levels of anxiety (Domschke, Stevens, Pfleiderer, & Gerlach, 2010). Questionnaires have revealed that individuals with high levels of Anxiety Sensitivity (AS), panic disorders or other anxiety-related disorders are hyperaware of their bodily sensations (Anderson & Hope, 2009; Ludewig et al., 2005; Olatunji, Cisler, & Tolin, 2007). In addition, studies using the HDT have reported a close relationship between high levels of anxiety and high levels of sensitivity to one's own heartbeat (Dunn et al., 2010; Pollatos, Traut-Mattausch, Schroeder, & Schandry, 2007; Stevens et al., 2011). Based on these results, we hypothesise that excessive attention to one's internal bodily state and close connections with the emotional reappraisal process can lead to salient negative emotions and enhanced anxiety.

Social interaction is a prominent situation known to produce anxiety. Social interaction is generally an unavoidable aspect of life. It is for this reason that this type of interaction can be very stressful. Social anxiety disorder or social phobia involves a fear or avoidance of social situations. It is a well-known problem and is listed as a subtype of anxiety disorder in the DSM-V. Social anxiety disorder appears to be related to the biased processing of emotional information obtained from others (Joormann & Gotlib, 2006) as well as heightened self-focused attention in social situations (Clark & Wells, 1995; Stevens et al., 2011). Highly accurate interoceptive awareness, measured by the HDT, can be taken as evidence of self-focused attention in individuals with high levels of social anxiety (Domschke et al., 2010; Stevens et al., 2011). Highlighting this point, a recent clinical study reported on the effectiveness of redirecting attention from internal to external information, when in social situations for reducing anxiety in individuals suffering from anxiety disorders (Bögels & Mansell, 2004). Together, these studies provide substantial support for the essential connection between sensitivity to interoceptive information and the interpretation of emotional information obtained from others.

While several studies have suggested that increased interoceptive perception can predict heightened emotional experiences (Dunn et al., 2010; Pollatos et al., 2005; Wiens et al., 2000), the number of studies that have examined the relationship between interoceptive sensitivity and the sensitivity to the emotions of others is still rather small. The mirror neuron system has been implicated in empathy (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003), and neural networks analogous to those activated when experiencing one's own emotions appear to underlie the empathetic process (Jabbi, Swart, & Keysers, 2007; Singer et al., 2004). This similarity between one's own emotions and the emotions of others indicates that interoceptive processing may be important in processing empathy. This is supported by findings from neuroimaging studies of empathy, which have reported enhanced activation of the anterior cingulate cortex and insular cortex when participants empathise with the pain of others (de Vignemont & Singer, 2006; Singer et al., 2004). These regions are known as essential areas for interoception, and thus the results of such studies indicate that interoceptive processing is involved in feeling the emotions of others. Bird et al. (2010) and Silani et al. (2008) focused on the relationship between empathy and interoceptive processes through the alexithymic trait and the activation of neural correlates of interoception. They found a negative correlation between the alexithymic trait and the activation of anterior insular cortex, suggesting that interoceptive deficits may lead to difficulties in describing and experiencing emotions. Fukushima, Terasawa, and Umeda (2011) revealed that experiencing the emotions of others enhanced responses on a neural index of interoceptive processing, which comprised a surface electroencephalographic pattern termed a heartbeat-evoked potential (HEP). The researchers also reported a close association between HEP amplitude and empathetic traits. These findings also support the notion that interoceptive awareness plays an essential role in processing the emotions of others.

The findings from these previous studies indicate that interoceptive sensitivity predicts sensitivity to one's own emotions and to the emotions of others. Cognitive or perceptual distortions towards the emotional responses of others, such as excessive sensitivity to others' emotions, may be connected with occurrences of social anxiety or social phobia, and thus may influence social function (Joormann & Gotlib, 2006; Sutterby, Bedwell, Passler, Deptula, & Mesa, 2012). Based on these findings, we hypothesise that interoceptive sensitivity has a large impact on individual cognitive traits for processing the emotional responses of others, as well as levels of social anxiety. In the present study, we examine this hypothesis and attempt to disentangle the triadic interaction among interoceptive sensitivity, individual cognitive traits for processing the emotional responses of others and levels of social anxiety. A deeper understanding of the relationship between primary interoceptive awareness and social cognition would facilitate the treatment and understanding of individuals with social anxiety.

METHODS

Participants

Thirty undergraduate and graduate students participated in this study [13 male and 17 female; mean age 21.4 years ± 1.80 standard deviations (*SD*s)]. No participants reported currently having any psychiatric disorders or taking any medication. All participants were right-handed. The experiment was performed with the approval of the Keio University Research Ethics Committee (No. 09006). Before participating in the study, all individuals read and signed a written informed consent form explaining (1) the purpose and procedure of the study and (2) that they were able to cease their participation in the study at any time. All participants completed the experiment.

Procedures

The experimental tasks and questionnaires used in the current study are as follows: two personality questionnaires (described below), a measure of resting heart rate (3 minutes), the HDT (Schandry, 1981) and the emotional sensitivity task.

Questionnaires

The anxiety traits of the participants were assessed using the following questionnaires: the Social Anxiety Disorder Scale (SADS) (Kaiya, 2009) and the Japanese version of the Manifest Anxiety Scale (MAS; Taylor, Abe, & Takaishi, 1985). SADS is a Japanese questionnaire that assesses traits of social anxiety on four subscales: social fear, avoidance, somatic symptoms and daily life interference. MAS is based on the Minnesota Multiphasic Personality Inventory (MMPI) and is commonly used as a general indicator of anxiety. The scale contains lie (L) scale items to improve validity by eliminating possible influences of social desirability. Participants completed all questionnaires individually.

The HDT

We used the HDT to examine individual interoceptive sensitivity. The task was based on a task developed by Schandry (1981) and Ehlers and Breuer (1992), which has been used in many studies. Heartbeats were measured using a pulse oximeter (Polymate AP1542, TEAC, Tokyo) during specific periods of time (2 × 35s, 2 × 25s and 2 × 45s). During the HDT, participants were asked to count the number of times they felt their own heartbeat during the measurement period. They were instructed not to predict their heart rate. The pulse oximeter probe was gently placed on their fingertips to prevent participants from feeling the pressure of their pulse. They were seated in a comfortable chair and instructed not to touch any part of their body during the task. Each trial began 3 s after the experimenter said "ready".

HDT error rates were calculated based on the discrepancy between the number of reported and actual heartbeats during the measurement period. The formula used to calculate the HDT was based on that used by Ehlers and Breuer (1992): (|actual heartbeats − reported heartbeats|/actual heartbeats) × 100. Six HDT error rates were obtained for each participant and averaged to obtain the individual HDT error rates.

Resting heart rates were recorded for three minutes. Participants were then asked to report their usual heart rate in beats per minute (BPM) in their daily life. If they could not report their daily BPM, then they were asked to make an estimate. The error rate of each reported heart rate was calculated using the above formula.

The time estimation task

While participants were instructed not to predict their heart rate in the HDT, it is possible that they estimated the passage of time, thus affecting the HDT data and contaminating our measure of interoception. If this were the case, then HDT error rates should correlate with time estimation ability. However, Dunn et al. (2010) overcame this possible contamination issue by demonstrating that HDT error rates did not correlate with time estimation accuracy. We addressed this possibility by having participants complete a time estimation task. In the task, participants were seated in a comfortable chair and asked to relax. They were then asked to count the number of seconds during a given period, and then the reported length was compared with the actual duration. We conducted six trials (2 × 23s, 2 × 40s, 2 × 56s) and time estimation error rates were calculated in a manner similar to that of the HDT error rate. Each trial began 3 s after the experimenter said "ready", and participants reported their estimated duration immediately after each trial.

Emotional sensitivity task

The task stimuli were prepared using photos selected from the Advanced Telecommunications Research Institute International (ATR) Facial Expression Database (DB99). The database includes several sets of photos of Japanese males and females, categorised by facial expression. We selected five photos each of a male (M01) and female (F03), with the following facial expressions: angry, sad, disgusted, happy and neutral. We also created morphed photos combining a neutral facial expression with one of the above-mentioned facial expressions, such as happy–neutral, sad–neutral, disgusted–neutral and angry–neutral. These morphed photos were made in eight variations, with each variation having different percentages of the neutral and emotion expressions, ranging from 100% neutral to 100% of each emotion, such as 100–0%, 90–10%, 80–20%, 70–30%, etc. This was done using the Popims Animator (http://www.popims.com/popims/licences/popims-animator) (see Figure 1a). A control computer running SuperLab version 4.5 generated the stimuli. Half of the participants were shown the photos of the male and half were shown the photos of the female. Combinations of the gender of the participants and the gender of the individual shown in the photos were counterbalanced. (Figure 1)

Each trial had the following sequence: (1) a stimulus was presented for 2s, (2) a screen appeared with text asking the participant to make a judgement about whether the stimulus made them feel an emotion and (3) if participants responded "Yes" to this question, then four options were presented on the screen: anger, sadness, disgust and happy. Participants were asked to choose the most appropriate option for the emotion that had been elicited by the stimulus. If participants selected "No", i.e., they did not feel any emotion from the stimulus, then the emotion options were not presented, and a fixation point was shown for 5s, after which the next trial began (Figure 1b). Participants responded using a computer keyboard. Each stimulus was presented five times in random order, with a total of 200 trials (4 emotion × 10 steps × 5 times). To maintain the attention of the participants, a short break was inserted between the former and the latter 100 trials. Stimuli that fully expressed a certain emotion (e.g., 100% anger) were labelled as having an

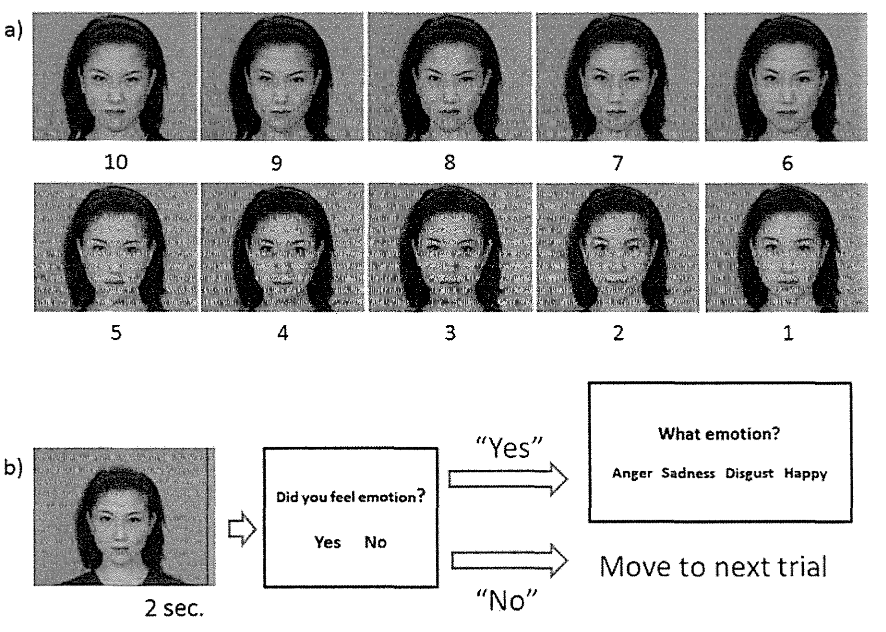

Figure 1. *Stimuli used in the task (a) and outline of a trial (b). (a) Morphed photos ranging between neutral (stimulus 1) and 100% of each facial expression (stimulus 10), i.e., angry. (b) A stimulus was followed by a judgement about whether the stimulus elicited an emotion. If participants responded "yes", options were presented and they were asked to choose the most appropriate emotion category. Reproduction of this figure is prohibited.*

"emotion value of 10", and neutral stimuli (e.g., 100% neutral) were labelled as having an "emotion value of 1". Each step between emotion value 10 and 1, that is, from 9 to 2, was labelled depending on the percentage of the emotional value present in the photo (see Figure 1b). The emotion value thus increased according to the intensity of the facial expression.

To estimate the emotional sensitivity of the participants, we calculated the number of times that they reported feeling emotions as a result of viewing each stimulus. We classified those stimuli that elicited an emotional response in a participant at least three times out of five (i.e., at least 60% of the trials) as having sufficient emotional value to consistently produce an emotional response. We posited that the threshold of emotional value was located near the midpoint between stimuli with low-emotional values (i.e., stimuli that do not produce an emotional response) and stimuli with high-emotional values (i.e., stimuli that do produce an emotional response). When participants reported that they felt an emotion three times when viewing a stimulus with an emotion value of six and two times when viewing the stimulus with an emotion value of 5, we considered their threshold for emotional response to be 5.5. Using this method, we calculated individual emotional response thresholds for each of the four emotions (anger, sadness, disgust and happy) for all participants. Participants with higher levels of emotional sensitivity were expected to exhibit lower thresholds for emotional response.

The perceived emotions in the emotion sensitivity task did not always correspond with the target emotions. For instance, some participants felt anger when viewing the photos of individuals with disgusted expressions. There is clearly a relationship between individual traits and the accuracy of emotion detection. Suzuki and Akiyama (2013) examined emotional sensitivity and age-related cognitive decline using morphed emotional expression photos. They computed the false alarm rate and Cohen's κ for evaluating the response bias and accuracy of facial expression recognition, respectively. In the current study, we computed the false alarm rate and Cohen's κ according to the methods used by Suzuki and Akiyama (2013). False alarm rate was computed using the following formula: (number of false alarms for a given emotion)/150, where 150 is the maximum number of false alarm responses. Cohen's κ is a correct response rate which corrected response bias, and thus it was computed using the number of correct responses and the number of correct responses expected to occur by chance.

RESULTS

Interoceptive sensitivity and personality scores

Table 1 shows the averages and *SD*s of the HDT error rates (%), the time estimation error rates (%), the personality scores and the emotional sensitivity scores. Averages of the threshold emotion values for each category of emotions were employed as the emotional sensitivity scores. Similar to previous studies, we found individual differences in the HDT error rates. Some participants detected their heartbeats accurately (good perceivers) while some could hardly detect their heartbeats (poor

Table 1. *Averages and SDs for HDT error rates, time estimation error rates, personality scores, and emotional sensitivity scores*

	Mean	SD
The interoception task		
HDT error rates	31.18	17.58
Time estimation error rates	19.66	10.92
Personality scores		
SADS		
Fear	9.40	5.69
Avoidance	7.33	6.96
Somatic symptoms	7.73	5.21
Daily life interference	2.00	4.07
Total	26.47	18.93
MAS		
Anxiety	20.59	8.95
Threshold emotion values		
Anger	3.00	0.86
Disgust	3.30	1.13
Happy	3.18	1.26
Sadness	3.67	1.76

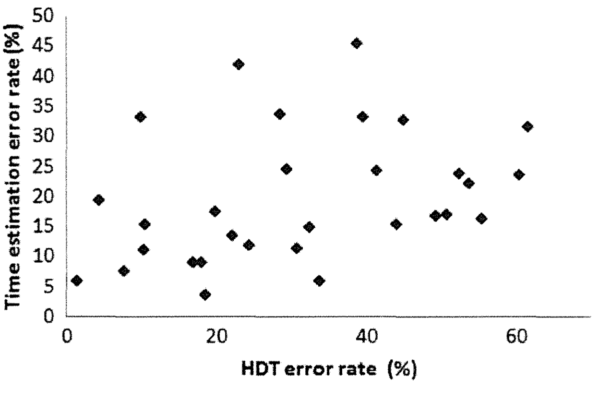

Figure 2. *HDT and time estimation error rates. There was no significant correlation between these two error rates.*

perceivers) (Figure 2). We calculated the correlation between the HDT error rates and the time estimation error rates to confirm the validity of the heart detection task as a measurement of interoceptive sensitivity. No significant correlations between these two tasks were found, $r(28) = .35$, ns, indicating that participants followed the instructions in the HDT (Table 1 and Figure 2).

We examined the difference in emotional sensitivity between "good perceivers" and "poor perceivers". Based on the HDT error rates, the highest 10 participants were designated as "poor perceivers" (HDT error rate mean ($\pm SD$) = 51.43 ± 6.76%), and the lowest 10 participants were designated as "good perceivers" (HDT error rate mean ($\pm SD$) = 11.82 ± 6.31%). Performance in the HDT, resting heart rates (BPM) and BPM estimation error are shown in Table 2. There was a significant difference between the good perceivers and the poor perceivers in terms of HDT error rate, $F(1,18) = 183.62$, $p < .001$ and estimated BPM error rate, $F(1,17) = 4.70$, $p < .05$. This result indicates that individual differences influence interoceptive sensitivity. Because we found no significant difference in measured BPM between the two groups, $F(1,17) = 1.72$, ns, the observed difference in interoceptive sensitivity does not seem to originate from the difference in heart rate.

We compared the anxiety levels between good perceivers and bad perceivers to examine the association between anxiety and interoceptive sensitivity. A one-way ANOVA on the total SADS score showed no significant difference between the good and bad perceivers, $F(1,18) = 0.395$, ns. Next we performed a one-way ANOVA on the MAS scores, but again we found no significant difference between the good and bad perceivers, $F(1,15) = 1.368$, ns.

We conducted an ANOVA with emotional sensitivity in the HDT (good vs. poor) as a between-subjects factor and the emotion category (anger, disgust, happy and sadness) as a within-subjects factor. A significant main effect of emotional sensitivity in the HDT was found, $F(1,18) = 4.92$, $p < .05$ (Figure 3). However, we found no main effects of the emotion category, $F(3,54) = 2.29$, ns, or of the interaction between the two

Table 2. *Heart rate and HDT performance*

	Mean	SD	
HDT error rate			
All participants	31.18	17.58	
Good perceiver	11.82	6.31	good < poor**
Poor perceiver	51.43	6.76	
BPM			
All participants	75.78	8.83	
Good perceiver	74.47	6.45	ns
Poor perceiver	81.37	9.56	
Reported BPM error			
All participants	16.64	12.59	
Good perceiver	14.91	17.57	good < poor*
Poor perceiver	18.58	10.28	

*$p < .05$; **$p < .001$.

Figure 3. *HDT performance and sensitivity to emotional expressions. Good perceivers were more sensitive to emotional expressions than poor perceivers.*

factors, $F(3,54) = 0.40$, ns. The ANOVA further revealed that individuals who are sensitive to their own bodily sensations exhibit a lower threshold for emotional response. Based on the findings of previous studies described previously, these individuals are likely to be more sensitive to the emotions of others. (Table 2 and Figure 3).

To examine whether interoceptive sensitivity or other personality traits affect emotional sensitivity, we conducted a stepwise multiple regression analysis using the thresholds for emotional reaction to each type of facial expression. SADS scores, MAS scores, resting heart rates and HDT error rates were entered into the analysis as predictors. If a variable was significant at $p < .05$, then it was retained as a predictor. The analysis revealed that for the sad expression, the HDT error rates alone predicted the thresholds for emotional reaction, $r = .41$, $r^2 = .17$, $F(1,25) = 4.95$, $p < .05$. Similarly, the HDT error rates were the only predictor of the thresholds for emotional reaction when viewing happy faces, $r = .47$, $r^2 = .22$, $F(1,25) = 7.05$, $p < .05$.

False alarm rates and Cohen's κ

Table 3 shows the averages and *SD*s of the false alarm rates and Cohen's κ. We examined the relationship between these data and the anxiety traits measured by the questionnaires. The correlation analysis revealed that the false alarm rate and Cohen's κ for the sad expression were positively correlated, $r = .51$, $p < .01$ and negatively correlated, $r = -.38$, $p < .05$, with social anxiety scores, respectively. We found no correlations between personal traits and the other emotion categories (Table 3).

DISCUSSION

In this study, we focused on the relationship between interoceptive sensitivity and emotional sensitivity by assessing responses to emotional facial expressions. Our results indicate that participants who had accurate interoceptive awareness were also more sensitive to the emotions of others

Table 3. *False alarm rates and Cohen's κ for each emotion*

	False alarm rates		*Cohen's κ*	
	Mean	SD	*Mean*	SD
Anger	0.03	0.03	0.69	0.14
Disgust	0.06	0.05	0.54	0.22
Happy	0.01	0.02	0.78	0.10
Sadness	0.02	0.02	0.68	0.22

when viewing photos of individuals with sad and happy expressions. We also found that false positive responses to sad faces were closely connected with an individual's level of social anxiety.

A significant relationship between interoceptive sensitivity and anxiety has been uncovered by measuring saliency or the arousal level of emotional experiences induced by exposure to emotional stimuli, such as movies (Barrett et al., 2004; Domschke et al., 2010; Pollatos et al., 2005; Schandry, 1981; Wiens et al., 2000). While there is an active body of research centred on the relationship between the perception of internal bodily change and subjective emotions, few studies have focused on the interoceptive mechanisms involved in interpreting the emotions of others. Several studies have reported similarities in facial muscle activation patterns and autonomic response patterns between the senders and receivers of emotional signals (Russell, Bachorowski, & Fernandez-Dols, 2003; Weyers, Muhlberger, Hefele, & Pauli, 2006). Additionally, the extent of synchrony of autonomic patterns between two people can predict the levels of empathy between them (Chartrand & Bargh, 1999; Levenson & Ruef, 1992). The relationship between empathy and interoceptive awareness has not yet been thoroughly investigated because it is not clear whether the observed peripheral responses affect subjective experiences of emotion. Fukushima et al. (2011) and Ernst, Northoff, Boker, Seifritz, and Grimm (2012) attempted to resolve this issue. Both studies measured central nervous system activity during the presentation of emotional facial expressions. They found that interoceptive processing enhances empathetic processing. However, there is also evidence of the opposite effect in studies of those with the alexithymic trait; such individuals have been shown to have lower activation in the neural correlates of interoception, such as the insular cortex (Bird et al., 2010; Silani et al., 2008).

Identification of the neural substrates of interoception improved our understanding of empathy, and indicated that internal bodily state is important for understanding the emotions of others. Facial expressions are commonly used in studies of empathy, and viewing other's emotional expressions has been shown to automatically trigger subtle imitation of the expression (Weyers et al., 2006). Because a shared system for feeling one's own emotions and the emotions of others has been suggested, such an imitation-based process is considered fundamental for empathy (Jabbi et al., 2007; Singer et al., 2004). Although the current study did not measure individual empathic performance directly, an imitation-experience system would help us to understand the emotions of others and, as shown by the results of our study, interoceptive sensitivity would have an impact on such a system.

The results of the current study are highly consistent with previous findings in that they demonstrate a relationship between interoceptive processing and subjective emotions. Our results suggest that subjective emotions and interoception have shared neural substrates, such as the insula and ventromedial prefrontal cortex, and that activations in these areas predict individual disposition in emotional experience (Terasawa, Fukushima, et al., 2013; Terasawa, Shibata, et al., 2013). This link is essential for unearthing the psychological mechanisms underlying emotion. Our procedure for measuring emotional sensitivity, which was based on psychophysical methods, was relatively free from response bias and spontaneous prediction by the participants. Thus, we are confident that our study contains a precise measure of emotional sensitivity. This is supported by our finding of a significant relationship between interoceptive sensitivity and emotional sensitivity, despite potential problems with participant estimation.

The circumplex model of emotion posits that emotions have two dimensions: arousal and valence (Russell, 1980). While some researchers suggest that the dimensions are orthogonal, others suggest that they are oblique (Barrett & Bliss-Moreau, 2009; Bernat, Patrick, Benning, & Tellegen, 2006; Kuppens, Tuerlinckx, Russell, & Barrett, 2012; Tellegen, Watson, & Clark, 1999). Peripheral autonomic responses are mainly known to reflect changes in arousal level; however, in some cases, they also reflect changes in valence

(Bernat et al., 2006). The insula, considered as an important site for interoceptive awareness, is also known as a neural correlate of recognising arousal (Berntson et al., 2011; Lewis, Critchley, Rotshtein, & Dolan, 2007). This implies that not only changes in peripheral autonomic response but also the ability to receive such changes will have an impact on arousal levels. In our study, the 10 prepared images for each emotion varied according to their respective levels of arousal and valence. Our findings also seem to support the notion that the detection of changes in internal bodily states is related to an individual's ability to perceive increases in arousal level (Barrett et al., 2004).

Based on the results of the current study, we suggest that interoceptive sensitivity modulates social communication through the recognition of the emotions of others. People who are highly sensitive to their own interoceptive information might themselves more easily detect changes in the arousal levels of others, as shown through their facial expressions. This ability may lead them to experience more salient emotions compared with people who are not sensitive to their own interoceptive information.

Recent studies have indicated that several biological factors affect interoceptive awareness and have suggested that interoceptive sensitivity is determined by multiple factors. Koroboki et al. (2010) reported that interoceptive awareness is affected by enhanced cardiovascular reactivity. Specifically, they found hypertension patients to have accurate interoceptive awareness and a mean HR that was higher than those in a normotensive group. These results indicate that prominent differences in autonomic neural systems may affect interoceptive sensitivity. However, our data suggest that individual interoceptive sensitivity was not affected by individual differences in resting HR. Because all the participants in our study were healthy young adults with no serious medical history, it can be assumed that there were no prominent differences in cardiac function. Interestingly, poor perceivers, as defined by the HDT, also exhibited poor accuracy when estimating their own resting HR. Our results support the ecological validity of HDT as a measure of interoceptive sensitivity, as well as demonstrate that interoceptive sensitivity varies with bodily state across individuals. It is possible that poor perceivers are less attentive to their bodily states in daily life, and thus are more predisposed to various diseases, such as hypertension. It is also possible that these individuals experience lower levels of anxiety or nervousness in stressful situations (Werner, Duschek, Marttern, & Schandry, 2009).

Although the ANOVA results of the thresholds of emotional response did not reveal a relationship between interoceptive sensitivity across the emotional category, our stepwise multiple regression analysis showed that interoceptive sensitivity predicted sensitivity to happy and sadness, but not to anger or disgust. There are several possible reasons for this discrepancy. As shown in Table 1, the variances of thresholds for emotional expressions in response to happy or sad facial expressions of different emotion values are larger than the thresholds for anger or disgust. This discrepancy may have been due to large individual differences in the happy and sad responses to the stimuli. In contrast, the variance in responses to the angry stimuli was the smallest, indicating that the threshold for anger did not reflect individual differences in emotional sensitivity. According to the circumplex theory of emotion (Coren & Russell, 1992; Russell, 1980), anger is an emotion associated with a high arousal level. It is thus likely that the participants could easily detect anger from the morphed angry faces, even when the expression contained only a slight increment of arousal. The high false alarm rate and low κ value in response to the facial expressions of disgust were also prominent. The low threshold of emotional response to the disgust stimuli may be explained by these stimuli capturing the threshold for detecting any negative emotions, rather than simply disgust alone. A previous study using morphed facial expressions demonstrated a close relationship between higher cognitive function and sensitivity to happy and sadness, but not to anger and disgust, in elderly people (Suzuki & Akiyama, 2013). Anger and disgust are extreme emotions, and thus it is likely that subtle differences in cognitive ability would not have a strong impact on the recognition of these emotions.

Our findings indicate an interesting association between sensitivity to emotion and anxiety; for instance, a positive correlation was found between levels of social anxiety and the false alarm rate for identifying sad facial expressions. Because individuals with high levels of social anxiety are excessively sensitive to negative emotional signals, it is possible that they confuse sad emotions with emotions that have a higher arousal level, such as anger and disgust. Previous studies have reported that individuals with social anxiety show characteristic patterns in social cognition (Sutterby et al., 2012). They may perceive feelings of anger or disgust in facial expressions that have only a slightly negative valence (Joormann & Gotlib, 2006; Simonian, Beidel, Turner, Berkes, & Long, 2001), as also shown in the current study. We suggest that individual disposition to the detection of threatening signals from negative expressions is closely related to our beliefs and behavioural patterns in social situations.

We did not observe a significant relationship between levels of anxiety and interoceptive sensitivity, as some previous studies have reported. We suspect that the small variance in anxiety levels of our participants is a contributing factor. We recruited healthy young adults, and thus the mean SADS and MAS scores were low, as shown in Table 1. A significant relationship between anxiety level and interoceptive sensitivity might be obtained when data from individuals with higher levels of anxiety are incorporated into the study. Interoceptive sensitivity is gaining attention in the field of psychiatry as a critical component of emotion disorders, such as anxiety disorders (Domschke et al., 2010) and somatoform disorders (Schaefer, Egloff, & Witthoft, 2012). Our findings provide important data for understanding the pathological mechanisms of these disorders with respect to emotional and interoceptive sensitivity. Further studies on interoceptive sensitivity and emotional processing in social situations with relevant patient populations will be valuable in pursuing this goal.

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第5章 心身症の治療

マインドフルネス

要旨

本稿では，近年，慢性疼痛などの心身症の治療において注目されているマインドフルネスについて概要を解説した．マインドフルネスの定義，マインドフルネスを促進する訓練であるマインドフルネストレーニングについて解説し，マインドフルネストレーニングを応用した心理療法であるマインドフルネスストレス低減法（MBSR）などについて概説した．また，心身症患者にマインドフルネストレーニングを適用する際の注意点についても述べた．

●キーワード

マインドフルネス
マインドフルネストレーニング
マインドフルネスストレス低減法
マインドフルネス認知療法
弁証法的行動療法

マインドフルネスとは

マインドフルネスとは「今この瞬間において，次々と生じている体験に，価値判断をしないで意図的に注意を向けることによって得られる気づき」[1]と定義される心理状態である．自分が今この瞬間にしていること，感じていること，考えていること，そこに存在していることに，良い悪いといった価値判断をしないで気づいている，あるいは意図的に注意を向けているという精神状態のことを指す．そのとき痛みや不安や抑うつ，怒りなど不快な感覚，感情状態にあったとしても，それらと共にいられるという精神状態でもある．もしそれができれば，患者が症状によって不快感を感じていたとしても，症状に圧倒されないで生活していけるようになると期待される．

マインドフルネストレーニング

マインドフルネスはマインドフルネストレーニング[2]によって学習可能である．訓練によってストレスや疾患を受け入れることを学ぶのである．マインドフルネスの源流は元来仏教の修行法で強調される態度であり，その訓練はマインドフルネス瞑想法と呼ばれていた．しか

し，最近は特定の宗教への信仰とは無関係にマインドフルネスの訓練が有用であることを強調して，瞑想法という用語を使わずに，マインドフルネストレーニングと呼ぶことが多い．マインドフルネストレーニングにおけるマインドフルネスや受容の強調は，症状や問題の消失や改善を強調してきた従来の伝統的医学とは対照的である．慢性疾患では症状の消失や改善が難しいことも多く，疾患を受け入れて生活できるようになることが望ましい．マインドフルネスと受容の観点は，変化と改善を目標とする伝統的西洋医学の発想とは相補的であり，西洋医学の限界をうまく補完する意義がある．

マインドフルネストレーニングを使った心理療法

1．マインドフルネスストレス低減法（MBSR）

Kabat-Zinn は，慢性疼痛や不安障害，がんの患者を対象とした MBSR を開発している[3]．MBSR は呼吸法（自分の呼吸を観察する訓練）やボディスキャン（自分の身体を意識して観察する訓練），ヨーガによってマインドフルネスや受容を促進するのが主要目標である．

治療プログラム（Kabat-Zinn，1990）は 8 週間にわたるもので，静座瞑想，ボディースキャン，ヨーガ瞑想法などから構成されている．これらを毎日 45 分間決まった時間に練習することで，マインドフルネスを体験的に学ぶことができる．正式な長時間の瞑想練習以外にも，毎日の生活の中でマインドフルに行動することも推奨されており，究極の目標は，常に気づきのあるマインドフルなライフスタイルの獲得である．痛みや不安，抑うつ，怒りなどの否定的な感情を無視せず，それらに気づいて観察し，受容するのを習慣とするのである．マインドフルでいれば，痛みなどの身体症状や否定的感情があっても，それらに圧倒されず，症状や痛みと共存して生活できるようになる．

静座瞑想とは，椅子に座る，あるいはあぐらをかくなどの姿勢で座る瞑想法である．さまざまな種類があるが，最初に行うのが呼吸法である．これは自分の呼吸を継続して観察し，注意が呼吸からそれたらそのことも観察し，また呼吸に戻るという，シンプルなものである．呼吸法では，息が入ってくるときの腹部の膨らむ感じや息が出て行くときの腹部がへこむ感じを意識する．これは意識的な腹式呼吸をしてリラックスしようとするものではない．自然に息をして，そのありよ

うをただ観察するだけである．また，練習中に抑うつや不安，考え込みなどに気がついたら，無視しないで観察するのも大切である．

ボディースキャンとは，仰向けになった状態で横になり，全身の身体感覚を意識して観察する練習である．最初は身体の一部，例えば左足のつまさきを意識し，そこにどんな感じがあるのかを探るようにして，身体感覚を意識する練習である．また，そこから息が出たり入ったりするように意識して呼吸する．その次は，くるぶしから下の部分というように意識する場所を少しずつ移動して練習し，最終的に頭のてっぺんまで意識をくまなく向けていく．ここでも，リラックスのような明確な身体感覚を得ることは目的ではない．ただ，身体に注意を向けるだけである．慢性疼痛患者が実施する場合，ボディースキャンの対象が痛む場所であることも当然ありうる．そのときは，痛みを観察することになる．本プログラムでは，痛みがあってもそれを取り去ろうとせず，痛みと共存して生活していくことを指向している．

ヨーガ瞑想法はよく知られているヨーガと同様に，さまざまなポーズをとるのであるが，一般的なヨーガが意識的な呼吸を行うのとは対照的に，あくまでも呼吸は自然なペースで行うのが特徴である．また，ポーズを作るときの身体の引っ張られる感じなどを意識するよう教示する．これらは本プログラムの中のほかの練習法と共通で，マインドフルネスを強調した教示法となっている．

2．マインドフルネス認知療法

マインドフルネス認知療法とは，Segal によって開発されたうつ病の再発予防プログラムである[4]．内容は MBSR と非常によく似ているが，目的がうつ病の再発予防に限定されているところが異なる．うつ病に対して有効性が認められている心理療法の一種である認知療法には，再発予防効果があることが従来知られていたが，これは認知療法を受けた患者は否定的な思考や気分に対して脱中心化ができるようになったためと考えられている．脱中心化とは，否定的な思考や気分を客観的にとらえて，そこから距離をとることである．認知療法では，患者は自分の気分や思考を客観的にとらえて記録用紙に記録するという課題を実施するのであるが，それが脱中心化を促進すると考えられている．脱中心化のできる患者は，否定的な気分や思考が生じたときに，そこから心理的に距離をとることができ，それがさらなる抑うつ

気分の悪化を防ぐのである．ところで，この脱中心化は，認知療法よりもずっとシンプルな技法であるマインドフルネストレーニングでも習得できる．そこでは，抑うつなどの否定的感情に気づいたらそれを客観的に観察するように教えるのである．そこで Segal は，MBSR をうつ病予防の目的に改変することで，脱中心化を参加者に教えるプログラムを開発した．マインドフルネス認知療法も認知療法同様にうつ病の再発を予防することが介入研究によって確かめられている．

3．弁証法的行動療法

弁証法的行動療法とは，Linehan によって開発された境界性パーソナリティ障害のための心理療法（認知行動療法）である[5]．境界性パーソナリティ障害とは，自傷行為や自殺未遂，不適切で激しい怒りなどを特徴とする性格傾向のことであり，治療者が対応に苦慮することが多い．摂食障害，疼痛性障害などの心身症と合併することもあり，心身症の治療現場でもしばしば見られる．

弁証法的行動療法では，患者に問題に対処するためのさまざまな対処戦略を教える．そこでは受容の技能として，マインドフルネストレーニングが教示される．自分や現実を受容する技能，つらい現実を認めて苦痛に耐える技能を患者に教育するのである．筆者の経験では，マインドフルネストレーニングを教えるという明確な構造のある治療方針は，患者の問題行動を減らすと同時に，治療者の心理的負担も著しく減らす印象であった．

マインドフルネストレーニングを使った心理療法の奏効機序

マインドフルネストレーニングの奏効機序は，Baer によれば，認知的変化，曝露，自己観察技能の向上，受容などであるとされる[2]．認知的変化とは，先に述べた脱中心化のことである．否定的な認知から心理的に距離をとれることで，それらの考えの影響力が減り，結果的に抑うつなどの症状が軽減するというものである．曝露とは，不安や恐怖などの否定的な感情反応を惹起するような不快な刺激に意識的に直面することで，慣れが生じ，不安などの反応が減弱，あるいは不快な刺激への耐性が形成されるという認知行動療法の治療技法のことである．マインドフルネストレーニングでは，痛みや不安，怒り，抑

うつなどの不快な体験に，意識的に注意を向けて観察する．痛みや不安，怒り，抑うつが全くなくなるわけではないが，それらに対する不安や否定的反応は減少する．痛みや不安や抑うつがひどくなることを恐れることや，悩んで考え込んでしまうこと，過剰反応を起してパニックになるような心理的傾向が減少する．自己観察技能の向上とは，常に自己観察する習慣をマインドフルネストレーニングによって訓練した結果，わずかな症状の悪化やストレスの増加に患者が早く気づくようになり，元来患者が持っていた症状対処法やストレス対処法を，早めに使用できるようになるというものである．受容の効果とは，症状や否定的感情状態を受け入れて何もしないことを学習することで，薬物やアルコール乱用のような不適切な症状対処法を使用する頻度が減少するということである．例えば，怒りを感じたときに，怒りを観察してそのまま何もしないでいるというマインドフルな対処ができたなら，酒を飲む，周囲の人に怒りをぶつけるという，不適切な対処法を使う必要がなくなるということである．

マインドフルネストレーニングを使った心理療法のエビデンス

マインドフルネストレーニングを使った心理療法については，複数のメタ解析が行われ，治療効果が認められている[6]．特に，MBSR は，慢性疼痛，がん患者の不安抑うつなどに対する効果が複数の介入研究によって証明されている．

心身症患者へのマインドフルネストレーニングの有用性

筆者の臨床経験ではマインドフルネストレーニングは感情の言語化が困難なアレキシサイミア傾向のある心身症の治療に有用と思われる．マインドフルネストレーニングは感情の言語化や表出を患者に要求せず，しかも，アレキシサイミア傾向を改善するという特徴があるからである．アレキシサイミアは，失感情症，失感情言語化症とも呼ばれ，自己の感情への気づきや感情の言語化が困難で，内省に乏しい性格傾向のことで，心身症によく見られるとされる[7]．一般的な心理療法は感情の言語化や表出，内省を患者に期待するため，アレキシサイミア傾向のある患者は心理療法実施が困難である．しかし，マイン