(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.

Manuscript received 17 June 2013
Revised manuscript received 10 December 2013
Manuscript accepted 26 January 2014
First published online 20 February 2014

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