

# News Release

## Title :

Effects of insular resection on interactions between cardiac interoception and emotion recognition

## Key Points

- **Interoceptive accuracy was not differed significantly between pre- and post-insular resection.**
- **Changes of interoceptive accuracy associated with changes of sensitivity to anger and happiness.**
- **Insular resection affects recognition of emotions through interoception**

## Summary

This work is mainly from the team of Yuri Terasawa (Associated professor, Department of Psychology) and Satoshi Umeda (Professor, Department of Psychology) in Keio University (Dean: Yoshimitsu Matsuura) and Kazuya Motomura (Associated professor, Department of Neurosurgery) in Nagoya University Graduate School of Medicine (Dean: Kenji Kadomatsu).

The insular cortex is considered an important region for feeling emotions through interoception. Most studies that report the role of the insula in integrating interoception and emotion have used neuroimaging techniques such as functional magnetic resonance imaging (fMRI); however, there are limited neuropsychological studies. The effects of insular lesions on emotion and interoception have not been suitably investigated. In this study, we examined the role of the insular cortex in cardiac interoception and recognizing emotions from facial expressions by comparing them pre- and post-operatively in patients with glial tumors or brain metastases associated with the insular lobe. Although no significant difference in interoceptive accuracy was observed between the two phases, there were significant associations between the changes in interoceptive accuracy and sensitivity to expressions of anger and happiness. An increased error rate in the heartbeat counting task in the post-operation phase was associated with a decreased accuracy in recognizing anger and happiness. Since most patients had left insula lesions, generalizability of the findings to patients with right lesions is a future subject. To the best of our knowledge, this is the first study to examine the change in interoception and emotion after insular resection in humans. The study results indicate that removal of the insula affects the recognition of emotions such as anger and happiness through interoceptive processing. The paper was published on the journal of Cortex on April 2021.

## Research Background

The insular cortex is considered an important region for feeling emotions through interoception. Some neuropsychological studies have suggested an essential role of the insula in feeling the emotions (Adolphs, Tranel, & Damasio, 2003; Borg et al., 2013; Calder, Keane, Manes, Antoun, & Young, 2000; Motomura et al., 2019; Terasawa, Kurosaki, Ibata, Moriguchi, & Umeda, 2015). Motomura et al., (2019) and Terasawa et al. (2015) revealed that insular lesion led to decreased accuracy for feeling highly aroused emotions, such as anger, and suggested that interoceptive sensation which supports feeling of aroused emotions are removed by

the lesion. Recent studies posit the insula as the nest for representing the prediction error between prediction and actual feedback about bodily state, and consider this system as a grand mechanism for interoception and emotions (Barrett & Simmons, 2015; Seth & Critchley, 2013). However, to the best of our knowledge, most of the studies that have reported the role of the insula in integrating interoception and emotion used neuroimaging techniques such as functional magnetic resonance imaging (fMRI), but the number of neuropsychological studies are limited.

In this study, we examined the role of the insular cortex in cardiac interoception and recognizing emotions from facial expressions by comparing them pre- and post-operatively in patients with glial tumors or brain metastases associated with the insular lobe. We employed the emotional sensitivity task that was used in our previous studies (Motomura et al., 2019; Terasawa, Moriguchi, Tochizawa, & Umeda, 2014). This task consisted of four kinds of emotional expression of various intensities and the images were presented repeatedly in the method of constant stimuli to define the thresholds to make the participant feel the target emotions. Although most research employ an emotion recognition task with clear emotional expressions, these tasks have low sensitivity to detect mild changes in feeling emotions in neuropsychological patients. Our task is optimized for this purpose and its reliability has been confirmed in our previous studies. We used the heartbeat counting task to measure the interoceptive accuracy, since this is the most widely used in this field. We assumed that these methods would allow us to examine the role of the insula in interoception and recognizing emotions with minimal influence of individual differences. To the best of our knowledge, this is the first study to examine the change of interoception and emotion after insular resection in humans.

## **Research Results**

As the above section revealed, we did not obtain a statistically significant difference in the heartbeat counting task pre- and post-operation in the group analysis. We further focused on the individual differences in the heartbeat counting and emotional sensitivity tasks. Multiple regression analyses of the accuracy of interoception and emotion recognition were performed using the difference in performance of the two tasks between the pre- and post-operation phases. The differences in the emotional sensitivity task for each emotion category were regarded as dependent variables in the regression analyses, and the difference in the heartbeat counting task and the difference of the time estimation task were regarded as independent variables. Standardized partial regression coefficients allowed us to understand the relationship between the changes of emotion recognition and interoceptive accuracy without the effect of the time estimation.

Only 11 participants who completed the two tasks in the pre- and post-operation phases were included in the regression analyses. Since one case (case 14) showed less than -2 SD from the average of the correct response index for anger recognition in the post-operation phase of all participants, it was excluded from the analysis of anger recognition as an outlier. The results revealed that increased error rates of the heartbeat counting task in the post-operation phase were associated with decreased accuracy of anger recognition (Figure 1).

Since there were no outliers for happiness, sadness, or disgust, the regression analyses were conducted with data of all 11 cases. The results showed that increased error rates of the heartbeat counting task in the

post-operation phase were associated with decreased accuracy of happiness recognition similar to anger (Figure 2). Similar analyses were performed for the sadness and disgust conditions, but neither were significantly associated with the performance of the heartbeat counting task.

We did not execute the regression analysis for the neutral condition, because psychological process for neutral versus other conditions would not be identical. Neutral conditions required the participants to decide that the stimuli did not contain emotional valence, in contrast other conditions required them to detect emotional valence from the stimuli.

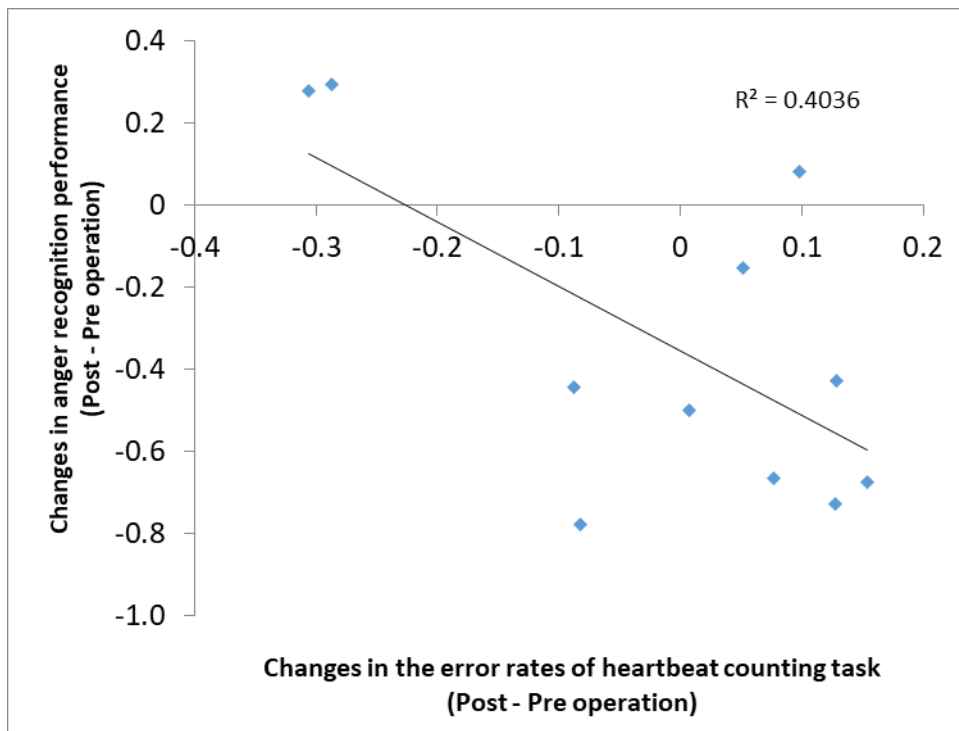


Figure 1. Relationship between performance change of the heartbeat counting task and sensitivity to expression of anger. The regression analysis showed that increased error rates of the heartbeat counting task in the post-operation phase was associated with the decreased accuracy of anger recognition.

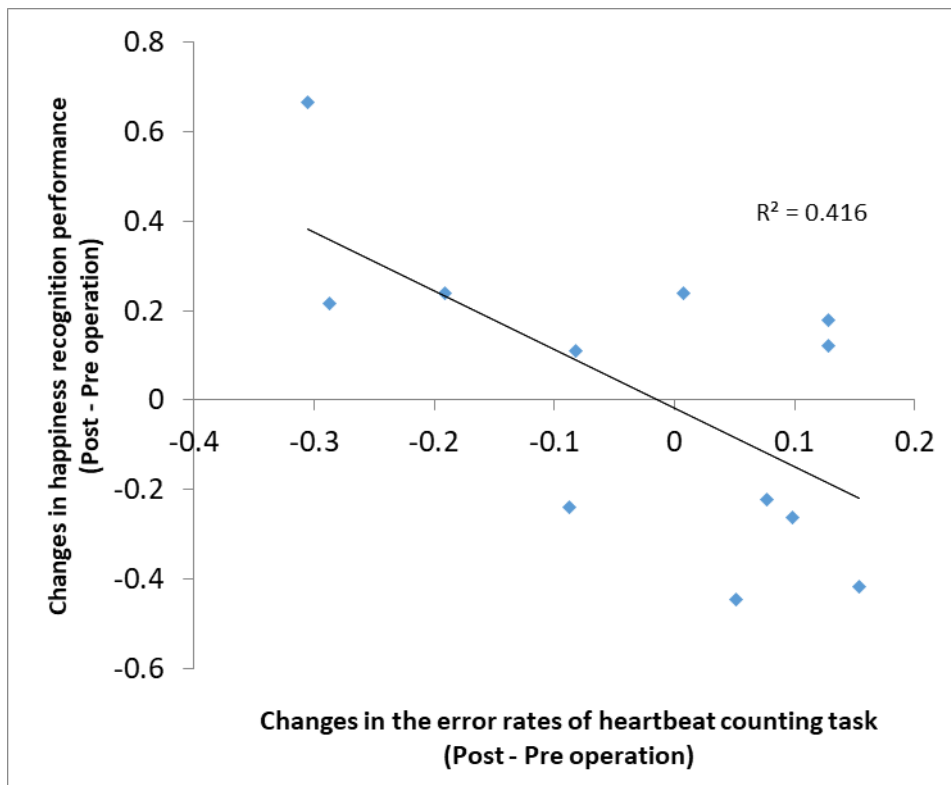


Figure 2. Relationship between the change in performance of the heartbeat counting task and sensitivity to happy expression. The regression analysis showed that increased error rates of the heartbeat counting task in the post-operation phase was associated with the decreased accuracy of recognition of happiness.

### Research Summary and Future Perspective

In this study, we examined the role of the insular cortex in cardiac interoception and recognizing emotions from facial expressions by comparing the task performance pre- and post-operatively for patients with glial tumors or brain metastases associated with the insular lobe. Though a significant difference in the interoceptive accuracy was not observed between the two phases, there were significant associations between the changes of interoceptive accuracy and sensitivity to expression of anger and happiness. Increased error rates of heartbeat counting task in the post-operation phase was associated with decreased accuracy of recognizing anger and happiness. Since majority of patients had left insula lesion, generalizability of the findings to right lesion patients is future subject. To the best of our knowledge, this is the first study to examine the change of interoception and emotion after insular resection in humans. The study results indicate that the removal of the insula affects the recognition of emotions such as anger and happiness through interoceptive processing.

### Publication

Yuri Terasawa, Kazuya Motomura, Atsushi Natsume, Kentaro Iijima, Lushun Chalise, Junko Sugiura, Hiroyasu Yamamoto, Kyohei Koyama, Toshihiko Wakabayashi, and Satoshi Umeda. Effects of insular resection on interactions between cardiac interoception and emotion recognition. *Cortex*, published on April

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