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How to Identify Mechanisms of Cultural Influences on Human Brain Functions

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A key goal of cultural neuroscience research is to identify causal effects of culture on functional organization of the human brain. An early approach to this goal employed transcultural neuroimaging (Han & Northoff, 2008; Han et al., 2013) that compared brain activities involved in a specific cognitive or emotional task in two cultural groups. This line of research has shown ample evidence for differences between individuals from two cultural groups in neural correlates of visual perception (Goh et al., 2007; Goh et al., 2010; Gutchess, Welsh, Boduroglu, & Park, 2006; Jenkins, Yang, Goh, Hong, & Park, 2010), visual attention (Hedden, Ketay, Aron, Markus, & Gabrieli, 2008; Lewis, Goto, & Kong, 2008), causal attribution (Han, Mao, Qin, Friederici, & Ge, 2011), semantic processing (Gutchess, Hedden, Ketay, Aron, & Gabrieli, 2010), musical processing (Nan, Knösche, & Friederici, 2006; Nan, Knösche, Zysset, & Friederici, 2008), mental calculation (Tang et al., 2006), recognition of one's own face (Sui, Liu, & Han, 2009), self-referential processing of personality traits (Han et al., 2010; Han et al., 2008; Ma et al., 2013; Zhu, Zhang, Fan, & Han, 2007), perception of bodily expression (Freeman, Rule, Adams, & Ambady, 2009), mental state reasoning (Adams et al., 2009; Kobayashi, Glover, & Temple, 2006), and empathy (de Greck et al., 2012). Chiao et al. (this issue) also give examples of their own transcultural neuroimaging studies that examined cultural influences on human brain functions.

Although these transcultural neuroimaging studies show evidence for cultural group difference in brain activity and have contributed greatly to the development of cultural neuroscience, the findings reported in these studies also raise important questions. For example, Do group differences in brain activity necessarily reflect cultural influences? How can we reveal a mechanism of cultural influences on human brain activity in transcultural neuroimaging studies? Can we identify a causal relationship between culture and brain functions? These questions are not discussed extensively in Chiao et al.'s (this issue) article. In this commentary, I first give an example that group differences in brain activity may not be necessarily attributed to cultural effects. I then discuss, by giving an example, what current cultural neuroscience research can do to uncover mechanisms of cultural group difference in human brain functions. Finally, I discuss an approach to the understanding of a causal link between culture and brain functions.

Do Group Differences in Brain Activity Necessarily Reflect Cultural Influences?

Several neuroimaging studies reported that individuals from an individualistic or collectivistic culture showed distinct patterns of neural responses to perceived emotion in others. In a functional magnetic resonance imaging (fMRI) study (Xu, Zuo, Wang, & Han, 2009), we reported the first neuroimaging evidence that Chinese participants exhibited stronger anterior cingulate activity to painful versus nonpainful stimulations applied to Asian than Caucasian models, whereas Caucasian participants (mainly from American and Europe) showed greater stronger anterior cingulate activity to painful versus nonpainful stimulations applied to Caucasian than Asian models. A following study found decreased sensorimotor responses to perceived painful stimulation applied to White versus Black hands in Whites, but a reverse pattern in Black participants (Avenanti, Sirigu, & Aglioti, 2010).

Do these apparently distinct patterns of brain activity involved in empathy for others' pain reflect a cultural influence? To give an affirmative answer to this question, one has to at least show evidence for an association between distinct neural responses in the two groups of subjects and a specific cultural measurement (e.g., a value). However, to date, the aforementioned studies did not report evidence for such an association. Avenanti et al. (2010) reported an association between distinct sensorimotor activity and implicit attitude toward racial ingroup/outgroup members, but such an association was similarly observed in White and Black participants. Can the apparently distinct patterns of brain activity involved in empathy for others' pain arise from cognitive or social mechanisms that are independent of cultural effects? Our recent research indicated that cognitive strategy and intergroup relationship play key roles in the distinct empathic neural responses to perceived pain in racial ingroup and outgroup members (Sheng & Han, 2012).

In Experiment 1 of Sheng and Han (2012), we recorded event-related brain potentials (ERPs) from

Chinese participants while they made race judgments on Asian and Caucasian faces with pain or neutral expressions. We found that, relative to neutral expressions, pain expressions increased frontal/central neural activity at 128 to 188 ms (P2) after stimulus onset, but this effect was evident for Asian faces but not for Caucasian faces. We hypothesized that an other-race person may be perceived as a symbol of a racial group rather than an individual person and the lack of individuation decreases references to an individual's personal situation and consequently weakens empathy for that person. We tested whether individuating other-race persons by increasing attention to each individual's feelings or enclosing other-race individuals within one's own social group can increase empathic neural responses to other-race individuals. Thus, in Experiment 2, we asked participants to judge whether a model was feeling pain so as to enhance participants' attention to each individual model's feeling. This manipulation resulted in increased P2 amplitudes to pain versus neutral expressions of both Asian and Caucasian faces and thus eliminated the racial bias in neural responses to others' suffering. In Experiment 3, we employed a group manipulation by assigning participants to a team consisting of both Asian and Caucasian models (a fellow-team) for a competition game against an opponent-team that also consisted of Asian and Caucasian models. We found that changing the intergroup relationships between an observer and a target by enclosing other-race models into one's own team increased empathic neural responses in the P2 time window to Caucasian faces, and this resulted in elimination of the racial bias in neural responses to others' suffering. These findings indicate that the distinct neural responses to perceived pain expression in same-race and other-race individuals can be attributed to (a) the differences in cognitive strategies used during the processing of same-race and other-face faces and (b) intergroup relationships between an observer and a target.

A more recent ERP study further uncovered a potential biological mechanism underlying distinct empathic responses to same-race and other-face others. We investigated whether oxytocin that has been linked to empathic concern and ingroup favoritism contributes to the distinct empathic neural responses to same-race and other-race others (Sheng, Liu, Zhou, Zhou, & Han, 2013). We recorded ERPs to Asian and Caucasian pain or neutral expressions after intranasal self-administration of oxytocin or placebo. We found that oxytocin treatment increased the frontal P2 amplitudes to pain expression of Asian models but not of Caucasian models. This finding suggests that oxytocin may contribute to the distinct empathic neural responses to the suffering of same-race and other-race others.

This line of research indicates that a group difference in brain activity can be understood by a cognitive mechanism (e.g., attention to an individual's emotion or social ingroup–outgroup relationship) or a biological mechanism (e.g., oxytocin) that may function in a similar vein in the two groups of subjects. That is to say, an apparent cultural group difference in brain activity may not necessarily arise from cultural influences and may be attributed to the same cognitive/biological mechanism.

How to Reveal Mechanisms of Cultural Influences on Human Brain Activity?

Although there are increasing transcultural neuroimaging studies that found cultural group differences in brain activity involved in human cognition, it is still a challenge for transcultural neuroimaging research to uncover mechanisms underlying differences in brain activity between two cultural groups. A common approach is to show a cultural group difference in brain activity and then provides a post hoc explanation of the difference. During the past 5 years, we have conducted a series of fMRI studies to address cultural influences on brain activity involved in self-related processing. Early transcultural neuroimaging studies compared brain activities involved in self-reflection on personality traits (e.g., Zhu et al., 2007) or self-face recognition (Sui et al., 2009) from individuals from individualistic or collectivistic cultures (e.g., Chinese vs. British). The findings of these studies are consistent with Markus and Kitayama's (1991) model of cultural difference in self-construal. This model claims that Western cultures encourage an independent view of a self who is inclined to be self-focused and attends to the self more than others, whereas East Asian cultures emphasize fundamental social connection and encourage an interdependent view of a self who is sensitive to information related to significant others and attends to intimate others as much as to the self. However, the transcultural neuroimaging findings did not tell the mechanism that mediates the cultural difference in the brain activity engaged self-related processing.

How can a transcultural neuroimaging study reveal a specific mechanism underlying cultural difference in human brain activity? Our recent transcultural neuroimaging research of self-referential processing illustrated an approach to this question (Ma et al., 2013). We believe that several aspects regarding empirical findings are critical for uncovering the mechanism of cultural group differences in the neural activity associated with self-referential processing.

Based on Markus and Kitayama's (1991) model of cultural differences in self-construals, we hypothesized that the interdependent self-construal in East Asian cultures may result in taking others' perspective even during self-reflection of one's own social attributes and the interdependence may mediate differences in neural activity in brain regions involved in mentalizing

others between individuals from East Asian and Western cultures. If this hypothesis is correct, we would first expect a difference in self-construals between individuals from East Asian and Western cultures. Thus we used the Self-Construal Scale (Singelis, 1994) to measure the interdependence of self-construals from a country dominated by a cultural value of independence (i.e., Denmark; Thomsen, Sidanius, & Fiske, 2007) and a country characterized by a high interdependent cultural value (i.e., China; Li, Zhang, Bhatt, & Yum, 2006). This measurement indeed showed significantly greater interdependence in Chinese than in Danes and provided evidence for a cultural group difference in interdependence of self-construals.

Second, we tested whether a brain region that is involved in mentalizing others (e.g., the temporoparietal junction [TPJ]; Saxe & Kanwisher, 2003) showed stronger activity during self-reflection of social attributes in Chinese than in Danes. Thus we scanned Chinese and Danish participants during reflection on social roles of themselves and a celebrity. We found that, relative to reflection on a celebrity's social roles, reflection on one's own social roles significantly activated the bilateral TPJ in Chinese but not in Danes. In addition, direct comparison between the two

activity related to others (Ng, Han, Mao, & Lai, 2010). We showed evidence that exposure to Western cultural icons as cultural primes increased the ventral medial prefrontal activity during self-reflection of personality traits, whereas Chinese cultural priming increased the ventral medial prefrontal activity related to others.

The findings of cultural priming studies indicate dynamic variations of the neural activity underlying the processing of the self and others and allows for causal inference regarding the relationship between cultural values and specific brain activity. These findings are consistent with the previous findings of transcultural neuroimaging studies that implicate chronic influences of cultural values and practices on human brain activity. The congruent patterns of neural activity changes arising from temporal or chronic cultural contexts provide evidence for a causal relationship between culture and neurocognitive processes in the human brain.

Conclusion

Cultural neuroscience studies have shown increasing evidence for cultural group differences in brain activity involved in varieties of cognitive processes. However, to simply show a cultural group difference in brain activity may not uncover an underlying mechanism. Cultural neuroscience research should examine associations between cultural values and observed cultural group differences in neural activity and test whether a cultural value can serve as a mediator of cultural group differences. Cultural priming studies complement transcultural neuroimaging research by providing evidence for a causal link between a cultural value and variation of neurocognitive processes. These approaches together contribute greatly to the understanding of neural mechanisms underlying cultural influences on human brain functions.

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