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Abstract:

Cultural neuroscience investigates whether and how cultural contexts and experiences shape functional organization of the human brain by integrating brain imaging with psychological paradigms such as cross-cultural comparisons and cultural priming. Cultural neuroscience studies have shown ample evidence for cultural group differences in, or cultural priming effects on, neural correlates of cognitive and affective processing. Future cultural neuroscience studies should examine how culture interacts with genes to modulate multiple-level neural mechanisms (from molecules to neural circuits) underlying human cognition and affection and how human behavior in a specific social context is related to cultural effects on brain activity.

Keywords: Affection; Brain imaging; Cognition; Cultural priming; Culture; fMRI; Gene

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Biographical Sketch

Shihui Han is a professor and the director of the Cultural and Social Cognitive Neuroscience Laboratory at the Department of Psychology, Peking University. He is the founding chief editor of 'Culture and Brain' and an associate editor of 'Social Cognitive and Affective Neuroscience' and 'Acta Psychologica Sinica.' Using brain imaging such as fMRI and EEG/ERP, he studies cognitive and neural mechanisms of social cognition such as self-face recognition, self-referential processing, empathy for pain, and death-related thoughts. His research focuses on both cultural and genetic influences on neurocognitive processes of social cognition and how culture interacts with gene to shape the human brain and behavior.

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Cultural Neuroscience

S Han, Peking University, Beijing, China

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p0010 Cultural neuroscience is an interdisciplinary field that investigates whether and how cultural contexts and experiences interact with and shape functional organization of the human brain. Cultural neuroscience research emerged during the first decade of the twenty-first century when cognitive neuroscience studies promoted the application of brain imaging (e.g., event-related brain potential (ERP) and functional magnetic resonance imaging (fMRI)) to investigate human brain functions. This allowed social and cultural psychologists to begin to explore neural correlates of social cognition and behavior using brain imaging. Cultural neuroscience integrates several approaches including cultural psychology, social cognitive neuroscience, neuroscience research of neural plasticity, and culture–gene interactions (Chiao & Ambady, 2007; Han & Northoff, 2008; Han et al., 2013). The goal of cultural neuroscience studies is to provide a neuroscientific account of cross-cultural variation in human psychological functions and behaviors by discovering socioculturally patterned neural mechanisms and their development.

p0015 Cultural neuroscience studies view culture as complex, dynamic social environments in which the human brain develops and shares ideas, values, beliefs, and behavioral scripts in people's mind. Rather than being a part of the innate biological condition of humans, culture functions as a dynamic environment and knowledge system that allows the brain to lay out its potential capacity to fit into different sociocultural contexts. This fits with the fundamental neuroscientific proposal of neural plasticity – an intrinsic nature of the human brain that allows the brain to change both structurally and functionally in response to the environment and new experiences (Shaw & McEachern, 2001). However, people from the same geographic region are not necessarily homogeneous in terms of their cultural values. An individual may have multiple cultural systems and switch between different cultural systems in response to specific social contexts and interactions (Hong, Morris, Chiu, & Benet-Martinez, 2000). Rather than attempting to find a 'biomarker' of culture in the brain, cultural neuroscience studies examine how cultural values, beliefs, and practices shared by a social group in daily life influence the functional organization of the human brain and how they might temporarily shift brain activity to reflect specific cultural values and beliefs (Han et al., 2013).

p0020 One cultural neuroscience approach focuses on differences in neural correlates of cognitive and affective processes between two cultural groups. Using brain-imaging measurements from individuals who are raised in different sociocultural contexts, cultural neuroscientists have shown increasing evidence for cultural group differences in brain activities involved in multiple cognitive and affective processes including perception (Goh et al., 2007, 2010; Gutchess, Welsh, Boduroglu, & Park, 2006; Jenkins et al., 2010), attention (Hedden, Ketay, Aron, Markus, & Gabrieli, 2008; Lewis, Goto, & Kong, 2008), causal attribution of physical events (Han, Mao, Qin, Friederici, & Ge, 2011), semantic relationship processing (Gutchess, Hedden, Ketay, Aron, & Gabrieli, 2010), musical processing (Nan, Knösche, & Friederici, 2006; Nan et al., 2009), mental calculation (Tang et al., 2006), recognition of one's own face (Sui, Hong, Liu, Humphreys, & Han, 2013; Sui, Liu, & Han, 2009), self-reflection on personality traits (Chiao et al., 2009, 2010; Han et al., 2010, 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), empathy (de Greck et al., 2012), and trait inference (Na & Kitayama, 2011).

p0025 Cultural modulations of brain activity exhibit different patterns. One pattern is that neural activity is modulated by a particular task in one cultural group but not in another cultural group (Han et al., 2011; Jenkins et al., 2010; Zhu et al., 2007). For example, reflection of personality traits of oneself and one's mother compared to a celebrity activates a common region in the medial prefrontal cortex and this effect is evident in Chinese individuals but not in Westerners (Wang et al., 2012; Zhu et al., 2007). In addition, decreased lateral occipital activity in response to scenes that are incongruent versus congruent to foreground objects is observed in Chinese but not in Americans (Jenkins et al., 2010). Another type of cultural modulation of brain activity is that two cultural groups show opposite patterns of neural activity during the same task (Freeman et al., 2009; Hedden et al., 2008). For instance, relative to a context-dependent task that requires judgments of whether a box and a line combination matches the proportional scaling of the preceding combination, Americans show greater prefrontal and parietal activity during the context-independent task (which requires judgments of whether the current line matches the previous line), regardless of the size of the accompanying box. In contrast, East Asians exhibit stronger

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activity in the prefrontal and parietal cortices during the context-independent than context-dependent tasks (Hedden et al., 2008). Americans show greater activity in the bilateral Au7 caudate nucleus and MPFC when perceiving people showing dominant versus subordinate gestures, whereas Japanese exhibit the opposite pattern of neural activity in these brain regions (Freeman et al., 2009). A more complicated pattern of cultural modulations of brain activity is observed when comparing Chinese and Danish individuals during self-reflection (Ma et al., 2013). Reflection of personality traits, physical attributes, and social roles of oneself versus a celebrity elicits greater activation in the medial prefrontal cortex in Danish individuals than in Chinese, whereas reflection on social roles of oneself versus a celebrity induces greater activity in the temporoparietal junction in Chinese than in Danish participants (Figure 1). These modulations of brain activity may reflect consequences of cross generationally transmitted values and associated behavioral patterns that surface in a specific sociocultural environment (Kitayama & Uskul, 2011).

p0030 The most exhaustively examined cultural differences in brain activity emerge from the comparison of individuals from East Asian and Western cultures. However, cultural effects are also observed in neural activity recorded from subcultural groups within a single national culture. For example, Chinese Christians and Buddhists show specific patterns of medial prefrontal and anterior cingulate activity during reflection of one's own personality traits compared to Chinese atheists (Han et al., 2008, 2010). Individuals of high versus low socioeconomic status in the same society also exhibit different patterns of neural activity during spontaneous trait inference (Varnum, Na, Murata, & Kitayama, 2012). After memorizing many pairings of a target face and a trait-implying behavior, American undergraduates perform lexical judgments on trait adjectives preceded by a face. Individuals with college-educated parents (middle class) show a stronger amplitude of an event-related potential component (N400) to the antonym (vs. the implied trait) compared with those with high-school-educated parents (working class), indicating differences in spontaneous trait inference between people with high socioeconomic status and with low socioeconomic status. Socioeconomic status also modulates the relationship between emotional responses and prosocial behavior as empathic neural responses to perceived pain in others predict the amount of monetary donations in individuals of high but not low socioeconomic status (Ma, Wang, & Han, 2011).

p0035 While some CN studies showed cultural group differences in both brain activity and a specific cultural value such as interdependence (e.g., de Greck et al., 2012; Goto et al., 2010; Ma et al., 2013), these findings do not uncover whether the observed cultural group differences in brain activity are mediated by the cultural value measured. This can be tested using a mediation analysis. For example, Chinese compared with Danish individuals show both greater value of interdependence in the self-construal and stronger activity in the temporoparietal junction during self-reflection (Ma et al., 2013). The measurement of interdependence also positively correlates with the temporoparietal junction activity across the whole sample. More importantly, the group difference in the temporoparietal junction activity is mediated by the degree of interdependence, providing evidence that endorsement of the cultural value of

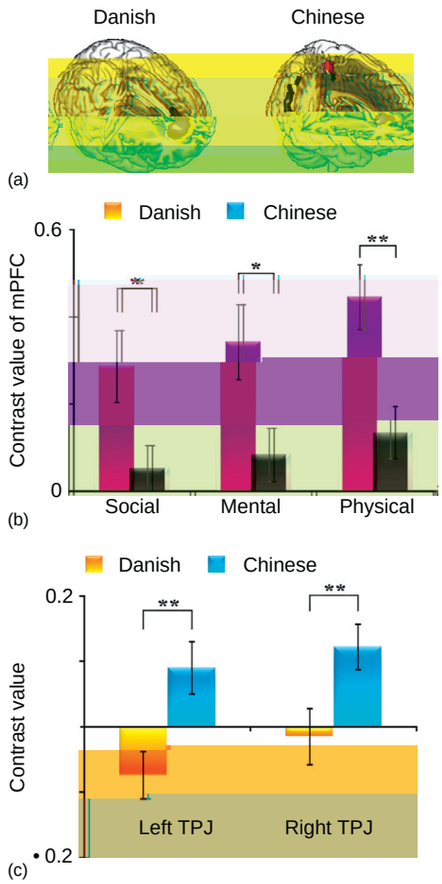
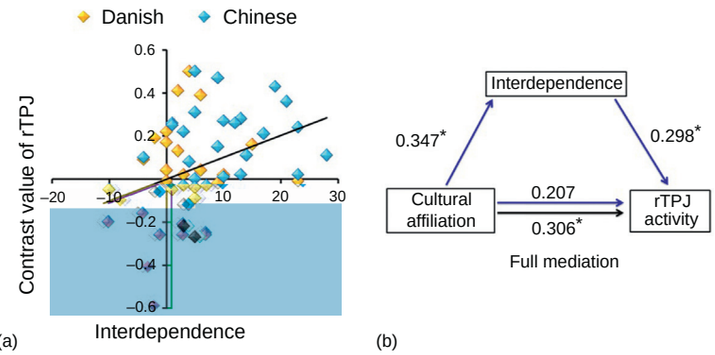


Figure 1 Illustration of cultural differences in brain activity involved p0010
in self-reflection. (a) Self-reflection on social roles only activates the medial prefrontal cortex in Danish participants, whereas reflection on social roles activates both the medial prefrontal cortex and the temporoparietal junction in Chinese participants. (b) Self-reflection on mental personality traits, physical attributes, and social roles is associated with the medial prefrontal activity that is stronger in Danish than in Chinese participants. (c) Self-reflection on social roles is associated with the activity in the temporoparietal junction that is stronger in Chinese than Danish participants.

interdependence is a mechanism underlying the observed cultural group difference in the temporoparietal junction activity (Figure 2). There may be differences in many aspects such as history, language, and geographic location between any two cultural groups. Thus, it is essential for cultural neuroscience studies to clarify which cultural value mediates the observed group differences in brain activity underlying cognitive and affective processes using tools such as the mediation analysis.

Another cultural neuroscience approach attempts to reveal p0040
a direct causal relationship between cultural orientation and neural mechanisms of cognitive and affective processes using 'cultural priming' in laboratories. Cultural priming has a root in the dynamic constructivist model of culture that proposes that exposing individuals to cultural symbols may activate specific cultural knowledge and result in mind-sets and behaviors that are consistent with that culture (Hong et al., 2000). Cultural priming studies usually expose participants with



f0015 Figure 2 Illustration of the cultural-value mediation effect on brain activity involved in self-reflection. (a) The temporoparietal junction activity during self-reflection on social roles is positively correlated with the measurement of interdependence. (b) The difference in the temporoparietal junction activity during self-reflection on social roles between Chinese and Danish participants is fully mediated by the degree of interdependence.

iconic cultural primes or words that make specific cultural values salient temporarily and then record brain activity underlying cognitive/affective processing. This procedure allows us to examine variations in neural processes as a consequence of cultural priming and reveals a causal link between variations in cultural values and the neural activity during following tasks. To date, there has been evidence for the effects of cultural priming on pain perception (Wang, Ma, & Han, 2013), visual perception (Lin, Lin, & Han, 2008), self-face recognition (Sui & Han, 2007), self-referential processing (Chiao et al., 2010; Harada, Li, & Chiao, 2010; Ng, Han, Mao, & Lai, 2010), motor processing (Obhi, Hogeveen, & Pascual-Leone, 2011), and resting-state activity (Wang, Oyserman, Li, Liu, & Han, 2013). To give an example, it has been found that priming independent self-construals by exposing individuals with independent pronouns (e.g., 'I' or 'me') results in faster behavioral responses to one's own face compared with a familiar face, whereas priming interdependent self-construals by exposing individuals with interdependent pronouns (e.g., 'we' or 'us') leads to slower responses to one's own face relative to a familiar face (Sui & Han, 2007). Moreover, self-construal priming modulates the neural activity in association with self-face recognition. The independent self-construal priming enhances the right middle and inferior frontal activity in response to one's own face. Conversely, the right frontal activity is reduced by the interdependent self-construal priming. Such findings support a cause–effect relationship between culturally specific self-construals and culturally specific styles of neurocognitive processes involved in self-face recognition.

p0045 The findings of cultural neuroscience research have important implications for understanding the human brain and behavior. Current cultural neuroscience research demonstrates that, rather than being doomed by biology, the human brain and neurocognitive processes related to cognition, affection, and behavior are flexible and continuously shaped by long-term and short-term cultural experiences in man-made sociocultural contexts. Besides culturally universal brain mechanisms, the human brain develops culturally specific neural cognitive and affective processes so as to guide appropriate behaviors in a specific cultural context. Cultural neuroscience findings make us rethink the biosocial nature of the brain that may bridge the gap between a biological entity and the social world of the environment and its culture. Cultural neuroscience research also leads us to rethink the nature of culture. If the human brain shows constitutive context dependence, the environment and thus culture, which are created by the human brain, are then not purely social. Instead, culture may then be considered to be sociobiological rather than being an exclusively social construction. Cultural neuroscience research also has practical implications. For example, the findings of cultural differences in neural cognitive and affective processes can help to understand why people from other cultural groups think and behave differently and help to deal with misunderstandings and conflicts between different cultural groups and reduce intergroup conflict and prejudice. At the individual level, since a person usually aims to reach his or her own goals in a specific sociocultural environment, how an individual's brain activity fits with cultural norms and values in that society may strongly influence his or her mental health and well-being. Cultural neuroscience research can help to understand the link between culturally specific neural cognitive and affective processes and an individual's well-being in a specific cultural context.

p0050 There are plenty of questions that can be addressed by future cultural neuroscience studies. To give a few examples, one may ask what kind of experiences during development may facilitate the ability of an individual's brain to fit into a specific culture and to interact with individuals from other cultures. This is an important issue since more and more people emigrate to other cultures and seek future carriers in different cultural environments. It is unknown what allows the brain to adapt to a new culture quickly. It is also interesting to examine whether there are any culturally specific neural or genetic mechanisms of mental disease and whether the association between genotype and mental illness is similar across cultures. Answering these questions may help to determine whether the same treatments are appropriate for mental disorders in different cultures. Another important issue for cultural neuroscience research is how culture may affect or interact with biochemical substances in the brain. Is it possible to trace cultural effects to the neuronal and biochemical levels in order to understand the relationship between culture and microlevel neural processes? Moreover, it is critical to understand whether and how culture and genes interact to affect neural processes in the human brain because this line of

research may offer a comprehensive description of human nature and provide further challenges for purely biological accounts of the brain.

See also: Acquisition Methods; Obtaining quantitative information from fMRI/MRI data (00002); EEG (00007); fMRI Dynamics (00085); Face Processing (00037); Emotion (00055); Memory (00056); Brain at Rest (00060); Clinical: Depression (00119); Neurobiology of anxiety (00120); Emotion and stress (00121); Social Perception (00128); Imaging genetics (00130); Cooperation & Competition (00143); How the Brain Feels the Hurt of Heartbreak (00144); Prosocial Motivation (00146); Self-knowledge (00149); Mentalizing (00169); Person Knowledge & Attribution (00170); Social Cognition During Social Interactions (00172); Resting State & Social Cognition (00173); Empathy (00177); Social Knowledge (00183); Anatomy & Physiology: Functional Connectivity (00212); Insular cortex (00237); Prefrontal Cortex (00241); Autobiographical memory and recollection (00281); Self-insight; Self-regulation Developmental Approaches to the Self; Amygdala & Social Perception; Genetic Neuroimaging of Social Perception; Cingulate cortex.

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