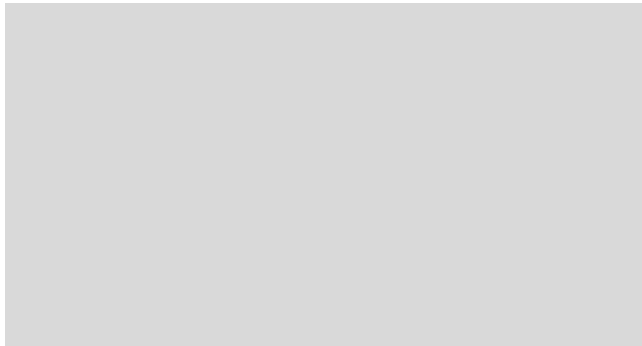




## Self-construal: a cultural framework for brain function

Shihui Han<sup>1</sup> and Glyn Humphreys<sup>2</sup>

Humans have created complex cultures that provide frameworks for our lives, guiding our behavior and thoughts. Recent brain imaging studies have uncovered cultural influences on brain activity in multiple tasks. We review recent cultural neuroscience findings that illustrate that (a) self-construal, a cultural trait that differentiates between East Asian and Western societies, mediates group differences in brain activity



emphasizing visual perception [14\*\*,15,16], attention [17\*\*], causal attribution [18\*\*], mental calculation [19], self-reflection [20\*\*], and mental state reasoning [21] (see highlights in reference for details). These studies, however, failed to uncover which cultural orientation mediated the observed group differences in brain activity. This is an important issue for cultural neuroscience research because participants from East Asian and Western societies differ across a variety of cultural beliefs and it is necessary to clarify what cultural beliefs underlie the observed group differences in brain activity.

One cultural neuroscience approach to solve this issue is to measure the particular cultural values such as independence/interdependence that are potentially mediating cultural effects. Such designs have allowed researchers to test specific hypotheses that the distinct patterns of brain activity in different cultural groups are mediated by self-construals. For example, Ma *et al.* [22\*\*] tested the hypothesis that activity in the medial prefrontal cortex (mPFC) — linked to encoding the self-relevance of stimuli [23,24] — is increased in Western relative to East Asian cultures, whereas activity in the temporoparietal junction (TPJ) — a cortical junction zone at the border of the posterior parts of the temporal lobe and the inferior parts of the parietal lobe, which has been shown to be involved in belief reasoning and perspective taking [25] — is enhanced in East Asian relative to Western cultures. In addition, Ma *et al.* investigated whether cultural group differences in brain activity were mediated by interdependent self-construals. They scanned Chinese and Danish college students as the participants made judgments of social, mental and physical attributes in relation to themselves and to public figures. Self-construals were measured using Singelis's Self-Construal Scale [26]. It was found that judgments of the self compared to a public figure elicited greater mPFC activations in Danes compared with Chinese participants regardless of attribute dimensions for judgments. On the other hand, self-judgments of social attributes induced greater TPJ activity in Chinese compared with Danes. The self-construal measure revealed greater interdependence in Chinese compared to Danish participants. More interestingly, the measure of interdependence was positively correlated with TPJ activity but negatively correlated with the mPFC activity. A mediation analysis further demonstrated that the difference in TPJ activity between Chinese and Danes was fully mediated by the interdependence of self-construal. These findings indicate that group-level differences in TPJ activity can be partially explained by individual differences in interdependence and that self-construals play a key role in mediating cultural group differences in brain activity related to taking others' perspective during self-reflection.

Cross-cultural ERP studies have also shown evidence for the mediating role of self-construal in cognition. Kitayama and Park [27] recorded ERPs from European

Americans and Asians while they performed a flanker task to earn reward points assigned either to themselves or a friend. Kitayama and Park found that the error-related negativity (ERN) — a form of brain activity contingent on error responses over the central/parietal region — was greater when participants performed the task for reward to the self relative to when rewards accrued for the friend. However, this self-centric effect was evident in European Americans but not in Asians. Furthermore, it was found that interdependent self-construal mediated the group difference in the ERN self-centric effect. Thus interdependent self-construal can be used to explain group differences in a neural correlate of self-centric motivation.

The mediating role of self-construal is not limited to brain activity underlying explicit self-related tasks. Na and Kitayama [28] reported culture-based variation in the N400, an ERP component sensitive to semantic processing. Presentation of a trait adjective was preceded by a facial photo with trait-implicating behavior that was semantically incongruent or congruent with the adjective. This effect was observed in European Americans but not in Asian Americans and the group difference in the N400 incongruity effect was mediated by independent self-construal. An earlier ERP study even reported that the parietal P3 component — a positive potential that peaks around 300–400 ms after stimulus onset with the maximum amplitude over the parietal or frontal scale sites — in response to target objects was larger in amplitude in European Americans than in East Asians and the group difference in the P3 amplitude was mediated by interdependent self-construal [29]. Taken together, these cross-cultural imaging studies indicate that group differences in brain activity engaged in different tasks/stimuli can be similarly mediated by the same cultural value, that is, the type of self-construal adopted by the individual.

### Priming interdependent/independent self-construals modulates brain activity

Cultural psychologists propose that an individual may identify with multiple cultural systems and may be able to switch between different cultural systems in response to specific social contexts and interactions [30]. This idea has stimulated investigations of how brain activity is modified by activation (or priming) of specific cultural values and beliefs. Based on an intervention through priming we may infer a causal relationship between culture and brain activity. The most frequent manipulation here has been the priming of interdependent/independent self-construals. A typical procedure to prime interdependent self-construal is to ask participants to read essays containing plural pronouns ('we' or 'us') or to think how the self is different from others. In contrast, to prime independent self-construal, participants read essays containing singular pronouns ('I' or 'me') or to think how the self is similar to others [31].

Early fMRI studies reported that priming independent compared to interdependent self-construals in Chinese participants induced greater right frontal activity in response to one's own face [32\*\*]. A later study found that priming individualistic vs. collectivistic values in Asian-Americans led to increased activation in self-related mPFC and posterior cingulate cortex (PCC) — a brain region engaged in episodic memory [33] — when participants reflected on their own traits in general [34]. Recent research has extended these early findings by demonstrating effects of self-construal priming on brain activity involved in other cognitive/affective processes. For example, priming East Asian Americans with interdependent values enlarged an N400 response to affective incongruity in the emotional expression of a central face relative to the surrounding faces as participants judged the expression of this central face [35], suggesting that interdependent self-construal facilitates attention to emotional context. Similarly, priming Chinese participants with interdependent self-construals increased the reward activity in the bilateral ventral striatum when winning money for a friend during a gambling game [36\*\*]; in this case, the activation of an interdependent processing mode may enhance reward associated with close

and large-scale emigration may generate more common cultural experiences across the globe. How do these within-lifetime changes modulate culturally-dependent thoughts and brain activity in future? We should not think of culture as a static factor but as an over-arching framework that is constantly evolving. Cultural neuroscience findings allow us to speculate and predict the emerging changes of the functional organization of the brain that provide a neural basis of social adaptation for the next generation.

## Conflict of interest statement

Nothing declared.

## Acknowledgements

This work was funded by the National Natural Science Foundation of China (Projects 31421003, 31470986, 91332125), the Ministry of Education of China (Project 20130001110049), and the Leverhulme Trust, United Kingdom.

## References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

•• of outstanding interest

- Nisbett RE, Peng K, Choi I, Norenzayan A: **Culture and systems of thought: holistic versus analytic cognition.** *Psychol Rev* 2001, **108**:291-310.
- Tsai JL: **Dynamics of ideal affect.** In *Changing Emotions*. Edited by Hermans D, Rimé B, Mesquita B. Psychology Press; 2013:120-126.
- Richerson PJ, Boyd R, Henrich J: **Gene-culture coevolution in the age of genomics.** *Proc Natl Acad Sci* 2010, **107**:8985-8992.
- Kim HS, Sasaki JY: **Cultural neuroscience: biology of the mind in cultural contexts.** *Ann Rev Psychol* 2014, **65**:487-514.
- Markus HR, Kitayama S: **Culture and the self: implications for cognition, emotion, and motivation.** *Psychol Rev* 1991, **98**:224-253.
- Su JC, Lee RM, Oishi S: **The role of culture and self-construal in the link between expressive suppression and depressive symptoms.** *J Cross-Cult Psychol* 2012, **44**:316-331.
- Ren XP, Lu KW, Tuerdi M: **Uyghur-Chinese and Han-Chinese differences on social orientation.** *Cult Brain* 2014, **2**:141-160.
- Kühnen U, Oyserman D: **Thinking about the self influences thinking in general: cognitive consequences of salient self-concept.** *J Exp Soc Psychol* 2002, **38**:492-499.
- Lin Z, Han S: **Self-construal priming modulates the scope of visual attention.** *Quart J Exp Psychol* 2009, **62**:802-813.
- Han S, Northoff G: **Culture-sensitive neural substrates of human cognition: a transcultural neuroimaging approach.** *Nat Rev Neurosci* 2008, **9**:646-654.
- Kitayama S, Uskul AK: **Culture, mind, and the brain: current evidence and future directions.** *Annu Rev Psychol* 2011, **62**:419-449.
- Han S, Northoff G, Vogeley K, Wexler BE, Kitayama S, Varnum MEW: **A cultural neuroscience approach to the biosocial nature of the human brain.** *Ann Rev Psychol* 2013, **64**:335-359.
- Chiao JY, Cheon BK, Pornpattananangkul N, Mrazek AJ, Blizinsky KD: **Cultural neuroscience: progress and promise.** *Psychol Inq* 2013, **24**:1-19.
- Gutchess AH, Welsh RC, Bodurođlu A, Park DC: **Cultural differences in neural function associated with object processing.** *Cogn Affect Behav Neurosci* 2006, **6**:102-109.
- This study scanned American and East Asians when viewing pictures of (1) a target object alone, (2) a background scene with no discernable target object, and (3) a distinct target object against a meaningful background. It was found that Americans, relative to East Asians, activated more regions implicated in object processing, including bilateral middle temporal gyrus, left superior parietal/angular gyrus, and right superior temporal/supramarginal gyrus. These results suggest that cultural experiences subtly direct neural activity, particularly for focal objects, at an early stage of scene encoding.
- Goh JO, Chee MW, Tan JC, Venkatraman V, Hebrank A, Leshikar ED, Park DC: **Age and culture modulate object processing and object-scene binding in the ventral visual area.** *Cogn Affect Behav Neurosci* 2007, **7**:44-52.
- Goh JO, Leshikar ED, Sutton BP, Tan JC, Sim SK, Hebrank AC, Park DC: **Culture differences in neural processing of faces and houses in the ventral visual cortex.** *Soc Cogn Affect Neurosci* 2010, **5**:227-235.
- Hedden T, Ketay S, Aron A, Markus HR, Gabrieli JD: **Cultural influences on neural substrates of attentional control.** *Psychol Sci* 2008, **19**:12-17.
- This study scanned East Asians and European Americans during performance of simple visuospatial tasks that required absolute judgments (ignoring visual context) or relative judgments (taking visual context into account). Both groups showed activations in frontal and parietal brain regions known to be associated with attentional control was greater during culturally non-preferred judgments than during culturally preferred judgments. The results suggest that the cultural background of an individual moderates activation in brain networks engaged during even simple visual and attentional tasks.
- Han S, Mao L, Qin J, Friederici AD, Ge J: **Functional roles and cultural modulations of the medial prefrontal and parietal activity associated with causal attribution.** *Neuropsychologia* 2011, **49**:83-91.
- This study investigated cultural differences in brain activity underlying causal attribution of physical events by scanning American and Chinese subjects. It was found that, while the medial prefrontal activity involved in causality judgments was comparable in the two cultural groups, the left parietal activity associated with causality judgments was stronger in Chinese than in Americans regardless of whether the contextual information was attended. The findings suggest that causal inference in the medial prefrontal cortex is universally implicated in causal reasoning whereas contextual processing in the left parietal cortex is sensitive to cultural differences in causality perception.
- Tang Y, Zhang W, Chen K, Feng S, Ji Y, Shen J, Liu Y: **Arithmetic processing in the brain shaped by cultures.** *Proc Natl Acad Sci* 2006, **103**:10775-10780.
- Zhu Y, Zhang L, Fan J, Han S: **Neural basis of cultural influence on self representation.** *NeuroImage* 2007, **34**:1310-1317.
- This study recorded brain activity using fMRI from Chinese and Westerners during reflection on personality traits of oneself and one's mother. The authors found overlapping activity in the medial prefrontal cortex during trait judgments on the self and mother in Chinese but stronger medial prefrontal activity during trait judgments on the self than mother in Westerners.
- Kobayashi C, Glover GH, Temple E: **Cultural and linguistic influence on neural bases of theory of mind': an fMRI study with Japanese bilinguals.** *Brain Lang* 2006, **98**:210-220.
- Ma Y, Bang D, Wang C, Allen M, Frith C, Roepstorff A, Han S: **Sociocultural patterning of neural activity during self-reflection.** *Soc Cogn Affect Neurosci* 2014, **9**:73-80.
- This study scanned Chinese and Danish participants using fMRI during judgments on physical, mental, and social attributes of oneself and a celebrity. It was found that Danish participants showed stronger activity in the medial prefrontal cortex during reflection on one's own attributes in all the three dimensions, whereas Chinese participants showed stronger activity in the temporoparietal junction during reflection on social attributes of the self.
- Northoff G, Heinze A, de Greck M, Bermpoh F, Dobrowolny H, Panksepp J: **Self-referential processing in our brain—a meta-analysis of imaging studies on the self.** *NeuroImage* 2006, **31**:440-457.
- Han S, Northoff G: **Understanding the self: a cultural**

25. Saxe R, Kanwisher N: **People thinking about thinking people: fMRI investigations of theory of mind.** *NeuroImage* 2003, **19**:1835-1842.
26. Singelis TM: **The measurement of independent and interdependent self-construals.** *Pers Soc Psychol Bull* 1994, **20**:580-591.
27. Kitayama S, Park J: **Error-related brain activity reveals self-centric motivation: culture matters.** *J Exp Psychol Gen* 2014, **143**:62-70.
28. Na J, Kitayama S: **Spontaneous trait inference is culture-specific: behavioral and neural evidence.** *Psychol Sci* 2011, **22**:1025-1032.
29. Lewis RS, Goto SG, Kong LL: **Culture and context east Asian American and European American differences in P3 event-related potentials and self-construal.** *Pers Soc Psychol Bull* 2008, **34**:623-634.
30. Hong Y, Morris M, Chiu C, Benet-Martinez V: **Multicultural minds: a dynamic constructivist approach to culture and cognition.** *Am Psychol* 2000, **55**:709-720.
31. Gardner WL, Gabriel S, Lee AY: **I value freedom, but — we value relationships: self-construal priming mirrors cultural differences in judgment.** *Psychol Sci* 1999, **10**:321-326.
32. Sui J, Han S: **Self-construal priming modulates neural substrates of self-awareness.** *Psychol Sci* 2007, **18**:861-866.   
 •• This is the first fMRI study that illustrates modulations of brain activity by cultural priming. The authors present fMRI evidence that the right frontal activity in response to one's own face is enhanced by independent vs. interdependent self-construal priming.
33. Cavanna AE, Trimble MR: **The precuneus: a review of its functional anatomy and behavioural correlates.** *Brain* 2006, **129**:564-583.
34. Chiao JY, Harada T, Komeda H, Li Z, Mano Y, Saito D, Iidaka T: **Dynamic cultural influences on neural representations of the self.** *J Cogn Neurosci* 2010, **22**:1-11.
35. Fong MC, Goto SG, Moore C, Zhao T, Schudson Z, Lewis RS: **Switching between Mii and Wii: the effects of cultural priming on the social affective N400.** *Cult Brain* 2014, **2**:52-71.
36. Varnum ME, Shi Z, Chen A, Qiu J, Han S: **When — Your reward is the same as — my reward: self-construal priming shifts neural responses to own vs. friends' rewards.** *NeuroImage* 2014, **87**:164-169.   
 This study manipulated participants' self-construal (independent vs. interdependent) and found that, when an independent self-construal was primed, subjects showed greater activation in the bilateral ventral striatum in response to winning money for the self (vs. for a friend) during a gambling game. However, priming an interdependent self-construal resulted in comparable activation in these regions in response to winning money for the self and for a friend. The findings suggest that interdependence may cause people to experience rewards for a close other as strongly as they experience rewards for the self.
37. Jiang C, Varnum MEW, Hou Y, Han S: **Distinct effects of self-construal priming on empathic neural responses in Chinese and Westerners.** *Soc Neurosci* 2014, **9**:130-138.
38. Wang C, Wu B, Liu Y, Wu X, Han S: **Challenging emotional prejudice by changing self-concept: priming independent self-construal reduces racial in-group bias in neural responses to other's pain.** *Soc Cogn Affect Neurosci* 2015, **10**:1195-1201.
39. Wang C, Ma Y, Han S: **Self-construal priming modulates pain perception: event-related potential evidence.** *Cogn Neurosci* 2014, **5**:3-9.
40. Obhi SS, Hogeveen J, Pascual-Leone A: **Resonating with others: the effects of self-construal type on motor cortical output.** *J Neurosci* 2011, **31**:14531-14535.
41. Wang C, Oyserman D, Li H, Liu Q, Han S: **Accessible cultural mindset modulates default mode activity: evidence for the culturally situated brain.** *Soc Neurosci* 2013, **8**:203-216.
42. Liu Y, Sheng S, Woodcock KA, Han S: **Oxytocin effects on neural correlates of self-referential processing.** *Biol Psychol* 2013, **94**:380-387.
43. Kitayama S, King A, Yoon C, Tompson S, Huff S, Liberzon I: **The dopamine D4 receptor gene (DRD4) moderates cultural difference in independent versus interdependent social orientation.** *Psychol Sci* 2014, **25**:1169-1177.
44. Ma Y, Wang C, Li B, Zhang W, Rao Y, Han S: **Does self-construal predict activity in the social brain network? A genetic moderation effect.** *Soc Cogn Affect Neurosci* 2014, **9**:1360-1367.
45. Luo S, Ma Y, Liu Y, Li B, Wang C, Shi Z, Li X, Zhang W, Rao Y, Han S: **Interaction between oxytocin receptor polymorphism and interdependent culture values on human empathy.** *Soc Cogn Affect Neurosci* 2015, **10**:1273-1281.   
 This study investigated whether and how oxytocin receptor polymorphism (OXTR rs53576) interacts with interdependence to affect human empathy. The authors scanned A/A and G/G homozygous of OXTR rs53576 during perception of others' pain. Hierarchical regression analyses revealed stronger associations between interdependence and empathic neural responses in the insula, amygdala and superior temporal gyrus in G/G compared to A/A carriers. The findings provide the first evidence for gene × culture interactions on empathic neural responses.