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# Self-construal: a cultural framework for brain function

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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 between East Asians and Westerners; and (b) priming interdependent/independent self-construals modulates brain activity engaged in sensory/motor and cognitive/affective processes. These findings provide new insights on human brain function and suggest that self-construals provide a cultural framework that constrains brain activity underlying multiple cognitive and affective processes.

## Addresses

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## Introduction

Culture, consisting of shared beliefs and behavioral scripts, has an enormous influence on human lives by providing a meaning system for both individuals and populations, which motivates their behavior within a particular cultural context. Culture functions as a framework for structuring behavior by setting up social rules and norms. Individuals start to learn specific cultural beliefs/values/norms and practice culturally specific behavioral scripts from early childhood. Cultural learning and experience not only help to formulate routine ways of doing things but also shape styles of mental (cognitive and affective) activity [1,2]. Cultural knowledge and traits are delivered from one generation to the next as an inheritance system that influence social/physical environments [3] and interacts with genes to shape human behavior [4].

Self-construal, that is, how an individual perceives, comprehends, and interprets the self, is one of the most important cultural traits that influences human behavior and has been used to explain cultural differences in behavior and cognition/emotion. Markus and Kitayama [5] proposed that Western culture encourages an independent self-construal that conceptualizes the self as an autonomous and bounded entity, emphasizing the independence and uniqueness of the self. In contrast, East Asian culture promotes an interdependent self-construal that conceptualizes the self as interconnected and overlapping with close others, emphasizing harmony with these close others. Self-construals mediate cultural group differences in emotion and cognition [6,7] and temporary priming of interdependent and independent self-construals leads to causal changes of cognition and behavior [8,9].

Interestingly, recent cultural neuroscience studies [10–13] have shown that influences of self-construals go beyond behavioral and psychological effects. By integrating brain-imaging techniques such as functional magnetic resonance imaging (fMRI) and event-related brain potentials (ERPs), researchers compared brain activity from two cultural groups dominated by independence or interdependence or recorded brain activity from one culture group after being primed with independence or interdependence. The results demonstrate that how we view the self and self/other relationships (i.e., self-construals) modulates the brain activity involved in self-referential processing and other cognitive/affective processes. Here, based on recent cultural neuroscience findings, we propose that these self-construals provide a cultural framework for the neural substrates of cognitive and affective processes. We review cross-cultural and self-construal priming imaging findings which indicate that the mode by which people think of the self (as either interdependent or independent), mediates cultural group differences in brain activity and causes changes of brain activity across a variety of tasks. These findings suggest that self-construal is a key cultural trait that activates a cognitive framework that constrains neural strategies and modulates the neural processes underlying cognition and emotion.

## Self-construals mediate cultural group differences in brain activity

Early cross-cultural brain imaging studies explored cultural influences on brain activity by searching for cultural group differences in neural activity. fMRI studies have reported distinct patterns of brain activity between participants from East Asian and Western societies in tasks

emphasizing visual perception [14<sup>••</sup>,15,16], attention [17<sup>••</sup>], causal attribution [18<sup>••</sup>], mental calculation [19], self-reflection [20<sup>••</sup>], 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<sup>••</sup>] 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 others. Priming self-construals also modulated empathic neural responses to strangers' physical pain that were decreased by interdependent self-construal priming among Chinese (possibly due to exclusion of strangers from ingroup by interdependent self-construal priming) but increased by independent self-construal priming among Westerners (possibly due to exclusion of any others from ingroup by independent self-construal priming) [37]. In addition, priming of independent self-construal, which possibly weakened ingroup/outgroup concept can reduce racial in-group biases in empathic neural responses within the anterior cingulate and insular [38].

Self-construal priming also modulates sensorimotor activity. Priming independent self-construals increased the amplitude of frontal EEG activity at about 130 ms after a painful electric shock was applied to the left hand of Chinese participants [39]. Here, the temporary shift in self-construal can affect pain perception by modulating the neural activities in early somatosensory processing of physical pain, suggesting that increased self-focus enhances pain experience. Priming interdependent self-construal compared to a no-priming baseline condition increased motor-evoked potentials induced by transcranial magnetic stimulation applied to the motor cortex [40], possibly due to that reminding the connections between oneself and others modulates the mirror system to tune the individual to social input. Self-construal priming even modulates the brain activity during a resting state (e.g., to keep eyes open and try not to think of anything particular). Wang *et al.* [41] first identified that, relative to a calculation task that required simple addition

and multiplication, both interdependent and independent self-construal priming increased activity in the ventral mPFC and PCC. They further revealed that interdependent compared to independent self-construal priming increased local synchronization of spontaneous activity in the dorsal mPFC but decreased local synchronization of spontaneous activity in the PCC during the resting state. These findings suggest that the interdependent self-construal priming may facilitate mental readiness for attention to social contexts whereas the independent self-construal priming may promote a mental readiness state for self-focusing. Taken together, these findings demonstrate variations of brain activity as a consequence of self-construal priming and thus provide evidence for a cause-effect relationship between specific cultural values and specific neurocognitive processes.

### Conclusion and directions for future research

The cultural neuroscience findings indicate that performing the same task involving the same stimuli can engage distinct patterns of brain activity in individuals from different societies, and these group differences in brain activity can be mediated by specific cultural values. Moreover, self-construal priming induces transient shifts in the default style of processing toward interdependent or independent ways of thinking, and this in turn is linked to changes in brain activity. These findings indicate that brain responses to stimuli during a task are, to a certain degree, constrained by both sustained (due to long-term cultural experiences) and transient cultural frameworks (due to short-term exposure to cultural values). This framework biases the brain to respond in a specific way to guide behaviors that can easily fit into a particular sociocultural context.

Cultural neuroscience findings raise important questions for future research. If there are sustained as well as transient effects of cultural factors, then it will be important to understand how these variations may be linked to intrinsic brain connectivity during a resting state [41]. Other research indicates that effects of the neurotransmitter/hormone oxytocin on brain responses were larger in those who showed stronger tendency of interdependence [42]. It is thus interesting to investigate how cultural values interact with the function of particular neurotransmitters in the brain. Also cultural differences in self-construals may be limited to individuals with specific genes (e.g., DRD4) ([43], also Kitayama *et al.*, in this special issue) and the associations between interdependence and brain activations linked to social cognition may also be genetically moderated (e.g., via the serotonin transporter polymorphism and oxytocin receptor gene) [44,45\*\*]. These results raise the question of whether and how the effects of culture on brain activity vary across individuals with different genotypes. Finally, there is the issue that cultural frameworks change over time — for instance, emerging factors such as the internet

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.

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