Cultural Neuroscience: Connecting Culture, Brain, and Genes

SHINOBU KITAYAMA and SARAH HUFF

Abstract

Cultural neuroscience emerged during the past decade at the intersection of cultural psychology, several subfields of human neuroscience, genetics, and epigenetics. In the present essay, we define the field, provide a selective review of its empirical accomplishment, and discuss its future directions. Cultural neuroscience conceptualizes the human mind as biologically prepared and grounded and, at the same time, as socially and culturally shaped and completed. This young field initially started as an effort to expand preceding behavioral work in cultural psychology with novel brain imaging methods. Increasingly, however, the field is poised to address the interplay between biology, environment, and behavior, as shown in our review of recent empirical work on (i) culture and the self, (ii) culture and genes, and (iii) multicultural identity. The future of the field hinges on several key initiatives including the use of brain stimulation methods, expansion of its database to cultures other than North America and Asia, and a more comprehensive analysis of gene–culture coevolution. In conclusion, we observe that further investigation of culture, brain, and genes may lead to an important insight that to study cultural diversity is no less to affirm the unity of humans as a common biological species.

INTRODUCTION

Cultural neuroscience has recently emerged as an important and highly promising area of investigation. The goal of the current essay is to introduce the rising field of cultural neuroscience, take stock of its progress, and then look over to its future. First, we discuss a general theoretical framework of cultural neuroscience. Second, we examine some select findings from the recent literature, with a focus on culture and the self, culture and genes, and multiculturalism. Third, we finish this essay by noting a few promising future directions for the field.

Emerging Trends in the Social and Behavioral Sciences. Edited by Robert Scott and Stephen Kosslyn.
 ISBN 978-1-118-90077-2.

CULTURAL NEUROSCIENCE: WHAT IS IT?

This section illustrates the overarching aim of the field of cultural neuroscience. It has been primarily defined in terms of the effort to expand the cultural psychological work with novel brain imaging methods. Increasingly, however, the field is poised to integrate evolutionary theory into the analysis of culture.

Is Culture "Embrained"?

Cultural neuroscience initially emerged as an effort to test whether cultural differences demonstrated in the preceding cultural psychological research (Kitayama, Duffy, & Uchida, 2007) could also be observed with novel brain measures such as functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG). For example, drawing on earlier behavioral evidence, Denise Park and colleagues have tested whether Asians are more holistic in visual attention than European Americans by using fMRI. In one study, researchers used fMRI and tested neural activity of the perceptual processing pathways devoted to an object versus its context (Gutchess, Welsh, Boduroĝlu, & Park, 2006). Researchers have focused on various components of EEG that are contingent on either stimulus onset or response execution (called event-related potential*s* or ERP*s*). They have then used the ERPs to examine cultural variations in holistic attention (Goto, Ando, Huang, Yee, & Lewis, 2010), self-evaluative threat (Park & Kitayama, 2012), and emotion suppression (Murata, Moser, & Kitayama, 2013). These initial efforts are informed by concurrent developments in various subdisciplines of neuroscience including cognitive, affective, and social neuroscience.

Simultaneously, there has been a resurgence of interest in neuroplasticity over the past decade (Maguire *et al.*, 2000). Researchers began documenting how malleable brain connectivity can be when individuals are trained in specific tasks such as juggling, spatial navigation, and meditation among many others. One seminal piece of evidence was reported by a group of researchers in the United Kingdom. They documented enlarged hippocampi (which serve a significant role in spatial navigation) among cab drivers in London (Maguire *et al.*, 2000). Crucially, the increased size of hippocampi was more pronounced for more experienced (and thus older) cabdrivers. The experience effect is remarkable because typically these brain regions steadily shrink in size as a function of age. This evidence thus suggests a causal influence of cab driving on the structural change of the brain.

As a whole, this newly reemerging work on neuroplasticity has provided an important theoretical rationale for the hypothesis that different aspects of the environment including cultural tools, practices, and tasks can change brain connectivity and possibly even structure. It may be hypothesized that through repeated active engagement in culturally prescribed tasks, the brain is often plastically changed over time. As a result, brain functions may eventually become closely attuned to the relevant tasks of a given cultural context (Kitayama & Uskul, 2011).

Grounding Culture in Biological Evolution

So far, much of the field of cultural neuroscience has been devoted to the effort to document cultural variations in brain functions (and structures). Some new findings with fMRI or EEG have gone far beyond what can be learned from behavioral indices alone. Now that much has been accomplished on this front, integrating both behavioral and neuroscience methods, the field appears poised to move on. Most importantly, the theoretical focus of cultural neuroscientists on the brain (a preeminently biological entity) in the analysis of culture has led them to novel questions regarding the possible links between culture and biological evolution (Chiao & Blizinsky, 2010; Kim & Sasaki, 2013; Kitayama *et al*., 2014). This work has begun to add important insights to the existing body of research in the area (Richerson & Boyd, 2008).

The currently reemerging interest in culture and evolution is reinforced by new evidence in population genetics. This evidence suggests that culture and genes must have coevolved ever since the advent of sedentary, increasingly non-kin-based forms of living over the past 10,000 years (Hawks, Wang, Cochran, Harpending, & Moyzis, 2007). One commonly cited example of culture or ecology influencing genes is the correspondence between geographic regions that support milk production and populations that carry genetic polymorphisms that afford more efficient lactose processing and, thus, tolerance of lactose during adulthood (Durham, 1991). The genetic changes that support lactose tolerance appear to be motivated by the adaptive need of pastoral people to process the milk and a variety of milk products. The case of lactose tolerance, however, is most likely to be only one example. The "10,000 year explosion" of genetic change in the recent human evolutionary history strongly suggests that there must be numerous other cases.

To account for the "10,000 year explosion," one must take into account many potentially relevant factors. For example, domestication of animals must have fostered strong selection of mutations that would protect humans against germs carried by the domesticated animals (Diamond, 1997). Likewise, invention of tools could make strong muscles obsolete, making it more advantageous to relocate biophysiological resources to other capacities, say, to dexterity in motor and cognitive functions. Furthermore, at the advent of larger social and cultural organizations, various genetic mutations that led to language processing, interpersonal empathy, or trust, and theory of mind capacities among many others, must have been strongly favored (Iriki & Taoka, 2011). Such large-scale social and cultural change must have taken place, at least in some parts of the world, approximately 9000 years ago (Diamond, 1997).

It would then follow that culture, as we know it today must have coevolved with a great variety of polymorphic genetic changes. That is to say, the genetic makeup of the protohumans was sufficient to give an initial impetus to certain rudimentary forms of culture. Once established, such cultural forms must have provided a new evolutionary context or adaptive niche in which further genetic change was fostered. This additional genetic change in turn must have helped humans elaborate their cultural forms and social structures. This mutual, recursive interaction between culture and genes must have accelerated over the past 10,000 years to produce the basis for the current, cultural form of human adaptation. While much of this analysis is theoretical at this point, there is a growing effort to test some aspects of this analysis by using a variety of methods including neuroimaging, genetics, and epigenetics and comparison with nonhuman primate species (Kim & Sasaki, 2013). Accordingly, there is increasing ground to argue that culture is not a mere overlay that should be set aside as noise in the investigation of the human mind/brain. To the contrary, it is likely to be the primary shaper of the human mind/brain over the past 10,000 years and, therefore, culture is a necessary element to take into account in the investigation of all aspects of the human mind/brain.

The interest in the coevolution of culture and genes is accompanied by another line of work on epigenetics, which examines environmental influences on gene expression (Cole, 2009). At the cellular level, DNAs are transcribed into RNAs, which in turn are translated into the production of relevant proteins. It is these proteins that eventually produce a variety of effects on neurophysiological, psychological, and behavioral responses. It has become increasingly clear that multiple processes are involved in the regulation of DNA transcription. While many of these processes are robust with respect to environmental variations, some are quite malleable, operating very differently depending on relevant environmental inputs. So far, much of this work is limited to effects of adverse environmental conditions (e.g., trauma, stress, and childhood abuse) on both the upregulation of inflammation-related genes and the downregulation of genes linked to immune-system responses (Cole, 2009). Extrapolating from this emerging work it is reasonable to hypothesize that other parameters of cultural environment may also regulate expression of relevant genes. These additional dimensions of culture include prevalence of competition versus cooperation, hierarchy (vs egalitarianism), and tightness (vs looseness) of cultural rules. The patterns of gene expression may become the part and parcel of the cultural system that is characterized by these parameters.

Cultural Neuroscience Defined

In sum, cultural neuroscience is emerging at the intersection of cultural psychology, several subfields of human neuroscience, genetics, and epigenetics. It conceptualizes the human mind as biologically prepared and grounded and, at the same time, as socially and culturally shaped, modified, and completed. The field is young. As noted earlier, it is only several years since the publication of the first paper bearing this name (Chiao & Ambady, 2007). The growth of the field is rapid, however. Now there is a substantial body of empirical work highlighting its promise and potential.

CURRENT EVIDENCE: A SELECTIVE REVIEW

In this section, we discuss the emerging empirical base of the field. Owing to space limitation, our literature review is selective, with a focus on three issues: (i) culture and the self, (ii) culture and genes, and (iii) multicultural identity.

Culture and the Self

Throughout the past two decades, cultural psychological work has drawn on global, macroscopic cross-cultural comparisons (Markus & Kitayama, 1991). The central assumption in this literature is that European Americans tend to be independently oriented. Thus, they are more eager to pursue personal (vs social) goals, focus on goal-relevant objects, and seek to maintain and enhance positive evaluations of their personal self. They are, therefore, motivated to increase self-esteem and self-efficacy, while valuing expression of these positive aspects of the self. In contrast, Asians tend to be interdependently oriented. Thus, they are more eager to pursue social (vs personal) goals, holistically attentive to norms and expectations of others, and seek to maintain and enhance in-group harmony, while inhibiting personal feelings and desires of the self. In the recent years, this behavioral work has been expanded with novel neuroscience methods (Kitayama & Uskul, 2011).

To begin with, the assumption that cultures vary on the social orientation dimension of independence and interdependence has received increasing support in recent cultural neuroscience research. In one early study, Zhu and colleagues (Zhu, Zhang, Fan, & Han, 2007) tested brain activity involved in the processing of the self and close others. Earlier social neuroscience evidence showed that the processing of information about the self (e.g., Am

I smart?) implicates the midline structure of the brain including the medial prefrontal cortex (mPFC), as well as, at least under certain conditions, the posterior cingulate cortex (PCC) (Kelley *et al.*, 2002). Zhu and colleagues found that the mPFC is recruited during the processing of the self regardless of culture. However, the same region is also recruited during the processing of information about close others (e.g., Is my mother smart?) for Chinese. The pattern is consistent with the hypothesis that Chinese selves are inclusive of close others such as their mothers (i.e., they are more interdependent), but the selves of the Westerners are not (i.e., they are independent).

Another way in which the self may be interdependent hinges on the degree to which perspectives of others are incorporated into the representation of the self. While independent selves may be defined primarily in terms of what they think of themselves, interdependent selves may incorporate judgments about the self from the perspective of relevant others (e.g., What do they think of me?). Consistent with this possibility, existing behavioral evidence shows that public aspects of the self are more important for Asians than for European Americans (Cohen, Hoshino-Browne, & Leung, 2007).

In a recent cross-cultural neuroimaging study, researchers asked both Danish adults in Denmark and Chinese adults in China to make judgments about physical, psychological, or social attributes of either the self or a public figure (Ma *et al.*, 2012). Regardless of culture and specific attributes at issue, the mPFC was consistently activated more in the self-judgment than in the judgment about the public figure. Importantly, in addition to the mPFC, Chinese showed a reliable activation of temporoparietal function (TPJ) when judging social aspects of the self (e.g., Am I a college student?). The TPJ is implicated in perspective taking (Decety & Lamm, 2007). Thus, one interpretation of the TPJ activity observed only for Chinese is that for Chinese self-processing simultaneously involves both direct appraisals (appraisals made from the first-person perspective, recruiting the mPFC) and indirect appraisals (appraisal made from third-person perspectives, recruiting the TPJ).

Intriguingly, as shown in, a functional connectivity analysis established that functional neural connections between mPFC and bilateral TPJ were much stronger for Chinese than for Danes during the judgment of social attributes of the self. We may infer from this result that the Chinese self is constituted by a more integrated, or holistic, representation of both direct and indirect appraisals. In comparison, the Western self appears more one-dimensional in the sense that it is defined largely on the basis of the first-person perspective alone.

Are independent selves more self-centric? Conversely, are interdependent selves more prosocial, ready to act on behalf of close others? Another recent cultural neuroscience study (Kitayama & Park, 2013) examined this question by taking advantage of a component of ERPs called error-related negativity (ERN). ERN is a negative-going deflection of electrocortical response that is contingent on error response in a simple cognitive task. Both European American and Asian participants were asked to perform a flanker task, wherein they were shown a series of five letters and asked to identify the center letter. When an error is made in the task, ERN is observed nearly simultaneously with the error response itself. Prior work suggests that ERN is caused by the detection of a mismatch between the executive response and the correct response. Importantly, ERN increases in magnitude as a function of the motivational significance of the cognitive task at hand. On the basis of this evidence, Kitayama and Park (2013) used the magnitude of ERN and tested whether the cognitive task may become motivationally more significant when performed for the self versus close friends.

The results were consistent with the expectation that independent selves are more self-centric than interdependent selves. As shown in Figure 1, ERN was significantly greater when European Americans performed the flanker task to earn points for themselves than when they did so to earn points on behalf of their friends. In contrast, Asians showed an equally strong ERN when they performed the task to earn points on behalf of their friends as when they did so to earn points for themselves. Importantly, the self-centric motivation as revealed in the ERN pattern became weaker as a function of interdependent self-construal. It thus appears that European Americans show the self-centric effect (while Asians do not) primarily because European Americans do not endorse the interdependent self-construal as strongly as Asians do.

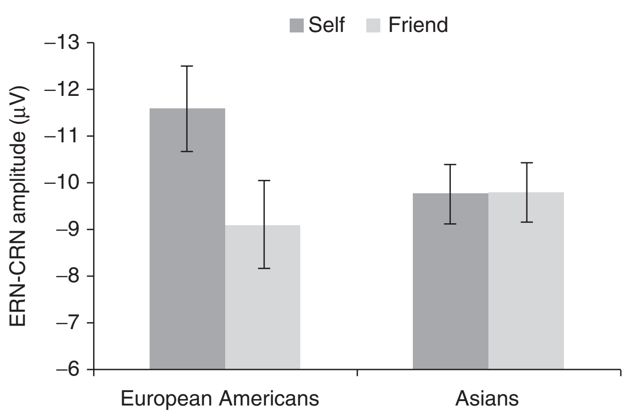

Figure 1 Magnitude of error-related negativity (ERN) shown by European Americans and Asians who performed a flanker task in order to earn reward points for either the self or their close friends. *Source*: Taken from Kitayama & Park, 2013, *Journal of Experimental Psychology: General*.

Culture and Genes

Although the evidence is clear that Asians are relatively more interdependent while European Americans are relatively more independent, this by no means implies that each cultural group is homogeneous. One important consideration that may shed new light on within-culture variation is potentially significant genetic differences across individuals. Traditionally, genes are seen as an alternative source of explanation for cultural differences. Such genetic explanations are seen as antagonistic to explanations in terms of experience. However, a recent discovery of plasticity genetic alleles has suggested that the conceptual juxtaposition of genes and experience may be misguided. Instead, allelic variations of certain genes may magnify the effects of experience (Belsky & Pluess, 2009). These alleles (called *plasticity alleles*) may magnify the effects of cultural experience (Kim & Sasaki, 2013).

One intriguing possibility suggests itself. We may start with the assumption that culture is learned, at least in part, through reinforcement learning. Not particularly controversial or novel by itself, this assumption can lead to an intriguing prediction once it is realized that individuals may vary in terms of genetic endowment that predisposes them to increased responsiveness to social rewards. We may expect that those who are genetically responsive to social rewards are more likely to acquire cultural norms and internalize them, as compared to those who are genetically less responsive to social rewards. Responsiveness to social rewards is strongly influenced by reward processing in the brain, which is regulated by a neurotransmitter, dopamine. One well-studied gene that regulates the signaling capacity of dopamine in the central nervous system is the dopamine D4 receptor gene (*DRD4*).

DRD4 is unique in two important respects. First, in one polymorphic region of the gene there are numerous variants that are defined by repetition of a particular genetic segment. The repetition can be as few as 2, but it can also be as many as 11. The most frequent variants are 2-repeat, 4-repeat, and 7-repeat. As it turns out, relative to 4-repeat carriers, carriers of 2- or 7-repeat variants show an increased capacity of dopamine signaling (Nikolova, Ferrell, Manuck, & Hariri, 2011). Correspondingly, the 2-repeat or 7-repeat carriers are likely to show enhanced sensitivity to rewards in general and to social rewards in particular. Second, a recent DNA-sequencing study that uses linkage-disequilibrium haplotype as a measure of the "genetic age" has shown that the 4-repeat variant is the most ancient form, from which the 7-repeat variant emerged around 40,000–50,000 years ago. Moreover, the 2-repeat variant is much more recent, emerging approximately 10,000 years ago. It is apparent then that these variants of *DRD4* emerged in the relatively recent past of the human evolution, when various cultural forms, as well as increasingly complex social structures and organizations that support them, were concurrently emerging. Accordingly, it is sensible to hypothesize that the allelic variations of DRD4 have coevolved with culture over the past 50,000 years (Chen, Burton, Greenberger, & Dmitrieva, 1999).

Will cultural norms be acquired to varying extents depending on genetically influenced responsiveness of each person to social rewards? In a recent study (Kitayama *et al*., 2014), approximately 400 undergraduates at the University of Michigan were genotyped for *DRD4*. About half were North Americans of European descent, while the remaining were Asians who had been born and raised in Asia. Replicating numerous previous studies, the researchers observed that European Americans are relatively more independent, whereas Asian-born Asians are relatively more interdependent. Importantly, as expected, this cultural difference was more pronounced for carriers of the 2- or 7-repeat variant of *DRD4*, relative to noncarriers. Indeed, among the noncarriers, the cultural difference was negligible. This finding is illustrated in Figure 2. Analogous moderation of cultural differences by

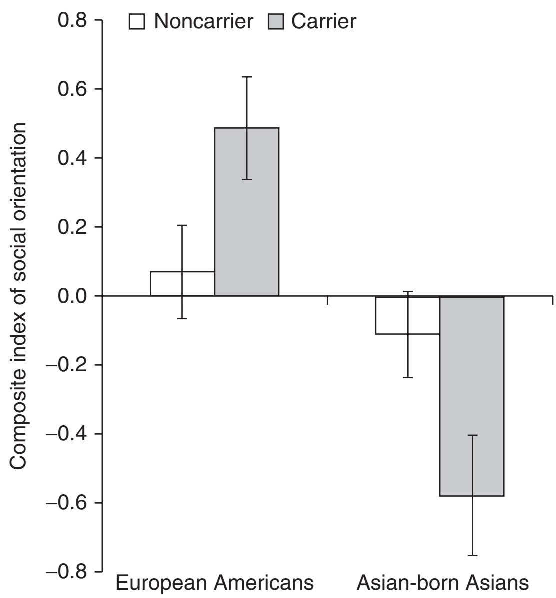

Figure 2 Culture × *DRD4* interaction effect on independent versus interdependent social orientation, as assessed by a difference between independence factor score and interdependence factor score. European Americans are more independent, while Asian-born Asians are more interdependent, but this is the case only for those who carry either 2- or 7-repeat variant of the *DRD4* gene. Among noncarriers there is no reliable cultural difference in social orientation. *Source*: Taken from Kitayama *et al*. (2014), *Psychological Science*.

oxytocin genes has also been reported, with new insights into how genes might interact with culture (Kim *et al*., 2010).

MULTICULTURAL IDENTITY

In the current, increasingly globalizing world, people are likely to hold multicultural identities. Another strand of cultural neuroscience work has investigated individuals with multiple cultural identities—individuals who are familiar with and knowledgeable about multiple cultural meaning systems. The guiding hypothesis is that multicultural individuals are able to access different cultural meaning systems depending on the contextual cues (Hong, Morris, Chiu, & Benet-Martinez, 2000). For example, an Asian American may endorse more independent self-construal after exposure to American cultural icons, whereas the same individual may endorse more interdependent self-construal following exposure to Asian cultural icons.

Evidence suggests that cultural priming is equally effective in modulating brain responses in a theoretically predictable manner. Previous behavioral work suggests that as compared to Asians, European Americans tend to define themselves in terms of general personal attributes (e.g., I am smart). In contrast, Asians tend to define themselves in a more context-dependent manner (e.g., I am smart at work for the most part) (Cousins, 1989). A recent fMRI study has shown that Asian Americans show both of these two response patterns depending on which cultural frame is made cognitively salient (i.e., primed). After being primed with independence, the Asian Americans exhibited a pattern that may be predicted for Westerners. That is, there was a reliably stronger activity in the midline cortical region of the brain (the areas noted earlier including the mPFC and the PCC that are recruited in self-processing) while judging themselves in context-general (vs context-dependent) terms. In contrast, after being primed with interdependence, they exhibited a pattern that may be predicted for Asians. That is, there was stronger activity in the same region in the context-dependent (vs context-general) judgment condition. We noted earlier that whereas Chinese show reliable mPFC activity when judging both the self and their mother, Westerners show this activity only when judging the self (Zhu *et al*., 2007). Recent evidence shows that bicultural Asians in Hong Kong show both of these patterns depending on cultural priming (Ng, Han, Mao, & Lai, 2010). Similar cultural frame switching has been observed with an ERP indicator of processing of the self versus friend (Sui, Liu, & Han, 2009).

In all likelihood, further work along this line is likely to reveal a more nuanced picture of how multicultural experiences might shape the brain. For example, a recent study examining Asian Americans in the United States (Huff, Yoon, Lee, Mandadi, & Gutchess, 2013) finds, as in the Zhu *et al*.

(2007) study discussed above, that the mPFC is recruited by processing of both the self and mother. Unlike the Zhu *et al*. (2007), however, this study observed the mPFC activity to be greater in the mother processing than in the self-processing.

CONCLUSIONS

The ultimate aim of cultural neuroscience is to achieve a more comprehensive understanding of how biology and culture might make each other up in constituting the human mind. Recent empirical work illustrates the considerable promise of the field by underscoring the power of neuroscience methods such as fMRI and EEG to uncover cultural influences on the brain. Further, the initial evidence for gene × culture interaction effects highlights the possibility that the human mind has significantly been shaped, genetically, over the past 10,000 years through its engagement with cultural environment. Cultural neuroscience started several years ago with a single-minded curiosity to see if behavioral cultural differences might replicate with neuroscience methods such as fMRI and EEG. The field has grown quite quickly. Indeed, so much so that it is now poised to address the interplay between biology, environment, and behavior.

The future of cultural neuroscience hinges on several key initiatives. First, as in other fields of neuroscience, neural data are often correlational, limiting the researcher's ability to make causal inferences. Creative use of brain stimulation methods such as transcranial magnetic stimulation is much needed (Obhi, Hogeveen, & Pascual-Leone, 2011). Second, cultures other than North America and Asia must be covered, along with important within-culture variations (Kitayama, Ishii, Imada, Takemura, & Ramaswamy, 2006; Talhelm *et al*., 2014). Third, markers of genetic ancestry (called *ancestry-informative markers*) may be utilized to explore another thorny issue (Pennisi, 2007), namely, the question of whether observed cultural differences are truly cultural (mediated by acculturation) or at least in part genetic (mediated by genetic proximity to certain ethnic ancestries). Fourth, it is likely that, in the near future, there will be a more comprehensive analysis of genetics and epigenetics in the context of cultural neuroscience (Cole, 2009). This work may prove to be instrumental in testing the hypothesized gene × culture coevolution.

Last, but not least, cultural neuroscience may offer a new insight into how we as a society may think about the relationship between cultural diversity and human unity. As noted earlier, evidence is already growing that human cultural diversity is an important consequence of the human mode of biological adaptation over the past 10,000 years. Accordingly, the ensuing investigation into culture, brain, and genes may lead to an important conclusion that to study cultural diversity is no less to affirm the unity of humans as a common biological species.

REFERENCES

Belsky, J., & Pluess, M. (2009). Beyond diathesis stress: Differential susceptibility to environmental influences. *Psychological Bulletin*, *135*(6), 885–908. doi:10.1037/a0017376

Chen, C., Burton, M., Greenberger, E., & Dmitrieva, J. (1999). Population migration and the variation of dopamine D4 receptor (DRD4) allele frequencies around the globe. *Evolution and Human Behavior*, *20*(5), 309–324. doi:10.1016/S1090-5138(99)00015-X

Chiao, J. Y., & Ambady, N. (2007). Cultural neuroscience: Parsing universality and diversity across levels of analysis. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology*. NewYork, NY: Guilford Press.

Chiao, J. Y., & Blizinsky, K. D. (2010). Culture-gene coevolution of individualism-collectivism and the serotonin transporter gene. *Proceedings of the Royal Society B: Biological Sciences*, *277*(1681), 529–537. doi:10.1098/rspb.2010.0714

Cohen, D., Hoshino-Browne, E., & Leung, A. K. (2007). Culture and the structure of personal experience: Insider and outsider phenomenologies of the self and social world. *Advances in Experimental Social Psychology*, *39*, 1–67.

Cole, S. W. (2009). Social regulation of human gene expression. *Current Directions in Psychological Science*, *18*(3), 132–137.

Cousins, S. D. (1989). *Culture and self-perception in Japan and the United states* (Vol. 56, pp. 124–131). *Journal of Personality and Social Psychology*.

Decety, J., & Lamm, C. (2007). The role of the right temporoparietal junction in social interaction: How low-level computational processes contribute to meta-cognition. *The Neuroscientist*, *13*, 580–593.

Diamond, J. M. (1997). *Guns, germs, and steel*. New York, NY: W. W. Norton & Company.

Durham, W. H. (1991). *Coevolution: Genes, culture, and human diversity*. Stanford, CA: Stanford University Pess.

Goto, S. G., Ando, Y., Huang, C., Yee, A., & Lewis, R. S. (2010). Cultural differences in the visual processing of meaning: Detecting incongruities between background and foreground objects using the N400. *Social Cognitive and Affective Neuroscience*, *5*, 242–253.

Gutchess, A. H., Welsh, R. C., Boduroĝlu, A., & Park, D. C. (2006). Cultural differences in neural function associated with object processing. *Cognitive, Affective, & Behavioral Neuroscience*, *6*(2), 102–109. doi:10.3758/CABN.6.2.102

Hawks, J., Wang, E. T., Cochran, G. M., Harpending, H. C., & Moyzis, R. K. (2007). Recent acceleration of human adaptive evolution. *Proceedings of the National Academy of Sciences*, *104*(52), 20753–20758.

Hong, Y.-Y., Morris, M. W., Chiu, C.-Y., & Benet-Martinez, V. (2000). Multicultural minds: A dynamic constructivist approach to culture and cognition. *American Psychologist*, *55*(7), 709–720. doi:10.1037/0003-066X.55.7.709

Huff, S., Yoon, C., Lee, F., Mandadi, A., & Gutchess, A. H. (2013). Self-referential processing and encoding in bicultural individuals. *Culture and Brain*, *1*(1), 16–33. doi:10.1007/s40167-013-0005-1

Iriki, A., & Taoka, M. (2011). Triadic (ecological, neural, cognitive) niche construction: a scenario of human brain evolution extrapolating tool use and language from the control of reaching actions. *Philosophical Transactions of the Royal Society, B: Biological Sciences*, *367*(1585), 10–23.

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, *14*(5), 785–794. doi:10.1162/08989290260138672

Kim, H. S., & Sasaki, J. Y. (2013). Cultural neuroscience: Biology of the mind in cultural contexts. *Annual Review of Psychology*, *65*(1), 130919205320001. doi:10.1146/annurev-psych-010213-115040

Kim, H. S., Sherman, D. K., Sasaki, J. Y., Xu, J., Chu, T. Q., Ryu, C., *et al*. (2010). Culture, distress, and oxytocin receptor polymorphism (OXTR) interact to influence emotional support seeking. *Proceedings of the National Academy of Sciences*, *107*(36), 15717–15721. doi:10.1073/pnas.1010830107

Kitayama, S., & Park, J. (2013). Error-related brain activity reveals self-centric motivation: Culture matters. *Journal of Experimental Psychology: General*. doi:10.1037/a0031696

Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain: Current evidence and future directions. *Annual Review of Psychology*, *62*(1), 419–449. doi:10.1146/annurev-psych-120709-145357

Kitayama, S., Duffy, S., & Uchida, Y. (2007). Self as cultural mode of being. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology* (pp. 136–174). New York: Guilford.

Kitayama, S., Ishii, K., Imada, T., Takemura, K., & Ramaswamy, J. (2006). Voluntary settlement and the spirit of independence: Evidence from Japan's 'northern frontier.' *Journal of Personality and Social Psychology*, *91*(3), 369–384.

Kitayama, S., King, A., Yoon, C., Tompson, S., Huff, S., & Liberzon, I. (2014). The dopamine D4 receptor gene (DRD4) moderates cultural difference in independent versus interdependent social orientation. *Psychological Science*. doi:10.1177/0956797614528338

Ma, Y., Bang, D., Wang, C., Allen, M., Frith, C., Roepstorff, A., & Han, S. (2012). Sociocultural patterning of neural activity during self-reflection. *Social Cognitive and Affective Neuroscience*. doi:10.1093/scan/nss103

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S. J., & Frith, C. D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences*, *97*, 4398–4403.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*(2), 224–253. doi:10.1037/0033-295X.98.2.224

Murata, A., Moser, J. S., & Kitayama, S. (2013). Culture shapes electrocortical responses during emotion suppression. *Social Cognitive and Affective Neuroscience* Retrieved from http://scan.oxfordjournals.org/content/8/5/595.short.

Ng, S. H., Han, S., Mao, L., & Lai, J. C. L. (2010). Dynamic bicultural brains: fMRI study of their flexible neural representation of self and significant others in response to culture primes. *Asian Journal of Social Psychology*, *13*(2), 83–91. doi:10.1111/j.1467-839X.2010.01303.x

Nikolova, Y. S., Ferrell, R. E., Manuck, S. B., & Hariri, A. R. (2011). Multilocus genetic profile for dopamine signaling predicts ventral striatum reactivity. *Neuropsychopharmacology*, *36*(9), 1940–1947. doi:10.1038/npp.2011.82

Obhi, S. S., Hogeveen, J., & Pascual-Leone, A. (2011). Resonating with others: The effects of self-construal type on motor cortical output. *Journal of Neuroscience*, *31*(41), 14531–14535.

Park, J., & Kitayama, S. (2012). Interdependent selves show face-induced facilitation of error processing: cultural neuroscience of self-threat. *Social Cognitive and Affective Neuroscience*. doi:10.1093/scan/nss125

Pennisi, E. (2007). Human genetic variation. *Science*, *318*(5858), 1842–1843. doi:10.1126/science.318.5858.1842

Richerson, P. J., & Boyd, R. (2008). *Not by genes alone: How culture transformed human evolution*. Chicago, IL: Chicago University Press.

Sui, J., Liu, C. H., & Han, S. (2009). Cultural difference in neural mechanisms of self-recognition. *Social Neuroscience*, *4*(5), 402–411.

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., & Kitayama, S. (2014). Large-scale psychological differences within China explained by rice versus wheat agriculture. *Science*, *344*, 603–608.

Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *NeuroImage*, *34*, 1310–1316.

SHINOBU KITAYAMA SHORT BIOGRAPHY

Shinobu Kitayama received his PhD from the University of Michigan, where he is currently Robert B. Zajonc Collegiate Professor of Psychology and the Director of the Center for Culture, Mind, and the Brain. He also directs the Culture and Cognition Program. His research focuses on cultural variations in cognition, emotion, and motivation. In the recent years, he has used neuroscience measures such as functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG) to investigate the nature of dynamic, recursive interaction between culture and the brain. He has also investigated how social orientations and other psychological characteristics might be acquired as a joint function of both genetic endowment and cultural experience. Before Michigan, he also taught at the University of Oregon, Kyoto University, and the University of Chicago. He was elected to be a Fellow at the Center for Advanced Studies in Behavioral Sciences twice (1995–1996, 2007–2008). He was a recent recipient of a Guggenheim Fellowship (2010–2011). He is an elected member of the American Academy of Arts and Sciences.

SARAH HUFF SHORT BIOGRAPHY

Sarah Huff is a PhD student in Psychology at the University of Michigan. Before arriving at Michigan she received her Master's Degree from Brandeis University and Bachelor's Degree from The Colorado College, both in Psychology. Her research focuses on self, identity, and culture. She is currently working on projects using neuroimaging (fMRI) to investigate how culture and genetic variations influence thinking about the self, emotion regulation, and making choices for the self and others. Sarah is also interested in how individuals manage multiply identities, especially different cultural identities. She is very excited to be spending this summer in Singapore as a National Science Foundation East Asia and Pacific Summer Institutes fellow studying multicultural identity and cultural adaptation.

RELATED ESSAYS

The impact of Bilingualism on Cognition *(Psychology)*, Ellen Bialystok
Language, Perspective, and Memory *(Psychology)*, Rachel A. Ryskin *et al.*
Emerging Trends: Asset Pricing *(Economics)*, John Y. Campbell
Cultural Differences in Emotions (*Psychology*), Jozefien De Leersnyder *et al*.
Understanding the Adaptive Functions of Morality from a Cognitive Psychological Perspective *(Psychology)*, James Dungan and Liane Young
State of the Art in Competition Research *(Psychology)*, Márta Fülöp and Gábor Orosz
Economics and Culture *(Economics)*, Gérard Roland
Language and Thought *(Psychology)*, Susan Goldin-Meadow
Genetics and Social Behavior *(Anthropology)*, Henry Harpending and Gregory Cochran
An Evolutionary Perspective on Developmental Plasticity *(Psychology)*, Sarah Hartman and Jay Belsky
Biology and Culture *(Psychology)*, Robert Peter Hobson
Group Identity and Political Cohesion *(Political Science)*, Leonie Huddy
The Development of Social Trust *(Psychology)*, Vikram K. Jaswal and Marissa B. Drell
Genetic Foundations of Attitude Formation *(Political Science)*, Christian Kandler *et al*.
Resource Limitations in Visual Cognition *(Psychology)*, Brandon M. Liverence and Steven L. Franconeri

Evolutionary Perspectives on Animal and Human Personality *(Anthropology)*, Joseph H. Manson and Lynn A. Fairbanks
Emerging Trends in Culture and Concepts *(Psychology)*, Bethany Ojalehto and Douglas Medin
Neural and Cognitive Plasticity *(Psychology)*, Eduardo Mercado III
A Bio-Social-Cultural Approach to Early Cognitive Development: Entering the Community of Minds *(Psychology)*, Katherine Nelson
Culture as Situated Cognition *(Psychology)*, Daphna Oyserman
Darwinism as a Decryption Key for the Human Mind *(Psychology)*, Csaba Pléh and Ottilia Boross
Attention and Perception *(Psychology)*, Ronald A. Rensink
The Role of Cultural, Social, and Psychological Factors in Disease and Illness *(Sociology)*, Robert A. Scott
Social Neuroendocrine Approaches to Relationships *(Anthropology)*, Sari M. van Anders and Peter B. Gray
The Intrinsic Dynamics of Development *(Psychology)*, Paul van Geert and Marijn van Dijk
How Form Constrains Function in the Human Brain *(Psychology)*, Timothy D. Verstynen
Speech Perception *(Psychology)*, Athena Vouloumanos
Theory of Mind *(Psychology)*, Henry Wellman
Behavioral Heterochrony *(Anthropology)*, Victoria Wobber and Brian Hare