

Culture and the Brain

Nalini Ambady and Jamshed Bharucha

Tufts University

ABSTRACT—*The goal of this article is to highlight recent work examining how culture affects neural activation. We suggest a framework for cultural neuroscience in which there are two objectives: culture mapping—or the mapping function from patterns characteristic of cultures to their neural processing—and source analysis—or the attempt to determine the sources of observed commonalities and differences. We review links between culture and the brain across fundamental domains of cognitive and social psychology.*

KEYWORDS—*culture; neuroscience; brain*

Culture and the brain historically have often been the subjects of different forms of discourse. But a growing recognition of the extent of the brain's plasticity, of the evolutionary basis of cognition, and of the coevolution of culture and the brain makes clear that cultural and neural processes are interwoven. Recent research on the ways in which the behaviors of individuals within a group converge or individuals across groups diverge, and on the neural mechanisms underlying these commonalities and differences, has paved the way for an emerging field: the neuroscience of culture.

Among its many functions, the brain is wired to enable social behavior and to adapt to new social groupings and patterns. Some of this wiring is a result of the coevolution of culture and the brain: Cultural practices adapt to neural constraints, and the brain adapts to cultural practice. Other circuits are wired as a result of learning, particularly implicit learning. In this latter respect, the brain is a cultural sponge—indeed, possibly, the organ of culture. It internalizes the structural regularities of its environment within the parameters of innate and developmental constraints, and it employs these internalized representations to facilitate interaction with the physical and social world.

Two fundamental objectives motivate the neuroscience of culture. The first is to map the cultural architecture of the brain. We call this culture mapping. The second is source analysis, the attempt to tease apart the sources of cultural mappings.

Address correspondence to Nalini Ambady, Department of Psychology, Tufts University, 490 Boston Avenue, Medford, Massachusetts 02155; e-mail: nalini.ambady@tufts.edu.

CULTURE MAPPING

Culture mapping is a research strategy that involves mapping cognitive or neural differences across cultures. It involves determining which cognitive or neural processes vary across cultures without determining whether the differences are learned or innate.

Culture mapping can take one of two forms. Both forms of culture mapping imply a tuning of cognitive or neural processes to the cultural environment. First, culture mapping can show how the environments of different cultures are processed differently by individuals from a given culture. This involves comparing the processing of familiar versus unfamiliar environments. For example, Americans process Western and Indian music differently. More specifically, Americans listening to sequences of tones whose pitches conform to familiar Western musical scales expect or mistakenly remember tones that were not played but that are typically played in the context of the sounded tones. In contrast, if the scales are from Indian music, Americans are less likely to expect or mistakenly remember tones that were not played but that are typically played (Curtis & Bharucha, 2009).

Second, culture mapping can show how the same environment is processed differently by individuals from different cultures. Differences in how Americans and Indians perceive music can be instructive here as well. Castellano, Bharucha, and Krumhansl (1984) found that although Western listeners could use the distribution of pitches to determine which are more stable than others in renditions of Indian classical music, the ratings of Indian listeners showed evidence of prior implicit knowledge of Indian *ragas* or melodic forms.

Examples of culture mapping are varied, so we will cite just a few to illustrate the range. Tang et al. (2006) examined the brain activity of native English and native Chinese speakers while performing three numerical tasks and a non-numerical task. Native English speakers showed more activation in the left perisylvian cortices such as Wernicke's and Broca's areas, which are associated with language processing, whereas Native Chinese speakers showed more activation in a visual-premotor association area, which is associated with visual-spatial processing and functions closely tied to cognitive functioning during the numerical tasks. These findings might be attributed to exposure to different visual patterns. Greater premotor activity for native

Chinese speakers could be due to the visuospatial nature of the Chinese language, whereas activation of language areas for English speakers suggests that, for them, the retrieval of mathematical facts may be mediated by phonological processing.

In the domain of perception, several studies suggest that Westerners tend to focus on objects whereas East Asians tend to focus on contextual and background information. Neural tuning associated with culture was suggested by a study in which Westerners demonstrated greater activation in brain areas associated with attentional control on a visuospatial task involving the judgments of the length of a line inside a box when making absolute judgments (ignoring the context—the size of the box); East Asians showed more engagement in these areas when making relative judgments (attending to the size of the box; Hedden, Ketay, Aron, Markus, & Gabrieli, 2008).

A similar pattern showing cultural effects on perception and neural activation was found by Gutchess, Welsh, Boduroglu, and Park (2006), who compared neural activation between East Asian Americans and non-Asian Americans as they performed a task involving the recognition of complex pictures showing an object against a background. East Asian Americans and non-East Asian Americans performed equally well but recruited different brain regions during the task. Asian Americans showed more activation in the object-processing areas in the ventral visual cortex than did the non-Asian Americans; the latter showed more activation in the left occipital and fusiform areas, which are associated with perceiving figure-ground relations.

In the social domain, people from different cultures may have divergent perceptions of the self. Individuals from Western cultures tend to value uniqueness and freedom and view the self as independent from others, whereas individuals from cultures like Japan tend to value social harmony and adherence to group norms and view the self as interconnected and interdependent with others. Cultural variation in these self-representations has been found to affect both cognitive and emotional processes (Markus & Kitayama, 1991). And these relative cultural differences in self-representations are mirrored in neural responses. In a study examining self-referential processing in China (Zhu, Zhang, Fan, & Han, 2007), the medial prefrontal cortex (MPFC), an area engaged in the representation of the self, was activated in both Caucasian and native Chinese participants when they judged whether an adjective described themselves. But Chinese participants also showed activation in the MPFC when judging whether it described their mother. The MPFC seems to be involved when thinking about close relatives as well as the self in Chinese participants, whereas in Western participants it is involved only in thinking about the self.

SOURCE ANALYSIS

Source analysis is the process of determining the source or causes of culture mappings. There are at least three sources of cultural universals and differences: genetic commonality or

difference, cultural learning mediated by brain plasticity, and the degree of similarity between cultural environments. We expect there are also interactions among these sources.

Processes that converge universally (for example, regions of brain activation that are common across cultures) would appear to be innate, allowing for the appropriate triggering environment. Processes that vary across cultures could either be the result of fundamental differences in the cultural environments or a result of learning (Nisbett, 2003). Differences in cultural environments can be found in written language, where orthographic differences drive divergences in neural processing (see below). But there also is clear evidence that learning and exposure affects neural activation patterns. For instance, Bengtsson et al. (2005) found difference in white matter between pianists and nonmusicians. Moreover, practicing piano in childhood was related to increased myelination, indicating that training can affect neural development. But before concluding that differences are a result of learning, it is important to rule out genetic differences.

The first source is genetic commonality or difference. For example, Japanese and European populations significantly differ in the number of individuals within the cultural group who carry the short (i.e., 14 repeat) versus long (i.e., 16 repeat) allele of the 5-HTT serotonin transporter gene. In a typical Japanese sample, 70 to 80% of individuals carry the short allele (s/s or s/l) compared to 20 to 30% of individuals carrying the long allele (Nakamura et al., 1997; Sen, Burmeister, & Ghosh, 2004). In a typical European sample, 55 to 60% of individuals carry the long allele and only 40 to 45% of individuals carry the short allele (Sen, Burmeister, & Ghosh, 2004). Behavioral-genetics studies examining the functional role of 5-HTT have found that individuals carrying the short allele seem more prone to higher levels of anxiety and depression relative to long-allele carriers (Sen, Burmeister, & Ghosh, 2004). Moreover, individuals with the short allele show greater amygdala activation during an emotion-matching task relative to individuals with the long allele (Hariri et al., 2002). Future work needs to examine the relationship between cultural variation in genetic frequencies, behavioral performance, and neural activation (Chiao & Ambady, 2007).

The second source is cultural learning and exposure mediated by brain plasticity. Strong evidence for cultural learning comes from examining neural processing in bilinguals and learners of a second language. Thus, Pallier et al. (2003) compared adult Koreans who were adopted by French families when they were younger than 8 years of age to French natives. The Korean-born subjects did not remember their native language and were fluent in French. Both groups showed similar patterns of activation to sentences spoken in French, Korean, or other foreign languages, suggesting that fluency in the language of the new culture was associated with corresponding neural changes. Recently, Kovelman, Shalinsky, Berens, and Petitto (2008) found evidence for a possible unique “signature” in the brains of bilinguals, such that proficient bilinguals showed distinct patterns of neural

activation compared to monolinguals. Both groups showed activation in Broca's area, but bilinguals also showed a unique pattern of activation in the left inferior frontal cortex.

The effects of cultural exposure on neural activation have also been found in the areas of emotion recognition and inferences of intentions. Neural responses to emotional expressions in Japanese and Caucasian faces by native Japanese participants in Japan and Caucasian participants in the United States were examined by Chiao et al. (2008). Distinct neural responses were found in response to ingroup members, with individuals from both cultures showing greater amygdala activation to faces expressing fear of members of their own cultural groups. Moreover, Moriguchi et al. (2005) also found activation to Japanese fear expressions in emotion-related areas of the brain in Caucasians who had lived in Japan for more than a year. These two studies suggest that exposure to a culture can affect neural responses to emotional expressions. In another study, the ability to infer intentions was evaluated from a "reading the mind in the eyes" task used in studies examining the ability to infer intentions and feelings from pictures of the eyes. This task agrees with traditional tests of theory of mind and has been demonstrated to reliably differentiate between nonclinical samples and populations exhibiting psychopathologic disorders marked by impaired theory of mind (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Japanese participants showed more activation in the superior temporal sulcus (STS), an area found to be activated in previous neuroimaging studies examining inferences of intentions, when they were judging the intentions of Japanese as compared to American targets from pictures of their eyes. Americans participants showed the opposite pattern, with more STS activation when judging intentions from Caucasian as compared to Japanese eyes (Adams et al., 2009). Thus, there seem to be selective neural responses to cultural ingroup faces, probably due to more exposure to these faces.

The third source is the similarity or difference in stimuli and pattern structures across cultures. In a meta-analysis comparing the neuroimaging results for word reading across different languages and cultures, Bolger, Perfetti, and Schneider (2005) found at least one common area of processing across languages and cultures, the visual-word-form area in the left mid-fusiform gyrus, which seems to be central to word recognition. But they also found culture- and language-specific patterns of activation. The Chinese writing system, for instance, requires more activation in the visual areas in both hemispheres than do western alphabets. Other studies suggest that dyslexia is associated not with a single area of the brain but with different parts of the brain, depending on the culture; it is hypothesized that this is due to languages' different orthographies (Paulesu et al., 2001). Thus, differences in pattern structure might account for cultural differences in neural activation. We expect there are also interactions among these sources. Processes that converge universally (for example, regions of brain activation that are common across cultures) would appear to be innate, allowing for the appropriate triggering environment. Pro-

cesses that vary across cultures could be the result of fundamental differences in the structure of the environment (Nisbett, 2003) or in genetic factors.

CONCLUSION

The neuroscience of culture is in its nascent stages, but it is emerging. Research identifying the sources of cultural differences is sparser than cultural mapping research, but new technologies promise to advance this component quickly. There has been virtually no longitudinal work examining responses to cultural exposure. Other questions that remain concern the role of critical periods in the acquisition of culture-specific neural patterns and the malleability of neural activation with exposure to new cultures and environments. Of considerable interest in helping to disentangle genetic versus learning effects would be an examination of neural processing in immigrants and bicultural and multicultural individuals. Finally, another promising area of work lies in examining how genetic differences within and across cultures might affect behavioral and neural responses. Comparing neural activation in individuals with similar genetics and ethnic origins who live in different cultures is a critical task.

The maturation of concepts and methodology in the three areas of neuroscience (i.e., social, cognitive, and affective neuroscience) and imaging genomics provides a solid foundation for examining the mutual interplay of cultural and biological forces throughout the life span. We predict that with advances in human behavioral genetics, our understanding of behavioral and neural tuning to the cultural environment will become clearer. Historically, psychology has swung between a focus on learning and a focus on innateness. An examination of the neuroscience of culture provides the exciting opportunity to examine the mutual interplay of culture and biology across multiple levels of analysis, from genes and brain to mind and behavior, across the life span.

Recommended Reading

- Chiao, J., & Ambady, N. (2007). (See References). One of the first papers to raise attention about cultural neuroscience across different levels of analysis in the domain of emotion.
- Nisbett, R.E. (2003). (See References). A classic, comprehensive, and highly accessible overview of what is known about the relationship between culture and cognition.
- Park, D., & Gutches, A. (2006). The cognitive neuroscience of aging and culture. *Current Directions in Psychological Science*, 15, 105–108. A clearly written, user-friendly, and comprehensive review for readers who wish to expand their knowledge of cognitive neuroscience on aging and culture.
-

Acknowledgments—The authors thank Joan Chiao, Maryanne Wolf, and Reginald Adams for their insights. This work was supported, in part, by a NIH R01 MH070833-01A1 grant to N.A.

REFERENCES

- Adams, R.B. Jr., Rule, N.O., Franklin, R.G. Jr., Wang, E., Stevenson, M.T., Yoshikawa, S., et al. (2009). Cross-cultural reading the mind in the eyes: An fMRI investigation. *Journal of Cognitive Neuroscience*. Advance online publication. Retrieved October 1, 2009, from <http://www.mitpressjournals.org/doi/pdf/10.1162/jocn.2009.21187>.
- Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The “Reading the Mind in the Eyes” test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*, 241–251.
- Bengtsson, S.L., Nagy, Z., Skare, S., Forsman, L., Forssberg, H., & Ullén, F. (2005). Extensive piano practicing has regionally specific effects on white matter development. *Nature Neuroscience*, *8*, 1148–1150.
- Bolger, D.J., Perfetti, C.A., & Schneider, W. (2005). Cross-cultural effect on the brain revisited, universal structures plus writing system variation. *Human Brain Mapping*, *25*, 92–104.
- Castellano, M.A., Bharucha, J.J., & Krumhansl, C.L. (1984). Tonal hierarchies in the music of north India. *Journal of Experimental Psychology: General*, *113*, 394–412.
- Chiao, J., & Ambady, N. (2007). Cultural neuroscience: Parsing universality and diversity across levels of analysis. In S. Kitayama & D. Cohen (Eds.), *The handbook of cultural psychology* (pp. 237–254). New York: Guilford Press.
- Chiao, J.Y., Iidaka, T., Gordon, H.L., Nogawa, J., Bar, M., Aminoff, E., et al. (2008). Cultural specificity in amygdala response to fear faces. *Journal of Cognitive Neuroscience*, *20*, 2167–2174.
- Curtis, M.E., & Bharucha, J.J. (2009). Memory and musical expectation for tones in cultural context. *Music Perception*, *26*, 365–375.
- Gutchess, A., Welsh, R., Boduroglu, A., & Park, D.C. (2006). Cultural differences in neural function associated with object processing. *Cognitive, Affective, & Behavioral Neuroscience*, *6*, 102–109.
- Hariri, A.R., Mattay, V.S., Tessitore, A., Kolachana, B., Fera, F., Goldman, D., et al. (2002). Serotonin transporter genetic variation and the response of the human amygdala. *Science*, *297*, 400–404.
- Hedden, T., Ketay, S., Aron, A., Markus, H.R., & Gabrieli, J.D.E. (2008). Cultural influences on neural substrates of attentional control. *Psychological Science*, *19*, 12–17.
- Kovelman, I., Shalinsky, M.H., Berens, M.S., & Petitto, L.A. (2008). Shining new light on the brain’s “bilingual signature”: A functional near infrared spectroscopy investigation of semantic processing. *NeuroImage*, *39*, 1457–1471.
- Markus, H.R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*, 224–253.
- Moriguchi, Y., Ohnishi, T., Kawachi, T., Mori, T., Hirakata, M., Yamada, M., et al. (2005). Specific brain activation in Japanese and Caucasian people to fearful faces. *Neuroreport*, *16*, 133–136.
- Nakamura, T., Muramatsu, T., Ono, Y., Matsushita, S., Higuchi, S., Mizushima, H., et al. (1997). Serotonin transporter gene regulatory region polymorphism and anxiety-related traits in the Japanese. *American Journal of Medical Genetics*, *74*, 544–545.
- Nisbett, R.E. (2003). *The geography of thought: Why we think the way we do*. New York: The Free Press.
- Pallier, C., Dehaene, S., Poline, J.-B., LeBihan, D., Argenti, A.-M., Dupoux, E., & Mehler, J. (2003). Brain imaging of language plasticity in adopted adults: Can a second language replace the first? *Cerebral Cortex*, *13*, 155–161.
- Paulesu, E., Demonet, J., Fazio, F., McCrory, E., Chanoine, V., Brunswick, N., et al. (2001). Dyslexia: Cultural diversity and biological unity. *Science*, *291*, 2165–2167.
- Sen, S., Burmeister, M., & Ghosh, D. (2004). Meta-analysis of the association between a serotonin transporter promoter polymorphism (5-HTTLPR) and anxiety-related personality traits. *American Journal of Medical Genetics B*, *127*, 85–89.
- Tang, Y., Zhang, W., Chen, K., Feng, S., Ji, Y., Shen, J., et al. (2006). Arithmetic processing in the brain shaped by cultures. *Proceedings of the National Academy of Sciences, USA*, *103*, 10775–10780.
- Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *NeuroImage*, *34*, 1310–1316.