

**HANDBOOK OF
CULTURAL
PSYCHOLOGY**

SECOND EDITION

edited by

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THE GUILFORD PRESS
New York London

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370 Seventh Avenue, Suite 1200, New York, NY 10001
www.guilford.com

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Printed in the United States of America

This book is printed on acid-free paper.

Last digit is print number: 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Names: Cohen, Dov, editor. | Kitayama, Shinobu, editor.

Title: Handbook of cultural psychology / edited by Dov Cohen, Shinobu Kitayama.

Description: Second Edition. | New York : The Guilford Press, 2019. | Revised edition of Handbook of cultural psychology, c2007. | Includes bibliographical references and index.

Identifiers: LCCN 2018036027 | ISBN 9781462536238 (hardback)

Subjects: LCSH: Ethnopsychology. | BISAC: PSYCHOLOGY / Social Psychology. | MEDICAL / Psychiatry / General. | SOCIAL SCIENCE / Social Work. | PSYCHOLOGY / Developmental / General. | SOCIAL SCIENCE / Anthropology / Cultural.

Classification: LCC GN502 .H3615 2018 | DDC 155.5089—dc23

LC record available at <https://lcn.loc.gov/2018036027>

CHAPTER 3

Cultural Neuroscience

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The field of cultural neuroscience seeks to understand how key features of culture, including beliefs, values, and practices, may get embrained and embodied in neurobiological systems through socialization. In so doing, it aims to investigate how deep the influence of culture may go in making neurobiological systems closely attuned to the surrounding environment. In this chapter, we provide an overview of this new field of research. First, we discuss known cross-cultural variations in self, cognition, emotion, and motivation as revealed in brain responses. Second, we examine how culture may interact with biological processes more generally by discussing recent work on (1) gene \times culture interactions and (2) links between culture and biological health. Our overarching goal is to elucidate how the neuroscience approach has helped address questions that are difficult to answer with existing behavioral and self-report measures alone. We conclude by highlighting directions for future research.

Cultural neuroscience is a young and vibrant field of research that is only 10 or so years old. The first publication bearing the name “cultural neuroscience” appeared in the first edition of this handbook (Chiao & Ambady, 2007). Since then, the number of publications in this field has increased exponentially. Major workshops have regularly been held in various venues around the globe. An independent handbook has been compiled for the field (Chiao, Li, Seligman, & Turner, 2016). Research articles have frequently been published in top outlets, including *Proceedings of National Academy of Sciences USA*, *Psychological Science*, *Perspectives on Psychological Science*, *Emotion*, *Social, Cognitive, and Affective Neuroscience*, and *NeuroImage*, just to name a few. As a testament to the growing importance of cultural neuroscience, the *Annual Review of Psy-*

chology recently featured three articles on this topic over the span of 4 years (Han et al., 2013; Kim & Sasaki, 2014; Kitayama & Uskul, 2011). In addition, a journal singularly devoted to the field (*Culture and Brain*) has been established. Despite its young age as a field, the contributions of cultural neuroscience have been numerous and are likely to grow.

WHAT IS CULTURAL NEUROSCIENCE?

The primary aim of cultural neuroscience is to investigate how deeply culture, including beliefs, values, and practices, may go “under the skin”; that is, the field aims to understand how key features of culture practiced over time, through socialization, may influence biological systems composed of both

brain and body to attune individuals to their environment (Han et al., 2013; Kitayama & Uskul, 2011). An important first step in accomplishing this broad aim was to establish differences between sociocultural groups in brain mechanisms underlying various psychological functions. The next step is to begin to shed light on how the effects of culture on the brain might have come about. Yet another step would be to investigate similar cultural effects in other biological systems, including genetics, epigenetics, and biological health.

Through this effort, the cultural neuroscience approach has provided some empirical substance for a time-honored argument by George Mead, Pierre Bourdieu, Anthony Giddens, and other early social scientists. These scholars argued that the body (and now the brain as well) is closely attuned to the sociocultural environment, while at the same time (since the attunement to the environment is not complete) the body–brain that is conditioned to the surrounding environment can simultaneously be autonomous, thereby constituting agency, being capable of producing volitional actions, which can lead to changes in the environment from which the agency has been derived. This circular or recursive process occurs continuously, not only in each person's lifetime but also across generations, hence eventually giving rise to changes in both historical and evolutionary timescales.

In the last decade, many researchers have contributed to the agenda of cultural neuroscience by investigating neurophysiological mechanisms of cultural influence in various substantive domains. They include perceptual processing (Goh et al., 2004), attention (Goto, Ando, Huang, Yee, & Lewis, 2010), the self (Han & Ma, 2014; Knyazev, Savostyanov, Volf, Liou, & Bocharov, 2012; Zhu, Zhang, Fan, & Han, 2007), social cognition (Knyazev, Savostyanov, Bocharov, & Merkulova, 2018), emotional experience (Immordino-Yang, 2014; Murata, Moser, & Kitayama, 2013; B. Park, Tsai, Chim, Blevins, & Knutson, 2016), perception of others' emotions (Goto, Yee, Lowenberg, & Lewis, 2013; Russell, Masuda, Hioki, & Singhal, 2015), empathy (Cheon et al., 2011), moral decision making (Han, Glover, & Jeong, 2014), norm violation detection

(Mu, Kitayama, Han, & Gelfand, 2015), reward processing (Varnum, Shi, Chen, Qiu, & Han, 2014), and motivation (Kitayama & Park, 2014). Most of these studies focus on patterns of functional activation of the brain with methods such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). However, an emerging line of work has examined cultural influences on other biological indices such as structural properties of the brain (Kitayama et al., 2017b; F. Wang, Peng, Chechlacz, Humphreys, & Sui, 2017), as well as markers of biological health and well-being (Kitayama & Park, 2017; Miyamoto et al., 2013). Furthermore, there is increasing interest in including biological and genetic evolution within the purview of the field (Kim & Sasaki, 2014; Kitayama et al., 2014).

The range of phenomena that are being explored cross-culturally with neuroscience methods is already vast, with a rapidly growing empirical base. In this chapter, we document how this relatively new approach in cultural psychology has made significant contributions that go beyond what was already known in the field. By doing so, we explicate how the neuroscience approach has enriched psychological theories of culture and, correspondingly, why this approach is invaluable for a better understanding of the dynamic interaction or mutual constitution between culture and the psyche (Markus & Hamedani, Chapter 1, this volume; Markus & Kitayama, 2010). Indeed, this approach may even be indispensable for achieving the overarching agenda of cultural psychology.

In what follows, we present a review of the budding field of cultural neuroscience. We do so in three steps. First, we discuss what the neuroscience approach offers in the study of culture. Second, we consider available evidence on cultural variations in brain responses in several domains, including self, cognition, emotion, and motivation. We also consider emerging work on culture and the regionally specific cortical volume of the brain. Third, we turn to the role of culture in regulating broader biological systems, with a focus on two areas, namely, gene \times culture interactions and biological health. We conclude by drawing attention to current limitations and future opportunities for the field.

WHY NEUROSCIENCE?

“Culture,” defined as a pattern of beliefs, values, and practices that constitute one’s environment, may be studied with interviews or surveys. It can be studied by analysis of cultural products and archival data. It is also possible to study it with a variety of behavioral experiments. It is therefore legitimate to raise this question: Why neuroscience? Why is it that we may want to expend extra labor, time, and substantial financial resources to use neuroscience to study culture?

In this section, we discuss several reasons why the neuroscience approach is not only useful but also indispensable for advancing our understanding of how culture influences the human mind. We consider what theoretical gains we can expect with this approach and explain why we may want to take the extra labor and time to utilize neural measures. We do so by highlighting concrete examples that illustrate the benefits of the neuroscience approach in research on culture.

Psychological Mechanisms

At the most concrete and tangible level, cultural neuroscience has enabled researchers to more directly tap into the psychological mechanisms that mediate cultural influences in various domains. By doing so, it has helped resolve earlier debates that were based solely on behavioral or self-report data.

For example, East Asians are known to report lower self-esteem than do European Americans (Heine, Lehman, Markus, & Kitayama, 1999). One possible interpretation of this cultural difference is based on tactical self-presentation. It might be the case that East Asians say they are not as high in self-esteem because of a strong modesty norm. That is to say, at heart, they may have views of the self that are as positive as Westerners’ views, but they may intentionally hide their high self-esteem, because showing it is socially inappropriate. An alternative interpretation is that these cultural differences in self-report may reflect real internal differences. For example, there might be cultural differences in automatic tendencies to pay attention to negative (vs. positive) self-relevant information; that is, East Asians might

appear to be modest in the eyes of outside observers because of their tendency to attend initially to potentially negative aspects of themselves. Since behavioral measures (e.g., in self-report, judgment, and memory, among others) necessarily tap downstream consequences only, it is both important and informative to directly probe the mediating psychological mechanisms by using neuroscience measures such as fMRI and EEG. Only by so doing can we address the initial question of genuineness in Asian modesty or the lack thereof. As we shall see, recent neuroscience investigations have favored the second account of this cultural difference.

The theoretical benefit of the neuroscience approach is not limited to the study of self-enhancement and self-criticism. The same is true in cognition, where research has shown that the fundamental attribution error (the bias to use dispositional reasons to explain another person’s behavior) is cross-culturally variable. Furthermore, this cross-cultural variation is due to automatic, early cognitive processing rather than later, more deliberate cognitive effects. It also applies to dissonance and other related motivational phenomena, which are now known to stem from a conflict detection system of the brain that is closely modulated by cultural conditioning. In this chapter, we provide a selective review of cases in which this type of specification of underlying mechanisms has been accomplished through the use of neural measures.

Biological Plasticity

The effort to clarify the mechanisms behind cultural differences has led to a broader theoretical realization that some seemingly rudimentary psychological mechanisms, such as attention and information seeking, are plastically shaped and modified by culture. Cultural neuroscience work has therefore challenged a long-standing assumption that the psychological system is analogous to a computer, being both fixed and pancultural. In this traditional view, cultural variations may be explained by assuming that people in different cultures use different software that handles different inputs and produces different outputs. In this view, however, the core of the mind, the hardware (or the cen-

tral processing unit; Shweder & Sullivan, 1990), is fixed and invariant across cultures. This assumption was at the base of the “cognitive revolution” of the 1950s. It was argued that if the computer can be studied and analyzed with science, why can’t the mind? This reasoning was used to legitimate the mind as a target of scientific investigation. Moreover, this computer-based view of the human mind has since undergirded many theories in various subdisciplines of psychology, including cognitive psychology, social cognition, and developmental psychology.

Keep in mind that cultural variations of various beliefs and behaviors can be explained without challenging the putative reality of the universal, fixed, computer-like mind. One may hypothesize, for example, that input to this fixed mind is systematically different across cultures (Berry, Poortinga, & Pandey, 1980). It would seem reasonable that with different inputs, the system will spit out varying outputs (e.g., beliefs and behaviors). Following this logic, as long as this explanatory scheme is sufficient to account for known phenomena, there is nothing in cultural psychology that would challenge the standard model of the mind as fixed and universal. Research on culture could comfortably sit within the framework laid out by the central assumptions of the cognitive revolution.

Cultural neuroscience has seriously challenged these assumptions. It has done so by providing evidence that cultural influences go deep. Indeed, it is now clear that significant components of the putative universal mind are demonstrably shaped and modified by culture. By showing that biological and neural mechanisms that underpin mental activity are plastic and constantly influenced by culture, cultural neuroscience has challenged the fundamental premise of many of the social and behavioral sciences.

Cultural neuroscience’s challenge to the computer model was not without precedent. In fact, one central impetus for it came from recent evidence from other fields documenting extensive neuroplasticity in humans. For example, a pioneering study tested London cab drivers, whose work required driving through and learning the layout of a large, geographically complicated city at a time when computer-based navigation systems had yet to be widely adopted (Maguire &

Gadian, 2000). Among these cab drivers, the area of the brain known to be implicated in spatial navigation and memory (the posterior hippocampi) increased in volume as a function of the years of experience driving a cab, despite the fact this area typically decreases in size with age. Likewise, a study focusing on Buddhist monks indicated that the high-frequency brain wave called the gamma (typically associated with active engagement of thought processes) becomes dominant during meditation and, moreover, is more prominent as a function of the years of meditation experience (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). The preponderance of the gamma wave may reflect certain structural properties of the brain (although this point has yet to be tested). Accordingly, these demonstrations hinted at the possibility that hard structures of the brain undergo significant changes as a function of extensive experience.

These studies extend previous work with nonhuman animals that underscores the significance of experience in the plasticity of both neural connectivity and the structural volume of relevant brain regions. Building on this work, cultural neuroscience research has begun to show that culture in fact constitutes an external environment that “trains” the brain. Thus, when the brains of two people who have been trained in different cultural contexts are compared, they tend to show neural effects that correspond to key features of their contexts. This work has led to new questions regarding how environmental factors might result in structural changes in the brain (Kitayama et al., 2017b). Furthermore, such structural changes of the brain are likely to be mediated by epigenetic mechanisms (Cole, 2014; Meaney, 2001). This line of inquiry may begin to highlight cultural influences at this neurobiological level.

Cumulative Effects of Culture

Our third point follows directly from our earlier point. There is reason to believe that cumulative experience of culture is stored and likely preserved in the brain (Kitayama & Salvador, 2017; Kitayama & Uskul, 2011). From the moment of birth (or even earlier), neural networks of the brain receive input from the external environment.

The neural networks are gradually shaped, presumably through reinforcement-based learning (Morris, Fincher, & Savani, Chapter 18, this volume), with a culture's beliefs and practices defining reward contingencies (i.e., whether and under what circumstances given behaviors are rewarded, not rewarded, or punished).

Figure 3.1 (adapted from Kitayama & Salvador, 2017) illustrates this point. Kitayama and Salvador suggested that by its nature, a human brain engages with its external environment constantly. When the brain is recruited to produce a certain behavior to carry out any given task or to cope with certain adversities in a culturally prescribed fashion, it receives either positive or negative feedback from the culture. This feedback, in turn, positively or negatively reinforces, not just the behavior, but also all neural connections that are recruited to produce the behavior. This engagement and feedback cycle is repeated continuously for the duration of a person's entire life. Correspondingly, the changes made on the relevant neural networks accumulate in accordance with the rule of Hebbian learning, which states that neurons that fire together wire together (Gallistel & Matzel, 2013).

This analysis makes one point rather clear. Cultural experience is likely to be stored and preserved in the brain. This may be the case even when the experience is long forgotten and unlikely to be recalled. It may not be suppressed or repressed in any Freudian fashion (although our framework would

surely not preclude such possibilities). Every bit of cultural experience shapes certain parts of the brain and, when this shaping occurs, it remains in the brain by virtue of the neural connections that it strengthens or inhibits. Subsequent changes are added to the earlier shaping, but they may never fully replace it.

It is important to keep in mind that while cultural beliefs and practices may differ greatly within any given culture, there are some common elements that cut across this variability. They may correspond to core values and beliefs of different cultures, say, independence and interdependence or individualism and collectivism. Such core beliefs and values are therefore likely to leave certain characteristic cumulative changes in the brains that engage in the culture. Hence, "the neural networks . . . emerge through socialization encode and store cumulative cultural experience" (Kitayama & Salvador, 2017, p. 844).

This form of cultural influence that occurs over a long period through socialization is distinct from and, most likely, independent of effects of any immediate experiences of the "here and now," including group pressures (Asch, 1956), various priming manipulations designed to activate certain cultural constructs (Oyserman & Lee, 2008; Oyserman & Yan, Chapter 20, this volume), images of others (Kitayama, Snibbe, Markus, & Suzuki, 2004) and goals (Chartrand & Bargh, 1996). These immediate factors of the "here and now" can be powerful. They build

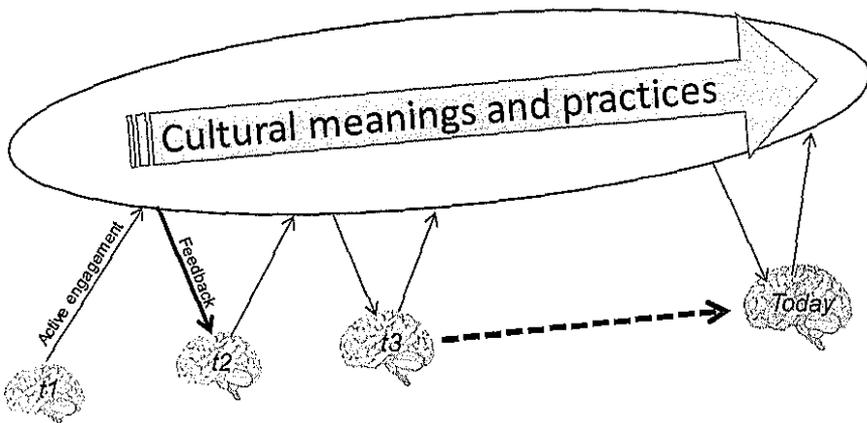


FIGURE 3.1. Shaping of the brain through reinforcement-based learning. Adapted from Kitayama and Salvador (2017).

on the effects of long-term socialization and sometimes “bring out” the long-term effects of prior experience, while at other times they “mask” the latter. However, especially at a time of fast cultural change, the effects of immediate social situations may or may not correspond to the cultural information accumulated in the brain, and vice versa. As we see below, exploring the effects of long-term socialization or cumulative cultural experience may require researchers to take advantage of both newly invented tools (e.g., those for studying structural change of the brain) and novel conceptualizations of culture (e.g., those emphasizing repeated engagement in certain culturally prescribed tasks).

If the *cumulative* cultural effects are stored in the brain in the forms of, say, patterned neural connections and cortical, as well as subcortical, structural changes, then these effects may best be observed when the brain is directly probed through the use of neural measures. Indeed, there is every reason to expect neural indicators to be more reliable and faithful to culture’s influences on the mind. For example, as we shall see, brain indicators of a culturally acquired trait (e.g., holistic attention) are often linked reliably to a theoretical construct measured through self-report scales (e.g., interdependent self-construal). This, however, is not typically the case with performance-based measures of the trait (Kitayama, Park, Sevincer, Karasawa, & Uskul, 2009; Na et al., 2010). It may be the case that the identity of the self as independent or interdependent causes systematic biases in the nature of the cumulative cultural experience, which leaves very reliable traces in the brain. Any specific behaviors in the “here and now” are influenced by these traces, but they are also influenced, perhaps to a larger degree, by other, extraneous factors. Thus, these behaviors are distant, downstream, and rather noisy indicators of prior cultural experience.

Cultural Insight

Since culture leaves its traces in the brain, it has become possible to make new inferences about the nature of culture by examining the neural effects of culture. This “reverse inference” has become a new tool for investigating the nature of culture by going backward, contrary to the typical inference from

culture to its effects on the brain. Thus, the neural traces of culture may enable us to discover fundamental features of culture that we might otherwise fail to note.

There is a growing body of evidence that in the processing of faces, Westerners (both Europeans and North Americans) tend to focus on the mouth region of the face, but Easterners (East Asians) tend to focus more on the eyes. Since an early behavioral demonstration (Yuki, Maddux, & Masuda, 2007), this hypothesis has received support from research using a more elaborate face recognition paradigm (Jack, Garrod, & Yu, 2012). Interestingly, this cultural bias in visual scanning (identified with a sophisticated eye movement analysis) can be reliably identified for 7-month-olds (Geangu et al., 2016). Moreover, consistent with this observation, earlier studies had documented that the so-called McGurk effect (wherein auditory perception of phonemes is biased by inconsistent lip movements), robust in Western populations, is substantially attenuated in Japanese and Chinese adults (Sekiyama, 1994, 1997; Sekiyama & Tohkura, 1991). As we see in a later section, in a series of studies that tested EEG signals, researchers have shown that the brains of East Asians tend to be “alerted” when exposed to human faces or face-like objects (presumably because the faces evoke a type of evaluation apprehension), whereas the brains of European Americans tend to be “relaxed” when exposed to such stimuli (presumably because the faces are linked to some sense of affirmation) (Hitokoto, Glazer, & Kitayama, 2016; Park & Kitayama, 2014).

Bringing these lines of evidence together, one may begin to see that when viewing another person’s face, people show remarkably different neuropsychological responses depending on their cultural backgrounds. Why is it that Westerners look at the person’s lips while feeling affirmed? Likewise, why is it that in the same situation, Asians look at the person’s eyes while feeling worried, concerned, or even threatened? Starting from these questions, one may begin to see, more clearly than before, that there are hidden dimensions in social interaction. Western social relations may be regulated by a principle of “mutual admiration or affirmation” (Kitayama & Markus, 2000). Individuals may therefore focus on what another person is saying (resulting in a focus on the lips

in face perception), which tends to be more positive and affirming, thus feeling safety in the experience. But East Asian social relations may be organized by a principle that may be called “mutual surveillance and criticism (Kitayama & Markus, 2000) through watchful eyes” (Kitayama et al., 2004). People may then focus on nonverbal indicators that may be hard to control (the eyes of the other person) to infer what the other person is “really” thinking, which may be relatively critical, resulting in the worry or threat response.

Admittedly, key data in an analysis like this do not have to be neural. Nevertheless, neural data may often prove to be crucial, because they are unlikely to be mediated by self-presentation or self-regulation. Instead, they are the culmination of long-term engagement in a culture’s reward contingencies. This feature of neural data enables scholars to make strong inferences on the nature of culture by examining the impact it has on the brain. It enables a “natural history” of socialization. Often archeologists learn a great deal about an evolutionary history by testing bones and other remains of animals, including humans, who once lived on the earth. Likewise, scholars of culture may learn much about the nature of their topic by testing its impacts on the human brain. This point deserves emphasis, because culture is typically tacit (Hall, 1982), with its most fundamental principles or dimensions hidden behind the surface, because these principles or dimensions are encoded not necessarily in each individual’s memory or conscious awareness but in culturally scripted social behaviors. Active participation and engagement in this cultural pattern leaves behind significant traces in the brain. Thus, these traces may provide a significant clue into the nature of such hidden principles or dimensions.

Theoretical Synthesis of Culture and Biology

The contributions of cultural neuroscience discussed so far concern different ways in which this approach enables the field to better understand the nature of both mind and culture. Cultural neuroscience, however, may allow us to go a step further, raising new questions about biology and evolution that undergird both the mind and culture. It

may do so by highlighting the fact that the brain and body represent an ultimate culmination of human biological evolution, while reflecting cultural influences. The neuroscience approach in cultural psychology may force researchers to rethink and reformulate the role of culture in human evolution, as well as the role of evolutionary processes in human culture (Sng, Neuberg, Varnum, & Kenrick, 2018).

It has been assumed that human cognitions, emotions, and other important functions of the mind have coevolved with sociocultural forms of living over the last 2 million years or so (Henrich, 2015; Mesoudi, Chapter, 5, this volume; Tomasello, 2014, 2016). However, it has yet to be fully appreciated that modern cultures that are intensively studied by cultural psychologists, such as cultures of honor, face, dignity (Leung & Cohen, 2011) and Eastern cultures or Western cultures (Markus & Kitayama, 1991), have evolved much more recently. These different cultures have likely differentiated gradually in Eastern versus Western regions of the Eurasian continent over the last 10,000 years, only after the emergence of sedentary forms of living that were grounded in different forms of subsistence such as farming, fishing, and herding (Talhelm et al., 2014; Talhelm & Oishi, Chapter 4, this volume; Uskul, Kitayama, & Nisbett, 2008).

What might have transpired biologically during this relatively recent period (over the last 10,000 years) is not well known. But some speculations are possible. To begin, it is possible that divergent forms of culture that emerged during this period are based on biological evolution, because culture provided an important context for biological evolution (Chiao & Blizinsky, 2010; Kim & Sasaki, 2014). Moreover, the regulation of gene expression through epigenetic mechanisms is likely to be strongly influenced by cultural environments (Cole, 2014; Kitayama, Akutsu, Uchida, & Cole, 2016; Meaney, 2001). Needless to say, the brain is the result of natural selection; moreover, there is every reason to believe that the force of natural selection is in operation even after the establishment of culture. Hence, questions regarding the relationship between culture and evolution are now at the forefront of cultural psychological theorizing (Kashima, Chapter 2, this volume).

As we see in later sections in which we discuss gene \times culture interactions, the emerging evidence is consistent with a general thesis that the human mind is based on a biological system that is prepared to accommodate and respond to characteristics of the ecocultural environment and is therefore shaped, modified, and completed through the participation in this environment. Needless to say, the cultural environment itself is enabled and constantly reproduced with changes and modifications by the collective working of numerous minds that have been so shaped. At the dawn of modern cultural psychology, Shweder proposed that culture and the psyche make each other up (Stigler, Shweder, & Herdt, 1990). This thesis has since been elaborated by a number of subsequent researchers (Kitayama & Uskul, 2011; Markus & Hamedani, Chapter 1, this volume; Markus & Kitayama, 2010). Cultural neuroscience has elaborated and expanded on the same thesis and illuminated how the brain and body may be transformed through culturally structured experience, as well as the genetic and epigenetic mechanisms underlying it.

CULTURE AND THE BRAIN

Having provided a general overview of the field of cultural neuroscience, we are now ready to discuss specific findings. In this section, we focus on how cultural variations in substantive domains (including self, cognition, emotion, and motivation) have been revealed in activation patterns of the brain. We further discuss potential cultural influences on more structural properties of the brain.

The Self

Much of the research in cultural psychology assumes that the form of the self varies across cultures (Markus & Kitayama, 1991; Triandis, 1989). In European and European American cultures, the self is said to be independent and individualistic. This form of self (called the “independent self”) is defined primarily by internal attributes such as traits, abilities, preferences, desires, and attitudes. Social relations are important, but they are seen as being derived from individ-

ual preferences and choices, as in romantic love. In contrast, in non-Western cultures, especially in Asian cultures, the self is said to be interdependent and collectivistic. This form of self (called the “interdependent self”) is primarily defined by relational or social attributes such as social roles, obligations, or duties that come with such roles. Personal preferences do exist, yet they are seen as being relatively secondary and therefore are to be tamed and subordinated to social demands.

Abstract Traits as the Defining Feature of the Self

Early behavioral work used a Twenty Statement Test to show initial evidence for the distinction between independent and interdependent selves. In one early study, for example, Cousins (1989) had American and Japanese college students describe themselves in 20 different ways and found that the percentage of abstract personality descriptions (e.g., smart, honest) was higher for Americans than for Japanese. This pattern has been replicated in subsequent work with other Asian groups, such as Koreans (Rhee, Uleman, Lee, & Roman, 1995). This evidence is consistent with the proposition that the independent self is defined primarily by a set of internal attributes including abstract personality traits, whereas the interdependent self is defined more in terms of social or relational contexts. With this evidence alone, however, it is uncertain whether this cultural difference is due to linguistic conventions in describing the self or whether it is reflecting something deeper and fundamental about the nature of the self.

Ma and colleagues (2014) compared a Western sample (Danish young adults) with an Asian one (Chinese young adults) in an fMRI experiment. They used an experimental paradigm called the self-referential judgment task, in which participants are shown one personality trait at a time and asked to report whether the trait is descriptive of either themselves (the self condition) or someone who is famous (the public figure condition). A consistent and robust finding using this paradigm from previous studies using Western samples is that the medial prefrontal cortex (mPFC), particularly its ventral region, is engaged to a greater extent in the

self condition than in the public figure condition (Heatherton et al., 2006; Kelley et al., 2002; Northoff & Bermpohl, 2004). The mPFC is interpreted to play a pivotal role in forming an evaluative judgment about the self, underscoring the hypothesis that self-perception is inherently evaluative. Moreover, given the fact that personality traits and other abstract features of the self are used as stimuli, the finding might also mean that these abstract internal traits constitute the way the self is habitually represented in the brain.

When the procedure was repeated in the Danish sample in the Ma et al. (2014) study, the pattern was duplicated in a highly robust fashion. Importantly, however, when the Chinese sample was tested, the pattern was discernible, but much weaker compared with what was observed for Danes (Figure 3.2A). This finding is consistent with the hypothesis that the self is less likely to be represented in terms of decontextualized abstract traits among interdependent people. Supporting this view, the cultural difference in the mPFC activation in the self (vs. public figure) condition was explained by the fact that Chinese were more interdependent than Danes, as assessed by a well-validated interdependent self-construal scale (Figure 3.2B).

Neural Representations of the Self and Close Others

As noted earlier, the mPFC is engaged during self-processing (Heatherton et al., 2006; Northoff & Bermpohl, 2004; Qin & Northoff, 2011). Moreover, as shown above, the same effect is observed for Asians although it is less pronounced. Building on this literature, Han and colleagues have investigated whether the mPFC region would also be recruited by close others for those with an interdependent self (Han, Ma, & Wang, 2016; Zhu et al., 2007). Such an outcome may be expected if close others are included in the self-representation of these individuals. In contrast, for those with an independent self, the self should be distinct even from close others. Hence, the mPFC region that is recruited by the self would not be recruited by close others for people high in independence.

Zhu and colleagues (2007) tested both Chinese young adults and Western young adult sojourners residing in Beijing. As in the prior self-referential judgement task, participants were shown a series of trait adjectives one at a time. They judged whether each adjective would apply to the self, their mothers (close other), or a public figure (the prime minister or the president). Replicating previous work, as compared to the public figure condition, the mPFC region was ac-

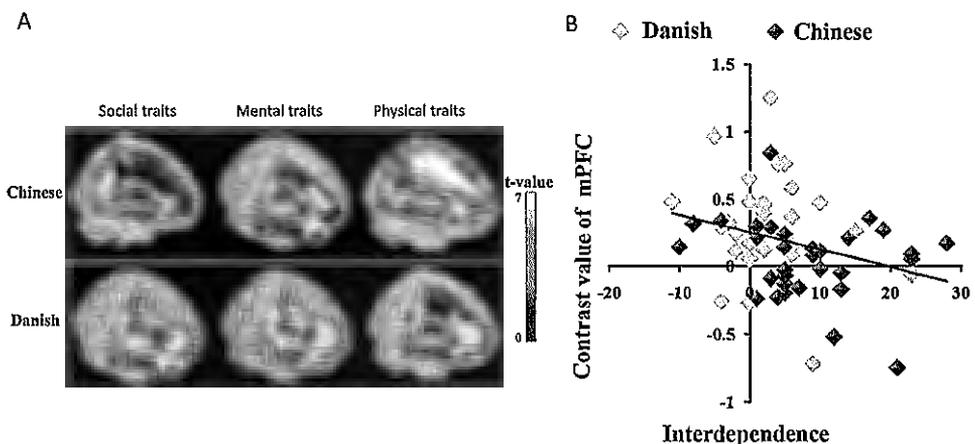


FIGURE 3.2. Activation of the MPFC in the self judgment condition relative to the public figure judgment condition in Chinese and Danish participants. (A) Areas activated in the self (vs. public figure) condition in reference to social, mental, and physical traits among Chinese and Danish participants. (B) The MPFC activation in the self (vs. public figure) condition is inversely predicted by interdependent self-construal. Adapted from Ma et al. (2014).

tivated more in the self-judgment condition for Westerners. This effect was also observed for Chinese participants. Unlike results in the Ma et al. (2014) study reviewed earlier (Figure 3.2A and B), however, the effect was no stronger for Westerners than for Chinese participants. More work is needed to see whether there might be any selection bias that diluted the self-reference effect for Westerners who resided in Beijing. It is important to note, however, that the pattern of activation for the mother condition varied across cultures. For Westerners, it was no different than the pattern observed for the public figure condition, but for the Chinese it was no different than the pattern found for the self condition.

How robust was the shared representation of both the self and a close other for Chinese participants? As it turned out, the mPFC activation for various close others such as a father and best friend was lower compared to that for mothers even among Chinese participants (G. Wang et al., 2012), although the effect is comparable in strength for one's spouse and children (Han et al., 2016). The effect outside of China appears less consistent, with a failure to obtain the equivalent mPFC activation for the self and the mother among Chinese sojourners in the United States (P. Chen, Wagner, Kelley, Powers, & Heatherton, 2013), as well as a *larger* mPFC activation observed for the mother than for the self among Asian Americans (Huff, Yoon, Lee, Mandadi, & Gutches, 2013). Thus, more investigation is warranted before reaching a firm conclusion on cultural variation outside of China. One study suggested that the overlapping mPFC representation for the self and close others might be linked to the length of the close relationship and shared experience (Han et al., 2016). Last, but not least, in this work so far, the strength of mPFC activation during self- versus other-referential judgment is used as a face valid index of the interdependent self that "includes" close others in itself. No attempt has so far been made to explore similarities and differences in the neural representations within a given region, say, in the mPFC. Future work may benefit from adopting more refined indices such as resemblance of the voxel-level patterns of activation between the two conditions (Kriegeskorte, Mur, & Bandettini, 2008).

Self-Enhancement and Self-Criticism

Defining features of independent selves are not only abstract but also are likely positive rather than negative. There is a vast body of evidence showing positivity biases among American and European selves, often called self-enhancement, positive illusion, or the better-than-average effect (Dunning, Johnson, Ehrlinger, & Kruger, 2003; Taylor & Brown, 1988). In contrast, defining features of interdependent selves are more contextually represented and therefore need not be positive, especially in the context of mutually supportive relations. In fact, it has been argued that focusing on negative aspects of the self might be instrumental in fitting into such relations. Consistent with this argument, studies conducted with Asian participants tend to find these positivity biases less often (Heine et al., 1999). Moreover, in some cases, the self-enhancing biases are reversed to show self-critical biases among East Asians (Chang & Asakawa, 2003; Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). Although important, this behavioral work left behind one significant question.

In particular, even though self-criticism has been found in studies that are carefully constructed to make sure that responses are anonymous (e.g., Kitayama et al., 1997), there still remains the question of whether East Asians intentionally presented themselves to be less desirable or more negative to conform to prevailing norms of modesty. With the self-report-based studies alone, it is not easy to exclude this possibility, because self-report can be modified and edited if it needs to be.

To address this question, Hampton and Varnum (2018a) assessed whether European Americans and Chinese differ in positive versus negative self-views in an ERP study focused on the N400 component. The N400 is a negative deflection of electrocortical response in the midline regions approximately 400 ms poststimulus that is thought to index the detection of semantic or affective incongruity. In this study, participants were asked to judge the valence of positive and negative trait adjectives following a prompt indicating that the adjectives referred to the self or to others. European Americans showed stronger N400 responses when negative

(vs. positive) traits words followed the self prompt, whereas Chinese participants did not. This is consistent with the idea that European Americans (but not Chinese) hold positive views of the self and therefore detect negative (vs. positive) traits as incongruent to the self. In addition, Chinese participants showed stronger N400 responses when negative (vs. positive) traits followed the prompt for an unfamiliar other, whereas European Americans did not, which suggests that Chinese may have an other-enhancing bias in addition to the lack of a self-enhancing bias (see also Sui, Hong, Hong Liu, Humphreys, & Han, 2013). This study also replicated previous self-report and behavioral evidence, providing further evidence for this cultural difference in self-enhancement.

Future research should extend the work reviewed here and explore potential boundary conditions. For example, all studies that show a self-critical bias among Asians use self-referential judgments, in which the self is foregrounded and explicitly focused on during judgment. It is possible that even among East Asians, the self is linked to positive feelings in subtle ways, which could come out when tested “implicitly,” without any overt reference to the self (Y. Chen et al., 2014; Kitayama & Karasawa, 1997).¹ For example, alphabetical letters included in one’s own name are evaluated more favorably even among Asians (Kitayama & Karasawa, 1997). There may also be some conditions or contexts in which East Asians and European Americans hold comparably positive self-views. For example, East Asians may be particularly self-aggrandizing when their status is elevated or when their sense of face or honor (the public recognition of self-worth) is threatened. These possibilities should be addressed in future work.

Cognition

Previous cross-cultural studies have provided convincing evidence that thinking styles vary systematically across cultures (in this volume, see Masuda, Russell, Li, and Lee, Chapter 8; Nisbett, Chapter 7). In particular, Nisbett, Peng, Choi, and Norenzayan (2001) amassed evidence indicating that whereas people in Western cultures tend to reason linearly, are more focused in attention, and have an analytic cognitive style, those in

Eastern cultures tend to be more cyclical in reasoning, broader in attention, and overall, more holistic in cognitive style. It has been argued that analytic style is linked directly to independent self-construal, because more independent people tend to guide their actions, including their thinking, by their own goals. Thus, they see what they need or want to (focused attention), categorize what they see, and connect various objects in causal or quasi-causal terms through linear reasoning (i.e., *A* leading to *B*, which in turn leads to *C*). In contrast, interdependent people are more attuned to social expectations. Thus, they pay attention to social surroundings to figure out others’ expectations and norms, which results in a broader scope of attention. They use various pieces of information regardless of self-goals or agendas, often accepting rather than resolving apparent inconsistencies to achieve a harmonious relationship with relevant others (dialectical reasoning) (see Grossmann & Kung, Chapter 13, this volume; Varnum, Grossmann, Kitayama, & Nisbett, 2010). Existing evidence for the distinction between analytic and holistic cognitive styles is wide-ranging (see Masuda et al., Chapter 8, this volume, for a more comprehensive review). Here we focus on three domains in which there is a fair amount of neuroscience evidence: holistic attention, spontaneous trait inference, and norm violation detection.

Holistic Attention

Early behavioral studies, such as the one by Masuda and Nisbett (2001), demonstrated a cultural difference in attention when participants were asked to perform a recall and recognition task of an underwater scene. Both European Americans and Japanese remembered focal fish equally well, but Asians recalled more about the background scene than did European Americans. Moreover, Japanese (but not Americans) were able to recognize objects better in their original scene rather than in a novel one. A later study by Kitayama, Duffy, Kawamura, and Larsen (2003) showed a similar cultural difference in attention by having participants complete a series of line drawing tasks. Participants were shown a line embedded in a square frame, followed by a blank square of different size. In the relative task, par-

ticipants were asked to draw a line identical in proportion to the original framed line, whereas in the absolute task, they had to draw a line identical to the original line, while ignoring the surrounding frame. The researchers found that European Americans were more accurate in the absolute task that required greater attention to the focal object, whereas Japanese were more accurate in the relative task, which required greater attention to context. The pattern that East Asians are more holistic than European Americans has been replicated across numerous other behavioral paradigms (see Miyamoto et al., 2013, for review). Moreover, this greater attention to relative positioning also shows up in the social realm, with Asians (vs. European Americans) showing a stronger brain response to social comparison information (Kang, Lee, Choi, & Kim, 2013).

However, the available evidence leaves some important theoretical questions unanswered. For example, it is not clear at what stages of processing the cultural difference might be observed. As in the case of self-enhancement, it is possible that the cultural difference may occur during an early stage of attention, but this issue needs to be investigated. Furthermore, it is not clear whether the broader scope of attention exhibited by East Asians is an obligatory process—a process that is spontaneously and automatically engaged. Nor is it clear whether the cultural bias in attention might be overridden with some cognitive effort. These questions have been subsequently addressed with neuroscience methods.

Kitayama and Murata (2013) presented to participants a series of images. A majority of them were standard stimuli (animal images), while the remaining images were infrequent, target stimuli (coffee mug) interspersed in the series of the standard images. Participants were to press a button when they saw target stimuli. The researchers found a reliable cultural difference around 200 ms post-target, characterized as the N2 component, a reliable index of early orienting attention. The N2 amplitude was significantly larger for European Americans compared to Asian Americans for the target. In addition, there was a greater slow wave component (an indication of cognitive elaboration) among European Americans in comparison to East Asians. These data support the hypothesis

that European Americans allocate more attention to the goal-relevant focal object (coffee mug) early on in stimulus processing.

How about context processing? European Americans are likely to be less attentive to context, whereas East Asians are likely to be more holistic, allocating more attention to it. Goto and colleagues (2010) addressed this question with an ERP marker of expectancy violation (N400). In one experiment, European Americans and Asian Americans were presented with a target object (e.g., a crab) and asked to judge whether the object was animate or inanimate. Right before the object was presented, a contextual scene was presented briefly for 300 ms. Importantly, the scene was either thematically congruent or incongruent with the object (e.g., in the case of the crab, a beach vs. a parking lot). The N400 amplitude was significantly larger on incongruous trials than on congruous trials for Asian Americans but not for European Americans. This suggests that the context was actively processed by Asian Americans but not by European Americans. Moreover, the magnitude of the N400 incongruity effect was correlated with interdependent self-construal, which partially accounted for the cultural difference in the N400 incongruity effect.

In a relatively recent study, Russell et al. (2015) used a different paradigm and found a similar cultural difference in an N400 incongruity effect, with East Asians more likely to respond to contextual incongruity than European Canadians. In this study, European Canadians who were high in independent self-construal seemed particularly oblivious to contextual incongruity. Moreover, the same researchers have shown that Japanese subjects are especially sensitive to incongruous context when trying to retrieve the memory of the focal object (Masuda, Russell, Chen, Hioki, & Caplan, 2014). In this case, this sensitivity to the (potentially misleading) contextual information predicts compromised memory performance.

The priority East Asians place on context processing appears automatic and obligatory and, conversely, as does the priority European Americans place on object processing. However, this cultural difference may be compensated for if extra processing resources are utilized. In an fMRI study, Hedden, Ketay, Aron, Rose Markus, and Gabrieli

(2008) showed that such compensatory processes may in fact be recruited to negate the cultural difference in automatic, obligatory cognitive biases. In this work, the researchers used a modified version of the frame line task (Kitayama et al., 2003) in which the performance was allowed to be sufficiently high, so that there was no cultural difference in the performance of either the relative or the absolute task. This enabled the researchers to examine brain responses that were not confounded by performance. Under these conditions, when participants performed a culturally nonpreferred task (i.e., the relative task for European Americans and the absolute task for East Asians), there was a significantly greater activation in the frontoparietal attention network, which is thought to be responsible for a deliberate, top-down form of selective attention or effortful processing. This finding has been replicated with an alternative imaging method (functional near-infrared spectroscopy [fNIRS]; Murata, Park, Kovelman, Hu, & Kitayama, 2015). Moreover, using a different fMRI paradigm, Goh et al. (2013) replicated the greater effort allocation during the relative task among European Americans compared to Asians.

One interesting offshoot of the cultural neuroscience work on holistic perception focuses on face perception, which is generally considered to be Gestalt-like and therefore predominantly configurational or holistic; that is, the entire Gestalt may have precedence over specific features that make up the Gestalt. However, any given face may also be seen as a composition of various elements such as eyes, a nose, a mouth, and some other features. Thus, people may sometimes use these component features to recognize faces as well. Accordingly, one may assume that configurational (or holistic) processing is engaged for faces by default, regardless of culture. In contrast, compositional (or analytic) processing may be optionally engaged. The latter may be likely for those who are culturally trained to be analytic (Westerners), but not for those who are culturally trained to be holistic (East Asians). Miyamoto, Yoshikawa, and Kitayama (2011) manipulated similarities across different faces in terms of either general gestalt (by using morphing) or specific features (by varying the number of shared parts such as eyes and

mouths). Perceived similarity of faces was influenced more by Gestalt-like processing for Japanese, but more by feature overlap for Westerners (Miyamoto et al., 2011).

Recent neuroimaging research has extended the Miyamoto et al. (2011) finding, focusing on brain regions linked to face processing, in particular an area in the occipital/parietal lobe called the fusiform face area. This area exists in both hemispheres. The right hemisphere is generally linked to holistic, configurational processing, whereas the left hemisphere is linked to more compositional, feature-based or analytic processing. Since face processing is predominantly holistic, it is plausible that the right fusiform face area (the putative holistic processing area) may well be engaged across all cultures. However, the left fusiform face area (the putative analytic processing area) may or may not be engaged, depending on culture. One fMRI study exposed participants to a face (vs. a house control) and found that the fusiform face area is bilaterally engaged for European Americans, but the engagement is right-lateralized for Singaporeans (Goh et al., 2010).

Spontaneous Trait Inference

The fundamental attribution error was once one of the most replicable effects in social psychology. It was first described as the error most people commit when they try to make a causal link between dispositions and behavior, without accounting for situational constraints (Gilbert & Malone, 1995; Jones, 1979; Ross, 1977). Earlier on, this effect was believed to be inherent in the nature of human information processing (Nisbett & Ross, 1980). It was reasoned that because a person is a figure (rather than ground) in social perception, it naturally stands out in the perceptual field (Heider, 1958). It may then be anticipated that the person receives privileged processing in lieu of the context that surrounds him or her. This should presumably result in additional weight assigned to the person (relative to his or her context) when the social perceiver tries to account for his or her behavior.

However, subsequent cultural studies provided clear evidence that the initial, universalistic hypothesis is overstated (Morris & Peng, 1994; Miller, 1984). These stud-

ies began to show that the fundamental attribution error or the dispositional bias in social perception reflects culturally specific models of the person. In cultures that sanction and reinforce a view of the person as independent and autonomous, the social perceiver looks for reasons for another person's behavior in internal traits, resulting in the dispositional attribution bias. However, in cultures that endorse a view of the person as an entity that is fully interdependent with the context (which includes other people, social norms, and expectations), the social perceiver looks for reasons for another person's behavior in the relationship between the actor and the context, thereby greatly attenuating the dispositional attribution bias. In support of this hypothesis, an fMRI study shows that East Asians are more likely to engage in spatial processing (indicating the processing of contextual information) than are European Americans, illustrating that certain spatial configurations of the context are being processed in conjunction with the focal behavior (Han, Mao, Qin, Friederici, & Ge, 2011).

One particularly powerful form of dispositional attribution, or the fundamental attribution error, is manifested as spontaneous trait inference (STI), which occurs when the perceiver automatically infers a disposition of another person upon observing a behavior of this person. More specifically, the perceiver encodes the behavior of another person by inferring a personality trait that corresponds to it, then assigns the trait to the representation of the person. Early on, the STI effect was shown to be quite robust among Americans (e.g., Winter & Uleman, 1984). Given the previous cultural hypothesis, it may be the case that Americans may routinely infer personality traits or dispositions from another person's behaviors and, as a consequence, this inference may eventually be automatic or spontaneous, carried out even when there is no need to do so. Moreover, from our cultural hypothesis it would also follow that Asians might not show any robust STI effect, since they do not routinely engage in dispositional inferences.

To address this issue, Na and Kitayama (2011) had participants memorize many pairings of faces and behaviors (e.g., checking a fire alarm before going to bed) implying a certain trait (e.g., careful). STI would occur

if the participants automatically inferred the trait and attached it to the face. To find out whether this effect occurred, in the next phase of the study, participants were asked to perform a lexical judgment task while their EEGs were monitored. Right before the stimulus was shown, participants were exposed to a brief flash of one of the faces used in the memorization phase of the study. Although participants were told to ignore this, as we saw earlier, face processing is highly spontaneous and automatic. Then, after they saw the face, it was followed by a word or nonword as the critical stimulus. When the critical stimulus was a word, it was either a trait that was matched to the behavior that had been paired with the face flashed on the trial (e.g., *careful*) or the antonym of the trait (e.g., *careless*). The researchers found that European Americans displayed an N400 in response to the antonym (e.g., *careless*), but not to the matched trait (e.g., *careful*). This demonstrates that when shown behaviors to memorize, the participants automatically inferred a corresponding trait and attached it to the face of the person. When shown the face during the lexical decision task, they also automatically recalled the trait linked to the face even if it was not part of the task. In contrast, East Asians showed no N400 regardless of whether the word was a matched trait or its antonym. Importantly, the greater N400 activity (in response to the antonym vs. the matched trait) was positively correlated with independent (vs. interdependent) self-construal (as assessed with the Singelis Self-Construal Scale), and this accounted for the cultural difference in the N400 antonym effect, indicated by a significant partial mediation.

Subsequent work extended the Na and Kitayama (2011) evidence in two directions. First, Varnum, Na, Murata, and Kitayama (2012) used the same N400 paradigm to assess STI and demonstrated an important within-cultural variation by social class. Specifically, European Americans of higher socioeconomic status exhibited a greater N400 antonym effect than those of low socioeconomic status, consistent with previous evidence that those of lower socioeconomic status pay greater attention to context and are therefore less prone to dispositional biases in attribution (Grossman & Varnum, 2011). Another study used the same N400

marker of STI and demonstrated another subgroup difference. Specifically, consistent with earlier work by Zárate, Uleman, & Voils, (2001), the N400 antonym effect tended to be weak among Hispanic Americans. Importantly, however, this effect became visible among those who were more acculturated into mainstream American culture and relatively more independent (Salvador & Lewis, 2017).

Norm Violation Detection

One dimension of culture that is distinct from, yet often correlated with independence and interdependence is the degree to which social norms are enforced either stringently or loosely—the dimension called tightness versus looseness (Gelfand et al., 2011). Gelfand and colleagues used a self-report-based measure of tightness versus looseness and have shown that individualistic countries (where independent self-construal is endorsed) tend to be loose, whereas collectivistic countries (where interdependent self-construal is endorsed) tend to be tight, although there are some notable exceptions. For example, certain Latin American countries or ex-Soviet countries are loose despite the fact that they are collectivist. Likewise, some Western societies (e.g., Germany) are tight despite the fact that they are relatively individualistic. Moreover, the societal-level tightness and looseness is linked to historical levels of man-made or natural threats. For example, tight nations have historically faced more disasters such as floods, cyclones, droughts, and greater territorial threats. The historical prevalence of pathogens and prevalence of tuberculosis and infant mortality are also related to greater tightness. Gelfand and colleagues argue that under high degrees of threat, stronger norms (and greater interdependence among people) may have been helpful in dealing with the threats.

In a relatively recent study, Mu and colleagues (2015) hypothesized that a conflict-monitoring system that is typically tied to the anterior cingulate cortex may be appropriated to detect social norm violations. To test this, they used the N400 component involved in the detection of semantic or affective violations, which is source-localized in the dorsal anterior cingulate cortex and its vicinity. Mu and colleagues had both

American and Chinese participants judge how appropriate various behaviors (i.e., dancing) were in various situations, so that the behaviors were normal (tango lesson), weakly norm-violating (subway platform), or strongly norm-violating (art museum). Across cultures, a greater N400 component was consistently observed over the central parietal regions in the norm-violating versus normal conditions. However, the N400 for norm-violating versus normal behaviors was also evident at the frontal and temporal regions for Chinese participants but not for Americans. Evidently, the central parietal N400 activation that was observed in both cultures spread to the frontal region only in Chinese participants.

The cultural difference in the norm-violation N400 effect is consistent with previous self-report-based evidence that cultural tightness is higher in China than in the United States. However, it is not clear whether perceived tightness of social norms is sufficient to account for the cultural difference. Salvador, Mu, Gelfand, and Kitayama (2017) hypothesized that perceived tightness or looseness of social norms influences the spontaneous neural reaction to norm violations when individuals are prepared to engage socially and relate to other individuals. When the motivation to relate to others is chronically high (as may be assumed to be the case for Chinese, who are known to be interdependent), the neural system may be “tightened” or “loosened” depending on the perceptions of tightness or looseness of the relevant social norms, thereby modulating the magnitude of the norm-violation N400 response. The neural system may be “tightened”; that is, it is set to respond even when a signal of norm violation is very weak; conversely, the system may be “loosened”; that is, it is set not to respond until the signal of norm violation becomes sufficiently strong. However, when the motivation or readiness to relate with others is comparatively less (as may be assumed to be the case for Americans, who are known to be independent), the perception of the social norms will be kept dormant. In this case, the neural system of norm violation detection may tend to be disengaged regardless of the perceived tightness or looseness of the social norms.

According to this hypothesis, Chinese in the Mu et al. (2015) study may have shown

a stronger norm-violation N400 response than did American, not only because Chinese perceived their societal norms to be tighter than that of Americans, but also because, compared to Americans, they were relatively more interdependent and were therefore more chronically relationally oriented toward others. By manipulating the relational orientation by using a well-validated priming procedure, Salvador et al. (2017) have provided initial evidence for the hypothesized joint influence of perceived tightness and the relational orientation on the norm-violation N400 response.

Emotion

Existing evidence shows that there is a great deal of commonality in emotion across cultures. For example, several prototypical emotions (called “basic emotions”) such as joy, anger, sadness, fear, surprise, and disgust are commonly recognized through facial gestures (Elfenbein & Ambady, 2002) or patterns of vocal intonation (Laukka et al., 2016). Moreover, cognitive appraisals associated with each of these emotions appear to be fairly common across cultures (Scherer, Shorr, & Johnstone, 2001). However, very much like classical music that is defined by a theme and its variation, these commonalities—or the themes of emotion—come with variations that are unevenly distributed across cultures. This point has been made most clearly in the area of emotion recognition. Due to variations in the expression of any given emotion across cultures, there is a small but robust ingroup advantage in the recognition of emotion, such that emotions expressed by ingroup members are recognized more accurately than those expressed by outgroup members (Elfenbein & Ambady, 2002).

High- versus Low-Arousal Emotions

Another important cultural difference lies in the value placed on high- versus low-arousal emotions. Tsai (2007; Tsai & Clobert, Chapter 11, this volume) has argued that in European American independent cultures, individuals are motivated to express themselves and to use their internal attributes to influence others. In these cultures, emotions are therefore to be expressed clearly

and perhaps to be up-regulated. In contrast, people in East Asian interdependent cultures are motivated to fit in and adjust to group expectations. In these cultures, emotions are to be moderated to achieve social harmony. In East Asian societies in particular, low-arousal emotions tend to be valued over high-arousal emotions, because high-arousal emotions are seen as too individualistic and therefore a hindrance to social harmony. Part of this cross-cultural variation in the value placed on high- versus low-arousal emotions might be due to the fact that independent cultures tend to be residentially more mobile over generations and therefore more heterogeneous in terms of ethnic composition (Rychlowska et al., 2015). In contrast, interdependent cultures tend to be more sedentary over generations and therefore be more homogeneous in terms of ethnic composition. Thus, clear emotion expression may be less of a pragmatic necessity in interdependent, homogeneous (vs. independent, heterogeneous) cultures.

Much of the current evidence for a stronger value placed on high- versus low-arousal emotions in independent versus interdependent cultures comes from self-report ratings of the desirability of experiencing high-arousal positive emotions such as excitement and joy as opposed to low-arousal positive emotions such as calmness and relaxation. Do these ratings show anything more than culturally desirable responding? In a recent cross-cultural fMRI study, Park and colleagues addressed this question (B. Park et al., 2016). In this study, participants were shown images of others expressing high- or low-arousal positive emotions. To test the notion that different levels of emotional arousal are preferred in different cultures, B. Park and colleagues tested the activation of the ventral striatum (vSTR, a brain region involved in the experience of reward) in response to faces expressing either high-arousal happiness (excitement) or low-arousal happiness (calmness). Among European Americans, vSTR was activated equally strongly regardless of the arousal level. Interestingly, however, for Chinese participants, vSTR showed a greater activation when the faces showed low-arousal happiness than high-arousal happiness. This study provided the first support for the hypothesis that culture modulates the neuro-

biologically encoded reward value of perceiving others' high- or low-arousal positive emotions.

Emotion Regulation

The culturally divergent values placed on high- versus low-arousal emotions may have far-reaching effects on the regulation of emotions. In cultures in which high-arousal emotions are valued because they are supposedly expressive of the personal, independent self, and because they are highly instrumental in explicit communication, people might be quite reluctant to down-regulate their emotional expression. In fact, doing so might be counterproductive, because it goes against the strong value placed on emotion expression. Previous self-report studies conducted in Western cultures have provided convincing evidence that suppression of emotional expression (called "expressive suppression") is maladaptive. People who reportedly suppress their emotional expressions often tend to be less healthy and less happy than those who reportedly do not do so as frequently (Gross & John, 2003; John & Gross, 2004).

Recent cultural neuroscience work has built on this literature and has shown that emotion suppression is a culturally desired task for East Asians (but not for European Americans). Mauss and Butler (2010) examined autonomic responses during anger provocation and found a pattern typically associated with the motivational state of challenge (Mendes, Reis, Seery, & Blascovich, 2003) for East Asians if they strongly endorsed the value of emotion control. The challenge response indicates that an attempt to control anger is relatively routine and norm-congruous for East Asians (Tsai, Knutson, & Fung, 2006). In contrast, European Americans showed a different pattern of autonomic response that is typically linked to the motivational state of threat if they endorsed the emotion control value. This threat response supports the contention that controlling emotions goes against the norm of self-expression, likely less routine, and more effortful for European Americans (Markus & Kitayama, 1991; Tsai et al., 2006).

Will East Asians effectively suppress emotions when asked to do so? Murata and colleagues (2013) addressed this question. Both

European American and East Asian participants were exposed to a series of negative or neutral images. When asked to suppress their negative emotions, East Asians readily down-regulated emotional arousal (captured by an ERP signal called the late-positive potential [LPP]; Keil et al., 2002; Luck, 2014; Schupp et al., 2000; Weinberg & Hajcak, 2010). This effect, however, was not in evidence for European Americans. In a recent study using a similar paradigm, Varnum and Hampton (2017) investigated whether these two cultural groups might also differ in the ability to up-regulate LPP in response to positive affective stimuli. This study showed that European Americans were able to enhance LPP in response to both positive and negative stimuli, whereas East Asians were not able to do so in this context. Varnum and Hampton also observed some trend-level evidence of stronger down-regulation of LPP among East Asians (vs. European Americans) when instructed to suppress emotional reactions, replicating the pattern observed by Murata and colleagues (2013). Taken together, these findings are consistent with the notion that cultural differences in the value placed on emotion regulation and affect intensity are reflected not only in the external expression of emotion but also in the relative ability to control one's internal experience of emotional arousal.

Somatic Basis of Subjective Experience

Typically, emotional expression is seen as a manifestation of subjective emotional experience. However, there is a long line of thought that acknowledges the reverse causation, in which sensations derived from somatic, visceral, and/or behavioral responses of the body are thought to play a critical role in the construction of subjective feelings. As famously noted by William James, we may not cry because we are sad; instead we may feel sad because we cry. The possible causal role of somatic responses in emotional experience was addressed by Levenson, Ekman, Heider, and Friesen (1992), who observed that facial feedback effect (wherein patterned activation of facial musculature results in subjective experience corresponding to the emotion of the patterned face) is evident among Americans but not among people in a Sumatra village that had minimal contact

with Western culture. They interpreted the cultural difference as showing that more socially oriented, interdependent people rely more on social relational information in the construction of emotion; therefore, somatic feedback from the facial musculature by itself might have little, if any, role in the construction of the subjective experience of emotion.

Recent cross-cultural fMRI studies by Immordino-Yang (2014; Immordino-Yang, Yang, & Damasio, 2016) have extended the Levenson et al. (1992) evidence. In particular, they scanned both Chinese and American participants while exposing them to video clips designed to elicit strong feelings of either compassion or admiration. Participants reported their feelings of either compassion or admiration as they watched the clips. Researchers tested the association between participants' subjective report of either compassion or admiration and the activation of the dorsal region of the anterior insula, an area of the brain that is believed to encode somatic and visceral sensations. Positive associations would indicate that individuals utilized the somatic or visceral information in calibrating the strength of their subjective feelings. When the two cultural groups were compared, this association was significantly positive for Americans but not for Chinese participants. Thus, it appears that Americans actively utilized their somatic and visceral information in constructing their subjective feelings (Immordino-Yang, 2014). However, the Chinese evidently reported their feelings without taking the somatic and visceral information into account; that is, for Chinese participants, subjective feelings appeared to be dissociated from somatic or visceral sensations. This evidence is consistent with a claim that the Chinese "somatize" depression, that is, that suffering as evidenced in somatic sensations is experienced without entailing corresponding feelings of sadness and despair (i.e., depression; Kleinman, 1977, see Chentsova-Dutton & Ryder, Chapter 14, this volume).

Another analysis by Immordino-Yang et al. (2016) reveals that the association between the anterior insula and subjective feelings increases as a function of emotional expressivity (assessed by a standard scale measure). First, the researchers find that Americans are more expressive than Chi-

nese. Indeed, a mediation analysis shows that cultural difference in the association between the anterior insula and subjective feelings was accounted for (or mediated by) the cultural difference in the emotional expressivity (Immordino-Yang et al., 2016). If individuals are emotionally expressive, they may refer to their internal sensations more closely (after all, they have to find something inside to express). This internal attention may increase the correspondence between subjective feelings and somatic sensations. However, if people are not expressive emotionally, they may refer to other sources of information, including relational contexts in which the experience takes place or cultural norms about what the feelings should be. This in turn may diminish any link between subjective feelings and somatic sensations. Future work should extend this work to other cultural groups, particularly to Latinos, who are considered as interdependent as East Asians, yet emotionally more expressive than European Americans (Kitayama & Salvador, 2017).

Motivation

Culture also affects motivation (Kim & Lawrie, Chapter 10, this volume). In East Asian societies, people tend to view the self as including close others and to place more importance on relationships than do Westerners (Markus & Kitayama, 1991; Varnum et al., 2010). In a similar vein, compared to Westerners, East Asians are less motivated by a desire to express autonomy and uniqueness, and more attuned to social norms (Kim & Markus, 1999). Compared to Westerners, East Asians appear to be more sensitive to the threat of social evaluation (Kitayama et al., 2004). Recent cultural neuroscience research has followed up on these leads offered by prior behavioral work in this area.

Self- versus Other-Orientations

As we noted earlier in our discussion of the self, European Americans (who are relatively more independent) are more attuned to positive (vs. negative) self-relevant information than are East Asians (who are relatively more interdependent). This pattern may stem from a more general motivational orientation that prioritizes the self over other

people around the self. As compared to interdependent individuals, independent individuals may be more motivated to pursue and realize the personal goals and interests that are unique to the personal self. Compared to independent individuals, interdependent individuals may be more motivated to pursue and realize goals and interests of ingroup members.

Researchers have investigated this possibility with self-report measures, asking directly whether “My happiness depends on the happiness of others” for interdependence or “I always try to have my own opinions” for independence. While responses to these questions are in fact used to define part of what independent versus interdependent self-construals are, they can be edited and modified intentionally when the individuals wish to do so. Thus, it is hardly possible to rule out the possibility that the individuals are responding in a socially and culturally sanctioned fashion even when they do not necessarily believe what they express (Kitayama & Salvador, 2017). As we discussed in the section on the self, it is possible that this type of tactical response management could influence the outcome greatly when the responses are measured with self-report. It is therefore important to use neural indicators that are hard to deliberately control.

This is exactly what Kitayama and Park (2014) tried to accomplish. In their experiments, both European American and Asian American participants performed a simple flanker task in order to earn reward points for themselves or for their best friends. They were told these points would be exchanged for gifts for the self or friend at the end of the study. When asked to report how hard they worked on the task for the self or a friend, no cultural differences were observed. For example, European Americans said they worked just as hard for their friends as they did for themselves, and this was not significantly different from East Asians assessments. However, the researchers also measured a neural response to an error when it was committed during the cognitive task. This response, called error-related negativity (ERN), is known to increase when the task at hand is motivationally more important. Moreover, ERN is known to occur nearly simultaneously with the initiation of the erroneous response; so there is every rea-

son to believe that it is automatic, plausibly preconscious when it is initiated, and hardly possible to control. Kitayama and Park found that ERN was significantly greater in the self condition than in the friend condition for European Americans, consistent with the hypothesis that independent people motivationally prioritize the self over others, including their best friend. However, Asian Americans did not show a difference between self and other. Moreover, the ERN difference between the self condition and the friend condition systematically decreased as a function of interdependent self-construal, which in fact was higher among Asian Americans than among European Americans. Thus, the cultural difference in the motivational priority to the self (observed in the ERN measure) was mediated in part by interdependent self-construal.

Further support for the notion that self-construal plays a key causal role in the modulation of personal motivation comes from a recent fMRI study (Varnum et al., 2014) in which Chinese participants played a gambling game; some trials were played for the self, and others were played for a friend. When primed with an independent self-construal, participants showed stronger activation in the vSTR (a region linked to the experience of reward or pleasure) in response to their own (vs. their friends’) wins. However, when primed with an interdependent self-construal, they showed comparable activation in the vSTR in the two conditions. The priming manipulation had similar effects on responses to monetary losses for oneself versus one’s friend, as indexed by right insula activity (a region linked to empathy for pain). The independence prime led to stronger right insula responses to one’s own (vs. a friend’s) losses. In contrast, the interdependence prime led to comparable activation of the right insula in response in the two conditions.

Last, but not least, in a series of studies, Telzer and colleagues have shown that Hispanics also show an interdependent pattern of neural responses (Telzer, Fuligni, & Galvan, 2015). For example, in one study (Telzer, Masten, Berkman, Lieberman, & Fuligni, 2010), they observed that compared to European Americans, Hispanics showed greater activation in the reward processing regions of the brain (vSTR) when they

gained money for their family while losing money for the self. This is despite both European Americans and Latinos self-reporting that they enjoyed giving to their family equally. They interpret this cultural difference to be due to a commitment to family that is particularly strong for Hispanics.

Motivational Effects of Social Eyes

Early behavioral research provided a somewhat puzzling cross-cultural difference in cognitive dissonance. In a free-choice dissonance paradigm, individuals typically change their preferences after a choice, such that the preference for the chosen item increases, while that for the rejected item decreases (Brehm, 1956). This classical dissonance effect, however, does not happen in a standard free-choice paradigm among East Asians (Heine & Lehman, 1997). Subsequent research has suggested, however, that the absence of any postdecision dissonance effect among East Asians could be due to the fact that in the standard free-choice paradigm, the choice is completely private and anonymous (Kitayama et al., 2004). For interdependent selves, social relations are very important and, in fact, constitutive of the self. This means, for example, that whereas they are concerned with what others might think of them, they might not care much about some of the choices they make when no one is watching them. According to this reasoning, East Asians ought to show postdecisional attitude change if they are led to believe that other people could witness their choice. This prediction received support in a series of studies that manipulated "social eyes." For example, in one study, participants were seated in front of a poster that was composed of several schematic faces that appeared to be watching the participants. This subtle social eyes priming manipulation was sufficient to change the results dramatically. As the researchers predicted, East Asians now began to show a sizable postchoice attitude change. Interestingly, for European Americans in the social eyes priming condition, postchoice attitude change was attenuated.

Kitayama and Tompson (2015) proposed a biosocial model of affective decision making and integrated the cultural effects in postchoice attitude change within a broader

theoretical perspective. Specifically, they hypothesized that the magnitude of decision conflict during choice (i.e., cognitive dissonance) is likely to be modulated by various cues indicating safety and threat. A brain system that monitors various conflicts (plausibly localized in the anterior/posterior cingulate cortex) is alerted and therefore sensitized when there is an impinging threat. For example, when you are driving a car and witness police in the distance, your system may be alerted to become more responsive to any existing conflict. Conversely, the conflict-monitoring system may be relaxed when there is a cue signaling safety. For example, when you are driving a car leisurely down a country road on a sunny afternoon, your system may be "relaxed" and become less responsive to any potential response conflicts. Note that once a conflict is detected during a choice, the decision maker will look for positive incentives in one of the decision options so as to be able to make a decision.¹ Consistent with this model, prior evidence shows that the magnitude of activation of the subcortical reward processing area (vSTR) during the decision predicts subsequent decision justification (Kitayama, Chua, Tompson, & Han, 2010). Without any conflict detected, this search for positive incentives will not be initiated, hence resulting in no postdecisional attitude change.

One important implication of the biosocial model is that the magnitude of the cognitive dissonance effect should depend on the sensitivity of a brain mechanism used to detect cognitive conflicts. The system of conflict monitoring is biologically grounded and likely to be available in all humans (and plausibly in all animals). However, culture can play an important role in the operation of this system by providing differing patterns of conditioning of both threat and safety to various significant stimuli. In particular, in social domains, others may serve as a cue of either threat or safety, depending on specific patterns of cultural conditioning. In all cultures, people in one's social network are expected to be supportive. But cultures may vary in what it is that is considered to be most supportive.

Specifically, in independent cultures, a strong premium is placed on internal attributes of the self that are desirable and posi-

tive, as well as unique. People in the network are therefore expected to affirm each other's internal attributes. This social network of mutual affirmation may be an important anchor of the self-enhancement effects that are pervasive in European American cultures, as previously reviewed. In the present context, however, one important implication is that an image of these others, or what George Mead called the generalized other, may begin to signal safety that relaxes the system of conflict detection. This could explain why the cognitive dissonance effect is attenuated when European Americans have made a decision in front of the watching schematic faces; that is, the mere exposure to schematic faces may relax the conflict detection system, which in turn reduces the magnitude of a cognitive conflict experienced during the decision, thereby leading to a reduction of the choice-justifying attitude change.²

By contrast, in interdependent cultures, a much greater emphasis is placed on social duties, responsibilities, and obligations. People in the social network may therefore be expected to be relatively critical, making sure that nobody will fail to live up to the high social standards of performing duties and obligations. This network of mutual surveillance and criticism may underpin the self-critical biases reviewed earlier. As a consequence of engaging in this social network, a conditioning arises, such that the image of others in the network functions as a threat cue that alerts the conflict detection system. This could explain why the cognitive dissonance effect is augmented when Asians have made a decision in front of the watching schematic faces; that is, the mere exposure to schematic faces may alert the conflict detection system, which in turn augments the magnitude of cognitive conflict experienced during the decision, thereby leading to an accentuation of the choice-justifying attitude change.³

Although the biosocial model is consistent with known cultural effects in post-choice attitude change, specific assumptions of the model require closer scrutiny. To test the neuropsychological mechanisms postulated in the biosocial model, it is important to draw on neural measures to test whether mere exposure to a face is sufficient to tighten or loosen the sensitivity of the conflict-monitoring system, depending on the culture

of the participants. Note that a cognitive conflict that drives the postdecisional attitude change involves a mismatch between two choice options. Hence, it is analogous to a cognitive error, which occurs when there is a mismatch between an actual response and the representation of a correct response. Thus, one way to address this problem is to use a neural marker of error detection, known as the ERN (discussed earlier), to examine the cultural difference in the effects of face priming. In a recent study, both Asian and European American participants performed a simple cognitive task (J. Park & Kitayama, 2014). On each trial, right before the stimulus for the cognitive task was presented, participants were exposed to a brief flash of either a face stimulus or a control stimulus (either a scrambled face or an image of a house). Results revealed that the brief exposure to the face is sufficient to modulate the ERP response to errors during the cognitive task. Specifically, the sensitivity to errors as assessed by the ERN amplitude on error trials was greater in the face-priming condition than in the control condition for East Asians, but it was significantly smaller in the face-priming condition than in the control condition for European Americans.

This pattern has since been extended to a gamble paradigm (Hitokoto et al., 2016). In this study, both Asian and European American participants played a gambling task (Figure 3.3A). In the task, they were presented with two cards. Upon a choice between them, they were given feedback of either a gain or loss of points. Right at the beginning of each gamble, a schematic face (or a control picture [a scrambled face]) was briefly flashed for 90 milliseconds. One ERP component that is similar to the ERN is feedback-related negativity (FRN), a negative-going deflection of ERP approximately 270 milliseconds postfeedback around the midcentral electrode (as shown in Figure 3.3B). It is likely to reflect either expectation violation (resulting from the negative outcome), depression of reward processing (due to the absence of any reward), or both (Gehring & Willoughby, 2004; Hauser et al., 2014). In gambles, the outcome is just as likely to be positive and, with a win, there is a sharp positive deflection that arises around the same time window, called "reward positivity," or rewP (Proudfit, 2015).

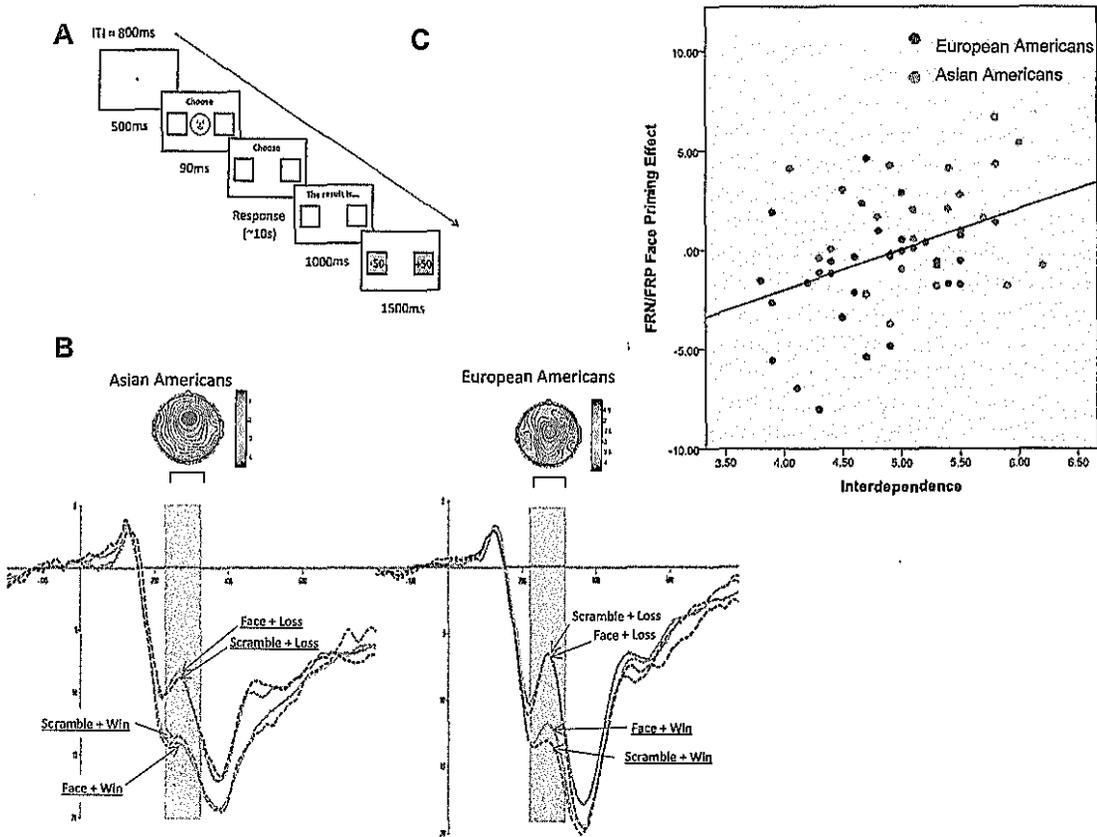


FIGURE 3.3. Face priming in a gambling task. (A) Trial structure. (B) Wave forms as a function of outcome and face priming for Asian Americans. (C) Face-priming effect as a function of interdependent self-construal. Adapted from Hitokoro, Glazer, and Kitayama (2016).

The rewP reflects a type of mismatch that is positively rewarding vis-à-vis an expected outcome, rather than a negative or punishing one, as in errors or cognitive conflicts. This positive mismatch called the “positive reward prediction error” will increase when the conflict detection system is alerted and sensitized.

In short, to the extent that the exposure to a face increases alertness, both of these components (FRN and rewP) should increase in magnitude. This in fact was the case for Asian Americans (the right-side panel of Figure 3.3B). In contrast, if the exposure to a face causes the system to be “relaxed,” both FRN and rewP should decrease in magnitude. This latter effect was observed for European Americans (the left-side panel of Figure 3.3B). Importantly, when the combined magnitude of the two components was test-

ed as a function of face priming, this face-priming effect was predicted by interdependent self-construal (Figure 3.3C), as would be expected under the hypothesis that faces are more alerting for those with interdependent self-construals.

Brain Structure

So far, all the evidence reviewed concerns functional properties of the brain, namely, the degree to which brain mechanisms are activated under different conditions as assessed by the blood oxygenation level dependent (BOLD) signals in fMRI or by electrocortical responses measured on the scalp (ERPs). However, in recent years, an increasing number of studies have underscored significant impacts of experience on the brain volume of specific brain regions.

This emergent body of evidence shows that experience can literally shape the brain, likely increasing the volume of brain regions that are recruited to carry out specific tasks, such as those involved in a job (e.g., cab driving; Maguire & Gadian, 2000), playing musical instruments, or other acts requiring visual-motor coordination (Draganski et al., 2004). Insofar as cultural experience entails intensive training in various tasks (Kitayama et al., 2009), long-term engagement in different cultures may result in variations in regionally specific brain volumes. At this point, this expectation has yet to be tested systematically. However, a few studies suggest that it deserves a concerted research effort.

Earlier on, Chee, Zheng, Goh, Park, and Sutton (2011) compared a large number of Singaporean Chinese and a matched sample of Americans to see whether any brain regions might differ between the two groups. Researchers assessed gray matter volume after controlling for total brain volume. They also investigated the thickness of cortical structures. As it turned out, several regions show greater volume, and increased thickness, for Americans than for Singaporeans. While the observed regions were diverse, they tended to be concentrated in prefrontal regions including the medial prefrontal cortex (mPFC) and the orbitofrontal cortex (OFC). Two more recent studies

complement the Chee et al. observation by showing that the cortical volume of certain regions is reliably predicted by self-construal. First, Wang and colleagues (2017) tested Chinese young adults and found that the gray-matter volume of mPFC (the region that is typically activated in self-referential processing) decreases as a function of interdependent (vs. independent) self-construal, with much of this effect due to interdependent (rather than independent) self-construal. Second, Kitayama and colleagues (2017b) tested young Japanese and found that the gray-matter volume of bilateral OFC systematically decreases as a function of interdependent self-construal, as illustrated in Figure 3.4.

The three studies reviewed previously (Chee et al., 2011; F. Wang et al., 2017; Kitayama et al., 2017b) are loosely consistent. The regions identified as negatively correlated with interdependent self-construal (mPFC and bilateral OFC) are contiguous, both located in the prefrontal cortex (PFC). Moreover, to the extent that the gray-matter volume of these regions decreases as a function of interdependent self-construal, it should be greater for Americans (who are less interdependent) than for East Asians, which is exactly what Chee et al. (2011) observed. mPFC is believed to play a central role in self-referential processing, although this processing may also play a role in the

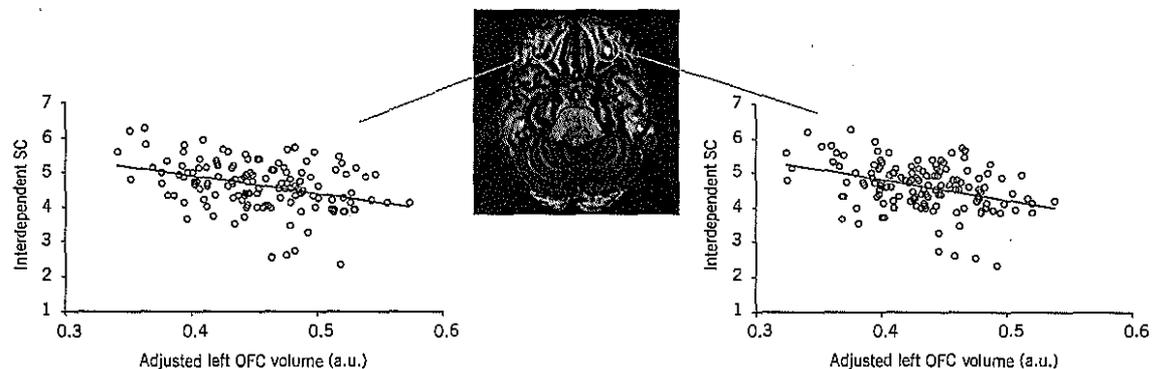


FIGURE 3.4. The association between the volume of bilateral orbitofrontal cortex (OFC) and interdependent self-construal. Voxel-based morphometry was employed to estimate cortical volume. The OFC regions were identified in a whole-brain analysis with a stringent statistical criterion (familywise error correction at the voxel level), which explains the small size of the regions of interest. Adapted from Kitayama, Yanagisawa, Ito, Ueda, and Abe (2017).

processing of information about close others. Moreover, OFC is known to be critical in the monitoring of reward contingencies and decision making based on this monitoring (called “value-based decision making”) (Fellows, 2011; O’Doherty, 2011). The pattern observed so far in the cross-cultural evidence on brain volume is consistent with the hypothesis that East Asians are less likely to engage self-related processes (as implicated in mPFC) or the monitoring of reward contingencies and the value-based decision making that accompanies it (as implicated in OFC) than are Westerners.

However, it is not clear why mPFC is identified in one study, while OFC is identified in the other. Moreover, Chee et al. (2011) failed to find any correlations between cortical volume and a measure of cultural values (which is different from the measure of self-construal used in the two more recent studies). Most importantly, all these studies are correlational and, as such, they do not justify any causal inferences. Thus, the cultural differences or the effects of interdependent self-construal on the cortical volume may be attributable to cultural experience, but they may at least partly be attributed to genetics. Future work must use training or interventions to clarify mechanisms underlying cultural variation in cortical volume. It may be sensible to focus on an age range (around puberty) in which cultural influences are likely to be maximal due to active neurogenesis (Giedd et al., 2006). This age range has also been identified as a “sensitive period” for cultural acquisition (Minoura, 1992). Alternatively, it may be useful to utilize genetic indicators of the susceptibility to environmental influences (as discussed in the next section on gene \times culture interactions) to test the extent to which plasticity in response to the environment may be involved in these cultural differences. If the cultural difference in brain structures is due to environmental influences, particularly to effects of cultural training, this difference may be expected to be more pronounced for those who show more effective cortical dopamine signaling for genetic reasons and who therefore presumably are more prepared to learn dominant cultural patterns (Kitayama, King, Hsu, Liberzon, & Yoon, 2016b).

CULTURE AND BIOLOGY

The bulk of evidence in cultural neuroscience pertains to brain processes for a good reason. After all, neuroscience refers primarily to the study of the brain. However, this exclusive focus on the brain might be too myopic and constraining; for the central nervous system is only one of two major biological systems that constitute the human. Another major system is the somatic system, including the somatic nervous system. Moreover, both the central nervous system and the somatic system are inscribed in the genes; thus, their integrity relies fundamentally on the integrity of the genome and the systematic and coordinated expression of the genes in it. Thus, any review of the field would be remiss if it failed to explore both the biological body and genetics under the purview of cultural neuroscience. Fortunately, there has emerged a small but exciting literature pertaining to these issues in recent years.

Gene \times Culture Interactions

Over the last few decades, researchers have observed that having a certain allelic variant of a particular gene does not determine any phenotype. To the contrary, the effect of the gene variant may depend on environmental conditions (Caspi, 2002; Caspi et al., 2003). These phenomena have been called gene \times environment interactions. More recently, cultural researchers have pointed out that culture constitutes one aspect of human environments, putting forward a hypothesis that phenotypic effects of some select genes may depend on culture (Kim & Sasaki, 2014; Kitayama & Uskul, 2011). These hypothesized effects are called gene \times culture interactions. A systematic exploration of these interactions may inform a theoretical analysis of how genes and culture may co-evolve such that culture serves as a context for genetic selection and evolution, and as a consequence, various cultural traits are favored by resulting genetic factors. When genes and culture interact over evolutionary and historical time, their mutual influence is called gene and culture coevolution. We thus define gene \times culture interactions as statistical interactions between allelic variants of

a given gene and different cultural groups, wherein phenotypic expressions of a particular gene depend on culture. In contrast, gene–culture coevolution is an evolutionary or historical mechanism underlying the mutual influences between genes and culture.

Coevolution of Culture and Genes

Recent research in population genetics suggests that over the past 50,000 years of human history, numerous polymorphic genetic changes have been positively selected. Moreover, the rate of positive selection appears to have accelerated over the last 10,000 years (Ding et al., 2002; Hawks, Wang, Cochran, Harpending, & Moyzis, 2007; E. Wang et al., 2004). The exponential increase of genetic change is likely related to the massive increase in human population and exposure to new environments (including domesticated animals and plants). The increase in exposure to new groups and ecologies resulted in diversity of both infectious diseases and available nutrition (Rozin, Ruby, & Cohen, Chapter 17, this volume). This is consistent with the hypothesis that genetic and cultural evolutions have proceeded in tandem (Eisenberg & Hayes, 2011; Feldman & Laland, 1996; Henrich, 2015; Laland & Brown, 2011; Mesoudi, Chapter 5, this volume; Richerson & Boyd, 2004). Initial evidence for gene–culture coevolution analyzed how the effects of herding and milk production were related to the emergence of genetic mutations that support the digestion of lactose—milk sugar (Tishkoff et al., 2007). The mutations to digest lactose were rapidly incorporated in the population, which supported the growth of dairy culture. Another example comes from a close population-level link between specific polymorphisms of certain genes and tonal linguistic expressions that is independent of geography and history (Dediu & Ladd, 2007). It appears that these polymorphisms and tonal forms of linguistic communication coevolved. There are several other well-validated cases of gene–culture coevolution (see Mesoudi, Chapter 5, this volume).

Far less certain is how the contemporary cultures including individualistic versus collectivistic cultures might have evolved in interaction with any particular genes (Chiao

& Blizinsky, 2010) and, indeed, there has yet to be a convincing hypothesis in this regard (Eisenberg & Hayes, 2011). However, it remains a possibility that cultural variations in key psychological tendencies might reflect variations in the frequencies of certain key genotypes to some extent. Thus, more systematic research on this topic is warranted.

The Plasticity Allele Hypothesis

One alternative way of conceptualizing the interaction between culture and evolution is to focus on a possibility that evolution afforded a set of polymorphic variants or alleles of certain genes that predispose carriers of these alleles to more effectively learn cultural norms and rules. Cultural norms, values, and practices may be shaped by a variety of factors that operate over many generations, including ecology, subsistence systems, natural threats (or the absence thereof), immigration, settlements, and many others (see Kitayama & Uskul, 2011, for a review). According to this alternative way of thinking, genes may be implicated in determining the readiness to learn, accept, and internalize the culture's norms, values, and practices.

Belsky and Pluess (2009, 2013) argued that certain genetic alleles, most prominently, the varying number tandem repeat (VNTR) of axon III of the dopamine D4 receptor gene (*DRD4*) and the short (vs. long) allele of *5-HTTLPR* of the serotonin transporter gene (*SLC6A4*) function as magnifiers of environmental influences. Carriers of these alleles are more likely to develop depression and other psychological disorders if exposed to early traumas and other adversities. However, carriers of these alleles are also more likely to develop *healthier* profiles (as compared to noncarriers) if brought up in advantageous environmental conditions. The plasticity allele hypothesis highlights an important variability in the data and thereby makes an important counterpoint to prior theories that portrayed these alleles as risk factors for mental illnesses. However, in and by itself, the hypothesis is agnostic about specific mechanisms by which the alleles might interact with environmental conditions to yield different mental health effects.

DRD4

Although several alleles have been referred to as plasticity alleles (Belsky & Pluess, 2013), one allele of the varying number tandem repeat (VNTR) of *DRD4* is particularly noteworthy in the context of cultural influence. Evidence suggests that some allelic variants of *DRD4* (called 7-repeat and 2-repeat variants) were incorporated into the human genome relatively recently over the last 50,000 years, during the period when humans spread “out of Africa” all over the globe. Moreover, these two relatively recent variants of *DRD4* show a remarkable regional variation, such that the prevalence of these two variants increases as a function of distance from Africa (C. Chen, Burton, Greenberger, & Dmitrieva, 1999; Matthews & Butler, 2011). Tovo-Rodriguez and colleagues (2010) also found that among different South American groups, there were significant differences in allele distribution between recent and past hunter-gatherer and agriculturalist populations, with the 7-repeat allele of *DRD4* being more common among hunter-gatherers. *In vivo*, the 7- and 2-repeat variants are associated with increased efficiency in dopamine signaling. The neurotransmitter dopamine is most prevalent in prefrontal regions involved in executive functions, as well as in subcortical, striatal areas that are crucial in reward processing. Thus, it stands to reason that *DRD4* would modulate the efficiency of reinforcement-based learning of cultural rules, beliefs, and values (Kitayama et al., 2016b). As noted earlier (see Figure 3.1), this form of learning is likely to be central in the acquisition and subsequent internalization of cultural beliefs, values, and norms (see Morris, Fincher, & Savani, Chapter 18, this volume). It may then be anticipated that carriers of the 7- or 2-repeat allele of *DRD4* are more likely to acquire and internalize norms that are salient in their environment.

Much of the evidence supporting this prediction comes from studies testing the effect of parenting quality on temperamental features of children. This work has so far been conducted with Western populations. The prevalence of the 2-repeat allele is quite low in these populations; thus, in all cases, researchers contrast children carrying the 7-repeat allele with those not carrying it. Ev-

idence shows that overall higher-quality parenting is associated with better self-control and fewer externalizing problems. As predicted by the notion that 7-repeat carriers are more sensitive to reward contingencies that are conveyed by social environments, including parents, this relationship is more pronounced for the 7-repeat allele carriers (Belsky & Pluess, 2013; Sheese, Voelker, Rothbart, & Posner, 2007). Importantly, this effect has also been observed in intervention studies in which parents are trained for better parenting (Bakermans-Kranenburg & van IJzendoorn, 2011; Bakermans-Kranenburg, van IJzendoorn, Pijlman, Mesman, & Juffer, 2008; van IJzendoorn et al., 2011). The effects of parent training programs are particularly beneficial for children with the 7-repeat allele.

DRD4 and Culture

Kim and Sasaki (2014) have applied the plasticity allele hypothesis to explore various gene \times culture interactions. Their work focused on genes other than the VNTR of *DRD4*, particularly, the oxytocin receptor gene (*OXTR*) (Kim et al., 2011; Kim et al., 2010a; Kim & Lawrie, Chapter 10, this volume) and the serotonin receptor gene (*5-HTT1A*) (Kim et al., 2010b) and reported initial evidence that they might also function similarly to *DRD4*. In one study, however, this group explored the effect of *DRD4* in the context of religious beliefs. Drawing on prior evidence that priming of religion increases prosocial behavior, Sasaki and colleagues (2013) found that this priming effect is more pronounced for carriers of the 7-repeat allele of *DRD4* as compared to noncarriers. The researchers interpreted the finding to suggest that the 7-repeat allele directly amplifies the priming effect. Alternatively, it may be that compared to noncarriers, carriers of this allele are more likely to acquire and internalize a cultural belief linking religion to prosocial behavior. Under this interpretation, it is because of the long-term effect of *DRD4* that the carriers showed a more pronounced priming effect than do noncarriers.

One prediction from the assumption that *DRD4* modulates the internalization of social norms is that carriers of the 7- or 2-repeat allele of *DRD4* should acquire values,

beliefs, and norms of their culture to a greater extent than would their noncarrier counterparts. Kitayama and colleagues (2014) tested this possibility. A total of 398 young adults (both European Americans and East Asians living in the United States) were genotyped for *DRD4*. Approximately, 35% of them carried the 7- or 2-repeat allele, whereas the remainder did not. The participants filled out a series of questionnaires assessing constructs related to both independence (independent self-construal, self-esteem, self-efficacy, and value in self-expression) and interdependence (interdependent self-construal and holistic cognitive style), yielding higher-order factors of both independence and interdependence. The results are summarized in Figure 3.5. As predicted by the hypothesis that the 7- or 2-repeat carriers tend to acquire the dominant norms and values of their culture, East Asians carrying these alleles were significantly more interdependent (or less independent) than their

European American counterparts. Interestingly, among the noncarriers, the cultural difference was negligible.

Consistent evidence has also been identified in the domain of emotional experience (Tompson et al., 2018). Specifically, in line with the hypothesis that emotional balance is culturally sanctioned among Asians and emotional positivity among European Americans, there was a significant culture \times *DRD4* interaction. East Asian 7- or 2-repeat allele carriers (versus noncarriers) reported experiencing greater emotional balance (i.e., weaker positivity bias) than noncarriers. For European Americans, however, the pattern was reversed such that the positivity bias was stronger, albeit nonsignificantly, among the carriers than among the noncarriers.

Additional evidence for the hypothesis that *DRD4* modulates the impact of situational influences comes from a recent study by Silveria and colleagues (2016), who tested the association between socioeconomic status and fat intake. Among girls living in low socioeconomic status neighborhoods, fat intake tended to be higher if they carried the 7-repeat allele than if they did not; but among those in high socioeconomic status neighborhoods, fat intake tended to be lower for carriers than for noncarriers. There was no such effect among boys. The finding raises more questions than it solves. But one possible explanation is that social norms encourage foods with high fat content in low- (vs. high-) socioeconomic status neighborhoods. Moreover, these norms are likely to be more salient for girls than for boys. Thus, they might have had a greater impact on girls carrying the 7-repeat allele of *DRD4*.

Altogether, cumulative evidence suggests that *DRD4* does in fact significantly modulate the sensitivity or susceptibility to environmental influences, including parenting, religiosity, cultural values, emotion, and eating behavior. Moreover, the evidence is consistent with the hypothesis that this effect of *DRD4* is likely mediated by reinforcement-based learning of cultural norms, beliefs, and values (Kitayama et al., 2016b). Future work must examine this hypothesized mechanism in greater detail. In particular, neuroimaging methods may be employed to test the hypothesis that the 7- or 2-repeat allele of *DRD4* enhances reward process-

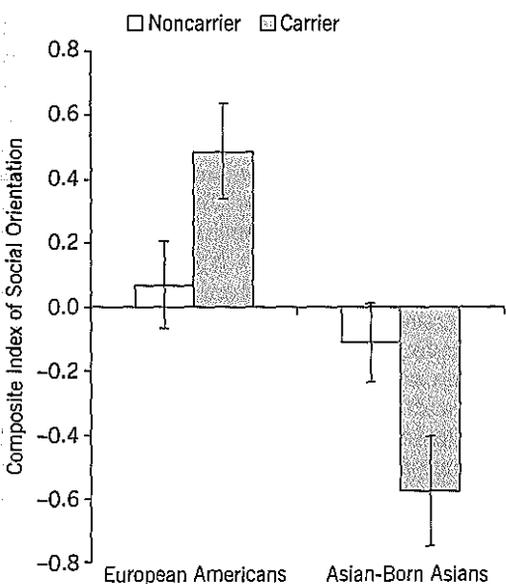


FIGURE 3.5. Independent versus interdependent orientation as a function of both culture and *DRD4*. European Americans are relatively more independent, and Asians are relatively more interdependent; but this cultural difference is apparent only among those who carry high dopamine-signaling variants of *DRD4*. Adapted from Kitayama et al. (2014).

ing. This process may in turn be conducive to enhanced capabilities for responding to reward contingencies in the environment, including those derived from sociocultural factors. Furthermore, it is of interest to explore how the reward contingencies in the environment might influence psychological processes. Would this influence occur at the level of explicit beliefs and values, as suggested by the Kitayama et al. (2014) study? Or, alternatively, would it also occur at the level of brain processes and mechanisms? Of course, the two possibilities are not mutually exclusive. At present, however, very few studies have tested the effect of *DRD4* on neural indicators of culture.

One thorny question to address is why *DRD4* and a relatively small number of select genes (Kim & Sasaki, 2014) have a singularly important influence on the acquisition of culture. It is possible that many other genes have similar functions, but they have not been identified so far. Another possibility is that these genes are in fact special in certain important ways. For example, these genes may serve as a “hub” in a network(s) of genes involved in cultural acquisition. Thus, the variations in them might have disproportionately large effects downstream, through the operation of other genes included in the network(s). For example, a gene network for reward processing might have been previously established. This network might then be “turned on” and up-regulated through subsequent mutation of certain genes that influence this network. *DRD4* might qualify as one such gene. Although speculative, this possibility is consistent with a recent finding (noted earlier) that the key variants of this gene (the 7- and 2-repeat alleles) were incorporated into the human genome relatively recently (over the last 50,000 years).⁴

Culture and Biological Health

Another important extension of cultural neuroscience comes from recent efforts to examine correlates of biological health across different cultural contexts. There are two primary motivations behind this work. First, it is important to explore the extent to which culture goes under the skin, influencing not only the brain but also the body. Culture may influence the body in a way that has yet to be discovered through, say,

certain forms of gene \times culture interactions or epigenetic pathways wherein cultural factors modulate expression of certain genes involved in pathogenesis. While these possibilities may seem no more than speculations at this point, all the evidence we have reviewed so far in this chapter points to their plausibility.

The use of biological measures in the investigation of cultural influences on health is important for another reason. In psychology, health has long been studied, but more often than not, measures of health are based on subjective self-reports. Most straightforwardly, researchers have used a single-item measure of subjective health, which itself has proven to be a valid indicator by reliably predicting mortality (Idler & Benyamini, 1997). Another typical example is a symptom checklist, in which respondents may be asked to check off all symptoms they feel or experience. A similar checklist is also used to assess chronic health problems and functional disabilities. These measures are often useful and valid. Indeed they are typically correlated with biological measures of health, for example, inflammatory markers such as interleukin-6 (IL-6) and C-reactive protein (CRP). Nevertheless, these subjective measures have an important limitation simply because they are subjective. A lot more is going on in the body that is not readily accessible to subjective reports. Furthermore, subjective measures of health could produce artificially high correlations with a variety of sociocultural variables because they are aligned on an important valence dimension. Simply put, health is good, and as a consequence, to the extent that any sociocultural variables have shades of meaning that are positive (or negative), this shared valence component would ensure a degree of positive (or negative) correlation between health and these variables (Kitayama & Park, 2017). For example, as we shall see, when various negative emotions (e.g., general negative affect) are correlated with subjective health, the correlations are often highly negative. Moreover, these correlations occur regardless of culture. At first glance, the observation might show negative health effects of the negative emotions. Alternatively, however, these negative correlations might simply mean that there is a substantial common component (negative valence) shared in both

the negative emotions and ill health. For this reason alone, it is important to explore correlates of health while assessing the latter with biomarkers.

Evidence available today on cultural variations in the correlates of biological health is rather limited. Much of it comes from matched, large-scale surveys conducted in both Japan and the United States (called the Survey of Midlife in Japan [MIDJA] and Midlife Development in the United States [MIDUS] surveys, respectively). The collection of biomarkers was completed relatively recently. Thus, only a few systematic comparisons have been conducted so far, and we hope that more comparisons are to come. Here we provide a glimpse into this effort to show that the cultural variation is in fact substantial.

Negative Affect and Biological Health across Cultures

In one earlier study, Miyamoto and colleagues examined a biological health correlate of negative affect by focusing on IL-6 (a commonly used indicator of inflammation, which in turn is a potent predictor of morbidity and mortality) (see Miyamoto, Yoo, & Wilken, Chapter 12, this volume). It is typically assumed that negative affect is biologically taxing and should therefore be associated with poor biological health. In fact, as noted above, across cultures, negative affect is typically correlated inversely with subjective health to a substantial extent. To the extent that subjective health and biological health are tapping the same reality (i.e., health), then this inverse relation between negative affect and health should hold across cultures. However, as also noted earlier, negative affect is obviously negative in valence; moreover, so is ill-health. Hence, part of the inverse correlation between negative affect and subjective health may be an artifact of this semantic overlap.

The possibility that the cross-cultural commonality of the positive association between negative affect and subjective ill-health might in part be a semantic artifact is reinforced by recent work on the cultural psychology of emotion, which suggests that European Americans seek positivity in the self, while avoiding negativity. For example, there is a strong motivational tendency

among Westerners to pursue a positive self-image (Heine et al., 1999). Moreover, these two states (positive and negative) are experienced as incompatible, as suggested by inverse correlations typically found between positive and negative affect ratings in Western populations. Given this cultural emphasis on the positive, the experience of negative affect may be quite threatening to the self, since it can imply a certain inadequacy or even moral failure of the self (“I am not adequate or not living up to the standards of my culture”). In contrast, East Asians do not typically show any push toward the positivity that is common among European Americans (Heine et al., 1999). Instead, they tend to have a more dialectical view of positivity and negativity, wherein the two states are mutually compatible and require one another to complete the full experience of emotion (Miyamoto & Ryff, 2011). Consistent with this hypothesis, among East Asians, the correlations between positive and negative affect tend to be either null or even positive (Kitayama, Markus, & Kurokawa, 2000; Miyamoto & Ryff, 2011). Hence, among East Asians, the experience of negative affect is unlikely to be threatening to the self.

In support of this analysis, when Miyamoto et al. (2013) correlated negative affect that was experienced “in the last 60 days” with IL-6, the correlation (after controlling for common covariates such as body mass index [BMI], age, sex, and education) was significantly negative among Americans, but virtually zero among Japanese. Although this original investigation focused solely on one biomarker, the same hypothesis has recently been tested with three additional biomarkers, including one additional inflammation marker (CRP) and two markers of cardiovascular risk (systolic blood pressure and the amount of low-density lipoprotein [LDL] cholesterol). The pattern has held up across the measures (see Kitayama et al., 2017a).

Anger Expression and Biological Health across Cultures

Another emotional state that is typically considered linked to compromised biological health is anger (Chida & Steptoe, 2009; Smith, Glazer, Ruiz, & Gallo, 2004; Thomas & Nelesen, 2004). However, earlier on, J. Park and colleagues (2013) provided evi-

dence that anger is not a monolithic emotion. Instead, it may have two contrasting prototypes that are differentially salient across cultures. First, anger is often construed as a venting of frustration. When frustrated, people vent by expressing anger. This form of anger is likely to be more dominant or salient in individualistic societies in which people have clear personal goals and are therefore prone to frustration in difficult life circumstances. Second, however, anger may also be construed as a display of dominance and status. When given a dominant, higher-status role, individuals may feel the privilege of expressing anger so as to show off their status. This form of anger is likely to be more prevalent and salient in collectivistic societies in which people are ranked in a strict fashion and only those high in status are permitted to express the emotion of anger that is otherwise seen as socially disruptive (J. Park & Kitayama, in press; J. Park et al., 2013). In support of this analysis, J. Park and colleagues found that among Americans, social status is inversely correlated with anger expression, so that lower-status Americans are more likely to report that they express anger than are their higher-status counterparts. In contrast, among Japanese, social status is positively correlated with anger expression, so that higher-status Japanese are more likely to report that they express anger than are their lower-status counterparts.

Based on the J. Park et al. (2013) findings, it may be assumed that anger expression is typically associated with compromised health in Western societies, not so much because anger expression is inherently unhealthy but because those who express anger in these societies tend to have more frustrating experiences, which in turn may have compromising effects on biological health. One critical test of this is to analyze the relationship between anger expression and biological health in societies in which anger is a privilege that is allowed only to higher status individuals. Kitayama and colleagues (2015) tested this prediction in a recent study and provided initial support for the prediction. As shown in Figure 3.6, whereas anger expression (assessed with a standard measure (Spielberger & Sydeman, 1994)) was associated with higher biological health risk as assessed by both inflam-

mation (IL-6 and CRP) and cardiovascular malfunction (blood pressure and amount of LDL cholesterol) among Americans, it was associated, equally significantly, with lower biological health risk assessed in the same way among Japanese. The culture \times anger expression interaction was highly significant after controlling for age, gender, BMI, and chronic conditions, all of which were related systematically to biological health risk.

Neuroticism and Biological Health

How about neuroticism, a personality disposition linked to various negative emotions such as anger, anxiety, and guilt (Costa & McCrae, 1987; Goldberg, 1992)? If neuroticism were linked to these negative emotions and, moreover, if these negative emotions were linked to poor biological health, neuroticism would also be linked to poor biological health. However, we have already seen that negative emotions might not be necessarily linked to lowered biological health, especially among Japanese (Miyamoto et al., 2013). In fact, expression of one of these emotions, anger, is clearly linked to better biological health among Japanese (Kitayama et al., 2015; see Figure 3.6). Both negative affect and anger expression are positively correlated with neuroticism, although there is reason to believe that neuroticism is a stable individual difference that is distinct from affective states that vary as a function of circumstance. It would seem worthwhile, then, to examine the relationship between neuroticism and biological health risk across cultures.

This is exactly what Kitayama and colleagues (2017a) attempted. Using the same MIDUS/MIDJA dataset, the researchers predicted biological health risk as a function of neuroticism (assessed by the degree of endorsement of traits such as worried, upset, irritated, and calm [reversed]) after controlling for a standard set of covariates, and found another striking cross-cultural difference. Among Japanese, higher neuroticism predicted lower biological health risk; that is, neurotic Japanese were biologically healthier. Among Americans, however, there was no reliable relationship between neuroticism and biological health risk. Although the cross-cultural difference might seem surprising, Kitayama and colleagues

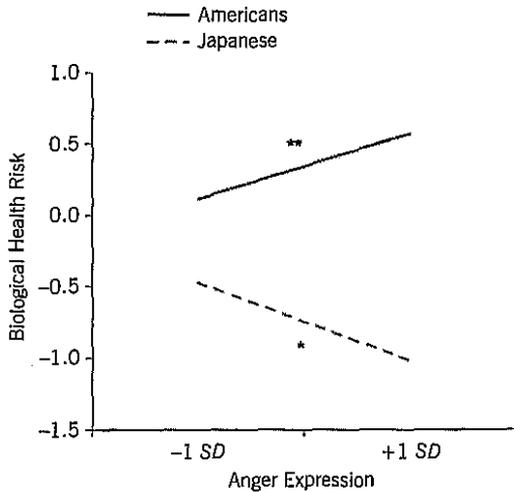


FIGURE 3.6. Biological health risk as a function of anger expression among Americans and Japanese. Biological health risk is indexed by a composite of four measures assessing inflammation (IL-6 and CRP) and cardiovascular malfunction (blood pressure and total to HDL cholesterol). Adapted from Kitayama et al. (2015).

had anticipated it. They argued that neuroticism is negative because it fosters attention to potential dangers and threats in the environment. This attention can be maladaptive if people have no means at their disposal to cope with such dangers and threats. However, Japanese are more likely than Americans to be flexible, willingly adjusting their behaviors to the dangers and threats so as to minimize any negative effects of these dangers and threats. They are therefore likely to be challenged (rather than threatened and helpless), resulting in reduced biological health risk. Kitayama and colleagues measured the propensity to flexibly adjust one's behaviors to environmental contingencies and provided evidence for this analysis.

CONCLUSIONS

Summary

Our main aim in this chapter has been to present an overview of a neuroscience approach to cultural psychology. We highlighted several possible benefits of this approach. First, the neuroscience approach focuses on

brain structures and functions when theorizing about the mechanisms underlying various psychological phenomena and cultural variations in those phenomena (*psychological mechanisms*). Second, recent evidence regarding the extent of human neuroplasticity makes it apparent that environmental influences, including cultural influences, can go deep under the skin. This evidence challenges the more traditional computer metaphor of the mind, wherein culture is thought to regulate only the inputs and outputs of an autonomous psychological system, without influencing the system itself (*biological plasticity*). Third, cultural influences at the neural level can be more reliably linked to cumulative cultural input, since cumulative cultural experience is stored and preserved in neural networks (*cumulative effects of culture*). Fourth, neuroscience can help us uncover new psychological phenomena that vary across cultural groups, of which we may not have been aware if we used more traditional behavioral or self-report methods (*cultural insight*). Fifth, and perhaps most important, the neuroscience approach makes it possible to pursue and eventually realize a theoretical synthesis of culture and biology or nurture and nature (*theoretical synthesis of culture and biology*). By realizing this synthesis, a more comprehensive understanding of the human mind—as a biological system that is fully embedded in and attuned to beliefs, values, and practices inherent in the sociocultural environment—can be achieved.

We illustrated these points by reviewing (1) several substantive domains of research on the relationship between culture and the brain; (2) gene \times culture interactions, with a focus on *DRD4* in addition to gene–culture coevolution; and (3) cross-cultural variations in the correlates of biological health. Biological responses underlying known cultural variations in some significant psychological functions illuminate the specific mechanisms of these cultural effects, which in turn bring up new questions about how these effects have come about, leading to recent work on gene \times culture interactions. Moreover, the same biological approach to culture has begun to reveal the profound extent to which sociocultural processes are implicated in biological health.

Limitations

Having taken stock of what the field has accomplished so far, it is fitting to step back and consider some important limitations to the body of literature produced by this emerging discipline. Four limitations deserve discussion. First, as in the rest of cultural research, the bulk of evidence is limited to a comparison between Westerners and East Asians. Although some studies have begun to include other cultural groups in cross-cultural comparisons, such as Latinos (Hampton & Varnum, 2018b; Kitayama & Salvador, 2017; Telzer et al., 2010), much more remains to be done to capture human cultural diversity using neuroscience methods. As these methods are typically labor-intensive, expensive, and not highly portable, expanding the database to include broader samples (e.g., residents of remote and small-scale societies) is logistically challenging. All the more, such work should be carefully designed so as to yield the greatest insight into the consequences and causes of cultural variations.

Second, much more concerted effort is needed to integrate cultural and evolutionary frameworks. Whereas the brain and body are genetically programmed at one level, they are deeply influenced by sociocultural environments. Moreover, recent research on the time course of genetic evolution makes it apparent that genetic evolution is inseparable from the evolution of culture. This coevolutionary dynamic must be more thoroughly theorized and empirically investigated. In so doing, methods of neuroscience, genetics, and epigenetics would be indispensable insofar as genes, and the expression of the genes, are one major means by which culture and biology interact. Indeed, the coevolution of culture and genes may occur in terms of not only the selection of certain genetic polymorphic variants but also the modification of how existing genes are transcribed and expressed. Just as the selection of genetic alleles may be conditional to environmental contingencies whether ecological, climatic, or otherwise cultural, the epigenetic pathways that emerge might also be conditional to such contingencies that are relatively stable over generations. Recent developments in epigenetics (Cole, 2014; Meaney, 2001) may be instrumental in developing new insights on cultural evolution. This effort must be

combined with emerging theories regarding the impact of evolutionary factors on cultural variation, cultural change, and cultural evolution (Diamond, 1998; Henrich, 2015; Oishi, 2014; Sng et al., 2018; Talhelm & Oishi, Chapter 4, this volume; Thompson et al., 2018; Varnum & Grossmann, 2017; Varnum & Kitayama, 2017).

Third, the hypothesis that genetics and epigenetics are deeply involved in cultural influences underscores the need to investigate sociocultural variations in brain structures in much finer detail. Pertinent evidence that is available today is limited in quantity, since there are only a few published studies. There is also limited evidence about the measures used, since typically only gray-matter volume (and, in one case, cortical thickness) was tested. However, there are many other structural properties. Particularly, future work may benefit from careful consideration of anatomical connectivity across different regions of the brain, as well as how they may interact with certain genes (including *DRD4*) that are demonstrably implicated in cultural evolution.

Fourth, most of the findings in cultural neuroscience are correlational. Such studies can help us identify ways in which cultural groups differ and may suggest mechanisms, but to truly understand why these differences exist, experiments are required. Future work would benefit from studies utilizing various manipulations and interventions that are theoretically motivated and targeted to specific mechanisms of interest (including not just psychological processes and situational factors but also specific biological systems).

Future Directions

Despite these limitations, the field of cultural neuroscience has matured over recent years and has contributed a great deal to the knowledge base of cultural psychology. We envision that over the next decade or so, some methods from this field may be incorporated into the mainstream of cultural psychology, particularly as costs come down. For example, the use of EEG and ERP in cultural psychology may become ubiquitous, much as reaction-time-based measures have become commonplace in cognitive psychology and social psychology over the past several decades. Expanding the cultur-

al psychologist's toolkit will enable greater sophistication and theoretical precision by providing insight into process and mechanism. It will help avoid common pitfalls that have troubled the field, such as cultural differences in response biases, social desirability, and issues inherent in translation. It will also likely uncover novel domains of cultural difference and may even change some fundamental ways in which we conceptualize certain phenomena. For these reasons alone, cultural neuroscience is indispensable for further development of theory and research in cultural psychology.

This brings us back to our initial question: Why neuroscience? Our review of the first 10 years of research in cultural neuroscience presents one response to this question. We trust that each reader will critically evaluate this response. As three of the proponents of the field, we believe that the case we have presented for the field is reasonably strong. While there are many specific instances in which critical evidence is still lacking or the theoretical analysis has yet to be made airtight and compelling, they do not necessarily represent a liability to the field. To the contrary, each of these "soft spots" in the current undertaking may be precisely the ones that define important points of departure for the next 10 years of the study of culture from a neuroscience point of view. With this caveat, we hope everyone agrees that the prospect of the field is promising. Indeed, the field may well be deserving of further investment by the next generations of talented researchers.

ACKNOWLEDGMENTS

Writing of this chapter was supported by National Science Foundation Grant No. SES 1325881 and National Institute on Aging Grant Nos. 5R37AG027343 and P01-AG020166.

NOTES

1. It bears an emphasis that the traditional view of cognitive dissonance assumes that a conflict detected during choice activates negative arousal (dissonance), which is reduced through postdecisional rationalization. In contrast, the Kitayama and Tompson (2015) model hypothesizes that the in-choice conflict initiates a search for positive incentives that would enable the de-

cision maker to make a clear choice. According to this model, what would appear to be postdecisional rationalization is in part realized before the choice is made, through the identification of decision-enabling positive incentives.

2. The interpretation presented here is different from that in an earlier analysis. For example, Imada and Kitayama (2010) argued that European Americans feel "social pressures" from the faces, which in turn diminished the need for rationalization. The two interpretations are not mutually exclusive and must be further investigated in future work.

3. An alternative interpretation is to assume that Asians are worried about what others might think of them when exposed to "social eyes" (Imada & Kitayama, 2010; Kitayama et al., 2004). This interpretation is consistent with the current analysis insofar as the anxiety associated with evaluation apprehension may also alert the conflict detection system.

4. This consideration might be part of the reason why the evolution of this gene appears to coincide with dramatic turns in the human way of being, particularly, the dispersion of humans into the Eurasian continent (50,000 years ago) and the beginning of herding, farming, sedentary living, and eventual formation of non-kin-based, large social groups (over the last 10,000 years). This speculation, however, must be tempered with a realization that there might be other genes or epigenetic processes that are functionally similar. Moreover, cultural evolution depends on a large number of factors that are fundamentally ecological, geographic, and historical (e.g., Diamond, 1998; Talhelm & Oishi, Chapter 4, this volume; see Markus & Hamedani, Chapter 1, this volume, on "downward constitution"). Hence, it would be not only simplistic but also incorrect to link civilization singularly with any particular genes.

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