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Culture Wires the Brain: A Cognitive Neuroscience Perspective

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Abstract

There is clear evidence that sustained experiences may affect both brain structure and function. Thus, it is quite reasonable to posit that sustained exposure to a set of cultural experiences and behavioral practices will affect neural structure and function. The burgeoning field of cultural psychology has often demonstrated the subtle differences in the way individuals process information—differences that appear to be a product of cultural experiences. We review evidence that the collectivistic and individualistic biases of East Asian and Western cultures, respectively, affect neural structure and function. We conclude that there is limited evidence that cultural experiences affect brain structure and considerably more evidence that neural function is affected by culture, particularly activations in ventral visual cortex—areas associated with perceptual processing.

Keywords

fMRI; fMR-A; eye movement; cultural differences; ventral visual cortex; object; context; age

There is a wealth of evidence that experiences sculpt both brain and behavior. Recent work in cognitive neuroscience has provided clear evidence that sustained experience changes neural structures. For example, London taxi drivers who engage in sustained wayfinding show larger gray matter of posterior hippocampi, with the magnitude of the effect increasing with experience, suggesting experience to be the causal mechanism (Maguire et al., 2000). Canadian postal workers spend thousands of hours sorting postal codes by letters and numbers jointly, and this experience changes categorical representation of these two symbolic systems into a single more unitary system (Polk & Farah, 1998). There is even evidence that sustained practice in learning to juggle increases the volume of cortical tissue in the bilateral midtemporal area and left posterior intraparietal sulcus (Draganski et al., 2004) and that the effect generalizes to older adults (Boyke, Driemeyer, Gaser, Buchel, & May, 2008).

As a trip to a foreign country often illustrates, values, behaviors, and environments differ markedly and systematically between cultures. Given the evidence described above showing that experiences affect the volume of neural structures and category organization, it is very reasonable to posit that sustained exposure to a set of cultural experiences and behavioral practices will affect neural structure and function. The burgeoning field of cultural

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psychology has provided innumerable demonstrations that there are subtle differences in the way individuals process information—differences that appear to be a product of cultural experiences. One seminal framework for understanding the impact of culture on cognitive function was proposed by Nisbett and colleagues (Nisbett & Masuda, 2003; Nisbett, Peng, Choi, & Norenzayan, 2001; Peng & Nisbett, 1999). Nisbett and colleagues propose that East Asian and Western cultures have different biases for processing information that result from contrasting cultural values and beliefs. According to Nisbett et al. (2001), Westerners, due to the individualistic, self-based focus of their culture, have a tendency to process central objects and organize information via rules and categories. In contrast, East Asians, based on their collectivist culture, tend to view themselves as part of a larger whole, resulting in a holistic information-processing bias in which object and contextual information are jointly encoded and in which relational information is prioritized over categorical information. This influential framework has received considerable support.

In this article, we briefly review behavioral evidence for this framework and consider evidence in particular suggesting that East Asians and Westerners differ in the information selected for attention, as measured by eye movements. We then focus on the consequences of cultural differences in information processing for neural structure and function. We first describe evidence from the functional imaging literature indicating that cultural differences exist in the ventral visual cortex (VVC)—an area of the brain highly associated with visual and perceptual processing. Evidence regarding neural differences in fronto-parietal function will be discussed next. Then we consider the few studies that address whether neural structures differ as a function of culture. Following that, we discuss the role of aging—which typically involves many years of immersion in a single culture—in understanding the relationship of cultural values and information processing biases to neural structure and function. We will close with the discussion of methodological considerations that need to be addressed in cross-cultural studies of neural structure and function. We should note that our focus on East Asian and Western culture should not be interpreted to indicate that this is the only, or even most important, value system that sculpts differences in cognition between cultures. Rather, this contrast is by far the most sophisticated and developed theorizing about culture's relationship to cognition and it has been invaluable in developing a roadmap to direct the study of neural differences that result from different cultural biases for information processing.

Behavioral Data Demonstrating That Culture Affects Cognition

There is a well-developed literature suggesting that stable differences can be observed between East Asians and Westerners with respect to attention, contextual processing, categorization, and reasoning, with evidence that East Asians are more biased to process context, utilize categories less, and rely more on intuitive rather than formal reasoning processes. With respect to differences in context, Masuda and Nisbett (2001) reported that Japanese participants were more likely, after viewing pictures of fish swimming in an underwater environment, to recall contextual details than were Americans. They also found that when participants encoded pictures of wildlife against a complex natural background (e.g. a goat on a grassy meadow), Japanese participants' recognition performance was more negatively affected by background changes than were Americans. Both of these findings are congruent with the notion that Japanese encoded information more holistically than Americans. In later work, Masuda & Nisbett (2006) reported that East Asians were more likely to detect changes in contextual information in a scene than were Westerners, a finding similar to that of Boduroglu, Shah, and Nisbett (2009), who found that East Asians allocated attention to a broader spectrum of a visual display and were more likely to detect color changes in the periphery of a scene, whereas Westerners detected central changes most effectively. In another domain that demonstrated more East Asian attention to context,

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Masuda, Gonzalez, Kwan, and Nisbett (2008) reported that East Asian participants were more likely to include greater details and background when taking photographs of a model when they were free to set the zoom function of the camera as they saw fit. Kitayama, Duffy, Kawamura, and Larsen (2003) used the Frame-Line Test and asked Japanese as well as American participants to draw a line of either the exact same length as one presented in a frame or one that was proportional in size to the one presented in the earlier frame. Americans were more accurate in the absolute task, suggesting better memory for the exact or absolute size of the focal object, but East Asians were more accurate in the relative (proportional) task, suggesting better memory for contextual relationships. Overall, the findings converge from many different behavioral task domains to indicate that East Asians are biased toward holistic, contextual processing, whereas Americans are more biased to process focal objects in visual stimuli. Other data (Chiu, 1972; Ji, Zhang, & Nisbett, 2004) provide convincing evidence that East Asians tend to process relationships among items more (e.g., cow–grass), whereas Westerners focus more on categories (e.g., cow–chicken), and there is also evidence that Westerners rely more on formal reasoning than intuition when the two or in conflict but that the reverse is true for East Asians (Norenzayan, Smith, Kim, & Nisbett 2002).

Culture Differences in Eye Fixations for Complex Visual Stimuli

The culture and cognition framework discussed thus far would predict that East Asians should be more likely to fixate on contextual information than Westerners and that Westerners should tend to fixate more on central objects. Eye-tracking hardware permits measurement of both the duration and location of fixations and provides evidence for modulation of eye movements to visual stimuli by culture. Chua, Boland, and Nisbett (2005) examined the pattern of eye movement in East Asians and Westerners when viewing scenes with embedded central objects. Westerners fixated longer and more on focal objects, whereas Chinese participants had shorter fixation durations and more saccades to background scenes, confirming basic predictions of culture and cognition models. However, in a later eye-tracking study, Rayner, Li, Williams, Cave, and Well (2007) failed to find evidence for more attention to context in East Asians, but they did find evidence for shorter fixation length in the East Asians, a finding suggestive of more scanning of stimuli. More recently, Rayner, Castelhano, and Yang (2009) failed to find evidence for culture differences in processing unusual elements of a scene, which they suggest disconfirms the idea that culture biases oculomotor control. Goh, Tan, and Park (2009) also investigated eye movement in reaction to changes in complex scenes in East Asians and Westerners. East Asians and Westerners passively viewed pictures containing selectively changing objects and background scenes that strongly captured participants' attention in a data-driven manner. They found that the number of object fixations in Westerners was more affected by object change than it was in East Asians. Also, in agreement with Rayner et al. (2007), Westerners consistently maintained longer durations for both object and background fixations, with eye movements that generally remained within the focal objects. In contrast, East Asians had shorter fixation durations with eye movements that alternated between objects and backgrounds, consistent with a bias to process contextual relationship between objects and backgrounds. Taken together, the data on eye movement and scenes provides considerable evidence for culture differences in visual fixations, but more work is needed to understand the variables controlling culture differences in gaze duration to different scene elements.

There is also an emerging literature focused on cultural differences in processing of facial stimuli. Blais, Jack, Scheepers, Fiset, and Caldara (2008) presented consistent evidence that, when viewing faces, East Asians focus on a single central region of the face, whereas Westerners scan more broadly, focusing on both eyes and mouth. The authors note that the finding is potentially consistent with the idea that East Asians holistically process faces, but it could also reflect gaze avoidance that is characteristic of East Asian cultures. Either way, the data unquestionably lead to the conclusion that cultural factors play a role in the processing a facial information. In a later study, the same research group reported a pattern of cultural differences for processing emotional faces (Jack, Blais, Scheepers, Schyns, & Caldara, 2009). East Asians were less effective than Americans at discriminating fear versus disgust and also showed a more limited scanning pattern for faces than did Americans who sampled the face broadly when judging emotions. The investigators conclude that their work broadly demonstrates that culture plays a role in modulating perceptions of emotion and suggest that these differences could be problematic for communication of emotion across cultures: "Easterners and Westerners will continue to find themselves lost in translation." (Jack et al, 2009, p. 4).

At the most global level, the eye-tracking data make a case that East Asians and Westerners likely "see" different things when confronted with a complex visual stimulus. East Asians will sample elements of scenes more frequently and distribute gaze more broadly, consistent with the Nisbett et al. (2001) framework. However, the processing of faces yields a more complex picture, with some evidence that East Asians show less sampling in general and less sampling of emotional faces, limiting the accuracy of their diagnosis of emotion. Although more research is needed on the fixation data, both the cognitive-behavioral and eye-movement paradigms provide clear evidence to suggest cultural differences that should conceivably be reflected in patterns of neural activation and possibly even neural structures.

Neural Function and Culture

The literature on functional differences in activation patterns associated with culture is better developed than the structural literature. Han and Northoff (2008) thoroughly reviewed functional neuroimaging studies associated with culture variables, and Goh and Park (2009) reviewed studies focused primarily on cognitive processes. In this section, we consider functional imaging studies of cognition that focus on perception of scenes, objects, and faces, as well as studies that focus on social-cognitive variables.

The first functional magnetic resonance imaging (fMRI) study to focus on the ventral visual cortex (VVC) and demonstrate differences in functional activation between cultures was reported by Gutchess, Welsh, Boduroglu, and Park (2006). East Asians and Westerners encoded pictures of individual objects (e.g., elephant alone), individual background scenes with no central object embedded (e.g., a jungle scene with no elephant), and background scenes with a target object embedded (e.g., elephant in a jungle). Congruent with the individualistic–collectivist hypothesis (Miyamoto, Nisbett, & Masuda, 2006; Nisbett & Masuda, 2003; Nisbett et al., 2001), Westerners showed more activation in object processing regions, including the bilateral middle temporal gyrus, left superior parietal gyrus, and right superior temporal gyrus, although no reliable activation differences were observed in context-processing regions for Asians, as the individualistic–collectivist hypothesis would predict.

Other recent research has focused on the VVC. The VVC is a broad region encompassing a number of neural structures across mediotemporal and occipital lobes that is specialized for processing the identity of objects—the "what" pathway (Mishkin, Ungerleider, & Macko, 1983)—with many structures within this region characterized by a high degree of neural specificity. There is evidence that the fusiform region within the VVC activates selectively to faces but not to other categories of stimuli (Kanwisher, McDermott, & Chun, 1997), and this region is often referred to as the fusiform face area (FFA). Selective responding to outdoor scenes, places, and houses occurs in the parahippocampal place area (PPA), and there is also evidence for specialization of object recognition in the lateral occipital complex (Epstein, Graham, & Downing, 2003). The hippocampus, in addition to its other roles, binds objects to contexts and integrates relationships among scene elements (Cohen et al., 1999). One method used to isolate regions of neural specialization within the VVC is through the use of an fMRI adaptation (fMR-A) paradigm. The fMR-A paradigm provides a means of measuring differences in selectivity and specialization in the VVC based on the phenomenon that brain response to repeated stimuli is typically reduced. This reduced activation provides an index of the brain's ability to detect similarity between stimuli and reflects the use of less neural resources to process repeated information. Goh et al. (2004) used this technique to isolate brain regions that were involved in processing objects from those involved in processing scenes. In that study, participants passively viewed quartets of pictures in which each picture consisted of a central object embedded within a background scene (Fig. 1a). Within a quartet, the pictures were repeated such that (a) the object and background scene were presented four times, (b) the central object was changed while the background scene was held constant, (c) the background scene changed while the object was held constant, or (d) both objects and backgrounds scenes were changed across the quartet of pictures. This selective repetition of pictorial components allowed Goh et al. (2004) to isolate brain regions that were sensitive to either object repetition (object-processing regions) or background scene repetition (scene-processing regions). The object regions were observed to be localized in the lateral occipital regions, whereas repeated scenes induced adaptation only in parahippocampal regions.

In a later study, Goh et al. (2007) utilized the same fMR-A paradigm to study neural differences in adaptation to objects and background context in East Asians and Westerners, both young and old. Participants were drawn from Singapore and the United States with careful matching of cognitive abilities as well as measurement of signal equivalence from scanner hardware (Sutton et al., 2008). Results are displayed in Figure 1b, and they indicate that background processing was relatively similar across both age and culture, as the parahippocampal place area showed nearly equivalent activation across all conditions. The lateral occipital complex, indexed as an object processing region, however, showed an Age × Culture interaction, with generally less efficient processing of objects by older adults. However, the object area adaptation was greatly attenuated in elderly East Asians than in Westerners, suggesting that object-processing regions decline with age disproportionately in East Asians. The findings demonstrate the malleability of perceptual processes by culture, with evidence that efficient object processing by young adults becomes more subject to cultural variations with age in the directions predicted by individualistic–collectivistic models of culture and cognition (Miyamoto et al., 2006; Nisbett & Masuda, 2003; Nisbett et al., 2001).

In another subsequent study that examined culture effects in an adaptation paradigm, Jenkins, Yang, Goh, Hong, and Park (2010) assessed cultural differences in neural adaptation to congruent and incongruent scenes. The incongruent scenes were created by placing an object against a background where it would not commonly be found (e.g., a cow in a kitchen). Results indicated that Chinese participants showed greater adaptation to the incongruent scenes in the lateral occipital complex, an object processing area. The findings suggest that the Chinese devoted more neural resources to object processing when the scenes were incongruent due to their enhanced sensitivity to the entire scene, whereas Americans were less likely to be affected by incongruent context, as they focus primarily on objects.

Although much of the functional imaging work has focused on the VVC, there is also evidence for cultural differences in fronto-parietal function. Hedden, Ketay, Aron, Markus, and Gabrieli (2008) conducted a modified framed-line test and examined the neural network activated when East Asian and Western subjects made judgments of line length that were either proportional to a box drawn around the line or were absolute and independent of the box. East Asians engaged more fronto-parietal activity (Fig. 2) when they made the absolute or context-free judgment, whereas Westerners showed more engagement in the condition requiring them to integrate the line with context. This provides an elegant demonstration of modulation of neural resources to support culturally preferred or nonpreferred tasks, with nonpreferred tasks requiring greater resource.

There is also an emerging literature suggesting that cultural values influence neural networks activated when recognizing and thinking about self or others. Chiao et al. (2008) demonstrated that native Japanese in Japan and Caucasians in the United States showed greater amygdala activation to fear expressed by members of their own cultural group, suggesting that the automatic, prepotent nature of the amygdala response to fear faces is modulated by culture. Zhu, Zhang, Fan, and Han (2007) reported that both East Asians and Westerners showed robust activation in the medial prefrontal cortex (MPFC) and anterior cingulate cortex when making judgments about self. When the same participants made judgments about their mother, the East Asian subjects showed more MPFC activation than did Westerners, reflecting the more collectivist view of self, in contrast to the Western individualistic representation. In a later event-related potentials study, Sui, Liu, and Han (2009) demonstrated that the British participants showed a larger anterior negative activity at 280–340 ms when responding to photo of their own face than those of a familiar face (i.e., a friend's face), whereas Chinese participants showed a reverse pattern, reflecting the cross-cultural differences in the neural correlates of self and other-referencing stimuli. Moreover, Chiao et al. (2009) also reported neural activation of the MPFC when making judgments about self or others depending on the strength of collectivistic or individualistic values. Similarly, Hedden et al. (2008) demonstrated that the more acculturated the East Asian participants were to Western individualistic culture, the stronger they showed the Western pattern of neural activation. Of particular interest was that the degree individuals from East Asian and Western cultures endorsed individualistic or collectivistic values, rather than culture of origin, determined neural activations. This is a particularly important study because it demonstrates that values associated with representation of self shape neural activations, making a compelling case for cultural values shaping neural function, at least in terms of representation of self.

Structural Differences in Brains Between Cultures

There is a small literature that has developed that examines the possibility that structural differences exist between East Asian and Western brains. The literature reviewed earlier indicating that life experiences with wayfinding (Maguire et al., 2000) and juggling (Boyke et al., 2008; Draganski et al., 2004) affects brain structure makes a strong case for the hypothesis that decades of exposure to cultural values or practices could shape or mold neural structures. In an early study, Zilles, Kawashima, Dabringhaus, Fukuda, and Schormann (2001) compared 56 Japanese and 56 European brains using MRI and 3-D reconstruction techniques. They reported evidence for intersubject variability that was related to cultural group and gender, with Japanese hemispheres being relatively shorter but wider than European hemispheres. Kochunov et al. (2003) examined brains of Chinese-speaking Asian and English-speaking Caucasian adults, all of whom dwelt in the United States, using deformation field morphometry. They reported four small regions across frontal, temporal, and parietal areas that were significantly larger in Chinese than in Americans and interpreted the results as being due to the orthographic, phonetic, and even semantic characteristics of speaking Chinese rather than genetic differences. They argued that cognitive strategy differences involved in language acquisition and usage molded brain form. Green, Crinion, and Price (2007) reported that a voxel-based morphometry (VBM) analysis of the brains of monolingual versus multilingual speakers also yielded evidence for greater gray matter density in Chinese speakers, regardless of whether they were Chinese or European. Greater density was reported in left superior and middle temporal gyri as well as the right superior temporal and left inferior frontal gyrus, and again, the interpretation was that these areas had greater volume due to the challenges of speaking Chinese.

In a recent study, Chee, Zheng, Goh, and Park (2010) collected structure MRI data using measures of cortical thickness and density on a sample of 140 participants that were drawn from four groups: young and old Singaporeans of Chinese ethnicity and young and old Americans of non-Asian ancestry. There were between 31 and 39 participants in each group and young adults from the two cultures were well matched for neuropsychological assessment such as speed of processing and working memory, as were old adults (who performed more poorly than young adults). Chee et al. (2010) reported that the volume of structures was generally equivalent in the young adults from the two cultures and that volume declined across many structures with age. When measures of cortical thickness were calculated, young Americans showed greater thickness in a number of frontal areas, as well as the right superior parietal lobule, in comparison with Asians. Only one region was thicker in Asian young and this was in the left inferior temporal gyrus (Brodmann Area 37). The increased density for frontal areas was confirmed with an alternative measure (VBM), suggesting the reliability of the cultural effect. There were no differences in older adults, partially because of the increased variability of thickness within each group of older adults. The authors suggested that the increased thickness in the frontal areas of young Westerners could conceivably be due to the increased focus Western culture puts on reasoning, problem solving, and independent thinking, whereas the East Asian cultures rely more on following direction and rote memory. However, alternate explanations were also considered, such as dietary, genetic, and environmental differences unrelated to culture per se.

Although the literature on brain structural differences as a function of culture or ethnicity is sparse, the extant literature suggests that this is an important and fertile area of investigation. We tentatively suggest that hypothesis-driven research in which specific regions of interest are related to specific behaviors engaged in by the two cultures differentially, such as differences in linguistic properties, may be the most likely to pinpoint clearly attributable differences in cultural practices or values. Reliable differences are of great interest because they provide insight into domains of neuroanatomy that are modifiable by experience and into structures that are invariant regardless of experiences.

Aging, Culture, and Cognition

The study of life-span differences in neurocognitive function across cultures is an important topic that can inform our understanding of the aging process as well as culture-associated neuroplasticity (see reviews by Park, 2008; Park & Gutchess, 2002, 2006; Park, Nisbett, & Hedden, 1999). The contrast of culture and aging allows for a simultaneous examination of the contributions of experience and biology to the process of aging. Behaviorally, the evidence to date suggests that the effects of aging are much larger than the effects of culture on free recall in memory (Gutchess et al., 2006), source memory (Chua, Chen, & Park, 2006), working memory (Hedden et al., 2002) and processing speed (Hedden et al., 2002). These data suggest that the basic “hardware of the mind” declines in a robust manner with age and that the process does not appear to be mitigated very much by cultural experiences. However, the neural data lead to similar but slightly more complex conclusions. The cross-cultural differences in brain structural data reported by Chee et al. (2010) from a large sample of carefully matched old and young adults suggest that there are pronounced, reliable differences in volume of frontal, temporal, and parietal regions with age. Moreover, the magnitude of the volumetric differences are similar for old and young adults, suggesting the strong role of biology rather than environment in mediating age changes in brain structure, as the experiences of the older adults differ markedly across the samples. At the same time, Chee et al. (2010) note that it is possible that the high degree of variability in volumes that occurs with age makes it difficult to assess any systematic differences, suggesting that very large samples, as well as detailed knowledge about experiences, would be required to detect differences. There is only one published study to date on functional neuroimaging data that includes a cross-cultural comparison of young and old adults (Goh et al., 2007). This study suggested that culture effects that were absent in young adults emerged when older adults were studied. That is, young East Asians and Westerners showed equivalent object processing activations, but significant age-related differences emerged with age, with old East Asians evidencing a nearly complete absence of an object-processing area. This decreased object processing in older East Asians reflected a bias to process context over objects rather than an inability to engage in object processing. The same elderly subjects were tested in an fMR-A study by Chee et al. (2006), but they were instructed to focus attention on the object in the pictures they studied. Under these conditions, a robust object-processing area emerged, but activation in the parahippocampal areas (specialized for processing background scenes) declined, suggesting that the older East Asians had an intact object-processing area, but a limited attentional capacity that prevented them from engaging both object and background regions. With age, the cultural bias to process context over objects emerged in East Asians. These data illustrate the importance of culture in shaping neural functioning, but they also demonstrate the flexibility of the brain and the fact that the cultural changes represent processing biases rather than immutable circuitry changes, as the culture effects were “overridden” by instructions to attend to objects.

There are many important questions that remain in the cognitive neuroscience of aging (Park, 2008). Park et al. (1999) argued that with age, both cultures would move toward a more balanced representation of self and others, leading Westerners to become less oriented to self and East Asians to conceivably become more self-focused. Many critical studies remain to be done that will allow us to understand what aspects of the brain are immutably changed by the biology of aging and which aspects are sculpted by cultural experiences.

Methodological Considerations Associated With Neuroimaging Culture Differences

The study of cultural differences in neurocognitive function is fraught with potential confounds and hazards that cloud interpretation of the data. The scope of this issue could easily encompass an entire volume. The focus here will be on three considerations particularly salient to neuroimaging studies. First, in conducting cross-cultural imaging work, it is important to recognize that neuroimaging data is very different from behavioral data. The dependent measure in an MRI study consists of *t* values for roughly 30,000 to 35,000 voxels of data, which if collected functionally, are typically sampled every 2 s, providing literally millions of data points as outcomes. This is quite a contrast with cognitive behavioral data that often involves only a few measures of memory, reaction time, or attention. Moreover, the data are collected from two groups of participants who typically differ in many systematic ways besides their cultural values, rendering interpretation of any differences found quite difficult. It is therefore critical that specific hypotheses grounded in knowledge of neural structures and behavioral data be tested (Park, Nisbett, & Hedden, 1999). As the above review of the behavioral data indicate, there is a wealth of evidence that visuo-perceptual processes differ between East Asian and Westerners. For this reason, it made sense for the initial work our research group did on neurocultural differences to focus on the VVC, an area of the brain associated with object recognition, contextual processing, and binding of scene elements. This allowed us to test specific hypotheses in regions of interest and limit the amount of neural “real estate” under investigation, increasing the prospects of finding interpretable, replicable differences that are related to cultural values and beliefs rather than to differences in diet, genetics, or medication usage (which, thus far, has always been higher in Western samples than in East Asian samples that we have tested).

A second issue to keep in mind when conducting cross-cultural studies of cognition is the importance of collecting some objective measure of performance suggesting groups are matched. Figure 3 presents neuropsychological data reported by Hedden et al. (2002) from a sample of old and young adults tested in China and the United States. The study demonstrates clearly that when numerically based tests of speed of processing (digit comparison) and working memory (backward digit span) were used, young Chinese showed superior performance to young Americans. Some research suggests that Chinese is less syllabically dense than English and permits more efficient rehearsal (Cheung & Kemper, 1993, 1994), resulting in an apparently greater working memory span for Chinese. When more neutral, spatially based tasks were used (pattern comparison for speed of processing and backward Corsi blocks for working memory), young and old participants were matched, providing good evidence for equivalence in ability (Fig. 3). When conducting studies of culture differences in cognition, it is very helpful to demonstrate that the groups selected for study are matched in basic component cognitive abilities like speed of processing and working memory (Park et al., 1999), as differences observed between cultures in cortical thickness or patterns of neural activation cannot then be attributed to a confounding of basic cognitive abilities with culture. The Hedden et al. (2002) study as well as a number of others (e.g., Gutchess, Welsh, Boduroglu, & Park, 2006; Jenkins et al., 2010) detail measures that are useful for demonstrating equivalence in East Asian and Western samples on a number of cognitive tasks.

The third issue to consider when collecting neuroimaging data between cultures is the potential hazards that exist if one is collecting data from two different MRI machines, with each instrument associated with a particular culture. Again, if one finds differences in the blood oxygen level-dependent (BOLD) signal between cultural groups, it is possible that the difference could occur as a result of differing properties between hardware, such as MRI machines and imaging coils, rather than differences in the activation patterns between cultures (Park & Gutchess, 2002). We have conducted some large cross cultural structural and functional imaging studies between Singapore and the United States, with both groups having identical imaging hardware and software. There was little data reported on between-scanner variability, and we wanted to be certain differences we observed between groups were due to culture differences rather than signal differences between imaging hardware. To assess this issue, we collected functional imaging data with a visual and motor task from 4 participants who were repeatedly imaged in identical 3-Tesla MRI machines both in Singapore and the United States, with two sessions at each site (Sutton et al., 2008). Data showed that there was minimal variance in BOLD signal as a function of site and that between-subject differences accounted for 10 times more variance than did site of data collection. Task variables (motor vs. visual) naturally also accounted for significant variance. We also routinely conducted a phantom scan before testing participants to evaluate noise and stability of the two scanners and reported results to be sure the two magnets were similarly calibrated. The data provided assurance that reported differences between cultures were not due to differing signal properties of the MRI machines between two sites.

Conclusion and New Directions

There is clear evidence that cultural values and experiences shape neurocognitive processes and influence patterns of neural activation and may even effect neural structures. The study of the “cultural brain” is a critically important topic that demonstrates how fundamental cultural values and practices are at influencing thought. An important direction for cognitive neuroscience of culture will be to develop broader frameworks that go beyond East Asian and Western cultures and to consistently consider the possibility that observed effects may not be determined by cultural values or experiences but may instead result from differences in diet, health, and even genetics. The focus on quantifying degree of identification with cultural values and its relationship to brain structure and function is important, as it provides validation that cultural values are controlling effects, in light of the many other sources of variance between different cultures. There is a clear need for multimodal imaging—the integration of structural differences with functional data, as well as an understanding of neural activations that occur when eye movement differences are found. The developmental trajectory of cultural differences also seems like an extraordinarily important domain that is relatively unexplored. How early in the life span do cultural values sculpt the brain? Similarly, does sustained exposure to a culture across one's lifespan enhance the effects of cultural values? This research is an important domain for understanding the malleability of the human brain and how differences in values and social milieus sculpt the brain's structure and function.

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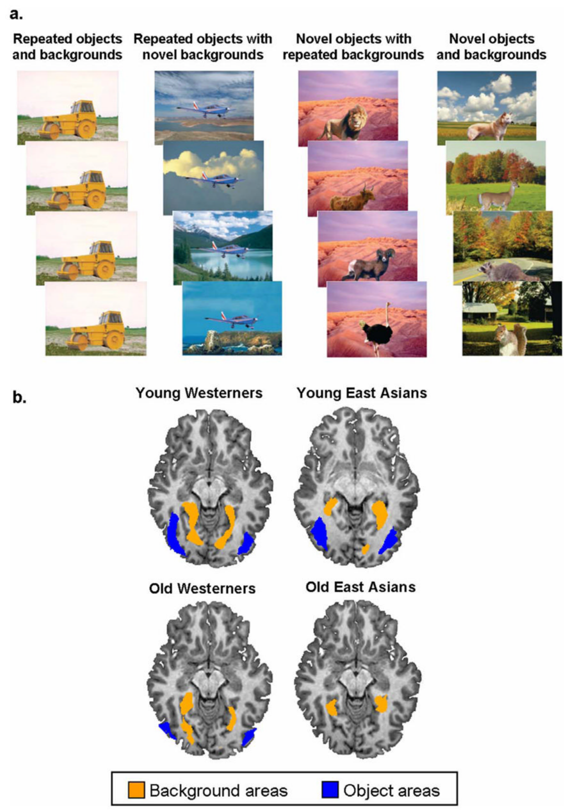

Fig. 1.

Cultural differences in the ventral visual cortex using the fMRI adaptation (fMR-A) paradigm, in which objects and backgrounds in the pictures were selectively repeated. a: Sample quartets stimuli used in the fMR-A paradigm. Each quartet consisted of four pictures of objects placed within background scenes. Within each of the four quartets, objects and background scenes in the pictures were either novel or repeated to isolate ventral visual regions that were sensitive to the either object or background scene repetition. b: Adaptation responses to background repetition in the parahippocampal regions (shown in light gray) were intact in all four groups. However, old East Asians showed significantly reduced object processing in the lateral occipital regions (shown in dark gray). This finding suggests that there is preserved context-focused processing across age and culture but that there are differences in object-based processing across cultures (adapted from Goh et al., 2007).

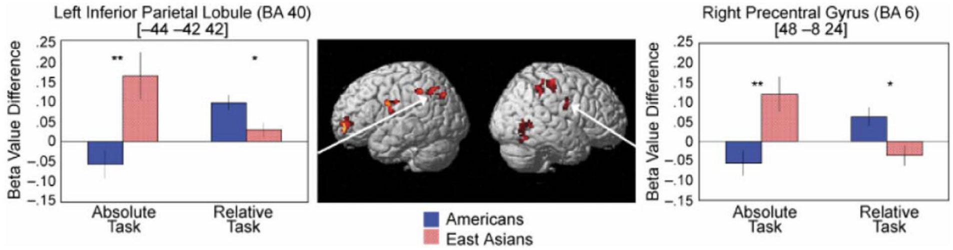

Fig. 2.

Neural activation in frontal and parietal brain regions when Westerners and East Asians perform both of the absolute and relative length judgments in a modified framed-line test. Participants from different cultures display activation in similar networks, but the regions known to be associated with attentional control showed greater activation during culturally nonpreferred judgments than during culturally preferred judgments (adapted from Hedden et al., 2008).

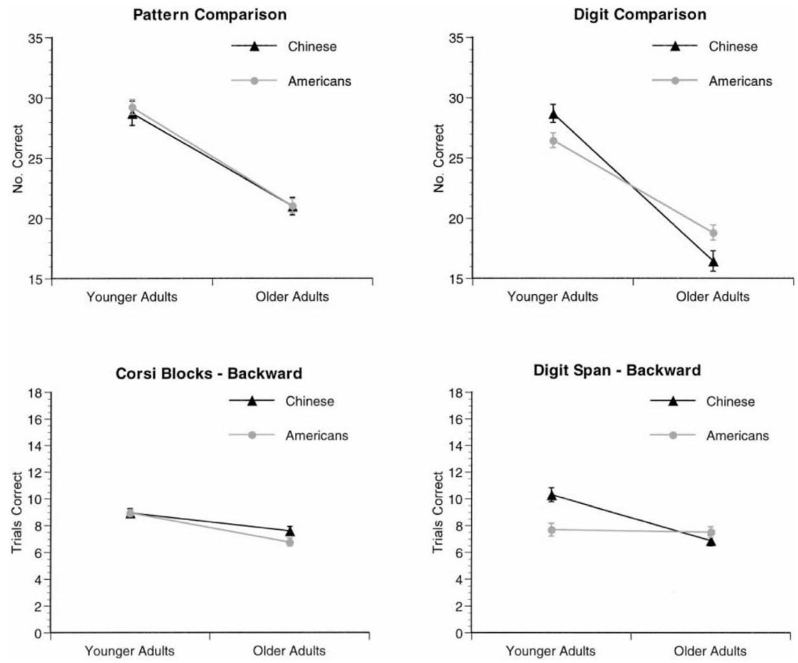

Fig. 3.
Cross-culture measures of verbal and visuospatial versions of speed of processing and working memory across the life span. Cultural equivalent performances were observed on the visuospatial measures of both working memory and speed of processing for either age group. However, the numerically based measure of both working memory and speed of processing show evidence of cultural and linguistic biases (adapted from Hedden et al., 2002).