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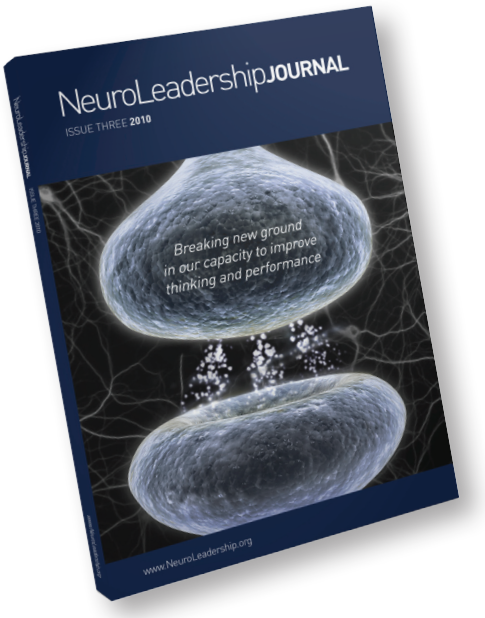

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The culturally intelligent brain: from detecting to bridging cultural differences

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Abstract

The aim of cultural neuroscience is to detect and explain the neurological underpinnings of cognitive and behavioral differences across cultures. Studies in cultural neuroscience are crucial for the education and development of global leaders. They raise awareness and appreciation of cultural differences in global leaders. Effective global leaders also *bridge* cultural differences. In this paper, we propose to extend cultural neuroscience research into intercultural neuroscience of the 'culturally intelligent' brain. We define the intercultural neuroscience of the culturally intelligent brain as the intercultural neurological bases of the capability of an individual to function effectively in multicultural contexts (Earley & Ang, 2003). We review briefly the existing research on cultural neuroscience and propose a critical new research agenda in intercultural neuroscience.

The culturally intelligent brain: from detecting to bridging cultural differences

Cultural psychology and neuroscience are closely inter-related disciplines. As Ames and Fiske (2010) aptly observed, "Culture is, after all, stored in people's brains". A number of scholars have recognized that the human brain possesses the unique ability to acquire basic cultural capacities such as language (Chomsky, 1965). Conversely, without these neurobiological capacities, culture could not function (Ames & Fiske, 2010). Therefore, the study of the culture-brain interaction, known as cultural neuroscience (Kitayama & Tompson, 2010), offers many exciting research avenues with important theoretical and practical implications for understanding human diversity. It is not surprising, therefore, that the field of cultural neuroscience is gaining huge popularity, evidenced by three special journals published in 2009 and 2010 (e.g., *Progress in Brain Research in 2009; Social Cognitive and Affective Neuroscience in 2010; Asian Journal of Social Psychology in 2010*).

Studies in cultural neuroscience are crucial for the education and development of global leaders.

What have we learned from the emerging field of cultural neuroscience so far? Broadly, neural research has demonstrated that "culture does indeed go under the skin" (Kitayama & Tompson, 2010). For instance, neural research confirms previous cultural behavioral studies that Westerners tend to focus on objects while Asians tend to focus on contexts and relationships (Gutchess, Welsh, Boduroglu, & Park, 2006). Neural research also suggests that cultural practices shape habitual neurological activation and, therefore, require less attentional capacity from individuals engaged in culture-specific tasks (Corbetta & Shulman, 2002; Gitelman *et al.*, 1999). Another fascinating stream of neural

research examines how people represent the self and others. Consistent with the interdependent view of the self by Asians (Markus & Kitayama, 1991; Zhu, Zhang, Fan & Han, 2007) show that thinking about a close other, such as one's mother, elicited preferential activation in the ventral medial prefrontal cortex (vmPFC) for Chinese participants, but not for Western participants, indicating that Easterners view close others as part of the self.

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In summary, the emerging field of cultural neuroscience has achieved considerable success in uncovering neurological substrates of cultural differences in a number of basic psychological processes. These studies have enriched our understanding of culture's effects on human behaviors, and offer tremendous practical implications for global organizations. According to a study of more than a thousand CEOs in more than 50 countries, a top concern is *how to effectively bridge* the cultural differences in a globalized workplace (PriceWaterhouseCoopers' 10th Annual Global CEO Survey). Cultural neuroscience, with its 'hard' basis of research, can help create a deeper level of appreciation for cross-cultural differences in organizational leaders when they work with people from different cultures.

However, effective bridging of cultural differences requires more than an understanding of how people in different cultures think and behave differently, which is the major focus of cultural neuroscience to date. We propose that expanding the current focus on *cross-cultural comparison* of neurological processes to *inter-cultural* capabilities can greatly contribute to the science and practice of global leadership. While the cross-cultural neuroscience perspective asks the question of how neurological processes of individuals from different cultures differ, the inter-cultural perspective asks the question of how neurological processes of individuals effective in bridging cross-cultural differences in intercultural interactions, differ from the less effective individuals.

In this paper, we propose that the theory of cultural intelligence offers a useful framework to direct cultural neuroscience research towards an inter-cultural perspective. Cultural intelligence (CQ) refers to the capability of individuals to function effectively in multicultural contexts (Earley & Ang, 2003). Grounded in contemporary theories of intelligence as a multi-dimensional individual aptitude (Sternberg & Detterman, 1986), the CQ construct provides a theoretical basis for examining neurological substrates of individuals effective in bridging cultures. Ultimately, we hope to integrate behavioral and neuroscience research on CQ to develop a deep and coherent body of knowledge on how individuals can be effective in bridging cultures.

The remainder of this paper is organized as follows. First, we briefly review selected findings from cultural neuroscience research and their implications for global leadership. Next, we review cultural intelligence theory and recent work exploring the relationship between CQ and leadership in culturally diverse contexts. These reviews will ground our explorations into possible intercultural neuroscience of CQ. We conclude these explorations by suggesting an agenda for future research on the culturally intelligent brain.

Cultural neuroscience

As organizations globalize and the workforce becomes more diverse, it is increasingly important to understand how leaders can operate effectively in culturally diverse situations (Gelfand, Erez, & Aycan, 2007). Leadership effectiveness depends on a leader's ability to solve complex social problems such as the coordination of thoughts and behaviors within social groups (Mumford, Zaccaro, Harding, Jacobs, & Fleishman, 2000; Wong & Law, 2002). In the culturally diverse context of global leadership, the social coordination problems a leader faces are especially complex because of the large cultural variations in the behaviors and expectations of various stakeholders.

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The current focus in cultural neuroscience studies is to document cultural variations in psychological, neural,

and genomic processes. The research goal is to describe how cultural characteristics and neurobiology shape each other (Chiao *et al.,* 2010). Cultural neuroscience studies have deepened global leaders' understanding of how cultural processes shape basic and higher-order cognitive processes and inspired optimism in uncovering the biological underpinnings of cultural differences in a range of cognitive processes (Ames & Fiske, 2010; Chiao, 2009). Such accomplishments are particularly remarkable in the research on the neurological basis of culturally characteristic perceptual styles and self-schemata, and in the ingroup advantage in emotion recognition. We briefly review these accomplishments because of their potential relevance to global leadership.

Cultural differences in perceptual styles, such as those in the relative attention to objects versus contexts, have an impact on how leaders make sense of situations. For example, selective attention to focal events facilitates analytical processing of the inherent properties of these events at the risk of overlooking their situational embeddedness (Nisbett, 2003).

How the individual views the self affects how he or she relates to others.

Considerable cross-cultural evidence shows that Westerners have a habitual tendency to selectively attend to focal events, whereas East Asians are more accustomed to focus on the embeddedness of the focal events in their physical and social environments (Chua, Boland, & Nisbett, 2005; Kitayama, Dufy, Kawamura, & Larsen, 2003; Nisbett & Miyamoto, 2005). Cultural neuroscience evidence has reinforced this conclusion. Compared to East Asians, Westerners show stronger neural activation in task-related regions of the brain during object processing (Gutchess *et al.,* 2006; Lin, Lin, & Han, 2008). Moreover, Westerners show less activation in brain regions associated with attentional control during object processing (Hedden, Ketay, Aron, Markus, & Gabrieli, 2008), indicating that object processing requires less mental control for Westerners than for East Asians. Nonetheless, brain-imaging results fail to reveal stronger neural activation among East Asians during context processing (Goh *et al.,* 2007; Gutchess *et al.,* 2006), calling into question whether Easterners have a greater habitual tendency to engage in contextual information processing.

How the individual views the self affects how he or she relates to others. Leadership research has provided ample evidence on how followers' self-views moderate the impact of leadership on follower attitudes and behavior (van Knippenberg, van Knippenberg, De Cremer, & Hogg, 2004). Cultures differ in the extent to which the self is seen as a self-contained entity (independent self-construal) or a socially embedded being (interdependent self-construal). Westerners are more likely to view the self as distinct from others, whereas East Asians are more likely to view the self as fundamentally related to others (Markus & Kitayama, 1991). Cultural neuroscience has confirmed the preponderance of interdependent self-views among East Asians. For both Easterners and Westerners, thinking about the self activates an area of the ventral mPFC / anterior cingulate cortex (ACC) (Craik *et al.,* 1999; Kelley *et al.,* 2002; Zhang *et al.,* 2006). However, thinking about significant others activates that same area only for individuals from Eastern cultures (Ng, Han, Mao, & Lai, 2010; Sui & Han, 2007; Zhu *et al.,* 2007). This finding implies that whereas Easterners engage the same region of the brain, Westerners engage different parts of the brain when processing information of the self and significant others.

Identifying emotions from facial expressions is an important people skill for effective leadership (Caruso, Mayer, & Salovey, 2002; Rubin, Munz, & Bommer, 2005). There is a well-documented 'ingroup advantage' in emotion recognition (Elfenbein & Ambady, 2002; Mesquita & Leu, 2007). That is, people are more accurate in recognizing the emotions of people from their own culture than from others. Cultural neuroscience evidence corroborates this finding, showing greater activity in regions of the brain associated with emotion processing when people are asked to identify emotions of their co-nationals than those of foreigners (Adams *et al.,* 2009; Chiao *et al.,* 2008; Freeman, Rule, Adams, & Ambady, 2009). In summary, cultural neuroscience research has demonstrated its capability to inform global leaders of the neurological basis of many important cognitive differences across cultures.

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Implications for global leadership

A major discovery in cultural neuroscience concerns the plasticity and environmental responsiveness of brain functioning. There is considerable evidence that neurological activations can be changed as a function of adapting to or learning from a new culture (Hedden *et al.,* 2008). Indeed, even a temporary, incidental exposure to another culture can change the brain activation pattern when performing the same cognitive task (Ng *et al.,* 2010; Sui & Han, 2007). This implies that whereas individuals develop a habitual pattern of neurological behaviors following chronic (repeated) exposure to a certain culture, the brain retains its potential to adapt to new cultural influences. This is good news for global leadership development because through exposure to multicultural environments, global leaders can acquire cognitive habits that are useful for meeting distinct expectations from different cultures. Like balanced multilinguals who can flexibly switch languages and smoothly navigate diverse linguistic communities, global leaders may be able to appropriate the pertinent cognitive and neurological resources and flexibly switch cognitive habits in response to the changing cultural demands in the current situation.

...people are more accurate in recognizing the emotions of people from their own culture than from others.

Nonetheless, not all leaders with multicultural experiences are culturally savvy. Furthermore, as noted above, the primary challenge for global leadership is the coordination of cultural differences among their stakeholders (Mumford *et al.,* 2000; Wong & Law, 2002). A major gap in cultural neuroscience research is that it has not yet addressed the cognitive neurological basis of the competencies that are essential for effective leadership in culturally mixed environments. One such core competency is CQ (Earley & Ang, 2003). In the following two sections, we seek to further connect the fields of cultural neuroscience and global leadership by elucidating the important role of CQ in global leadership and its possible neurological basis.

Cultural intelligence and global leadership

To explain why some individuals function more effectively than others in culturally diverse settings, Earley and Ang (2003) drew on Sternberg and Detterman's (1986) multidimensional perspective on intelligence to develop a conceptual model of CQ. Ang and colleagues (Ang & Van Dyne, 2008; Ang *et al.,* 2007) defined CQ as the capability of an individual to function effectively in situations characterized by cultural diversity, and theorized that CQ is a multidimensional concept comprizing mental (metacognitive and cognitive), motivational, and behavioral dimensions.

...not all leaders with multicultural experiences are culturally savvy.

The mental dimension of CQ consists of the metacognitive and the cognitive facets. The metacognitive facet refers to an individual's level of conscious cultural awareness during intercultural interactions. Metacognitive CQ involves higher-level cognitive strategies – those that allow individuals to develop new heuristics and rules for social interaction in novel cultural environments by promoting information processing at a deep level. Whereas metacognitive CQ focuses on higher-order cognitive processes, the cognitive facet reflects knowledge of norms, practices, and conventions in different cultures acquired from education and personal experience. Cognitive CQ includes knowledge of cultural universals as well as knowledge of cultural differences. It encompasses an individual's level of knowledge about culture, different cultural environments, and how the self is embedded in a cultural context.

The motivational dimension of CQ reflects the capability to direct attention and energy toward learning about and operating in culturally diverse situations. Kanfer and Heggestad (1997) argued that such motivational capacities "provide agentic control of affect, cognition and behavior that facilitate goal accomplishment." According to the expectancy-value theory of motivation (Eccles & Wigfield, 2002), the direction and magnitude of energy channeled toward a particular task involve two elements – the expectation of, and value associated with, successfully accomplishing the task. Those with high motivational CQ can direct attention and energy toward cross-cultural situations because of their intrinsic interest in cultures (Deci & Ryan, 1985) and confidence in intercultural effectiveness (Bandura, 2002).

Finally, the behavioral dimension of CQ reflects an individual's capability to exhibit culturally appropriate verbal and nonverbal actions when interacting with people from other cultures. It also includes judicious use of speech acts – the exact words and phrases used when communicating specific messages. Although it is impossible for one to master all the etiquette and rules of various cultures, certain new behaviors should be learned and certain old habits can be modified. This is important because when one initiates and maintains face-to-face interactions with culturally diverse others, they do not have access to one's thoughts, feelings, and motivations. Yet they rely on what they see and hear in one's verbal, vocal, facial, and other bodily expressions to form an impression of oneself. In doing so, however, they are likely to depend on their own cultural lens to make sense of one's behavior. Those with high behavioral CQ adapt their behaviors to culturally appropriate forms in order to facilitate effective interactions and to make culturally diverse others feel at ease. The three dimensions of CQ are qualitatively different facets of the overall capability to function and manage effectively in culturally diverse settings (Ang & Van Dyne, 2008; Ang *et al.,* 2007). That is, mental, motivational, and behavioral CQ are distinct types of capability that together form the overall CQ construct.

...awareness during intercultural interactions allows leaders to understand the impact of their own culture and background...

CQ is related to global leadership effectiveness in three ways (Offermann & Phan, 2002). First, awareness during intercultural interactions allows leaders to understand the impact of their own culture and background and their attendant values and biases on their behaviors in the workplace. It also makes them aware of the expectations they hold for themselves and others in leader/follower relationships. Second, their spontaneous predilection to verify the accuracy of their cultural assumptions, coupled with their knowledge of other cultures, helps them understand the values, biases and expectations that others hold of them. Third, this understanding of self and others combined with behavioral flexibility enables them to adapt their leadership behaviors appropriately to concrete cross-cultural situations. In summary, CQ is highly useful to effective leadership in situations characterized by cultural diversity.

There is consistent empirical support for the unique contribution of CQ to global leadership effectiveness. Rockstuhl, Ng, Seiler, Annen, and Ang (2009) studied the leadership effectiveness of Swiss military officers working in both domestic and international contexts. The investigators collected peer ratings of both general and cross-border leadership effectiveness to provide an objective measure of the leaders' effectiveness in these two contexts. Controlling for general intelligence, emotional intelligence, and personality, leaders' overall cultural intelligence predicted their cross-border, but not general leadership, effectiveness.

In another study, Rockstuhl, Ang, Ng, Van Dyne, and Lievens (2010) found that to be effective, global leaders require both mental and behavioral CQ. In an attempt to determine which team members in multicultural teams were most likely to emerge as team leaders, the investigators separately assessed the two CQ dimensions, using a newly developed performance-based measure of mental CQ and peer ratings of behavioral CQ. Again controlling for cognitive achievement, emotional intelligence and personality, the joint effect of mental and behavioral CQ best predicted leadership emergence in multicultural teams. That is, individuals who had both high mental and behavioral CQ were more likely to emerge as leaders in multicultural teams. Together, these results suggest that CQ is a capability that is especially relevant to global leadership. We next explore the potential neurological basis of the different CQ components.

Neuroscience of cultural intelligence

The three (mental, motivational, and behavioral) dimensions of CQ map well onto the functional differentiation of the medial frontal cortex (MFC, including the ACC). Based on the results from meta-analyses of MFC activities across a range of tasks (Amodio & Frith, 2006; Koski & Paus, 2000; Steele & Lawrie, 2004), we propose that social cognitive processes related to the mental dimension of CQ, such as self-reflection, person perception or inference of others' thoughts, are associated with activity in the anterior rostral MFC (arMFC), which includes the paracingulate cortex. Processes related to the motivational dimension of CQ, such as the monitoring of gains and losses engage the orbital MFC (oMFC). Finally, processes related to the behavioral dimension of CQ, such as the control and monitoring of action, are associated with activity in the posterior rostral MFC (prMFC), including the dorsal ACC. We propose that individuals with high mental (motivational or behavioral) CQ are particularly likely to engage the associated region of the brain when they perform culturally relevant tasks or culturally neutral tasks in culturally mixed environments.

Neural correlates of the mental CQ

The arMFC is implicated in thinking about psychological attributes of both self and others, as well as in judgments about the dispositions and mental states of others. Thus, we propose that the arMFC also mediates mental CQ, which requires awareness of how leaders' and followers' cultural experiences shape their self-attributes and interpersonal expectancies.

Thinking about the self

Self-awareness requires differentiation of the self from other objects and recognizing the attributes and preferences related to the self. Research has shown the arMFC mediates a wide range of cognitive activities that demand self-awareness, including evaluation of self-related traits (Fossati *et al.,* 2003; Kelley *et al.,* 2002), monitoring one's emotional states (Ochsner *et al.,* 2004), reflecting on others' perceptions of the self (Ochsner *et al.,* 2005), and thinking about one's behavioral guides (e.g., hopes, aspirations, duties, and obligations) (Johnson *et al.,* 2006).

Self-awareness requires differentiation of the self from other objects...

Fossati *et al.* (2003) obtained fMRI images of the participants' brains while they processed positive and negative personality descriptors in one of three experimental conditions. In the self-referential processing condition, participants judged the extent to which they possessed a trait. In the other-referential processing condition, participants judged evaluative connotations of the descriptors. In the letter-recognition control condition, participants decided whether the descriptors contained a certain letter. The results showed that self-referential encoding evoked bilateral activation in the arMFC regardless of whether the descriptors referred to a positive or negative trait, whereas the other-referential condition evoked activation in lateral prefrontal areas. In another study, Ochsner *et al.* (2004) obtained whole-brain fMRI data from participants while they were viewing photos depicting a person in a positive, negative, or neutral scene. Participants were instructed to report their own emotional response to each photo, the emotional state of the central figure in each photo, or (in a baseline condition) whether the photo was taken indoors or outdoors. Judgments of one's own affective responses, relative to the baseline condition, evoked stronger activation of the arMFC region.

In yet another study, Ochsner *et al.* (2005) compared the neural mechanisms underlying both reflected self-appraisal (i.e., the participant's perception of how others view him or her) and direct self-appraisals (i.e., how participants view themselves) and found that both forms of self-appraisal activated the arMFC region. These investigators therefore concluded that the arMFC may mediate the metacognitive processes that are recruited for both direct and reflected self-appraisals. Finally, Johnson *et al.* (2006) examined fMRI brain images of people thinking about their behavioral guides (hopes, aspirations, duties, obligations) versus topics unrelated to the self. The results showed that self-related thoughts engaged the arMFC more.

Collectively, these studies indicate that the arMFC region plays a vital role in supporting self-awareness and that greater self-awareness correlates with stronger activity in the arMFC region. As we have discussed earlier, leaders high in mental CQ have greater self-awareness during their interactions with culturally diverse others than leaders low in mental CQ. We, therefore, expect leaders with high mental CQ to exhibit stronger activity in regions of the arMFC associated with self-awareness when interacting with culturally diverse others than leaders with low mental CQ.

Thinking about others

The arMFC is also implicated in mentalizing others (i.e., understanding others' mental states and their correspondent behaviors; Frith & Frith, 1999). A considerable body of evidence shows that mentalizing the self and others may rely on similar neural mechanisms (Lieberman, 2007). For example, in a fMRI study, Lombardo *et al.* (2009) compared the neural mechanisms implicated in mentalizing the self and others. The investigators analyzed their fMRI data using functional connectivity analyses, which allowed them to characterize neural interactions between different neural regions during a particular task. Using this approach, they found that mentalizing the self and others produced identical functional connectivity patterns between the arMFC and areas distributed across low-level embodied neural systems such as the frontal operculum/ventral premotor cortex, the anterior insula, the primary sensorimotor cortex, and the presupplementary motor area. These areas are generally associated with sensorimotor processes and subjective emotional experience. Based on these results, the investigators infer that the arMFC is responsible for integrating the low-level embodied simulation processes that support higher-level inferences while mentalizing the self or others.

Such findings raise the possibility that leaders can project their own private experiences to others or use their own

thoughts and feelings as a starting point to simulate others' private experiences. Projection of personal thoughts and feelings to culturally dissimilar others could lead to ethnocentrism – an indication of low mental CQ. Thus, culturally intelligent leaders do not simply assume that culturally diverse others think and feel in the same way as the self does. Instead, leaders high in mental CQ assess the cultural differences between the self and others and adjust their ideations of others based on these assessments (Offerman & Phan, 2002).

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The arMFC is also responsible for making this kind of adjustment. Mitchell, Banaji, and Macrae (2005) measured neural activity while participants attended to either the mental or physical aspects of a series of faces. Later, they asked participants to rate targets' similarity to the participants themselves. Parametric analysis revealed that the level of activity in a region in the arMFC – previously found to be implicated in self-referencing tasks – correlated with the perceived self/other similarity, but only when the participants attended to the mental states of others. These results suggest that people project mental states of the self to others only when others are sufficiently similar to the self.

Vogeley *et al.* (2001) examined whether taking an egocentric perspective and attending to the mental states of others involve the same neural mechanisms. To answer this question, the investigators developed a task that allowed comparison of these two psychological processes in a two-way factorial design. They found that both processes involved self-projection (associated with activity in the area of the right temporoparietal junction) and adjustment (associated with activity in the anterior cingulate cortex). Most importantly, they found a strong interaction effect of the two processes in a region of the arMFC, indicating that this region is responsible for deciding which perspective (self or other) will be taken in a concrete situation.

Tamir and Mitchell (2010) also found that adjusting for dissimilarity of others involves a process of 'anchoring and adjustment'. According to the anchoring and adjustment hypothesis, perceivers make initial inferences based on their own introspection and subsequently use individuating information to refine their inferences. The investigators examined this hypothesis in a fMRI study, in which participants judged the preferences of another person and their own preferences for the same items. Whole-brain parametric analyses showed that activity in a region in the arMFC was related linearly to the self–other discrepancy in ratings. Because a larger discrepancy reflects greater adjustment from the initial egocentric inference, these findings suggest that the arMFC region is responsible for using mental state inferences about dissimilar others to refine initial egocentric inferences.

Effective global leaders are inclined to consider similarities and differences in the cultural experiences of the self and others when judging others.

Taken collectively, the extant evidence indicates that areas of the arMFC are responsible for mentalizing others, for tracking similarity between the self and others, and for refining initial egocentric projections with readings of others' mental states when others are dissimilar to the self. Effective global leaders are inclined to consider similarities and differences in the cultural experiences of the self and others when judging others. This psychological quality – which is a hallmark of mental CQ (Offerman & Phan, 2002) – protects leaders from rendering ethnocentric judgments. Because activity in the arMFC region mediates adjustment of judgments of others based on perceived differences between the self and others, we expect leaders with higher mental CQ to exhibit stronger activity in regions of the arMFC, particularly when interacting with culturally diverse others.

Based on its role in mediating self-awareness and mentalizing others, we suggest that the arMFC region is likely to be the neural base underlying mental CQ.

Neural correlates of motivational CQ

Motivational capacities reflect a leader's "agentic control of affect, cognition, and behavior that facilitate goal accomplishment" (Kanfer & Heggestad, 1997). Motivational CQ involves sensitivity to the incentive structure associated with various agentic behavioral choices in intercultural contexts.

The orbitofrontal cortex has been implicated in processing information related to rewards and punishments (Rolls, 1996). Based on neuroimaging studies of learning and gambling tasks, Elliott, Dolan, & Frith (2000) held that the oMFC is involved in monitoring the reward value of stimuli and responses. Similarly, Amodio & Frith (2006) contended that the oMFC guides behavior via the value associated with possible outcomes.

Results from a fMRI study (Coricelli *et al.,* 2005) support this view. In this multiple trial study, participants chose between two gambles on each trial. At the end of each trial, the experimenters induced regret by providing information about the favorable outcome of the unchosen gamble.

Motivational capacities reflect a leader's "agentic control of affect, cognition, and behavior that facilitate goal accomplishment".

Over repeated implementations of the same procedures, participants became increasingly regret-averse, and this behavioral change was accompanied by enhanced activity within the oMFC and amygdala. Increased activities in these brain regions were also recorded just before the participants made a choice, indicating that the same neural circuitry mediates direct experience of regret and its anticipation. The investigators concluded that the oMFC modulates acquisition of adaptive emotional responses to anticipatory gain or loss in decision-making.

Using event-related fMRI, Knutson, Taylor, Kaufman, Peterson, and Glover (2005) tracked the neural activities that occurred when participants anticipated monetary gains and losses of varying magnitudes and probabilities. They found that the level of activation in the oMFC varied systematically with the probability of anticipated gain. In addition, oMPFC activation correlated with subjective estimates of the gain and loss probabilities. These results suggested that the oMFC mediates probabilistic estimates of expected outcomes and plays an important role in integrating affective valuation and probabilistic estimates of expected values.

...effective global leaders adapt their behaviors flexibly and discriminatively in response to changing cultural demands...

Taken together, these results are consistent with the idea that the oMFC represents and updates the value of possible future outcomes and the perceived probability of achieving them. Leaders high in motivational CQ enjoy intercultural interactions and are confident that they can achieve their goals during such interactions. Neuroscience research suggests that the intrinsic value and confidence in the achievement of goals correlate with activity in the oMFC region. Thus, this region may mediate a leader's preference for, and confidence in, intercultural interactions. In other words, we expect that leaders with higher motivational CQ would exhibit stronger activity in the oMFC region *during intercultural interactions*. We, therefore, suggest that the oMFC is the neural base underlying motivational CQ.

Neural correlates of behavioral CQ

We posit that effective global leaders adapt their behaviors flexibly and discriminatively in response to changing cultural demands in culturally diverse environments. Action monitoring is particularly important in culturally diverse contexts because it is often necessary for the leader to inhibit a prepotent but culturally ethnocentric response. Individuals with high behavioral CQ monitor and control their actions to ensure consistency with their intentions and

the current situational context. Thus, behavioral CQ requires continuous internal monitoring of action and its situational appropriateness, which is known to be mediated by the prMFC and dorsal ACC (Botvinick, Cohen, & Carter, 2004).

To elaborate, neuroimaging and event-related potential research have linked the process of action monitoring to prMFC activity. In an extensive meta-analysis of functional imaging studies that included data from various action monitoring tasks, Barch *et al.* (2001) found the neural activities while performing these tasks generally cluster in the dorsal ACC.

Furthermore, a number of neuroimaging studies have examined the process whereby individuals intentionally override a prepotent response or impulse. Intentional regulation of behavior requires two components: a) implementation of control; and b) monitoring performance and signaling when adjustments in control are needed. MacDonald, Cohen, Stenger and Carter (2000) used event-related fMRI and a task-switching version of the Stroop task to examine whether these components of behavioral control have distinct neural bases in the human brain. They found that the implementation of control is localized in a region of the prMFC – Brodmann's area 9 (BA9), while performance monitoring is localized in the dorsal ACC. The inhibitory function of BA9/BA45 is also implicated in the ability of high-proficiency bilingual individuals to understand and speak one of their languages without apparent interference from the other (Rodriguez-Fornells, Rotte, Heinze, Noesselt, & Muente, 2002), suggesting that it plays a crucial role in the ability to switch between alternative ethnolinguistic modes.

Culture influences a range of cognitive processes and their attendant neurological behaviors.

Consistent with the idea that the prMFC and dorsal ACC are responsible for different behavioral control functions, a number of studies have implicated the dorsal ACC in detecting the conflict between a current goal and a prepotent response (Botvinick *et al.,* 2004), whereas the prMFC has been more closely tied to maintaining the current goal in working memory and implementing the top-down control needed to produce appropriate responses (Aron, Robbins, & Poldrack, 2004). In particular, Richeson *et al.* (2003) found that the activity in BA9 when white participants viewed faces of black people corresponded to the amount of cognitive depletion (due to cognitive control and suppression of inappropriate responses) these participants experienced after interacting with a black person.

In summary, whereas the oMFC represents and updates the value of possible future outcomes, the prMFC is involved in representing and continuously updating the value of possible future actions to regulate behavior (Holroyd & Coles, 2002). These characterizations are also consistent with the anatomical connectivity of these regions, with the prMFC being primarily connected to the motor system and the oMFC being primarily connected to sensory association areas (Amodio & Frith, 2006).

...cultural influences on neurological behaviors are not static.

Leaders with high behavioral CQ are able to adapt their behavioral responses based on the culture of their interaction partner. That is, they are better able than leaders with low behavioral CQ to inhibit their own culturally habituated response in favor of a culturally appropriate response. Neuroscience research suggests that activity in the prMFC (in particular BA9) correlates with inhibition of habituated behavioral responses. Hence, we expect leaders with higher behavioral CQ to exhibit stronger activity in this prMFC region, particularly during interactions with culturally diverse others. We, therefore, suggest that the prMFC mediates behavioral CQ.

Neural tuning and overall cultural intelligence

The neuroscience evidence we have reviewed thus far suggests possible mappings of different CQ components onto different specific regions of the medial frontal cortex. In addition, higher overall CQ may correspond to a greater capability to tune one's patterns of neural activity to varying cultural contexts. Culture influences a range of cognitive processes and their attendant neurological behaviors. Nonetheless, it is important to note that cultural influences on neurological behaviors are not static. For example, neurological behaviors can change as individuals adapt to a new cultural milieu (Hedden *et al.,* 2008; Goh *et al.,* 2007; Maguire *et al.,* 2000).

The malleability of neurological behaviors is further illuminated in the phenomenon of culture priming. Habitual use of a certain cultural orientation increases the overall likelihood of displaying culture-specific behaviors and their associated neurological activities. Yet, momentary priming (situational cueing) of a certain cultural orientation can also activate this orientation. Hence, cultural priming can elevate at least temporarily the likelihood of displaying the cognitive and neurological behaviors associated with the activated cultural orientation (Hong & Chiu, 2001; Hong, Morris, Chiu, & Benet-Martinez, 2000).

...individuals with higher overall CQ have greater cognitive and neurological flexibility in response to changing demands across cultural contexts.

Every culture has its iconic symbols, which, like magnets of meanings, can powerfully evoke other knowledge in that culture. The presence of such iconic cultural symbols in the immediate environment can call out from memory the dominant psychological orientation in the culture, as well as the cognitive and neurological behaviors that accompany the activated orientation. This view has received support from cultural neuroscience experiments that applied the priming procedures to bicultural individuals – individuals who have extensive exposure and hence knowledge of two cultures. In these experiments, incidental exposure to one or the other culture increases the likelihood of exhibiting the cognitive and neurological behaviors characteristic of the primed culture (Lin *et al.,* 2008; Ng *et al.,* 2010). These results suggest that many bicultural individuals can spontaneously switch their interpretive frame in response to shifting cultural expectations in the immediate context. Nonetheless, there are individual differences in the degree to which individuals can flexibly adapt their cognitive and neurological behaviors in response to variations in the cultural contexts. We contend that individuals with higher overall CQ have greater cognitive and neurological flexibility in response to changing demands across cultural contexts.

Agenda for future research

Having outlined potential neurological substrates of the culturally intelligent brain, we now turn our attention to an agenda for future research. Our recommendations for extending research on the culturally intelligent brain center on three research designs: 1) situating neuroscience research in intercultural contexts; 2) comparing intercultural novices and experts in intercultural interactions; and 3) tracking neurological changes associated with CQ development.

Situating neuroscience research in intercultural contexts

Global leadership, by definition, is necessarily situated in intercultural contexts (Ng, Van Dyne, Ang, 2009). Yet, to the best of our knowledge, little or no neuroscience research has focused on intercultural situations. Hence, we suggest that future intercultural neuroscience research should adopt intercultural research designs that could empirically validate the proposed neurological underpinnings associated with a cultural intelligent brain.

With regard to neurological substrates of mental CQ, we suggest that one fruitful approach would be to compare neurological activities of leaders solving monocultural vis-à-vis intercultural decision dilemmas. Previous CQ research has shown the importance of mental CQ for solving intercultural decision dilemmas (Ang *et al.,* 2007; Rockstuhl *et al.,* 2010). Yet, we still understand little about the extent to which effectiveness in such dilemmas depends on general problem solving skills and unique intercultural skills. Neuroscience methods of contrasting brain activity during decision making in domestic and intercultural contexts offer an elegant way to test our assertions about the neurological substrates of mental CQ. They also hold potential to inform theorizing on CQ by disentangling the effects of general problem solving and unique intercultural skills for such important leadership tasks.

Similarly, neuroscience research on choice behaviors to date has primarily studied economic rather than cultural choice games. We thus propose that future cultural neuroscience research would benefit from contrasting neurological predictors of culture-free choices (e.g., the choice between two local foods) with neurological predictors of intercultural choices (e.g., the choice between a local and an international food). The aim of such research would again be to disentangle general motivational factors from motivational CQ.

We further suggest that research on the behavioral dimension of CQ would benefit from comparing actual behaviors and their neurological substrates when leaders have to interact with someone culturally similar versus someone culturally dissimilar. Global leadership contexts most amenable to such studies could include contexts such as intercultural negotiations, global coaching and mentoring, leading multicultural teams, and resolving intercultural conflicts.

The cultural intelligence research further suggests two ways of behavioral adaptation in intercultural situations. The first approach is to match one's behavior to the cultural style of one's interaction partners (Earley & Ang, 2003). Yet, as we know, flexing one's behavior chameleon-like is very difficult and cognitively taxing (Chartrand & Bargh, 1999; Dalton, Chartrand, & Finkel, 2010). The second approach is to adopt a general 'behavioral sweet spot' that would work effectively across different cultures. For example, Imai and Gelfand (2010) found that in effective intercultural dyads, negotiators engage in a particular negotiation style that is in between culturally preferred styles of the dyads. Future cultural neuroscience research that compares the neurological activity of leaders who flex their behaviors to match their counterparts with those that adopt a 'sweet spot' behavior may further our understanding of the costs and benefits associated with both behavioral strategies.

Comparing intercultural novices and experts

Ever since Chase and Simon (1973) compared master and novice chess players to understand the cognitive structures associated with chess-competence, comparisons of novices and experts have been instrumental in furthering our understanding of cognitive bases of competency (Chi, Glaser, & Farr, 1988). In particular, the expertize approach has led to numerous advances in our understanding of the neurological bases of domain competencies (Bukach, Gauthier, & Tarr, 2006; Grabner, Neubauer, & Stern, 2006).

Global leadership, by definition, is necessarily situated in intercultural contexts.

Hence, another research design that can substantiate the links between the brain and cultural intelligence would be to compare the neurological activity of intercultural novices and experts who are engaged in the same intercultural tasks. An important goal for future research would be to discover the distinct neurological behaviors of intercultural novices and experts in representing culturally different groups. For example, regions in the arMFC have recently been implicated in the application of stereotypes when mentalizing others (Mitchell, Ames, Jenkins, & Banaji, 2008; Quadflieg *et al.,* 2008). From what we know from cultural psychology, intercultural novices tend to rely on simple stereotypes (e.g., based on an irrational dislike of dissimilar people) whereas experts rely more on sophisticated stereotypes (e.g., based on theoretical concepts and lacking negative attributions) to characterize a culturally dissimilar group (Osland & Bird, 2000). Neuroscience research on stereotype application to date has not distinguished between simple and sophisticated stereotypes. We encourage future neuroscience research into stereotypes to assess whether qualitatively different stereotypes (simple vs. sophisticated) are related to different neurological behaviors.

Research by Earley & Ang (2003) and Ang & Van Dyne (2008) further suggest that culturally intelligent individuals adopt sophisticated stereotypes about culturally diverse others as starting points but dynamically update their assumptions during intercultural interactions. Future research into the neuroscience of CQ could, therefore, trace the neural activities of initial anchoring through to the subsequent dynamic updating of stereotypes.

Examining neurological changes associated with CQ development

Another research design focuses on documenting changes in neurological activity as a result of CQ development or training. Here, intercultural neuroscience could be informed by two learning theories: experiential learning theory (Kolb, 1984), and situated learning theory (Lave & Wenger, 1991). Experiential learning theory is an adult learning theory that highlights the critical role experience plays in affecting learning and change (Kolb & Kolb, 2005). To date, experiential learning theory has received widespread attention in the global leader development literature (Kayes, Kayes, & Yamazaki, 2005; Yamazaki & Kayes, 2004). Initial evidence suggests that CQ does indeed improve as a consequence of developmental interventions that focus on experiential learning (Ng, Van Dyne, & Ang, 2009; MacNab & Worthley, 2010). We see great potential for future research that examines the neurological changes associated with CQ training or specific CQ developmental exercises.

CQ training exercises could also be grounded in the theory of situated learning (Collins, Brown, & Newman, 1989; Lave & Wenger, 1991; Ng, Tan, Ang, in press).

Situated learning theory emphasizes the importance of exposure to 'authentic' activities as a powerful source of learning and skill acquisition. Activities may be authentic with regard to the "ordinary practices of the culture" (Brown, Collins, & Duguid, 1989), or they may be authentic with regard to the specific mental functions they activate (Fox, 2006). Understanding which regions of the brain change as leaders develop their CQ allows trainers to design exercises that specifically target similar regions of the brain. Such exercises would be authentic in that they activate mental functions relevant to CQ and thus provide a platform for situated learning to occur. We, therefore, particularly encourage future research that tracks neurological changes associated with situated learning of CQ.

In increasingly globalized business environments, leaders are confronted with the complex role of managing people from diverse cultural backgrounds.

Conclusion

In increasingly globalized business environments, leaders are confronted with the complex role of managing people from diverse cultural backgrounds. Hence, effective global leaders are expected to not only understand but also bridge cultural differences. Studies in cultural neuroscience are crucial for the education and development of global leaders as they raise awareness and appreciation of cultural differences in global leaders. Levering off the recent advances in identifying the neurological substrates of different cognitive processes, we propose to extend cultural neuroscience research into intercultural neuroscience of the 'culturally intelligent' brain. Specifically, we identify the theory of CQ (Ang & Van Dyne, 2008), with its focus on intercultural capabilities, as a theoretical framework for charting a new research agenda into intercultural neuroscience.

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