Running head: TRACES OF CULTURE

**Traces of Culture:**

**The Feedback Loop Between Behavior, Brain, and Disorder**

**Daina Crafa**

*Interacting Minds Centre, Aarhus University*

**Saskia K. Nagel** *RWTH Aachen University*

**Corresponding author:**

Dr. Daina Crafa

Interacting Minds Centre

School for Culture and Society

Aarhus University

Jens Chr. Skous Vej 4

8000 Aarhus, Denmark

Email: [daina.crafa@cas.au.dk](mailto:daina.crafa@mail.mcgill.ca)

Twitter: [@dcrafa](https://twitter.com/dcrafa)

**CITATION: Crafa, D., & Nagel, S.K. (In press). Traces of culture: the feedback loop between brain, behavior, and disorder. Transcultural Psychiatry.***Submitted August 2012; accepted November 2014.*

**Authors Note**

This work was funded by the German Ministry of Research and Education (BMBF / DLR - 01GP1010) and the Sievert Stiftung für Wissenschaft und Kultur (S248/10006/2013).

**Abstract**

Culture is part of an extensive series of feedback loops, which involve multiple organismic levels including social contexts, cognitive mediations, neural processes, and behavior. Recent studies in neuroscience show that culturally contingent social processes shape some neural pathways. Studying the influence of cultural context on neural processes may yield new insights into psychiatric disorders. New methodologies in the neurosciences offer innovative ways to assess the impact of culture on mental health and illness. However, implementing these methodologies raises important theoretical and ethical concerns, which must be resolved to address patient individuality and the complexity of cultural diversity. This paper discusses cultural context as a major influence on (and consequence of) human neural plasticity and advocates a culture-brain-behavior (CBB) interaction model for conceptualizing the relationship between culture, brain, and psychiatric disorders. Recommendations are made for integrating neuroscientific techniques into transcultural psychiatric research by taking a systems approach to evaluating disorders.

***Keywords:*** *transcultural psychiatry, cultural neuroscience, fMRI, neural plasticity, culture-brain-behavior interaction model, CBB model, cognitive mediation*

**Traces of Culture:**

**The Feedback Loop Between Behavior, Brain, and Disorder**

Culture involves dynamic social processes that influence most psychiatric disorders. Culture can be defined as systems of converging social and contextual elements, in which people within a specific demographic or social group participate (Kemmelmeier & Kühnen, 2012; Markus & Kitayama, 2010; Hong et al., 2000). Many psychiatric disorders, including schizophrenia, depression, and anxiety, exhibit cross-cultural variations in reported symptoms and clinical presentation (Kalra, Bhugra, Shah, 2012; Bhugra, 2006; Kirmayer, 2001; Kirmayer & Groleau, 2001). There may also be cultural variations in their etiology and underlying biological mechanisms. However, culture is not simply a discrete set of factors that lead to the emergence of psychopathology; instead psychopathology results from dynamic feedback loops between culture, mind, and brain mediated by processes at multiple levels (Crafa & Nagel, 2014, 2018; Kirmayer & Crafa, 2014; Ryder, Ban, & Chentsova-Dutton, 2011).

Recent findings from non-patient studies using fMRI suggest that some potentially clinically relevant brain-based differences exist across cultural contexts (e.g., Chiao et al., 2013; Chiao & Blizinsky, 2013; Meyer, Way, Eisenberger, 2013; Severance et al., 2013; Wang, Ma, Han, 2013; Cheon, Marthur, & Chiao, 2010). The few neuropsychiatric studies that have been conducted transculturally support this claim (e.g., Koh & Milne, 2012). Considering that both psychiatric disorders and related neural events vary by culture, ‘Western’-dominance in neuropsychiatry may produce systematic sampling biases and under-represent the global population in the data and current literature (Crafa & Nagel, 2014). Since neuropsychiatric research is used as a basis for medical practice, the effects of culture on neuropsychiatric processes ought to be examined to ensure that patients from diverse backgrounds receive adequate care. Increasing use of neuroscientific methods in transcultural psychiatric research could expand knowledge to diverse patient populations across social and cultural groups, and potentially help identify important similarities and differences that may be relevant to diagnosis or treatment (Crafa & Nagel, 2014, 2016).

Although this article advocates increased integration of fMRI and other neuroscientific methods, their use in transcultural psychiatric research must be conducted with the utmost care. In particular, implementing these methodologies risks reliance on cultural stereotyping to form hypotheses or to interpret findings, and care must be taken to avoid reinforcing social stigma or cultural prejudices. Current culture-brain interaction models rely on studies comparing ethnocultural groups, which share the risks of stereotyping. Most of these models do not account for issues relevant to cross-cultural studies of psychiatric disorders: for example, the primacy of individual variation and malleability, or the complexity of the culture-brain interaction across the lifespan (Freeman, 2013; Han et al., 2013). New models are needed to address these issues.

By synthesizing the strengths of cultural neuroscience (CN) methodologies with the priorities and considerations central to transcultural psychiatry, many possible pitfalls can be avoided and more mechanisms can be considered. In the following sections, we outline the Culture-Brain-Behavior (CBB) interaction model, a theoretical framework that attempts to avoid neuroreductionism and emphasize individual malleability and diversity across the lifespan (Crafa & Nagel, 2013, 2016, 2018). First, we will illustrate the potential for fMRI research to identify cultural variations in the phenotypes of psychiatric disorders by focusing on recent findings in CN. Second, we outline problems with over-reliance on fMRI, demonstrating the necessity for a refined model for implementing fMRI in transcultural psychiatric studies to achieve a better understanding of patient populations. The third section specifically addresses the reasons that neuroreductionism is problematic for cultural psychiatry. Finally, the CBB interaction model will be offered as an alternative systems approach to transcultural research.

**Potential Applications of Cultural Neuroscience in Psychiatry**

Perhaps more than any other methodology, neuroimaging research in psychiatry is subject to what is commonly termed ‘Western’ *bias* (Henrich, et al., 2010), meaning that scientific research disproportionately comes from North American and Western European countries. Despite important contributions from some ‘Eastern’ countries, such as China and Japan, a majority of cultures and subcultures are not represented in neuroimaging studies (Henrich, et al., 2010; Isamah et al., 2010; O'Brien et al., 2006; Gogolin, 2002). For example, studies of psychopathology and its treatments are dominated by a handful of countries, leaving their findings potentially biased and of uncertain generalizability. In psychiatry, findings from fMRI studies are increasingly used in efforts to characterize disorder endophenotypes and may be used as theoretical justification for promoting specific medications or therapeutic approaches, but many populations are underrepresented in this research (e.g., Pliszka, 2012).

The emergence of CN over the last decade has brought new approaches to studying cultural diversity by using neuroimaging, especially fMRI. Some CN studies compare groups of people living in ‘Eastern’ and ‘Western’ countries while other studies compare recent immigrants or ethnic minorities to dominant or native populations. These studies have shown that brain activity differs in key areas when participants from different cultures are asked to perform particular tasks (Zhu et al., 2007) or when participants from the same culture are placed in different sociocultural situations (Sui et al., 2013). Although these studies usually are performed with healthy control participants, they have implications for clinical research. In particular, many of the brain regions that have been commonly reported by recent studies as varying in activity across cultures substantially overlap with brain regions that have been repeatedly shown by contemporary research studies to vary for several psychiatric disorders (Table 1). For example, culture-based differences have been reported in areas of the prefrontal cortex (Han et al., 2011; Ray et al., 2010), cingulate cortex (Harada, Lia, Chiao, 2010; Ray et al., 2010), parietal lobe (Hedden et al., 2008), and amygdala (Derntl et al., 2012). These regions exhibit distinctive patterns of activity in many disorders, such as schizophrenia (Mukherjee et al., 2013; Pedersen et al., 2012; Pomarol-Clotet et al., 2010; Torrey, 2007), post-traumatic stress disorder (Stevens et al., 2013), autism (Kleinhans et al., 2010; Gilbert et al., 2008), major depression (Korb et al., 2011; Murray, Wise, Drevets, 2011), and general anxiety disorder (Ressler, 2010). Accordingly, the brain activity associated with some psychiatric disorders may also vary across cultural groups (Crafa & Nagel, 2016, 2014).

**Table 1. Examples of regional brain activity and processes that vary across cultures and disorders.**

|  |  |  |
| --- | --- | --- |
| **Brain Region** | **Differences Identified via Cross-Cultural Comparisons** | **Neuropsychiatric Conditions Associated with Regional Differences** |
| **Medial prefrontal cortex** | Different activity patterns during social tasks (e.g., self-affiliation)1 | Autism2, schizophrenia3, bipolar disorder4, general anxiety disorder5, major depressive disorder6 |
| **Rostral anterior cingulate cortex** | Different activity patterns during social tasks (e.g., self-other representation)7 | Autism8, schizophrenia9, bipolar disorder10, social anxiety disorder11, major depressive disorder12 |
| **Left inferior parietal lobe** | Different activity patterns during attentional tasks and social cognition (e.g., visual attention control)13 | Autism14, schizophrenia15 |
| **Amygdala** | Different activity patterns depending on sociocultural meaning of stimuli (e.g., in-group/out-group)16 | Autism17, schizophrenia18, bipolar disorder19, general anxiety disorder20, major depressive disorder21, social anxiety disorder22 |

**Originally published in Crafa and Nagel, 2016: p. 49. Reprinted with permission, with updated regions and references.** Citations indicated by superscript: 1Chiao et al. (2009), Huang et al. (2019); 2Gilbert et al. (2008), Padmanabhan et al. (2017); 3Hu et al. (2017), Pomarol-Clotet et al. (2010), Wang et al. (2018); 4Herold et al. (2017), Keener et al. (2013), Zhong et al. (2019); 5 Blair et al. (2017), Kim et al. (2011); 6Kaiser et al. (2016), Murray et al. (2011); 7Pornpattananangkul et al. (2016), Ray et al. (2010); 8Abrams et al. (2019), Chan et al. (2011); 9Pedersen et al., 2012; 10 Rutherford et al. (2019), Wang et al. (2009); 11 Cui et al. (2019), Klumpp et al. (2013, 2017); 12Cooney et al., (2010), Webb et al. (2019); 13Hedden et al. (2008), Moss (2016); 14Carlisi et al. (2017), Koshino et al. (2005), Yang & Hofmann (2016); 15 Fassbender et al. (2014), Jáni et al. (2018), Torrey (2007); 16Derntl et al. (2012); 17Kleinhans et al. (2010); 18Mukherjee et al. (2013); 19Brotman et al. (2010); 20Usher et al. (2010); 21Suslow et al. (2010); 22Sladky et al. (2012).­­

­­­Some recent studies already demonstrate how neuropsychiatric research could be informative for transcultural diagnosis and treatment. For example, one study compared visual processing in children with and without autism spectrum disorders in England and Singapore to evaluate Central Coherence Theory (CCT) (Koh & Milne, 2012; Milne & Szczerbinski, 2009). CCT claims that a certain perceptual-cognitive style underlies the disturbances in autism (Happé & Frith, 2006; Frith, 1989). When researchers tested CCT across cultures, Singaporean children – whether autistic or not – displayed a different processing style than expected. This evidence suggests that the trait described by CCT may be culture-specific – and the theory may be too (Koh & Milne, 2012). This finding underlines the powerful influence sociocultural experiences can have on biological processes associated with psychiatric disorders. Similar studies conducted across a variety of disorders and cultures could improve understanding of fundamental variations in disorder phenotypes.

CN research could help clarify many current issues in cultural psychiatry. For example, as Seligman and Kirmayer (2008) point out, many studies of dissociation focus on pathology. It might be helpful to conduct fMRI research in cultural contexts where non-pathological dissociation is prevalent, such as those where spirit possession is commonly practiced, in order to identify neural processes that correlate with pathological dissociation versus non-pathological dissociation. Again, current findings identify relationships between certain patterns of brain activity and cognitive process, such as memory suppression or shifts in self-regulatory attention, that appear to have different consequences across cultural contexts, which might contribute to cultural differences in dissociative processes (Seligman & Kirmayer, 2008).

Improved understanding of functional brain processes across ethnocultural communities will help parse the relationship between cultural context and disorder. CN studies must be designed carefully to avoid oversimplifying the relationship between culture and neural processes. However, if pursued correctly, such studies have the power to use neuroscientific tools to clarify relationships that are currently confounded or conflated and to extend neuropsychiatry to global populations.

Despite the potential it holds for cultural psychiatry, CN is a relatively new field and it is still working out methodological challenges. For example, CN is sometimes criticized for broadly defining *culture* according to geographic borders and examining poorly defined or uncontrolled cultural variables (Kagawa Singer, 2012; Dressler, 2004; Hunt & Bhopal, 2004; Winker, 2004). CN has also received criticism for the use of East/West dichotomies, which arguably reduces culture to binary categories (Vignoles et al., 2016). Other binary contrasts, including collectivist/individualist, interdependent/independent, and holistic/analytic, are commonly used in these experiments. For example, Koh and Milne’s (2012) autism study described above compared individuals from ‘Eastern’ and ‘Western’ countries to investigate ‘holistic’ versus ‘analytic’ visual processing styles stereotypically ascribed to ‘collectivist’ versus ‘individualist’ cultures. These categories may be especially problematic if they simply are assigned based on previous research on groups from the participants’ birth country and not by measuring the relevant constructs in individual study participants.

Binary categories are not as useful as other systems for describing culture, such as ecocultural approaches (Georgas, van de Vijver, & Berry, 2004) or multidimensional measurements (Choudhury & Kirmayer, 2009). These more nuanced approaches can be used to supplement simpler categorical measures to provide a more complete picture of the cultural context and individual variation. For example, multidimensional measures can be used to describe the diverse social and ecological dynamics within cultural contexts (e.g., the varying degrees of autonomy and relatedness observed in different social situations and cultures, cf. Keller, Demuth, Yovsi, 2008; Keller, 2003) as well as individual variations in the beliefs and practices that are common within a particular subculture or in bicultural populations (Chiao et al., 2009, 2010. The emphasis on East/West comparisons in CN research leaves much of the global population unexamined and points to the need to expand the study of brain-culture interactions to other populations.

Despite these criticisms, CN has taken important first steps toward integrating the study of neural and cultural phenomena, through studies that provide a foundation for future work (Chiao & Cheon, 2012; Crafa & Nagel, 2016, 2014; Han et al., 2013). Indeed, past criticisms can be seen as opportunities for future growth. By carefully integrating fMRI methods into cultural psychiatric research, knowledge of the patient can be extended to include neurological dimensions that add to our understanding of disorders and their cultural variability.

**Adequacy of Cultural Neuroscience Models for Transcultural Psychiatric Research**

While fMRI research is not inherently incompatible with the aims of cultural psychiatry, the current methods and interpretations of fMRI findings contain theoretical biases that preclude the recognition of patient individuality, changeability, and perspective. In particular, current models describing the relationship between brain and culture — the neuro-culture interaction (NCI) model being among the most prominent (Kitayama & Uskul, 2011) — because they do not account for neurocognitive flexibility, seem to treat the relationship between culture and neural events as fixed or immutable. Current CN models describing human cultural development in terms of feedback loops can provide a more adequate model (e.g., Crafa & Nagel, 2013; Han & Ma, 2015). However, some of these models (e.g., Han & Ma, 2015) rely heavily on binary East/West, individualist/collectivist distinctions and do not acknowledge the range of contextual, biological, and individual dimensions that are necessary to account for diverse populations including migrants and patients with psychopathology (Crafa & Nagel, 2013; Vogeley & Roepstorff, 2009; cf. Maruyama, 1977 for historical background).

In current CN models, *culture* is usually defined as collectively shared meanings, beliefs, behaviors, and conventions

(Kitayama & Uskul, 2011). Individual psychological processes are influenced by the collective culture that the individual is exposed to, and the act of repeating adopted attitudes and practices directly alters the brain: “the brain acts as a crucial site that accumulates the effects of cultural experience” (*ibid*., p. 422). According to Kitayama and Uskul, after culture-specific attitudes and practices have been adopted, they become ‘embrained’ and are no longer cognitively mediated.[[1]](#endnote-2) In the NCI model, neural events initially reflect cultural learning and subsequently, behavioral practice. Although we initially act according to our values, repeating these actions causes deep neural changes so that the culturally shaped behaviors or patterns of response eventually become automatic (Kitayama & Uskul, 2011).

Although careful to acknowledge individual behavioral diversity and malleability elsewhere (e.g., Kitayama et al., 2015), the NCI model does not describe mechanisms of this diversity and is nonetheless presented as universally applicable. The model also posits that, “Culturally shaped activation patterns of the brain… enable the person to perform culturally scripted behaviors...both automatically and seamlessly” (*ibid.*, p. 424). Statements such as these imply, first, that culturally scripted behaviors can be prescriptively learned and, second, that once learned, the cultural script becomes automated. Although the authors may not intend this to be a rigid description, the eventual automaticity of these processes nonetheless presumes a degree of stability that seems too inflexible to capture most culturally influenced actions.

Current literature calls the assumptions of prescriptive leaning and automaticity both into question (see e.g., Pecchioni, 2012; Bohn, 2010; Chiu et al., 2010; Li et al., 2010). Many psychiatric disorders are characterized by inappropriate social behaviors, suggesting that culturally scripted behaviors may have been incorrectly learned or that some process is interfering with their performance. Most psychiatric disorders, for example, are characterized by social behaviors that are considered socially unacceptable or maladaptive in some way, which indicates that some cultural scripts dictating appropriate social behavior may have been violated. In some countries approximately half of the population experiences a mental disorder during their lifetime, suggesting that there is substantial population-wide variability in learning social behaviors (Reeves et al., 2011). Moreover, there is a difference between understanding cultural scripts and emulating them (Thomas, 2010).

The assumption of automaticity in performing according to cultural norms also runs contrary to some of what is currently known about neural and social and cultural change across the lifespan (e.g., Canu et al., 2012). While some automaticity may occur, both cultural scripts and neural events are highly variable and change dynamically across the lifespan (for reviews of change in cultural scripts see: During et al., 2011; of neural plasticity see: Jäncke, 2009; Pascual-Leone, Amedi, Fregni, 2005; Poldrack, 2000; Buonomano, 1998). In fact, the human brain exhibits pervasive neural plasticity, which is reflected by sometimes dramatic changes in neural network processes in response to individual social experiences (Thomas & Baker, 2012; Burke & Barnes, 2006) even late into adulthood (Thomas & Baker, 2012; Kempermann, 2012; Gould, 2007; Dinse, 2006; Rakic, 2002). Experience-dependent neural plasticity occurs when brain events are changed through practice or observational learning (Yu, Roland, Xu, & Stein, 2013; Kleim, 2008). It has been theorized that personal changes resulting from self-reflection, such as may occur in psychotherapy, can also bring about brain-based changes; however, this research is still in the early stages (Morgiève et al., 2013; Zaman, 2010; Frewen, Dozois, Lanius, 2008; Linden, 2006; Roffman et al., 2005).

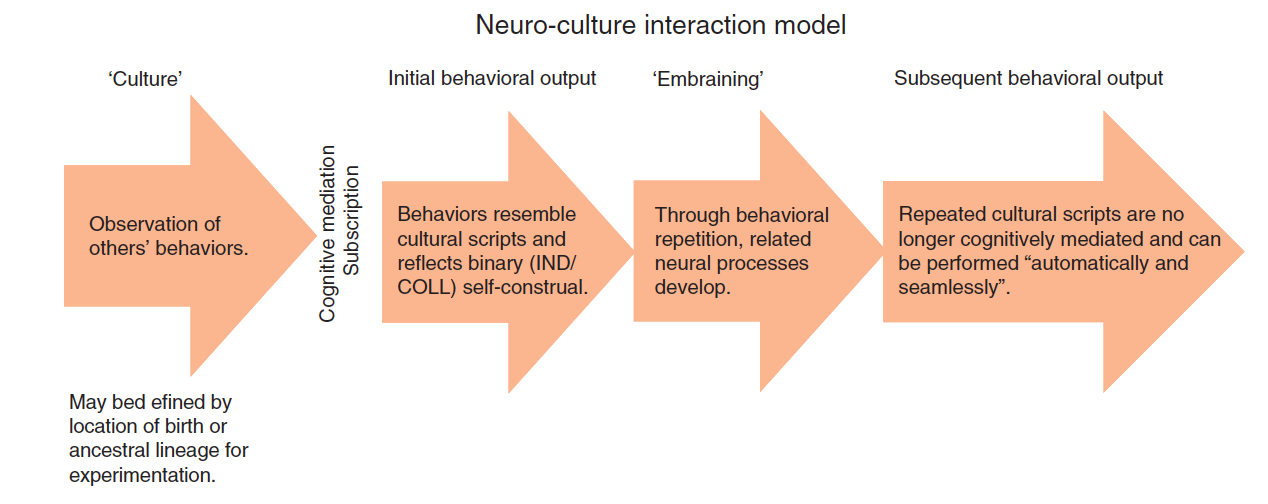
Three sets of conceptual problems occur when designing and interpreting fMRI studies in CN: (1) neuroreductionism; (2) attempts to ‘locate’ culture in the brain; and (3) reliance on cultural stereotypes to form hypotheses or interpret results. These problems are particularly important for cultural psychiatry because they undermine recognition of patients’ social circumstances. By providing a more nuanced framework describing the relationship between culture and disorder, the CBB model aims to avoid these problems.

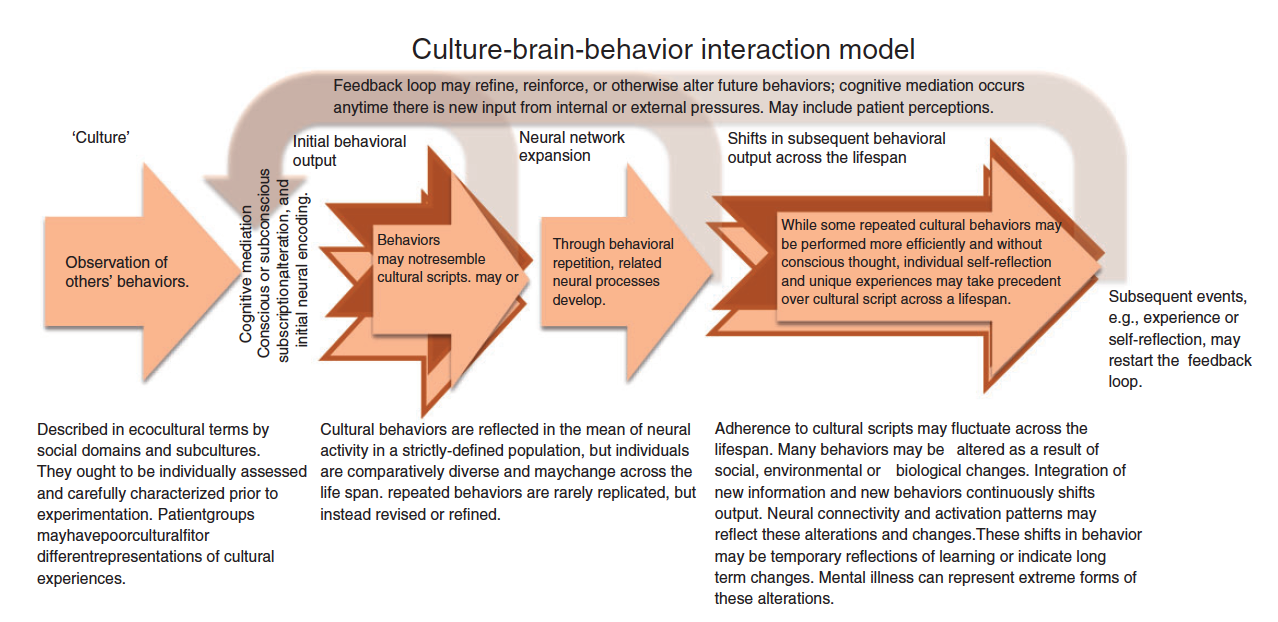
In the context of fMRI studies, neuroreductionism is seen in the assumption that our brains solely determine our actions, thereby attributing beliefs and behaviors entirely to neural events (Kirmayer & Gold, 2012; Choudhury & Kirmayer, 2009; Choudhury, Nagel, Slaby, 2009; Gold, 2009). Neuroreductionism can preclude consideration of dynamic ‘human factors,’ such as meaning, experience, and culture, and ignores other organismic levels such as physiology and perception, which may be reflected in neural events but are not necessarily reducible to them (Kirschner, 2010).[[2]](#endnote-3) Although fMRI and other neuroimaging methods can provide information about changes in individuals’ internal states, these are only part of the larger organism-environment interaction to which the brain adapts, which must be included for ecologically valid research and clinical applicability (Fuchs, 2011).

A second major set of issues arise from trying to ‘locate’ culture in the brain. Brain-based measures of cultural traits sometimes downplay both the brain’s plasticity as well as the diversity and changeability of culture. The neural processes examined in CN studies may change within an individual’s lifetime or from one social situation to the next or over time as cultures change (e.g., Chiao et al., 2010; 2009). Although some brain-based commonalities among individuals may reflect the influence of similar sociocultural experiences, these similarities are not identical with ‘culture’ and are more parsimoniously described as byproducts of specific sociocultural learning.

Reliance on crude ethnocultural categories and stereotypes is another issue sometimes encountered in CN research. Choudhury and Kirmayer (2009) point out the problem of conflating culture with nationality, for example. Individuals residing within the same national borders are all too often assumed to belong to the same culture. Attention to the ascription of cultural identities is essential for the study of cultural differences, given the history of marginalizing minority groups and reinforcing racist stereotypes (Kagawa Singer, 2012; Choudhury & Kirmayer, 2009; Chen, 2008; Schouten & Meeuwesen, 2006). Some studies in CN include recent immigrants (e.g., labelled in terms of their geographic origin, e.g. an ‘East Asian’ sample), without acknowledging either the heterogeneity of the population or the fact that immigrants may be experiencing acculturation (e.g., Gutchess et al., 2010), which can occur rapidly and result in great variability in culturally related behaviors (Yorulmaz & Işık, 2011).

Figures 1 and 2. Comparison of the NCI and CBB models.





Considering that people experience and subscribe to different cultural domains to different degrees and may display different degrees of cultural fit in different domains (Crafa et al., 2018; Weller, 2007), experiments designed in terms of specific cultural domains rather than ‘culture’ as an general category will produce more meaningful results (Keller, 2006; Greenfield et al., 2003).

With these caveats in mind, useful insights can be gained from current CN models. In particular, the NCI model describes practiced behaviors as leading to neural changes which reflect sociocultural differences (Kitayama & Uskul, 2011). While the initial changes are flexible they may become automatized—an order of events that agrees with evolutionary theories of adaptation to the environment, and with developmental studies of children across cultures (Kärtner, Keller, Yovsi, 2010). The CBB model, described below, takes a systems approach to the relationship of culture and the brain, accounting for behavior as a means of cultural learning. Figures 1 and 2 depict the similarities and differences between the NCI and CBB model. The CBB model aims to avoid the pitfalls of other models through carefully interpreting recent findings to clarify the relationship between culture, brain, and disorder. The CBB model diverges from central claims of previous models of culture-brain relationships by rejecting the assumptions that 1) cultural scripts are performed automatically and seamlessly and that 2) after culture-specific attitudes and practices have been adopted, they are no longer cognitively mediated. Instead, the CBB model posits that 1) cultural scripts are not always correctly performed and 2) cognitive mediation is an ongoing mechanism of change across the lifespan (Figure 2). In fact, cognitive mediation is integral to the rich interplay between culture, ‘mind,’ and brain in everyday life and to the effectiveness of many forms of clinical intervention. Finally, the CBB model offers ways to define cultural and pathological behaviors that complement existing descriptive definitions while being more easily operationalized for quantitative research. These definitions are meant to replace the binary categories used in previous studies.

The CBB approach agrees with other models that present culture, ‘mind,’ and brain as multiple levels of a single, organic system (e.g., Ryder et al., 2011; Fuchs, 2011). Further, this model extends the endeavor to consider individual behaviors and clinical variations within cultures by integrating neuroscientific tools into the repertoire of methods used to build a comprehensive and globally oriented understanding of the patient. Ultimately, the CBB model is designed to provide a conceptual foundation for neuroscientific research in cultural psychiatry.

**Table 2. Central tenets, caveats, and characteristics of the CBB model.**

|  |  |
| --- | --- |
| **Central tenets** | |
| **Tenet 1** | The ability to change in response to the environment at any time during the lifespan is central to all organismic levels of organization. |
| **Tenet 2** | Fluctuations at multiple levels create feedback loops, allowing the levels to inform and change each other. |
| **Tenet 3** | Individual variations fall along cultural continua of common behaviors within a defined group. |
| **Caveats** | |
| **Caveat 1** | Cultural scripts are not always correctly performed. |
| **Caveat 2** | Cognitive mediation is a recurring mechanism of change across the lifespan. |
| **Characteristics of Proposed Methods** | |
| **Characteristic 1** | Taking a systems approach to the study of culture, brain and behavior avoids overemphasis on a single organismic level. |
| **Characteristic 2** | Grounding the approach in neuroplasticity and epigenetic mutability acknowledges individual variation and lifespan change. |
| **Characteristic 3** | Defining cross-cultural groups in terms of multiple domains and dimensions rather than discrete categories or binary oppositions. |

**Central Tenets of the CBB Model**

The central tenets of the CBB model can be summarized as follows: 1) the ability to change in response to the environment at any time during the lifespan is central to all organismic levels of organization; 2) fluctuations at multiple levels create feedback loops, allowing the levels to inform and change each other; and 3) individual variations fall along cultural continua of common behaviors within a defined group. Each of these tenets emphasizes the flux that all organismic levels are constantly undergoing. Although embracing the complexity of human phenomena raises difficult questions, such as how to operationally define culture, it avoids the three pitfalls described above and provides alternative paths to understanding the impact of cultural variations. Replacing the idea that culturally scripted behaviors are performed “automatically and seamlessly” after being acquired through cognitive mediation (Kitayama & Uskul, 2011, p. 424), the CBB model proposes that cognitive mediation re-occurs across a person’s lifetime and participates in a feedback loop between brain, behavior, and experience that propels learning and leads to fundamental changes in beliefs, intentions, or behaviors that may substantially deviate from previously learned cultural scripts and that are reflected in biological changes.

The first tenet of the CBB model recognizes that neuroplasticity is prerequisite for all learning. The process of cultural acquisition and individual change may be based on a dynamic interplay between social learning and behavioral observation (Meltzoff, 2007a, 2007b; Gergely & Csibra, 2005). Infants show measurable culture-specific behaviors (Kärtner et al., 2010; Tomasello et al., 2005) and these behaviors often become more entrenched but, as the individual progresses toward adulthood, a sophisticated repertoire of behaviors may develope that are distinct from those of other members of the same culture (e.g., Scharf & Mayseless, 2010; Krings et al., 2008; Seiffge-Krenke & Gelhaar, 2008; Nelson & Chen, 2007; Arnett, 2007, 2006; Shanahan, 2000; Côté, 2000).

Self-other mapping, for example, is one potential mechanism underlying cultural differentiation and its diversity (Paulus Hunnius, Bekkering, 2012; Losin, Dapretto, Iacoboni, 2009; Meltzoff, 2007a, 2007b). *Self-other mapping* refers to the processes of learning the behaviors of others by mapping their actions onto oneself through observation and mimicry (Brooks & Meltzoff 2002, 2005; Gallagher & Meltzoff, 1996). Previous research demonstrates that self-other mapping engages brain regions including the prefrontal cortex (PFC), which exhibits different activity patterns relative to sociocultural identity (Saito et al., 2010; Losin et al., 2009). The latest studies suggest that physiological or neural synchronization between two or more people may also contribute to ease of learning from others (Bevilacqua et al., 2019; Davidesco et al., 2019; Wass et al., 2019). This self-other mapping helps a person to understand others and acquire new behaviors, and it is hypothesized to be at the heart of learning culture-specific behaviors (e.g., Tomasello et al., 2007; Gergely & Csibra, 2005; Brooks & Meltzoff 2002, 2005; Gallagher & Meltzoff, 1996).

In principle, this mapping may be implicit in the processes of cognitive mediation and ‘embraining’ described by the NCI model. However, the NCI model does not explain how cognitive mediation occurs or how social behaviors are produced prior to ‘embraining’. We suggest self-other mapping as one possible mechanism for this process. Through exposure to cultural scripts and practiced behaviors, social conventions are learned and the brain changes. However, unlike other models, the CBB model emphasizes that individuals may alter observed or learned culturally scripted behavior as they are integrated through cognitive mediation and through either imperfect behavioral mimicry or refinement of observed behaviors. For example, evidence suggests that infants generally mimic successful behaviors (Paulus et al., 2011; Hauf & Aschersleben, 2008). On the one hand, when infants observe someone failing to complete an attempted task, they frequently attempt behaviors that are both different from and more effective than the behaviors they observed (Meltzoff, 2007a, 2007b). On the other hand, disruptions to motor processes or even failure to pay attention to an observed action can result in imperfect mimicry (Cossu et al., 2012). In both cases, the behavior varies but the intention remains the same. However, the demands of different environments may lead to alterations in behaviors by changing intentions (e.g., Legare et al., 2015; Koepke & Denissen, 2012; Hammack, 2008). Through a mechanism like self-other mapping, it seems likely that cultural behaviors are learned and interact with many other organismic levels and ecocultural pressures. However, these learned behaviors are not direct replicas of the original behavior. Instead, they deviate from the observed or even mimicked behaviors through cognitive mediation and circumstance.

In this instance, the order of events proposed by the NCI model is preserved in the CBB model (see Figure 1). The CBB model adds to this by integrating the literature from neural plasticity and human development regarding the ability to change is a necessary predecessor for social learning and cultural acquisition (Han et al., 2013; Ambady & Bharucha, 2009; Hari, 2009), which is implicitly assumed but not accounted for in the NCI model. Moreover, the CBB model integrates studies of individual variability and those reporting that social learning behavioral change continues throughout the human lifespan (Caroni, Danato, Muller, 2012; Pavlowsky, Chelly, Billuart, 2012; Valnegri, Sala, Pasafaro, 2012). Evidence from research on neural plasticity during human development demonstrates the prevalence of biological plasticity by showing that the ability to change also holds for biological change, which does not contradict the NCI model but is pervasive and explained in the CBB model. Once learned, cultural behaviors, like all behaviors, must be maintained through repetition (Shors et al., 2012). For example, across a lifetime, individuals partially forget unused language skills, migrants who have acculturated partially unlearn certain culturally scripted behaviors (Aslan et al., 2011; Weltens et al., 2012). Analogously, the new skills that replace the old – such as a frequently spoken second language language or newly acquired cultural script – arguably lead to neural changes. Considering their respective bodies of work, Kitayama and Uskul are doubtlessly aware of such changes; however, the NCI model itself does not explain how they might occur or how exactly they might alter brain relevant processes. The CBB model adds this component.

The above point can be extended: Even for practiced behaviors, the same behavior is not simply replicated but constantly altered and refined over time. Corresponding neural circuits are continuously altered and refined as well. This point is essential to cultural learning and leads to the second tenet of the CBB model: fluctuating organismic levels, which can include socio-environmental changes, biological changes, or self-reflection, may prompt cognitive mediation and constitute the circuitry of the feedback loop between informational output and information processing and neural encoding.

Such changes may accumulate or resonate within us, and eventually feed back into our sociocultural environment in subtle ways. Our behaviors and other actions create sociocultural experiences that can reinforce or help alter the behaviors and neural events of others. In essence, we act as subtle progenitors of cultural change. This second feedback loop between internal processes of cognition and encoding and external processes of behavioral displays and culture is ongoing with each new experience, and research may discover differences in individuals and populations over time.

When considering the application of fMRI to cultural psychiatry, cognitive mediation plays a key role in the interplay between culture and brain by acting as an intermediary during sociocultural learning. Both new and repeated experiences initiate learning processes, which are cognitively mediated. Through cognitive mediation, new experiences can lead to the development of new behaviors. Repeated experiences sometimes reinforce existing behaviors, but they can also reveal qualities that the individual finds imperfect or no longer values and potentially reactivate cognitive mediation and lead to behavioral change.

The CBB model breaks from the view that once culture-specific attitudes and practices have been adopted, they become ‘embrained’ and are no longer cognitively mediated (cf. Kitayama & Uskul, 2011). Instead, it claims that the process of cognitive mediation feeds back into cultural learning, altering both the lessons that have been learned and the corresponding neural changes that occur and ‘embraining’ of discrete cultural attitudes and practices may be altered or incomplete. This accords with the observation that cultural scripts are not always performed “automatically” or “seamlessly”. Furthermore, cognitive mediation is a mechanism that can alter performance of cultural scripts. Such alterations feed back to the other organismic levels, and are reflected in behavioral and neural changes. This claim is supported by recent neuroimaging studies of cognitive behavioral therapy (CBT), a technique that assumes cognitive mediation can alter behavior. These studies demonstrate that cognitive mediation also alters neural activity (Frewen, Dozois, Lanius, 2008; Linden, 2006; Roffman et al., 2005). The CBB model offers a paradigm shift away from the traditional reductionisms pervasive in neuroscience. Previous models have failed to truly represent the neurology of cultural behaviors, partly because they do not directly discuss the role of plasticity across the lifespan and revisions that may occur to earlier learning — thus simultaneously neglecting the continuous and dynamic link between culture, the brain, and behavior.

Similarly, the failure to address the role of individual diversity within previous models reflects the failure to understand the mechanics of the interplay between culture, the brain, and behavior. As the third tenet of the CBB model holds, individual variations fall along cultural continua of behavioral dimensions common to a defined group. In any population, there is a large amount of individual variation although certain practices clearly vary by cultures that may be common to a geographic region, ethnic group or nation, making cultural phenomena worth studying. However, these broad cultural groupings are too general for research to solely rely on as they neglect the substantial individual variability that exists within delineated groups. The high cultural variability observed in many psychiatric disorders, which are most pronounced in culture-bound syndromes, demonstrates that sharing similar sociocultural contexts can lead to specific behavioral outcomes relevant to psychiatry. Individual diversity reflects the subscription to particular cultural beliefs and practices and in the ways that processes and experiences are recombined.

Definitions of culture used in cross-cultural psychology and cultural neuroscience have tended to equate culture with country or ethnicity and rely on stereotypes to characterize cultural difference. Hypotheses that avoid these pitfalls are usually built upon more nuanced models, such as ecocultural approaches that consider local environmental and social factors, or by methods that assess participants’ values and attitudes to determine variations in cultural domains. Ecocultural approaches that seek to characterize the cultural traits of a population may use more complex methods for assessing culture, such as using semi-structured interviews to describe the local culture or developing questionnaires based on responses from local participants instead of or in addition to using pre-existing materials (Georgas et al., 2004; Berry, 2003; Ataca, 1998; Dona & Berry, 1994; Pruegger, 1993). Such approaches are useful for examining personality traits and values in very specific demographic and geographic contexts. Likewise, studying cultural domains can be more useful for evaluating common behavioral traits and continua of individual variations. Using both ecocultural approaches and cultural domains allows study of individual diversity while still identifying culturally shared traits. Single-subject analyses, a method for statistically evaluating an individual study participant most typically used in clinical research, can further probe diversity within populations (for methods and discussion see Nourbakhsh & Ottenbacher, 1994). By combining ecocultural frameworks with cultural domains, individual variability can be more sensitively characterized for studying the interplay between neurobiology and culture.

Practically, mixed-methods approaches are needed to establish converging evidence of cultural differences (for relevant anthropological discussions, see Weisner, 2012; Lieber & Weisner, 2010). Operationally, a statistical definition of culture may be the most useful for conducting neuroscientific research in cultural psychiatry, which approaches like Cultural Consensus Analysis provide (for complete discussion see Weller, 2007; for example of applications to neuropsychiatry, see Crafa et al., 2018). From this perspective, culture can be treated as a set of statistically common beliefs and behaviors within a certain population, region, and time period. Neural activity regularly co-occurring with these behaviors therefore might also be statistically common.

Statistical frequency within a population can be evaluated in narrower frames, for example, by neighborhood, family, or self-defined group membership. Regional subcultures can be viewed either as cultural subsets or as distinct groups. However, in theory, the frequency distributions of common behaviors between the mainstream culture and regional subcultures should be different. Subcultures are influenced by mainstream behaviors common to a region, but may also have a subset of statistically common behaviors that are unique to the specific, and usually self-identified, group (cf. Choudhury & Kirmayer, 2009). For example, Hispanic culture in Southern California differs in many ways from Hispanic culture anywhere else in the world, and the 1960s hippie movement in California was unique even for its time. Both examples identify subcultures that are distinct from the dominant culture, but still uniquely situated within it. In theory, observational and self-report measures can be used to isolate statistical commonalities and help describe various sociocultural similarities and differences between groups. Using a variety of measures as part of a mixed-methods approach may help avoid binary East/West dichotomies and allow for a more complex picture of common sociocultural traits within a population.

**Psychiatric Disorders in the CBB Model**

In contrast with the NCI model, which implicitly suggests cultural scripts can be ‘correctly’ learned, the CBB model proposes that cultural scripts are always individually altered, resulting in multiple spectra of culturally-situated practices within any cultural context. Psychiatric disorders can be understood as outliers of these spectra. Most psychiatric disorders are characterized by socially inappropriate behaviors, difficulties with sociocognitive processing, or, as in the case of certain neurogenetic disorders, reduced neural plasticity (Ramakers et al., 2012; Cramer & Galdzicki, 2012; Gipson & Johnston, 2012).

However, the symptoms and presentations of nearly all psychiatric disorders are influenced by culture, indicating that the processing or developmental pathways giving rise to sociocultural learning occur differently in these clinical populations. These extreme variations exist within culture and are also part of cultural feedback loops. Cultural scripts draw attention to certain symptoms, amplifying some experiences while minimizing others (Ryder et al., 2011) and many cultural scripts interplay simultaneously (Ryder et al., 2008). Individual mechanisms involved in these loops may occur differently from the ‘statistically common’ mechanisms observed in the general population, and an interplay between atypical cognitive processes and cultural scripts could also contribute to clinical symptoms.

This raises the question of whether or not ‘abnormal’ (or statistically uncommon) neural processes are shared across cultures in specific psychiatric disorders. Shared symptoms may or may not reflect shared neural processes. Disorders are largely influenced by cultural norms and certain symptoms and syndromes appear to develop in response to different cultural and environmental stressors; it follows that neural processes formed *a posteriori* will be unique across diverse psychiatric populations (Escobar & Gureje, 2007). Considering current interest in developing brain-based definitions of various disorders (e.g., Agarwal et al., 2010; Miller, 2010; Hyman, 2007), these are important questions that the CBB model provides a framework to address.

From a statistical perspective, patients with different psychiatric disorders can be thought of as forming their own subgroups, which are simultaneously culturally influenced yet may be distinct in terms of certain social beliefs and behaviors. While certain behaviors associated with individual disorders may be uncommon relative in the general population, they are common among other patients with the same disorder and may also be geographically or temporally unique, just as subcultures are (e.g., 1960s hippie movement). These definitions are useful for neuroscientific inquiries into the effects of ‘culture,’ because they suggest a framework for defining idioms, symptoms, behaviors, or neural events as common to a certain group within a certain culture and compared to groups across cultures. For example, dissociative phenomena are experienced by people in diverse cultures who may have different culture-specific explanations and symptoms (Seligman & Kirmayer, 2008). By statistically evaluating neural activity, we can evaluate the neural events that may be shared by one group of patients with dissociation but not another. This has the potential to lead to a more nuanced understanding of the neural activity that subserves dissociation and possibly resolve some of the heterogeneity in brain-based findings observed in patient populations.

**Testing the CBB Model**

The proposed methodological components of the CBB model are supported by current literature on culture, neuroscience, and psychiatry (e.g. Chiao et al., 2010; Weller, 2007; Wheeler et al., 2007), but have not been directly tested using the integrated approach proposed in this paper. This opens the door for a rich array of studies investigating claims supporting each of the three central tenets. For example, different cultures are known to have different cultural learning pathways, which are often studied by comparing mother-infant dyads across cultures (Graf et al., 2013; Bornstein et al., 2012; Keller et al., 2011; Enquist et al., 2010). Self-other mapping based on imitation is hypothesized to make these interactions effective for cultural learning (Shimpi, Akhtar, Moore, 2013; Gergely & Csibra, 2005) and some corresponding neural activity have already been identified (Paulus, Hunnius, Bekkering, 2012). Complementary studies could investigate the neural events that underlie self-other mapping or alternate theories that explain the neurobiological encoding of observed actions, to determine whether they are active during these cultural exchanges. Such studies could also assess whether different social cues produce this neural activity, identifying 1) neural correlates of different cultural pathways and 2) whether cultural learning can cause certain neural changes. This second outcome is particularly salient, because it would help characterize the role of sociocultural events in shaping the brain. Such studies would support the framework for cultural learning proposed in the first tenet of the CBB model. They could be further extended to include children who are at-risk for certain disorders, by identifying differences in sociocultural pathways, neural events, or execution of cultural scripts. For example, mothers across cultures teach behaviors that they want their children to learn, such as saying “thank you” when someone gives them a gift. Children with learning or developmental disabilities may learn different lessons from this maternal modeling than children without disabilities do (Tronick & Beeghly, 2011), for example, they may over- or undergeneralize when to say “thank you” or they may not learn from the interaction at all. Divergences in lessons and learning processes can lead to different behavioral phenotypes emerging across cultures (e.g., Keller et al., 2011; Tronick & Beeghly, 2011). This type of research would be informative for understanding mechanisms that contribute to the development of disorders, and could lead to methods for early diagnosis and intervention.

The role of cognitive mediation in the feedback loop between social experiences and neural encoding could be tested by studying the effects of social interactions on self-construal or social values (cf. studies by Crafa, 2017). Self-construal and social values are generally assumed to be reasonably stable during adulthood (Markus & Kunda, 1986). However, some studies (e.g., of active self-concepts) have demonstrated dynamic changes in personal identity as a result of new social interactions, information, or contexts (Wheeler et al., 2007) while others have demonstrated that extreme cultural experiences can influence social encoding (Chiao et al., 2010). These studies, however, have not evaluated changes in neural activity as a result of typical social experiences in the general adult population and thus the encoding of social information has not been assessed. Likewise, the role of cognitive mediation in the feedback loop between self-reflection and neural encoding could be tested by studying effects of talk therapy, CBT, journaling, or similar interventions that activate self-reflection or self-concepts. Longitudinal studies that test changes in neural activity and behaviors after controlled social interactions could evaluate the first tenet of the CBB model – the centrality of the ability to change in response to the environment. By testing the ability of cognitively mediated change to influence multiple organismic levels, they would also test the second tenet of the CBB model – that fluctuations create feedback loops that inform and change each other. Testing the CBB model can best be done by using mixed-method designs, which include multiple organismic levels, or at least test a combination of changes in self-perception, behavior, and neural activity.

The third tenet of the CBB model – that individual variations fall along cultural continua of common behaviors within a defined group – can be tested by using Cultural Consensus Analysis to examine the distributions of cultural traits among a population. Cultural Consensus Analysis uses data reduction, such as principle components analysis, to generate a statistical model of a cultural domain and assess cultural fit of each group member individually (Weller, 2007). This analysis is flexible enough to include multiple cultural domains and to be applied to sensitive patient cohorts (Dressler et al., 2014, 2007).

**The CBB Model as a Systems Approach to Transcultural Neuropsychiatry**

The CBB interaction model proposed in this paper can resolve many of the incompatibilities between CN and transcultural psychiatry. Through this systems approach, behavior, brain, and culture become three levels of a flexible feedback loop. The CBB model maintains that the use of neuroscience in cultural psychiatric research must be grounded in recognition of the pervasive changeability and equal importance of each organismic level. Accordingly, it employs a statistical definition of culture that simultaneously considers individual and circumstantial variability while also allowing for generalizations about regional or ethnic groups.

While the CBB and NCI models agree that practiced behaviors can lead to neural changes, the models diverge substantially in other ways. These divergences are reflected in the CBB model’s three central tenets. By taking a systems approach, the CBB model also avoids the three main theoretical pitfalls discussed earlier. First, neural events play key roles in the model, but the individual is not reducible to neural events. Instead, the CBB model acknowledges individuals’ capacity to change, thus altering their behaviors and neural events. Secondly, the CBB does not view culture as ‘locatable’ in the brain. Although culturally common neural events may be statistically observable on the group level, they cannot be located within individuals who are assumed to change across situations and lifetimes. Thirdly, the CBB model proposes nuanced alternatives to avoid reliance on cultural stereotypes. Some ‘Western’ cultures may share certain cultural domains with some ‘Eastern’ cultures, while other cultures located within the same geographic hemisphere do not. Additionally, subcultures may have notable differences in cultural domains when compared to the surrounding dominant culture. People within the subculture may respond or self-identify differently depending on whom they are interacting with (Matsunaga et al., 2010).

In resolving the incompatibilities of contemporary models with cultural psychiatry, we propose a few additional points. 1) Taking a systems approach to the study of culture and mental health avoids overemphasizing one organismic level, and views the whole patient as a single individual with multilevel organismic pressures. Within such an approach, culture is mediated by behavior, the brain, genes, experience, etc. and is not ‘unmediated’ as other models have proposed. 2) Grounding such an approach in the phenomenon of neuroplasticity acknowledges the patient’s individuality without ignoring related neural events. 3) In line with Choudhury and Kirmayer’s (2009) proposal, culture is not a single entity defined by geographical or political boundaries. Instead, it is composed of sets of cultural domains, which are behaviors and beliefs that are common within a specific historical time and ecocultural group. This conceptualization replaces binary categories like ‘collectivist cultures,’ which are used synonymously with ‘Eastern’ cultures, with more nuanced categories. These categories are based on empirically measured participant-reported values rather than stereotypes and would theoretically be observable in cultures across hemispheres.

**Neuroscience and the Benefits of a Systems Approach to Transcultural Psychiatry**

In conclusion, the current dearth of neuroscience in transcultural psychiatry research and of cultural diversity in traditional neuropsychiatry research leave a majority of the global population underrepresented in biomedical research. Extending cultural psychiatric research to include neuroscientific techniques could benefit patients who have immigrated into countries where biomedical psychiatry is practiced or who are receiving treatments through global mental health outreach efforts. Despite underlying theoretical conflicts, many current studies in CN are directly applicable to the patient population (Crafa & Nagel, 2014). They can be modified to provide new insights into disorders and have the potential to better represent diverse patient populations.

Transcultural psychiatry provides an interdisciplinary space that is uniquely suited to debate difficult theoretical questions, such as what it means to say that culture is “stored in people’s brains” (Ames & Fiske, 2010, p. 72) or what the role of specific brain regions like PFC may be in storing or producing “the shared webs of signification that make up culture” (Domínguez et al., 2009, p. 60). Evaluating these questions through the lens of cultural diversity in psychopathology provides a unique framework for identifying answers and developing a richer understanding of neurocultural events.

The overarching conclusion of studies from CN is that culture and neural events are “inextricably linked” (Zhou & Cacioppo, 2010). Although this conclusion is not surprising, it highlights the potential fMRI has for shedding new light on the relationship between culture and disorder. Although neuropsychiatry is an international research enterprise that includes patient populations around the world, very few studies directly evaluate cultural differences in the neural activity of patient cohorts (Hajek et al., 2013; Schlesinger et al., 2013). By applying the CBB model, CN paradigms could be adapted to investigate cultural variations in the psychiatric community. For example, numerous studies of healthy individuals have found differences in neural activity across cultural backgrounds (e.g., Goh et al., Leshikar, Sutton, 2010; Gutchess et al., 2010; Kitayama & Park, 2010; Chiao et al., 2008; Hedden et al., 2008). Many of these studies have focused on differences in neural pathways used for language or self-knowledge processes, while others show differential activity in regions like the hippocampus and amygdala that are associated with memory and emotion. Each of these brain processes are commonly associated with features of psychiatric disorders (Carmichael et al., 2012; Liemburg et al., 2012; Lombardo et al., 2010). For example, the high variability of amygdalar responses to certain events or stimuli may have implications for anxiety patients with diverse backgrounds (Sotres-Bayon et al., 2008).

Schizophrenia provides a second example. Although schizophrenia is globally ubiquitous, its symptoms and outcomes are highly heterogeneous (Kalra et al., 2012; Suhail & Cochrane, 2002). Higher rates of schizophrenia are associated with immigration, social inequality, and racial discrimination (Kirkbride et al., 2013; Kirkbride et al., 2012; Smith et al., 2006; Jarvis, 1998). Subcortical variations in neural network activity have been observed in individuals with schizophrenia (for review see Shenton et al., 2001), as has abnormal PFC volume (Wible, Anderson, & Shenton, 2001) as well as PFC connectivity and processes (Tan, Sust, Buckholtz, 2006; Hill et al., 2004; Callicott, 2003). Abnormalities in the PFC predict individual affect and have additionally been tied to altered consciousness and pathological dissociations as well as related symptoms of schizophrenia (Steiner & Coan, 2011; Winkelman, 2011; Seligman & Kirmayer, 2008; for review see Oertel-Knöchel & Linden, 2011). The PFC also seems to be closely tied to sociocultural self-identity (e.g., Ma et al., 2012; Sul, Choi, & Kang, 2012). Studying the role of the PFC in schizophrenia across cultural contexts may help disentangle some of the cross-cultural heterogeneity observed in this disorder because certain brain processes may be accounted for by culture while others may be common to patients with schizophrenia across cultures (LeWinn et al., 2017; Crafa & Nagel, 2014).

CN paradigms may also be used to investigate fundamental controversies, such as the theory of mind debate (Wilkinson & Ball, 2012), and may yield new insights into psychopathology in patients with impaired ability to self-report. For example, many disorders (e.g., schizophrenia, autism) involve disruptions to ‘self’ processes (Lombardo et al., 2010; Stephan, Friston, & Frith, 2009), impairing the ability to self-report and limiting the therapist’s access to the patient’s experience. Some fMRI studies of autism have identified disruptions in the neural networks that are normally active when thinking about oneself (Lombardo et al., 2010). Complementary studies in CN have shown that neural ‘self’ processes exhibit some flexibility across social situations (Ng et al., 2010; Chiao et al., 2010; 2009), raising the question of whether the same degree of flexibility exists in people with these disorders (Meyer-Lindenberg & Tost, 2012; Lazar et al., 2011; Dawson, 2008). Modifying paradigms used by cultural neuroscientists to study neural flexibility in psychopathology may contribute to understanding the mechanisms behind key aspects of clinical phenomena (Crafa, 2017).

A final benefit of fMRI research for transcultural psychiatry may be the ability to learn more about brain and biological processes through identifying functional similarities across cultures (Ryder et al., 2011). Identification of similar neuroanatomical features or neural processes associated with psychopathology across cultures may help illuminate variations in symptoms. Finding cross-cultural neural similarities in disorders like autism, for example, may help identify biomarkers because sociocultural variations may obscure neurocognitive processes that underlie key symptoms. Thus, determining similar neurological traits between common disorders (e.g., schizophrenia) and culture-bound syndromes could allow analogies to be drawn that improve understanding and, potentially, treatment options for patients with these disorders (Crafa & Nagel, 2014).

The research questions and methods advocated in this paper aim to enrich biomedicine by promoting the inclusion of diverse patient populations in research. Although this perspective should in theory help improve the treatment options available for patients globally, biomedicine is not the only mental health system and it is not always the most appropriate treatment framework (Kirmayer, 2012). The focus on biomedical research in this article is due to the authors’ expertise, and different types of research questions may be needed to accommodate other medical systems.

The CBB model proposed in this paper offers an alternative to other contemporary models of brain-culture relationships. Through applying the CBB model, transcultural psychiatry would be uniquely positioned to study the relationship between culture and the brain by making observations on three levels: i) culturally common behaviors and neural processes, ii) individual variations within those behaviors and neural processes, and iii) circumstances in which the individual may behave mor­e or less according to social convention. All three levels are relevant to understanding the relationship between normal functioning and pathology. The use of fMRI provides a way to examine cultural processes that may contribute to variations in symptom experience and may provide new insights to refine nosology and guide the development of interventions. Developments in CN hold promise for new understandings of the relationship between culture and disorder.

**Biographical Note**

**Daina Crafa**, M.Sc., M.Sc., Ph.D. is an award-winning early career Neuroscientist and Assistant Professor at the Interacting Minds Centre, Aarhus University. She studies the relationships between culture, the brain, and disorders. Her current projects investigate variations in brain activations as functions of sociocultural context and cognitively mediating self-concepts. Her published work discusses conceptual issues concerning the consideration of culture in neuropsychiatry and experimentally probes clinical and cultural variations in neurobiological processes and social cognitions.

**Saskia K. Nagel** is Professor for Applied Ethics and Ethics of Technology at RWTH Aachen University, Germany, working at the intersection of ethics, philosophy, life sciences, and technologies. With a background in Cognitive Science and Philosophy, she develops approaches to individual and societal challenges in a technological culture. Her published work focuses on ethical research, in particular on questions of autonomy and trust, as well as neuroscientific and philosophical work on the relationship between environment, body, and mind. Her recent work concerns questions of self-determination throughout the lifespan. She has a strong interest in studying public attitudes towards sciences and technology.

**References**

Abrams, D. A., Padmanabhan, A., Chen, T., Odriozola, P., Baker, A. E., Kochalka, J., & Menon, V. (2019). Impaired voice processing in reward and salience circuits predicts social communication in children with autism. eLife, 8, e39906.

Agarwal, N., Port, J. D., Bazzocchi, M., & Renshaw, P. F. (2010). Update on the use of MR for assessment and diagnosis of psychiatric diseases. *Radiology, 255*, 23–41.

Agorastos, A., Haasen, C., & Huber, C. (2012). Anxiety disorders through a transcultural perspective: Implications for migrants. *Psychopathology, 45*, 73–83.

Ambady, N., & Bharucha, J. (2009). Culture and the Brain. *Current Directions in Psychological Science, 18*, 342–345.

Ames, D. L., & Fiske, S.T. (2010). Cultural neuroscience. *Asian Journal of Social Psychology, 13*, 72–82.

Arnett, J. J. (2007). Suffering, selﬁsh, slackers? Myths and reality about emerging adults. *Journal of Youth and Adolescence, 36*, 23–29.

Arnett, J. J. (2006). Emerging adulthood: Understanding the new way of coming of age. In J. J. Arnett & J. L. Tanner (Eds.), *Emerging adults in America: Coming of age in the 21st century* (pp. 3–19). Washington, DC: American Psychological Association.

Aslan, A., & Bäuml, K. H. T. (2011). Individual differences in working memory capacity predict retrieval-induced forgetting. *Journal of Experimental Psychology, 37*, 264.

Asmal, L., Mall, S., Kritzinger, J., Chiliza, B., Emsley, R., & Swartz, L. (2011). Family therapy for schizophrenia: Cultural challenges and implementation barriers in the South African context. *African Journal of Psychiatry, 14*, 367–371.

Ataca, B. (1998). *Turkish Immigrants in Canada* (Doctoral dissertation, Queen's University Kingston).

Beckstead, Z., Cabell, K. R., & Valsiner, J. (2009). Generalizing through conditional analysis: Systemic causality in the world of eternal becoming. *Human Mente, 11*, 65–80.

Bevilacqua, D., Davidesco, I., Wan, L., Chaloner, K., Rowland, J., Ding, M., & Dikker, S. (2019). Brain-to-brain synchrony and learning outcomes vary by student–teacher dynamics: Evidence from a real-world classroom electroencephalography study. *Journal of Cognitive Neuroscience, 31*(3), 401-411.

Berry, J.W. (2003). Conceptual approaches to acculturation. In K.Chun, P. Balls-Organista, & G. Marin (Eds.), *Acculturation: Advances in theory, measurement and applied research* (pp.17–37). Washington: APA.

Bhugra, D. (2006). Severe mental illness across cultures. *Acta Psychiatrica Scandinavica, 429*, 17–23.

Blair, K. S., Otero, M., Teng, C., Geraci, M., Ernst, M., Blair, R. J. R., & Grillon, C. (2017). Reduced optimism and a heightened neural response to everyday worries are specific to generalized anxiety disorder, and not seen in social anxiety. *Psychological Medicine, 47*(10), 1806-1815.

Bohn, A. (2010). Generational differences in cultural life scripts and life story memories of younger and older adults. *Applied Cognitive Psychology, 24*, 1324–1345.

Bornstein, M. H., Cote, L. R., Haynes, O. M., Suwalsky, J. T. D., & Bakeman, R. (2012). Modalities of infant–mother interaction in Japanese, Japanese American Immigrant, and European American dyads. *Child Development, 83*, 2073–2088.

Borrelli, E., Nestler, E. J., Allis, C. D., & Sassone-Corsi, P. (2008). Decoding the epigenetic language of neuronal plasticity. *Neuron, 60*, 961–974.

Brooks, R., & Meltzoff A. N. (2002). The importance of eyes: How infants interpret adult looking behaviors. *Developmental Psychology, 38*, 958–966.

Brooks, R., & Meltzoff A. N. (2005). The development of gaze following and its relation to language. *Developmental Science, 8*, 535–543.

Brotman, M. A., Rich, B. A., Guyer, A. E., Lunsford, J. R., Horsey, S. E., Reising, M. M., & Leibenluft, E. (2010). Amygdala activation during emotion processing of neutral faces in children with severe mood dysregulation versus ADHD or bipolar disorder. *American Journal of Psychiatry, 167*, 61–69.

Buonomano, D. (1998). Cortical plasticity: From synapses to maps. *Annual Review of Neuroscience, 21*, 149–168.

Burke, S. N., & Barnes, C. A. (2006). Neural plasticity in the ageing brain. *Nature Reviews Neuroscience, 7*, 30–40.

Carlisi, C. O., Norman, L., Murphy, C. M., Christakou, A., Chantiluke, K., Giampietro, V., & Rubia, K. (2017). Disorder-specific and shared brain abnormalities during vigilance in autism and obsessive-compulsive disorder. Biological Psychiatry: *Cognitive Neuroscience and Neuroimaging, 2*(8), 644-654.

Callicott, J. H. (2003). Complexity of prefrontal cortical dysfunction in schizophrenia: More than up or down. *American Journal of Psychiatry, 160*, 2209–2215.

Carmichael, O., Xie, J., Fletcher, E., Singh, B., Decarli, C., & Alzheimer's Disease Neuroimaging Initiative. (2012). Localized hippocampus measures are associated with Alzheimer pathology and cognition independent of total hippocampal volume. *Neurobiology of Aging, 33*, 1124.e31–1124.e 41.

Canu, M. H., Coq, J. O., Barbe, M. F., & Dinse, H. R. (2012). Plasticity of adult sensorimotor system. *Neural Plasticity, 2012*, 768259.

Caroni, P., Danato, F., & Muller, D. (2012). Structural plasticity upon learning: Regulation and functions. *Nature Reviews Neuroscience, 13*, 478–490.

Chan, A. S., Han, Y. M., Leung, W. W. M., Leung, C., Wong, V. C., & Cheung, M. C. (2011). Abnormalities in the anterior cingulate cortex associated with attentional and inhibitory control deficits: a neurophysiological study on children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 5*, 254–266.

Chen, F. F. (2008). What happens if we compare chopsticks with forks? The impact of making inappropriate comparisons in cross-cultural research. *Journal of Personality and Social Psychology, 95*, 1005–1018.

Cheon, B. K., Mathur, V. A., & Chiao, J. Y. (2010). Empathy as cultural process: Insights from the cultural neuroscience of empathy. *WCPRR,* 32–42.

Chiao, J. Y., Cheon, B. K., Pornpattananangkul, N., Mrazek, A. J., & Blizinsky, K. D. (2013). Cultural neuroscience: Progress and promise. *Psychological Inquiry, 24*, 1–19.

Chiao, J. Y., & Cheon, B. K. (2012). Cultural neuroscience as critical neuroscience in practice. *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience,* p. 287–303. Oxford: Blackwell.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2010). Dynamic cultural influences on neural representations of the self. *Journal of Cognitive Neuroscience, 22*, 1–11.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2009). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping, 30*, 2813–2820.

Chiao, J. Y., Iidaka, T., Gordon, H. L., Nogawa, J., Bar, M., Aminoff, E., et al. (2008). Cultural Specificity in Amygdala Response to Fear Faces. *Journal of Cognitive Neuroscience, 20*, 2167–2174.

Chiu, C. Y., Gelfand, M. J., Yamagishi, T., Shteynberg, G., & Wan, C. (2010). Intersubjective culture: The role of intersubjective perceptions in cross-cultural research. *Perspectives on Psychological Science, 5*, 482–493.

Choudhury, S., & Kirmayer, L. J. (2009). Cultural neuroscience and psychopathology: Prospects for cultural psychiatry. *Progress in Brain Research, 178*, 263–279.

Choudhury, S., Nagel, S. K., & Slaby, J. (2009). Critical neuroscience: Linking neuroscience and society through critical practice. *BioSocieties, 4*, 61–77.

Cossu, G., Boria, S., Copioli, C., Bracceschi, R., Giuberti, V., Santelli, E., et al. (2012). Motor representation of actions in children with autism. *PLoS One, 7*, e44779.

Côté, J. E. (2000). *Arrested adulthood: The changing nature of maturity and identity*. New York, NY: New York University Press.

Crafa, D. (2017). *Adapting Differently to Changing Contexts: Flexible Yet Atypical Neural and Behavioral Responses to Dynamic Social Contexts in Schizophrenia*. (Doctoral dissertation, McGill University Montreal).

Crafa, D., Liu, J. Q., & Brodeur, M. B. (2018). Social values and determinants of cultural fit in Quebec: The roles of ancestry, linguistic group, and mental health status. *Frontiers in Psychology,* in revision.

Crafa, D., & Nagel, S.K. (2018). The adaptive self: Culture and social flexibility in feedback networks. Commentary on Borsboom, Cramer and Kalis. Behavioral and Brain Sciences, in press.

Crafa, D., & Nagel, S.K. (2016). Representing human cultural and biological diversity in neuropsychiatry: Why and how. In *Unity, Diversity and Culture* (Eds. B. Voyer et al.). IACCP.

Crafa, D., & Nagel, S.K. (2014). Group differences in mental health: A role for culture in neuropsychiatry. *WCPRR*, 144–150.

Crafa, D., & Nagel, S. (2013, May). *Accounting for Heterogeneity: The Culture-Brain-Behavior Interaction Model*. Poster presented at the first meeting of the International Cultural Neuroscience Consortium (ICNC), Evanston, IL, USA.

Cramer, N., & Galdzicki, Z. (2012). From abnormal hippocampal synaptic plasticity in Down syndrome mouse models to cognitive disability in Down syndrome. *Neural Plasticity, 2012*, 101542.

Cui, Q., Vanman, E. J., Long, Z., Pang, Y., Chen, Y., Wang, Y., & Chen, H. (2017). Social anxiety disorder exhibit impaired networks involved in self and theory of mind processing. *Social Cognitive and Affective Neuroscience, 12*(8), 1284-1295.

Davidesco, I., Laurent, E., Valk, H., West, T., Dikker, S., Milne, C., & Poeppel, D. (2019). Brain-to-brain synchrony between students and teachers predicts learning outcomes. bioRxiv, 644047.

Dawson, G. (2008). Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. *Development and Psychopathology, 20*, 775–803.

Derntl, B., Habel, U., Robinson, S., Windischberger, C., Kryspin-Exner, I., Gur, R. C., et al. (2012). Culture but not gender modulates amygdala activation during explicit emotion recognition. *BMC Neuroscience, 13*, 54.

Dinse, H. R. (2006). Cortical reorganization in the aging brain. *Progress in Brain Research, 157*, 57–80.

Domínguez, D. J. F., Lewis, E. D., Turner, R., & Egan, G. F. (2009). The brain in culture and culture in the brain: A review of core issues in neuroanthropology. *Progress in Brain Research, 178*, 43–64.

Dona, G., & Berry, J. W. (1994). Acculturation attitudes and acculturative stress of Central American refugees. *International Journal of Psychology, 29*, 57–70.

Dressler, W. W., Balieiro, M. C., & Dos Santos, J. E. (2014). Finding culture change in the second factor: stability and change in cultural consensus and residual agreement. *Field Methods, 27*, 22–38.

Dressler, W. W., Balieiro, M. C., Ribeiro, R. P., & Dos Santos, J. E. (2007). Cultural consonance and psychological distress: Examining the associations in multiple cultural domains. *Culture Medicine and Psychiatry, 31*, 195–224.

Dressler, W. W. (2004). Culture and the risk of disease. *British Medical Bulletin, 69*, 21–31.

During, E. H., Elahi, F. M., Taieb, O., Moro, M. R., & Baubet, T. (2011). A critical review of dissociative trance and possession disorders: Etiological, diagnostic, therapeutic, and nosological issues. *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie, 56*, 235–242.

Enquist, M., Strimling, P., Eriksson, K., Laland, K., & Sjostranda, J. (2010). One cultural parent makes no culture. *Animal Behaviour, 79*, 1353–1362.

Escobar, J. I., & Gureje, O. (2007). Influence of cultural and social factors on the epidemiology of idiopathic somatic complaints and syndromes. *Psychosomatic Medicine, 69*, 841–845.

Fassbender, C., Scangos, K., Lesh, T. A., & Carter, C. S. (2014). RT distributional analysis of cognitive-control-related brain activity in first-episode schizophrenia. *Cognitive, Affective, & Behavioral Neuroscience, 14*(1), 175-188.

Feinberg, A. P. (2007). Phenotypic plasticity and the epigenetics of human disease. *Nature, 447*, 433–440.

Freeman, J. B. (2013). Within-cultural variation and the scope of cultural neuroscience. *Psychological Inquiry*. Retrieved from

http://www.dartmouth.edu/~freemanlab/pubs/2013\_Freeman\_PsychInquiry.pdf

Frewen, P. A., Dozois, D. J. A., & Lanius, R. A. (2008). Neuroimaging studies of psychological interventions for mood and anxiety disorders: Empirical and methodological review. *Clinical Psychology Review, 28*, 229–247.

Frith, U. (1989). *Autism: Explaining the Enigma*. Oxford, U.K.: Basil Blackwell.

Fuchs, T. (2011). The brain–A mediating organ. *Journal of Consciousness Studies, 18*, 196–221.

Gallagher, S., & Meltzoff, A. N. (1996). The earliest sense of self and others: Merleau-Ponty and recent developmental studies. *Philosophical Psychology, 9*, 211–233.

Gardner, W. L., Gabriel, S., & Lee, A. Y. (1999). “I” value freedom, but “we” value relationships: Self-construal priming mirrors cultural differences in judgment. *Psychological Science, 10*, 321–326.

Georgas, J., van de Vijver, F. J. R., & Berry, J. W. (2004). The ecocultural framework, ecosocial indices, and psychological variables in cross-cultural research. *Journal of Cross-Cultural Psychology, 35*, 74–96.

Gergely, G., & Csibra, G. (2005). The social construction of the cultural mind: Imitative learning as a mechanism of human pedagogy. *Interaction Studies, 3*, 463–481.

Gilbert, S. J., Bird, G., Brindley, R., Frith, C. D., & Burgess, P. W. (2008). Atypical recruitment of medial prefrontal cortex in autism spectrum disorders: An fMRI study of two executive function tasks. *Neuropsychologia, 46*, 2281–2291.

Gipson, T. T., & Johnston, M. V. (2012). Plasticity and mTOR: Towards restoration of impaired synaptic plasticity in mTOR-related neurogenetic disorders. *Neural Plasticity, 2012*, 486402.

Gould, E. (2007). How widespread is adult neurogenesis in mammals? *Nature Reviews Neuroscience, 8*, 481–8.

Graf, F., Borchert, S., Lamm, B., Goertz, C., Kolling, T., Fassbender, I., et al. (2013). Imitative learning of Nso and German infants at 6 and 9 months of age: Evidence for a cross-cultural learning tool. *Journal of Cross-Cultural Psychology,* [Epub ahead of print].

Greenfield, P. M. (2009). Linking social change and developmental change: Shifting pathways of human development. *Developmental Psychology, 45*, 401–418.

Greenfield, P. M., Keller, H., Fuligni, A., & Maynard, A. (2003). Cultural Pathways Through Universal Development. *Annual Review of Psychology*, *54*, 461–490.

Gogolin, I. (2002). Linguistic and cultural diversity in Europe: A challenge for educational research and practice. *European Educational Research Journal, 1*, 123–138.

Goh, J., Leshikar, E., & Sutton, B. (2010). Culture differences in neural processing of faces and houses in the ventral visual cortex. *Social Cognitive Affective Neuroscience*, 5, 227–235.

Gold, I. (2009). Reduction in psychiatry. *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie, 54*, 506–512.

Gutchess, A. H., Hedden, T., Ketay, S., Aron, A., & Gabrieli, J. D. E. (2010). Neural differences in the processing of semantic relationships across cultures. *Social Cognitive and Affective Neuroscience, 5*, 254–263.

Hajek, T., Cullis, J., Novak, T., Kopecek, M., Blagdon, R., Propper, L., & Paus, T. (2013). Brain structural signature of familial predisposition for bipolar disorder: replicable evidence for involvement of the right inferior frontal gyrus. *Biological Psychiatry, 73*, 144–152.

Hammack, P. (2008). Narrative and the cultural psychology of identity. *Personality and Social Psychology Review, 12*, 222–247.

Han, S., Northoff, G., Vogeley, K., Wexler, B.E., Kitayama, S., & Varnum, M. E. W. (2013). A cultural neuroscience approach to the biosocial nature of the human brain. *Annual Review of Psychology, 64*, 335–359.

Han, S., Mao, L., Qin, J., Friederici, A. D., & Ge, J. (2011). Functional roles and cultural modulations of the medial prefrontal and parietal activity associated with causal attribution. *Neuropsychologia, 49*,83–91.

Han, S., & Ma, Y. (2015). A culture–behavior–brain loop model of human development. *Trends in Cognitive Sciences, 19*, 666–676.

Happe, F., & Frith, U. (2006). The weak central coherence account: Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 36*, 5–25.

Harada, T., Lia, Z., & Chiao, J. Y. (2010). Differential dorsal and ventral medial prefrontal representations of the implicit self modulated by individualism and collectivism: An fMRI study. *Social Neuroscience, 5*,257–271.

Hari, R. (2009). Brain basis of human social interaction: From concepts to brain imaging. *Physiological Reviews, 89*, 453–479.

Hauf, P., Aschersleben, G. (2008). Action-effect anticipation in infant action control. *Psychological Research, 72*, 203–10.

Hedden, T., Ketay, S., Aron, A., Markus, H. R., & Gabrieli, J. D. E. (2008). Cultural influences on neural substrates of attentional control. *Psychological Science, 19*, 12–17.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *The Behavioral and Brain Sciences, 33*, 61–135.

Herold, D., Usnich, T., Spengler, S., Sajonz, B., Bauer, M., & Bermpohl, F. (2017). Decreased medial prefrontal cortex activation during self-referential processing in bipolar mania. *Journal of Affective Disorders, 219*, 157-163.

Hill, K., Mann, L., Laws, K. R., Stephenson, C. M. E., Nimmo-Smith, I., & McKenna, P. J. (2004). Hypofrontality in schizophrenia: A meta-analysis of functional imaging studies. *Acta Psychiatrica Scandinavica, 110*, 243–256.

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

Hu, M. L., Zong, X. F., Mann, J. J., Zheng, J. J., Liao, Y. H., Li, Z. C., & Tang, J. S. (2017). A review of the functional and anatomical default mode network in schizophrenia. *Neuroscience Bulletin, 33*(1), 73-84.

Huang, C. M., Doole, R., Wu, C. W., Huang, H. W., & Yi-Ping, C. (2019). Culture-related and individual differences in regional brain volumes: A cross-cultural voxel-based morphometry study. *Frontiers in Human Neuroscience, 13*, 313.

Hunt, S. M., & Bhopal, R. (2004). Self report in clinical and epidemiological studies with non-English speakers: The challenge of language and culture. *Journal of Epidemiology and Community Health, 58*, 618–622.

Hyman, S. E. (2007). Can neuroscience be integrated into the DSM-V? *Nature Reviews Neuroscience, 8*, 725–732.

Inglehart, R. (2005). *Modernization, cultural change, and democracy: The human development sequence.* Cambridge, U.K.: Cambridge University Press.

Isamah, N., Faison, W., Payne, M. E., MacFall, J., Steffens, D. C., Beyer, J. L., et al. (2010). Variability in frontotemporal brain structure: The importance of recruitment of African Americans in neuroscience research. *PloS One, 5*, 1–6.

Jäncke, L. (2009). The plastic human brain. *Restorative Neurology and Neuroscience, 27*, 521–538.

Jáni, M., & Kašpárek, T. (2018). Emotion recognition and theory of mind in schizophrenia: a meta-analysis of neuroimaging studies. *World Journal of Biological Psychiatry, 19*(sup3), S86-S96.

Jarvis, E. (1998). Schizophrenia in British immigrants: Recent findings, issues, and implications. *Transcultural Psychiatry, 35*, 39–74.

Kagawa Singer, M. (2012). Applying the concept of culture to reduce health disparities through health behavior research. *Preventive Medicine, 55*, 356–361.

Kaiser, R. H., Whitfield-Gabrieli, S., Dillon, D. G., Goer, F., Beltzer, M., Minkel, J., & Pizzagalli, D. A. (2016). Dynamic resting-state functional connectivity in major depression. *Neuropsychopharmacology, 41*(7), 1822-1830.

Kalra, G., Bhugra, D., & Shah, N. (2012). Cultural aspects of schizophrenia. *International Review of Psychiatry, 24*, 441–449.

Kärtner, J., Keller, H., & Yovsi, R. D. (2010). Mother–infant interaction during the first 3 months: The emergence of culture-specific contingency patterns. *Child Development, 81*, 540–554.

Keener, M. T., Fournier, J. C., Mullin, B. C., Kronhaus, D., Perlman, S. B., LaBarbara, E., & Phillips, M. L. (2012). Dissociable patterns of medial prefrontal and amygdala activity to face identity versus emotion in bipolar disorder. *Psychological Medicine, 42*, 1913–1924.

Keller, H., Borke, J., Lamm, B., Lohaus, A., & Yovsi, R. D. (2011). Developing patterns of parenting in two cultural communities. *International Journal of Behavioral Development, 35*, 233–245.

Keller, H., Demuth, C., & Yovsi, R. D. (2008). The multi-voicedness of independence and interdependence: The case of the Cameroonian Nso. *Culture Psychology, 14*, 115–144.

Keller, H. (2006). Cultural models, socialization goals, and parenting ethnotheories: A multicultural analysis. *Journal of Cross-Cultural Psychology, 37*, 155–172.

Keller, H. (2003). Moving towards consensus on how to characterize culture. *Human Development, 46*, 328–330.

Kemmelmeier, M., & Kühnen, U. (2012). Culture as process: The dynamics of cultural stability and change. *Social Psychology, 43*, 171–173.

Kempermann, G. (2012). Neuroscience. Youth culture in the adult brain. *Science, 335*, 1175–1176.

Kim, M. J., Gee, D. G., Loucks, R. A., Davis, F. C., & Whalen, P. J. (2011). Anxiety dissociates dorsal and ventral medial prefrontal cortex functional connectivity with the amygdala at rest. *Cerebral Cortex, 21*, 1667–1673.

Kirkbride, J. B., Jackson, D., Perez, J., Fowler, D., Winton, F., Coid, J. W., et al. (2013). A population-level prediction tool for the incidence of first-episode psychosis: Translational epidemiology based on cross-sectional data. *BMJ Open, 3*, pii: e001998.

Kirkbride, J. B., Jones, P. B., Ullrich, S., & Coid, J. W. (2012). Social deprivation, inequality, and the neighborhood-level incidence of psychotic syndromes in East London. *Schizophrenia Bulletin*, [Epub ahead of print].

Kirmayer, L. J. (2001). Cultural variations in the clinical presentation of depression and anxiety: Implications for diagnosis and treatment. *Journal of Clinical Psychiatry, 62 (Suppl. 13)*, 22–28.

Kirmayer, L. J. (2012). Cultural competence and evidence-based practice in mental health: Epistemic communities and the politics of pluralism. *Social Science and Medicine, 75*, 249–256.

Kirmayer, L. J., & Ban, L. (2013). Cultural psychiatry: Research strategies and future directions. *Advances in Psychosomatic Medicine, 33*, 97–114.

Kirmayer, L. J., & Crafa, D. (2014). What kind of science for psychiatry? *Frontiers in Human Neuroscience, 8*, 435.

Kirmayer, L. J., & Gold, I. (2012). Re-socializing psychiatry: Critical neuroscience and the limits of reductionism. In S. Choudhury & J. Slaby (Eds.), *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience*. Oxford: Blackwell.

Kirmayer, L. J., & Groleau, D. (2001). Affective disorders in cultural context. *Psychiatric Clinics of North America, 24*, 465–478.

Kirschner, S. R. (2010). Sociocultural subjectivities: Progress, prospects, problems. *Theory & Psychology, 20*, 765–780.

Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain: Current evidence and future directions. *Annual Review of Psychology, 62*, 419–449.

Kitayama, S., & Park, J. (2010). Cultural neuroscience of the self: Understanding the social grounding of the brain. *Social Cognitive and Affective Neuroscience, 5*, 111–129.

Kitayama, S., Park, J., & Cho, Y. (2015). Culture and neuroplasticity. *Handbook of Advances in Culture and Psychology, 5*, 38–100.

Kleim, J. A. (2008). Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. *Journal of Speech, Language, and Hearing Research, 51*, S225–S239.

Kleinhans, N. M., Richards, T., Weaver, K., Johnson, L. C., Greenson, J., Dawson, G., et al. (2010). Association between amygdala response to emotional faces and social anxiety in autism spectrum disorders. *Neuropsychologia, 48*, 3665–3670.

Klumpp, H., Post, D., Angstadt, M., Fitzgerald, D. A., & Phan, K. L. (2013). Anterior cingulate cortex and insula response during indirect and direct processing of emotional faces in generalized social anxiety disorder. *Biology of Mood & Anxiety Disorders, 3*, 7.

Klumpp, H., Fitzgerald, J. M., Kinney, K. L., Kennedy, A. E., Shankman, S. A., Langenecker, S. A., & Phan, K. L. (2017). Predicting cognitive behavioral therapy response in social anxiety disorder with anterior cingulate cortex and amygdala during emotion regulation. *NeuroImage: Clinical, 15*, 25-34.

Koepke, S., & Denissen, J. J. A. (2012). Dynamics of identity development and separation–Individuation in parent–child relationships during adolescence and emerging adulthood – A conceptual integration. *Developmental Review, 32*, 67–88.

Koh, H. C., & Milne, E. (2012). Evidence for a cultural influence on field-independence in Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 42*, 181–190.

Korb, A. S., Hunter, A. M., Cook, I. A., & Leuchter, A. F. (2011). Rostral anterior cingulate cortex activity and early symptom improvement during treatment for major depressive disorder. *Psychiatry Research, 192*, 188–194.

Koshino, H., Carpenter, P. A., Minshew, N. J., Cherkassky, V. L., Keller, T. A., & Just, M. A. (2005). Functional connectivity in an fMRI working memory task in high-functioning autism. *Neuroimage, 24*, 810–821.

Krings, F., Bangerter, A., Gomez, V., & Grob, A. (2008). Cohort differences in personal goals and life satisfaction in young adulthood: Evidence for historical shifts in developmental tasks. *Journal of Adult Development, 15*, 93–105.

Lazar, N. L., Singh, S., Paton, T., Clapcote, S. J., Gondo, Y., Fukumura, R., et al. (2011). Missense mutation of the reticulon-4 receptor alters spatial memory and social interaction in mice. *Behavioural Brain Research, 224*, 73–79.

Legare, C. H., Wen, N. J., Herrmann, P. A., & Whitehouse, H. (2015). Imitative flexibility and the development of cultural learning. *Cognition*, 142, 351–361.

LeWinn, K. Z., Sheridan, M. A., Keyes, K. M., Hamilton, A., & McLaughlin, K. A. (2017). Sample composition alters associations between age and brain structure. *Nature Communications, 8*, 874.

Li, Y., Wang, M., Wang, C., & Shi, J. (2010). Individualism, collectivism, and Chinese adolescents' aggression: Intracultural variations. *Aggressive Behavior, 36*, 187–194.

Lieber, E., & Weisner, T. S. (2010). Meeting the practical challenges of mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of Mixed Methods Research*, p. 559–579. Thousand Oaks, C.A.: Sage.

Liemburg, E. J., Vercammen, A., Ter Horst, G. J., Curcic-Blake, B., Knegtering, H., & Aleman, A. (2012). Abnormal connectivity between attentional, language and auditory networks in schizophrenia. *Schizophrenia Research, 135*, 15–22.

Linden, D. E. J. (2006). How psychotherapy changes the brain: The contribution of functional neuroimaging. *Molecular Psychiatry, 11*, 528–538.

Lord, B., & Lord, G. D. (2010). *Artists, patrons, and the public: Why culture changes*. Berkeley, C.A.: AltaMira Press.

Lombardo, M. V., Chakrabarti, B., Bullmore, E. T., Sadek, S. A., Pasco, G., Wheelwright, S. J., et al. (2010). Atypical neural self-representation in autism. *Brain, 133*, 611–624.

Losin, E. A. R., Dapretto, M., & Iacoboni, M. (2009). Culture in the mind's mirror: How anthropology and neuroscience can inform a model of the neural substrate for cultural imitative learning. *Progress in Brain Research*, *178*, 175–190.

Ma, Y., Bang, D., Wang, C., Allen, M., Frith, C., Roepstorff, A., at al. (2012). Sociocultural patterning of neural activity during self-reflection. *Social Cognitive Affective Neuroscience*, [Epub ahead of print].

Matsunaga, M., Hecht, M. L., Elek, E., & Ndiaye, K. (2010). Ethnic identity development and acculturation: A longitudinal analysis of Mexican-heritage youth in the southwest United States. *Journal of Cross-Cultural Psychology, 4i*, 410–427.

Markus, H. R., & Kitayama, S. (2010). Cultures and selves: A cycle of mutual constitution. *Perspectives on Psychological Science, 5*, 420–430.

Markus, H., & Kunda, Z. (1986). Stability and malleability of the self-concept. *Journal of Personality and Social Psychology, 51*, 858.

Maruyama, M. (1977). Heterogenistics: an epistemological restructuring of biological and social sciences. *Acta Biotheoretica, 26*, 120–136.

Meltzoff, A. N. (2007a). “Like Me”: A foundation for social cognition. *Developmental Science, 10*, 126–134.

Meltzoff, A. N. (2007b). The “Like Me” framework for recognizing and becoming an intentional agent. *Acta Psychologica, 124*, 26–43.

Meyer, M. L., Way, B. M., & Eisenberger, N. I. (2013). Broadening the scope of cultural neuroscience. *Psychological Inquiry, 24*,47–52.

Meyer-Lindenberg, A., & Tost, H. (2012). Neural mechanisms of social risk for psychiatric disorders. *Nature Neuroscience, 15*, 663–668.

Miller, G. (2010). Psychiatry: Beyond DSM: Seeking a brain-based classification of mental illness. *Science, 327*, 1437.

Milne, E., & Szczerbinski, M. (2009). Global and local perceptual style, field independence, and central coherence: An attempt at concept validation. *Advances in Cognitive Psychology, 5*, 1–26.

Mukherjee, P., Whalley, H. C., McKirdy, J. W., Sprengelmeyer, R., Young, A. W., McIntosh, A. M., et al. (2013). Altered amygdala connectivity within the social brain in schizophrenia. *Schizophrenia Bulletin,* [Epub ahead of print].

Morgiève, M., N'diaye, K., Haynes, W. I., Granger, B., Clair, A. H., Pelissolo, A., et al. (2013). Dynamics of psychotherapy-related cerebral haemodynamic changes in obsessive compulsive disorder using a personalized exposure task in functional magnetic resonance imaging. *Psychological Medicine,* [Epub ahead of print].

Murray, E. A., Wise, S. P., & Drevets, W. C. (2011). Localization of dysfunction in major depressive disorder: Prefrontal cortex and amygdala. *Biological Psychiatry, 69,* e43–e54.

Moss, L. E. (2016). The relationships among acculturation, executive functioning and English language proficiency in bilingual adults.Nelson, L. J., & Chen, X. (2007). Emerging adulthood in China: The role of social and cultural factors. *Child Development Perspectives, 1*, 86–91.

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

Nourbakhsh, M. R., & Ottenbacher, K. J. (1994). The statistical analysis of single-subject data: a comparative examination. *Physical Therapy, 74*, 768–776.

O'Brien, R. L., Kosoko-Lasaki, O., Cook, C. T., Kissell, J., Peak, F., & Williams, E. H. (2006). Self-assessment of cultural attitudes and competence of clinical investigators to enhance recruitment and participation of minority populations in research. *Journal of the National Medical Association, 98*, 674–682.

Oertel-Knöchel, V., & Linden, D. E. (2011). Cerebral asymmetry in schizophrenia. *Neuroscientist, 17*, 456–467.

Padmanabhan, A., Lynch, C. J., Schaer, M., & Menon, V. (2017). The default mode network in autism. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 2*(6), 476-486.

Pascual-Leone, A., Amedi, A., & Fregni, F. (2005). The plastic human brain cortex. *Annual Review of Neuroscience*, 28, 377–401.

Paulus, M., Hunnius, S., & Bekkering, H. (2012). Neurocognitive mechanisms underlying social learning in infancy: Infants’ neural processing of the effects of others’ actions. *Social Cognitive and Affective Neuroscience,* [Epub ahead of print].

Paulus, M., Hunnius, S., Vissers, M., & Bekkering, H. (2011). Bridging the gap between the other and me: the functional role of motor resonance and action effects in infants’ imitation. *Developmental Science, 14*, 901–10.

Pavlowsky, A., Chelly, J., & Billuart, P. (2012). Emerging major synaptic signaling pathways involved in intellectual disability. *Molecular Psychiatry, 17*, 682–693.

Pecchioni, L. L. (2012). Interruptions to cultural life scripts: Cancer diagnoses, contextual age, and life narratives. *Research on Aging, 34*, 758–780.

Pedersen, A., Wilmsmeier, A., Wiedl, K. H., Bauer, J., Kueppers, K., Koelkebeck, K., et al. (2012). Anterior cingulate cortex activation is related to learning potential on the WCST in schizophrenia patients. *Brain and Cognition, 79*, 245–251.

Pliszka, S. R. (2012). Pharmacotherapy of Child and Adolescent Psychiatric Disorders. (D. R. Rosenberg & S. Gershon, Eds.) *Pharmacotherapy of Child and Adolescent Psychiatric Disorders* (pp. 65–104). Chichester: John Wiley & Sons, Ltd.

Poldrack, R. A. (2000). Imaging brain plasticity: Conceptual and methodological issues – a theoretical review. *NeuroImage, 12*, 1–13.

Pomarol-Clotet, E., Canales-Rodríguez, E. J., Salvador, R., Sarró, S., Gomar, J. J., Vila, F., et al. (2010). Medial prefrontal cortex pathology in schizophrenia as revealed by convergent findings from multimodal imaging. *Molecular Psychiatry, 15*, 823–830.

Pornpattananangkul, N., Hariri, A. R., Harada, T., Mano, Y., Komeda, H., Parrish, T. B., & Chiao, J. Y. (2016). Cultural influences on neural basis of inhibitory control. *NeuroImage, 139*, 114-126.

Pruegger, V. (1993). *Aboriginal and non-Aboriginal work values*. Unpublished doctoral dissertation, Queen’s University, Kingston, Canada.

Rakic, P. (2002). Neurogenesis in adult primate neocortex: An evaluation of the evidence. *Nature Reviews Neuroscience, 3*, 65–67.

Ramakers, G. J. A., Wolfer, D., Rosenberger, G., Kuchenbecker, K., Kreienkamp, H. J., Prange-Kiel, J., at al. (2012). Dysregulation of Rho GTPases in the αPix/Arhgef6 mouse model of X-linked intellectual disability is paralleled by impaired structural and synaptic plasticity and cognitive deficits. *Human Molecular Genetics, 21*, 268–286.

Ray, R. D., Shelton, A. L., Hollon, N. G., Matsumoto, D., Frankel, C. B., Gross, J. J., et al. (2010). Interdependent self-construal and neural representations of self and mother. *Social Cognitive and Affective Neuroscience, 5*, 318–323.

Reeves, W. C., Strine, T. W., Pratt, L. A., Thompson, W., Ahluwalia, I., Dhingra, S. S., et al. (2011). Mental illness surveillance among adults in the United States. *Center for Disease Control and Prevention: Morbidity and Mortality Weekly Report, 60 (Suppl. 3)*, 1–29.

Ressler, K. J. (2010). Amygdala activity, fear, and anxiety: Modulation by stress. *Biological Psychiatry, 67*, 1117–1119.

Roffman, J. L., Marci, C. D., Glick, D. M., Dougherty, D. D., & Rauch, S. L. (2005). Neuroimaging and the functional neuroanatomy of psychotherapy. *Psychological Medicine, 35,* 1385–1398.

Rogers, D. S., & Ehrlich, P. R. (2008). Natural selection and cultural rates of change. *Proceedings of the National Academy of Sciences of the United States of America, 105*, 3416–3420.

Rutherford, A., Whitton, A. E., Ironside, M. L., Jensen, J. E., Du, F., Farabaugh, A., & Pizzagalli, D. A. (2018). F87. Rostral Anterior Cingulate Glutamate Levels are Linked to Abnormal High-Frequency Resting-State Functional Connectivity in Bipolar Disorder. *Biological Psychiatry, 83*(9), S271.

Ryder, A. G., Ban, L. M., & Chentsova-Dutton, Y. E. (2011). Towards a cultural–clinical psychology. *Social and Personality Psychology Compass, 5*, 960–975.

Ryder, A. G., Yang, J., Zhu, X., Yao, S., Yi, J., Heine, S. J. et al. (2008). The cultural shaping of depression: Somatic symptoms in China, psychological symptoms in North America? *Journal of Abnormal Psychology, 117*, 300–313.

Saito, D. N., Tanable, H. C., Izuma, K., Hayashi, M. J., Morito, Y., Komeda, H., et al. (2010). "Stay Tuned": Inter-individual neural synchronization during mutual gaze and joint attention. *Frontiers, 4*, 1–12.

Scharf, M., & Mayseless, O. (2010). Finding the authentic self in a communal culture: Developmental goals in emerging adulthood. *New Directions for Child and Adolescent Development, 130*, 83–95.

Schlesinger, D., Grinberg, L. T., Alba, J. G., Naslavsky, M. S., Licinio, L., Farfel, J. M., & Dos Santos, A. C. F. (2013). African ancestry protects against Alzheimer's disease-related neuropathology. *Molecular Psychiatry, 18*, 79.

Schouten, B. C., & Meeuwesen, L. (2006). Cultural differences in medical communication: A review of the literature. *Patient Education and Counseling, 64*, 21–34.

Schübeler, D. (2009). Genetics and epigenetics: Stability and plasticity during cellular differentiation. *Trends in Genetics, 25*, 129–136.

Seiffge-Krenke, I., & Gelhaar, T. (2008). Does successful attainment of developmental tasks lead to happiness and success in later developmental tasks? A test of Havighurst’s (1948) theses. *Journal of Adolescence, 31*, 33–52.

Seligman, R., & Kirmayer, L. J. (2008). Dissociative experience and cultural neuroscience: Narrative, metaphor and mechanism. *Culture, Medicine and Psychiatry, 32*, 31–64.

Severance, L., Bui-Wrzosinska, L., Gelfand, M. J., Lyons, S., Nowak, A., Borkowski, W., et al. (2013). The psychological structure of aggression across cultures. *Journal of Organizational Behavior, 34*, 835–865.

Shanahan, M. J. (2000). Pathways to adulthood in changing societies: Variability and mechanisms in life course perspective. *Annual Review of Sociology, 26*, 667–692.

Shenton, M. E., Dickey, C. C., Frumin, M., & McCarley, R. W. (2001). A review of MRI findings in schizophrenia. *Schizophrenia Research, 49*, 1–52.

Shimpi, P. M., Akhtar, N., & Moore, C. (2013). Toddlers’ imitative learning in interactive and observational contexts: The role of age and familiarity of the model. *Journal of Experimental Child Psychology, 116*, 309–323.

Shors, T. J., Anderson, M. L., Curlik, D. M. II, & Nokia, M. S. (2012). Use it or lose it: How the brain keeps fit for learning. *Behavioral Brain Research, 227*, 450–458.

Sladky, R., Höflich, A., Atanelov, J., Kraus, C., Baldinger, P., Moser, E., et al. (2012). Increased neural habituation in the amygdala and orbitofrontal cortex in social anxiety disorder revealed by FMRI. *PloS One, 7*, e50050.

Smith, G. N., Boydell, J., Murray, R. M., Flynn, S., McKay, K., Sherwood, M., et al. (2006). The incidence of schizophrenia in European immigrants to Canada. *Schizophrenia Research, 87*, 205–211.

Sotres-Bayon, F., Corcoran, K. A., Peters, J., & Sierra-Mercado, D. (2008). Neural correlates of individual variability in fear extinction. *The Journal of Neuroscience, 28*, 12147–12149.

Steiner, A. R. W., & Coan, J. A. (2011). Prefrontal asymmetry predicts affect, but not beliefs about affect. *Biological Psychology, 88*, 65–71.

Stephan, K. E., Friston, K. J., & Frith, C. D. (2009). Dysconnection in schizophrenia: From abnormal synaptic plasticity to failures of self-monitoring. *Schizophrenia Bulletin, 35*, 509–527.

Stevens, J. S., Jovanovica, T., Fania, N., Elya, T. D., Glovera, E. M., Bradleya, B., & Resslera, K. J. (2013). Disrupted amygdala-prefrontal functional connectivity in civilian women with posttraumatic stress disorder. *Journal of Psychiatric Research, 47*, 1469–1478.

Suhail, K., & Cochrane, R. (2002). Effect of culture and environment on the phenomenology of delusions and hallucinations. *International Journal of Social Psychiatry, 48*, 126–138.

Sui, J., Hong, Y. Y., Liu, C. H., Humphreys, G. W., & Han, S. (2013). Dynamic cultural modulation of neural responses to one's own and friend's faces. *Social Cognitive and Affective Neuroscience, 8*, 326–332.

Sul, S., Choi, I., & Kang, P. (2012). Cultural modulation of self-referential brain activity for personality traits and social identities. *Social Neuroscience, 7*, 280–291.

Suslow, T., Konrad, C., Kugel, H., Rumstadt, D., Zwitserlood, P., Schöning, S., et al. (2010). Automatic mood-congruent amygdala responses to masked facial expressions in major depression. *Biological Psychiatry, 67*, 155–160.

Tan, H., Sust, S., & Buckholtz, J. (2006). Dysfunctional Prefrontal Regional Specialization and Compensation in Schizophrenia. *American Journal of Psychiatry, 163*, 1969–1977.

Thomas, C., & Baker, C. I. (2012). Teaching an adult brain new tricks: A critical review of evidence for training-dependent structural plasticity in humans. *NeuroImage*, [Epub ahead of print].

Thomas, D. C. (2010). *Cultural intelligence: Living and working globally*. San Francisco: Berret-Koehler Publishers.

Tomasello, M., Hare, B., Lehmann, H., & Call, J. (2007). Reliance on head versus eyes in gaze following of great apes and human infants: The cooperative eye hypothesis. *Journal of Human Evolution, 52*, 314–320.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, 28, 1–61.

Torrey, E. F. (2007). Schizophrenia and the inferior parietal lobule. *Schizophrenia Research, 97*, 215–225.

Tronick, E., & Beeghly, M. (2011). Infants' meaning-making and the development of mental health problems. *American Psychologist, 66*, 107–119.

Valnegri, P., Sala, C., & Pasafaro, M. (2012). Synaptic dysfunction and intellectual disability. *Synaptic Plasticity, 970*, 433–449.

Vignoles, V. L., Owe, E., Becker, M., Smith, P. B., Easterbrook, M. J., Brown, R., & Lay, S. (2016). Beyond the ‘east–west’dichotomy: Global variation in cultural models of selfhood. *Journal of Experimental Psychology: General, 145*, 966.

Vogeley, K., & Roepstorff, A. (2009). Contextualising culture and social cognition. *Trends in Cognitive Sciences, 13*, 511–516.

Wang, F., Kalmar, J. H., He, Y., Jackowski, M., Chepenik, L. G., Edmiston, E. E., et al. (2009). Functional and structural connectivity between the perigenual anterior cingulate and amygdala in bipolar disorder. *Biological Psychiatry, 66*, 516–521.

Wang, C., Ma, Y., & Han, S. (2013). Self-construal priming modulates pain perception: Event-related potential evidence. *Cognitive Neuroscience*, 1–7.

Wang, S., Zhan, Y., Zhang, Y., Lyu, L., Lyu, H., Wang, G., & Guo, W. (2018). Abnormal long-and short-range functional connectivity in adolescent-onset schizophrenia patients: a resting-state fMRI study. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 81*, 445-451.

Wass, S., Whitehorn, M., Phillips, E., Haresign, I. M., & Leong, V. (2019). Interpersonal neural synchrony and responsivity during early learning interactions.

Webb, C. A., Olson, E. A., Killgore, W. D., Pizzagalli, D. A., Rauch, S. L., & Rosso, I. M. (2018). Rostral anterior cingulate cortex morphology predicts treatment response to internet-based cognitive behavioral therapy for depression. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 3*(3), 255-262.

Weisner, T. S. (2012). Mixed methods should be a valued practice in anthropology. *Anthropology News (Published by the American Anthropological Association), 53*, 3–4.

Weller, S. C. (2007). Cultural consensus theory: Applications and frequently asked questions. *Field Methods, 19*, 339–368.

Weltens, B., de Bot, K., & van Els, T. (Eds.). (2012). *Language attrition in progress* (Vol. 2). Walter de Gruyter.

Wheeler, S. C., DeMarree, K. G., & Petty, R. E. (2007). Understanding the role of the self in prime-to-behavior effects: The active-self account. *Personality and Social Psychology Review, 11*, 234–261.

Wible, C., Anderson, J., & Shenton, M. (2001). Prefrontal cortex, negative symptoms, and schizophrenia: An MRI study. *Psychiatry Research, 108*, 65–78*.*

Wilkinson, M., & Ball, L. J. (2012). Why studies of autism spectrum disorders have failed to resolve the theory theory versus simulation theory debate. *Review of Philosophy and Psychology, 3*, 263–291.

Winker, M. A. (2004). Measuring race and ethnicity: Why and how? *Journal of the American Medical Association, 292*, 1612–1614.

Winkelman, M. (2011). A paradigm for understanding altered consciousness: The integrative mode of consciousness. *Altering Consciousness: Multidisciplinary Perspectives, 1*, 23–41.

Yang, J., & Hofmann, J. (2016). Action observation and imitation in autism spectrum disorders: an ALE meta-analysis of fMRI studies. *Brain Imaging and Behavior, 10*(4), 960-969.

Yorulmaz, O., & Işık, B. (2011). Cultural context, obsessive-compulsive disorder symptoms, and cognitions: A preliminary study of three Turkish samples living in different countries. *International Journal of Psychology, 46*, 136–143.

Yu, L., Rowland, B. A., Xu, J., & Stein, B. E. (2013). Multisensory plasticity in adulthood: cross-modal experience enhances neuronal excitability and exposes silent inputs. *Journal of Neurophysiology, 109*,464–474.

Zaman, R. (2010). Psychological treatments and brain plasticity. *Psychiatria Danubina, 22 (Suppl. 1)*, 6–9.

Zhong, Y., Wang, C., Gao, W., Xiao, Q., Lu, D., Jiao, Q., & Lu, G. (2019). Aberrant resting-state functional connectivity in the default mode network in pediatric bipolar disorder patients with and without psychotic symptoms. *Neuroscience Bulletin, 35*(4), 581-590.

Zhou, H., & Cacioppo, J. (2010). Culture and the brain: Opportunities and obstacles. *Asian Journal of Social Psychology, 13*, 59–71.

Zhu, Y., Zhang, L., Fan, J. & Han, S. (2007). Neural basis of cultural influence on self representation. *Neuroimage, 34*, 1310–1317.

1. According to the NCI model, *cognitive mediation* refers to the initial judgment of a cultural attitude or practice, in which the observer may consciously or unconsciously subscribe to (i.e., accept and produce) that attitude or practice. *‘Embraining’* refers to the neurobiological encoding of these attitudes and practices and the formation of neural connections that produce these executable culturally-learned attitudes and actions. Although these terms are interrelated, cognitive mediation relies on multiple neurocognitive processes, presumably related to judgment and self-identity, which have been behaviorally observed but are difficult to study (Kitayama & Uskul, 2011; Gardner et al., 1999). ‘Embraining’, on the other hand, describes the neurobiological processes that immediately follow cognitive mediation, producing the neural architecture and connections that can be measured using neuroimaging [↑](#endnote-ref-2)
2. *Organismic levels* is defined here as including the appropriate classic taxonomic levels of biological systemics (physiologic, molecular, behavioral, ecologic and geographic characteristics, but excluding morphology) as well as genetic and epigenetic processes and social constructs representing mental processes, such as perception, cognition and psychology, and the physical and social environments. [↑](#endnote-ref-3)