Cultural Neuroscience and its Implications in Healthcare - a Narrative Review

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Introduction

Culture provides a framework in which individual cognitions and behaviours are understood, realized and made meaningful.[1] Cultural influences, including language, shared values and social structures, play a critical role in shaping neural organization and brain development. For instance, reading difficulties such as dyslexia manifest differently across cultures, shaped by the characteristics of the writing system used. In alphabetic systems like English, where letters correspond to sounds, dyslexia is linked to dysfunction in the left temporoparietal and occipitoparietal regions[2,3], areas essential for phonological processing and decoding written language. In contrast, in logographic systems such as Chinese, which rely on symbols representing words or concepts, dyslexia primarily affects the left middle frontal gyrus,[4] a region involved in visuospatial and motor processing.

Differences in information processing also arise from shared values and beliefs, which differ significantly across societies. For example, East Asian cultures – rooted in collectivism – tend to process information holistically, prioritising context and intuitive reasoning.[5,6] In contrast, Western cultures – characterized by individualism – focus on specific objects in visual stimuli and rely on formal reasoning.[5] Functional differences in visual stimuli processing have been observed in the ventral visual cortex, where evidence suggests that Western individuals exhibit greater activation in object-processing regions.[5]

Previous reviews on cultural neuroscience have highlighted the importance of integrating culture into the study of brain and development[1], and posit that neural connectivity is likely modified through sustained engagement in cultural practices.[7,8] This narrative review aims to explore new findings in the emerging field of cultural neuroscience, focusing on how an individual's culture and environment influences their neurocognitive processes, and how this understanding can be applied to advance community-based, inclusive research.

Methods

ELIGIBILITY CRITERIA

All study methodologies were included in this review in order to capture a complete picture of the existing literature. Studies included any modality of assessing structural or functional brain differences, including but not limited to magnetic resonance imaging, computed tomography, and voxel-based morphometry. Specific inclusion criteria were: 1) studies published in English 2) studies will the full text available 3) studies comparing cultural (i.e. linguistic and sociological) differences as opposed to difference in race or ethnic background.

INFROMATION SOURCES

Searches were completed on PubMed, Cochrane Library, Embase and Academic Search Complete from 2000 to December 8th, 2024. Database searches included synonyms of the following terms: race, culture, ethnicity, neural changes and cortical changes. This search was adequately reproduced on all databases included in the review. Furthermore, references listed in the included studies were also searched for eligibility based on the eligibility criteria outlined above.

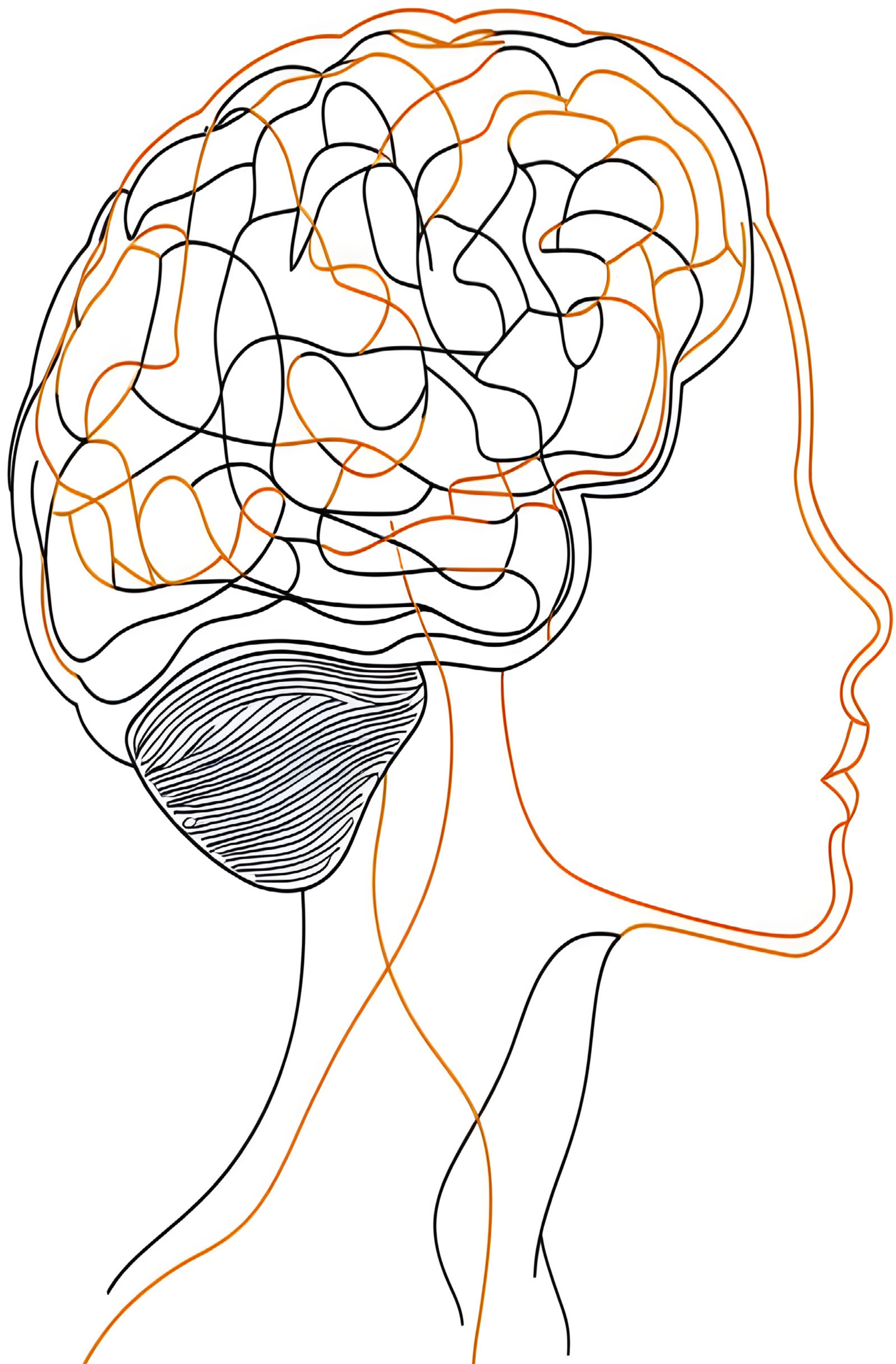
Results

Our search ultimately yielded 7 articles published from 2004 to 2024 included in this review and summarized below. The articles included a wide variety of study methodology, target population and outcome measures, but all attempted to differentiate between cultural (i.e. language, shared values, etc.) vs. racial or ethnic explanations for their findings.

DIFFERENCES IN NORTH AMERICAN VS EAST ASIAN POPULATIONS

Five studies (Table 1) found noticeable differences in structure, cognitive processing and underlying neural networks across Western and East Asian cultures.

Mechelli et al. (2004)[9], Wang et al. (2017)[10], Huang et al. (2019)[11], and Yu et al. (2019)[12] all employed voxel-based



morphometry (VBM) in combination with a variety of genetic and cultural factors. Mechelli et al. found Chinese speakers had significant enhancement of grey matter density in the right and left superior temporal gyrus, right inferior frontal gyrus, and left middle temporal gyrus. This study found the same structural differences in Chinese speakers who learned it as both their first and second language, thereby confirming the effect was as a result of language rather than ethnicity.

Yu et al. found that individuals who carried the 7- or 2-repeat allele of the dopamine D4 receptor gene were more sensitive to environmental and cultural influences. They found that grey matter volume was significantly higher in both Caucasian Americans and DRD4 variant carriers. Additionally they found that, among East Asian carriers, the number of years spent in the US predicted increased grey matter volume, supporting the finding that culture shapes the brain by mobilizing epigenetic pathways that are gradually established through socialization and enculturation.

Both Wang et al. and Huang et al. found that individuals who displayed independence (vs. collectivist) traits had increased grey matter volume in a number of brain regions associated with self-relation, including the ventromedial prefrontal cortex. This is consistent with other findings in Western populations, which are associated with independent cultural orientations, in cross-cultural comparisons by Masuda & Nisbett (2006)6, Chee et al. (2011)13 and Tang et al. (2018)4.

Hisanaga et al. (2016)14 found that English speakers process multisensory speech more efficiently than auditory only, and the reverse was true for Japanese speakers. They suggest these results indicate that cultural and linguistic experiences lead to the development of unique neural systems for audiovisual speech perception. These cross-linguistic effects are also supported by previous findings in a review by Green et al. (2007)15.

DIFFERENCES IN NORTH AMERICAN VS LATINX POPULATIONS

Only two studies examined difference between Latinx and North American/Caucasian populations (Table 2).

In an fMRI study of adolescents, Telzer et al. (2011)16 found that Caucasian participants displayed more mesolimbic (reward) activity when gaining a monetary reward for themselves, while Latino participants showed similar or increased activity during costly donations to their family rather than their own gain. The authors posited that these findings were consistent with the cultural emphasis placed on family obligation from Latino families and cultures, and possibly with a stronger importance of family identity to their sense of self.

Ferjan Ramírez et al. (2016)17 found that Spanish-English bilingual infants displayed increased magnetoencephalograpy (MEG) activity in the prefrontal and orbitofrontal cortex when compared to English monolingual infants. This increased activity in areas linked to executive functioning is theorized to arise as a result of a constant need to resolve conflict at a linguistic level, which then translates to the ability to resolve non-linguistic conflict.

Limitations

Firstly, the majority of the studies available to include in this review compare East Asian and English-speaking Western populations. The findings' generalizability is limited by this restrictive scope, which excludes other ethnic and cultural groups such as Indigenous communities, Middle Easterners, and Africans. Given the steady global increase in multiculturalism, a more thorough study spanning a range of cultural backgrounds is necessary to completely comprehend the wider influence of culture on neural development.

Secondly, even though this analysis highlights the influence of culture, it's crucial to acknowledge that other elements like nutrition, exposure to the environment, socioeconomic status, and heredity also affect the structure and development of the brain. The intricate relationship between these elements and cultural effects is not adequately covered in the examined studies.

Finally, cross-sectional approaches, which might show correlations but not causality, are used in the majority of the included studies. To ascertain whether observed changes are due to cultural exposure or other underlying variables, as well as how cultural influences impact brain anatomy over time, longitudinal studies are required.

Conclusion

The emerging concept of cultural neuroscience aids the ever-evolving understanding of how we develop thinking and learning skills, and particularly how these are reflected differently in various cultures. A greater understanding of how cultural differences affect neurocognitive development affords us the opportunity to approach neuroscience in a culturally sensitive manner, rather than as a one-size-fits-all endeavor. Understanding the neuroanatomical and neurophysiological differences that manifest across cultures can help to improve myriad aspects of neuroscience and healthcare, including tailored neuroimaging protocols, improved specificity of clinical trials and interventions, and providing a biological basis for understanding cultural differences across groups.

Future advances in this field might involve the inclusion of other ethnic groups to ensure greater diversity and provide a more detailed view of cultural differences beyond an Eastern versus Western cultural comparison. Additionally, it would be of value to consider other cultural factors together with language systems when exploring the cultural underpinnings of neuroconnectivity, as well as individual differences in experience and how these may impact neurocognitive development.

The increasing emphasis on cultural differences in brain anatomy remind us that medicine cannot be practised in a vacuum independent of lived experience. Rather, the way our brains are shaped is to some degree dependent on the context in which we experience life, which is strongly influenced by our cultural setting.

Table 1. Studies examining East Asian vs. Western populations

Study	Methodology	Sample Size	Primary Outcomes	Findings
MECHELLI ET AL. (2004)	Case Control	83	VBM of grey matter density	Increased grey matter density in left posterior supramarginal parietal region in bilinguals
HISANAGA ET AL. (2016)	Case Control	39	RT, ERP and eye tracking in syllable identification task	English-speakers: visual speech facilitates auditory speech Japanese-speakers: visual speech does not facilitate auditory speech
WANG ET AL. (2017)	Cross Sectional	265	VBM	A relative focus of independence (vs. interdependence) was associated with increased gray-matter volume in a number of self-related regions, including vmPFC, right DLPFC, and right RLPFC
HUANG ET AL. (2019)	Case Control	113	VBM and SCS	VBM results demonstrated that Western participants showed greater gray matter volume in the fronto-parietal network, whereas Taiwanese participants showed greater regional volume in temporal and occipital regions
YU ET AL. (2019)	Case Control	132	VBM and DRD4 allele carrier status	VBM Grey matter volume of the medial prefrontal cortex and the orbitofrontal cortex was significantly greater among European Americans than among East Asians. The difference in volume was significantly more pronounced among carriers of the 7/2-R allele of DRD4 than among non-carriers

DLPFC = dorsolateral prefrontal cortex, DRD4 = dopamine D4 receptor gene, ERP = event-related brain potentials, RLPFC = rostrolateral prefrontal cortex, RT = response time, SCS = Singelis Self-Construal Scale, VBM = voxel-based morphometry, vmPFC = ventromedial prefrontal cortex

Table 2. Studies examining Latinx vs. Western populations

Study	Methodology	Sample Size	Primary Outcomes	Findings
TELZER ET AL. (2011)	Cross Sectional	28	fMRI of reward system activation	White participants: Increased VS, DS and VTA activity during self gain Latino participants: Increased activity during sacrifice for benefit of family
FERIAN RAMIREZ ET AL. (2016)	Case Control	35	MEG of neural activity	Bilingual infants show increased brain activity in bilateral brain areas, with significant right hemisphere bias, and extension into prefrontal and orbitofrontal cortices
DS = dorsal striatum, fMRI = functional magnetic resonance imaging, MEG = magnetoencephalography, VS = ventral striatum, VTA = ventral tegmental area				

References

1. Qu Y, Jorgensen NA, Telzer EH. A Call for Greater Attention to Culture in the Study of Brain and Development. Perspect Psychol Sci. 2021;16(2):275-293.
2. Sun YF, Lee JS, Kirby R. Brain imaging findings in dyslexia. Pediatr Neonatol. 2010;51(2):89-96.
3. Aylward EH, Richards TL, Berninger VW, et al. Instructional treatment associated with changes in brain activation in children with dyslexia. Neurology. 2003;61(2):212-219.
4. Tang Y, Zhao L, Lou Y, et al. Brain structure differences between Chinese and Caucasian cohorts: A comprehensive morphometry study. Hum Brain Mapp. 2018;39(5):2147-2155.
5. Park DC, Huang CM. Culture Wires the Brain: A Cognitive Neuroscience Perspective. Perspect Psychol Sci. 2010;5(4):391-400.
6. Masuda T, Nisbett RE. Culture and change blindness. Cogn Sci. 2006;30(2):381-399.
7. Kitayama S, Uskul AK. Culture, mind, and the brain: current evidence and future directions. Annu Rev Psychol. 2011;62:419-449.
8. Kim HS, Sasaki JY. Cultural neuroscience: biology of the mind in cultural contexts. Annu Rev Psychol. 2014;65:487-514.
9. Mechelli A, Crinion JT, Noppeney U, et al. Neurolinguistics: structural plasticity in the bilingual brain. Nature. 2004;431(7010):757
10. Wang F, Peng K, Chechlacz M, Humphreys GW, Sui J. The Neural Basis of Independence Versus Interdependence Orientations: A Voxel-Based Morphometric Analysis of Brain Volume. Psychol Sci. 2017;28(4):519-529.
11. Huang CM, Doole R, Wu CW, Huang HW, Chao YP. Culture-Related and Individual Differences in Regional Brain Volumes: A Cross-Cultural Voxel-Based Morphometry Study. Front Hum Neurosci. 2019;13:313.
12. Yu Q, Abe N, King A, Yoon C, Liberzon I, Kitayama S. Cultural variation in the gray matter volume of the prefrontal cortex is moderated by the dopamine D4 receptor gene (DRD4). Cereb Cortex. 2019;29(9):3922-3931.
13. Chee MW, Zheng H, Goh JO, Park D, Sutton BP. Brain structure in young and old East Asians and Westerners: comparisons of structural volume and cortical thickness. J Cogn Neurosci. 2011;23(5):1065-1079.
14. Hisanaga S, Sekiyama K, Igasaki T, Murayama N. Language/Culture Modulates Brain and Gaze Processes in Audiovisual Speech Perception. Scientific Reports. 2016;6(1):35265.
15. Green DW, Crinion J, Price CJ. Exploring cross-linguistic vocabulary effects on brain structures using voxel-based morphometry. Biling (Camb Engl). 2007;10(2):189-199.
16. Telzer EH, Masten CL, Berkman ET, Lieberman MD, Fuligni AJ. Gaining while giving: an fMRI study of the rewards of family assistance among white and Latino youth. Soc Neurosci. 2010;5(5-6):508-518.
17. Ferjan Ramírez N, Ramírez RR, Clarke M, Taulu S, Kuhl PK. Speech discrimination in 11-month-old bilingual and monolingual infants: a magnetoencephalography study. Developmental science. 2017;20(1):e12427.