

Cultural Factors in Neuroregulation: A Review of Evidence and Theoretical Framework

Leslie H. Sherlin*

Sherlin Consulting Group, Scottsdale, Arizona, USA
Ottawa University, Surprise, Arizona, USA
Grand Canyon University, Phoenix, Arizona, USA
Sonoran University of Health Sciences, Tempe, Arizona, USA
Fuller Theological Seminary, Phoenix, Arizona, USA
Nova Tech EEG, Inc, Mesa, Arizona, USA

Abstract

Introduction. Despite increasing diversity in patient populations and documented health disparities, the neuroregulation field has given minimal attention to cultural factors influencing treatment access, engagement, and outcomes. **Methods.** This article reviews existing literature examining cultural factors across neuroregulation modalities (neurofeedback, transcranial electrical stimulation, photobiomodulation, peripheral biofeedback) and synthesizes theoretical frameworks from cultural neuroscience, cultural humility, and health disparities research. **Results.** Literature review reveals striking paucity of cultural considerations research across all neuroregulation modalities. While fundamental physiological mechanisms (operant conditioning, neuroplasticity, autonomic regulation) appear universal across human populations, cultural factors profoundly influence treatment perceptions, explanatory models, technology acceptance, and therapeutic relationships. Evidence suggests comparable outcomes across diverse populations when access barriers are addressed. Key disparities stem from structural inequities rather than differential treatment response. **Conclusion.** The neuroregulation field requires systematic integration of cultural considerations while maintaining scientific understanding of universal physiological mechanisms. Distinguishing between invariant biological processes and culturally variable implementation factors provides foundation for developing inclusive, effective interventions across diverse populations.

Keywords: cultural neuroscience; neurofeedback; biofeedback; health disparities; therapeutic alliance; cultural competence

Citation: Sherlin, L. H. (2026). Cultural factors in neuroregulation: A review of evidence and theoretical framework. *NeuroRegulation*, 13(1), 65–76. <https://doi.org/10.15540/nr.13.1.65>

***Address correspondence to:** Leslie H. Sherlin, PhD, 7272 E. Indian School Rd, Suite 540, Scottsdale, AZ 85251, USA. Email: leslie@drsherlin.com

Copyright: © 2026. Sherlin. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC-BY).

Edited by: Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA

Reviewed by: Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA
Randall Lyle, PhD, Mount Mercy University, Cedar Rapids, Iowa, USA

Introduction

The field of neuroregulation has evolved substantially over 4 decades, demonstrating efficacy for various neurological and psychological conditions through neurofeedback, biofeedback, and neuromodulation techniques. However, this evolution has occurred with remarkably limited attention to cultural factors that may influence treatment access, engagement, and outcomes. This gap becomes increasingly problematic as practitioners serve more diverse populations while

health disparities in neurological and behavioral healthcare persist (Saadi et al., 2017).

The absence of cultural considerations in neuroregulation research and practice is striking. Systematic reviews reveal that over 90% of human neuroimaging publications originate from Western countries (Chiao, 2009). The vast majority of neuroregulation research has been conducted with predominantly white, Western, middle-class populations, raising questions about generalizability of protocols and normative databases. A

comprehensive literature search reveals only a handful of studies explicitly examining cultural factors in neuroregulation interventions.

Recently, Eisenbarth et al. (2025) conducted one of the first systematic investigations of culturally diverse perceptions of electroencephalography (EEG) and neurofeedback research. Their study of 181 participants in New Zealand found significant barriers to participation among diverse populations, including low awareness of these interventions and cultural concerns about electrode placement procedures. Notably, 19.34% of participants indicated that experimenter gender would matter for procedures involving head contact, highlighting intersections of cultural, religious, and gender considerations.

This absence of cultural consideration creates multiple problems. Protocols and normative databases developed with homogeneous populations may not generalize appropriately. Cultural barriers may prevent equitable access to potentially beneficial treatments. Practitioners may inadvertently create cultural mismatches that undermine therapeutic alliance and treatment effectiveness. The lack of culturally responsive approaches perpetuates systemic healthcare inequities. Additionally, the field misses opportunities to learn from diverse cultural perspectives on mind-body relationships, self-regulation, and healing.

This article provides an examination of cultural factors in neuroregulation, reviewing existing evidence across modalities and synthesizing theoretical frameworks to understand how culture influences treatment engagement and outcomes. The analysis distinguishes between universal physiological mechanisms underlying neuroregulation and culturally variable factors affecting implementation. This foundation is essential for developing truly inclusive and effective neuroregulation practices.

Theoretical Foundations

Cultural Humility and Cultural Competence: Complementary Frameworks

Understanding culturally responsive practice in neuroregulation requires integrating two complementary frameworks: cultural humility and cultural competence. These approaches, while distinct, work synergistically to guide practitioners in navigating cultural complexity while maintaining clinical effectiveness.

Cultural humility, introduced by Tervalon and Murray-García (1998), emphasizes an ongoing process rather than an endpoint. Unlike cultural competence, which implies achievable mastery, cultural humility recognizes that cultural learning is never complete. This perspective is particularly relevant for neuroregulation practitioners who must navigate not only general cultural differences in health beliefs but also specific cultural perspectives on brain function, consciousness, technology, and mind-body relationships.

The framework encompasses three core dimensions with direct application to neuroregulation practice. First, lifelong self-evaluation and self-critique require practitioners to continuously examine assumptions about “normal” brain function, treatment compliance, and appropriate goals that may reflect cultural biases. For example, privileging individual symptom reduction over family harmony or spiritual balance reflects Western individualistic values rather than universal treatment priorities.

Second, addressing power imbalances inherent in practitioner-client relationships becomes especially complex in neuroregulation. Practitioners possess specialized technical knowledge about brain function and sophisticated equipment, creating additional distance from clients’ lived experiences. When interpreting EEG patterns or making statements about clients’ internal states based on physiological readings, practitioners wield considerable technical authority. This must be balanced with recognition that clients are experts on their own experiences, cultural contexts, and treatment priorities.

Third, institutional accountability extends beyond individual practitioners. Organizations must examine systemic barriers to culturally responsive care, including why certain populations are underrepresented in research samples, whether clinic locations and hours create access barriers, and how equipment design may inadvertently exclude populations (such as EEG caps incompatible with diverse hair textures or religious head coverings).

While cultural humility provides philosophical grounding, cultural competence offers practical skill development frameworks. Campinha-Bacote’s (2002) model identifies five constructs directly applicable to neuroregulation.

1. Cultural awareness involves recognizing one’s own worldview and biases, including beliefs about consciousness, brain-mind

relationships, technology's role in healing, and what constitutes healthy brain function. Concepts like "self-regulation" and "optimal performance" are culturally constructed with varying meanings across contexts.

2. Cultural knowledge encompasses understanding diverse worldviews and health beliefs, including how cultures conceptualize mental processes, technology acceptability, health locus of control, and traditional practices that might complement or conflict with neuroregulation. For instance, understanding that some Asian cultures express emotional distress through somatic symptoms rather than psychological constructs influences how practitioners explain neurofeedback for anxiety.
3. Cultural skill refers to conducting culturally responsive assessments and interventions, including adapting communication styles, modifying procedures for cultural factors, selecting appropriate feedback displays, and integrating neuroregulation with clients' existing cultural resources. This might include working with interpreters during sessions or adapting protocols for clients who find certain stimuli culturally inappropriate.
4. Cultural encounters involve direct engagement with diverse clients. Research indicates meaningful cross-cultural clinical experiences, accompanied by reflection and supervision, accelerate competence development more effectively than didactic training alone. For neuroregulation practitioners, this means seeking opportunities with diverse populations, community outreach, and engagement with cultural communities.
5. Cultural desire represents genuine motivation to engage in the cultural competence process. This intrinsic motivation sustains ongoing efforts, particularly when facing challenges or mistakes. In neuroregulation, cultural desire manifests as curiosity about diverse populations' experiences, commitment to accessibility, and willingness to adapt established protocols.

The integration of cultural humility and competence provides a robust framework recognizing that

practitioners need both foundational knowledge about cultural factors and ongoing process orientation acknowledging knowledge limitations. This synthesis is essential for understanding technical aspects of interventions alongside cultural factors influencing client perceptions and engagement.

Distinguishing Universal Mechanisms From Cultural Variations

A critical consideration in culturally responsive neuroregulation involves distinguishing physiological processes that are universal across human populations from treatment aspects that are culturally influenced. This distinction helps practitioners avoid both assuming everything is culturally relative and ignoring important cultural variations.

Fundamental physiological mechanisms underlying neuroregulation appear universal across human populations. The autonomic nervous system functions similarly across cultures, with sympathetic activation increasing heart rate and parasympathetic activation slowing it (Porges, 2011). Basic neurophysiological processes of operant conditioning underlying neurofeedback, including the ability to modify brain activity through reinforcement, have been demonstrated across diverse populations studied (Sherlin et al., 2011). The physiological stress response, involving hypothalamic-pituitary-adrenal (HPA) axis activation with characteristic changes in heart rate variability (HRV), cortisol release, and EEG patterns, shows remarkable consistency across cultures (McEwen, 2017).

EEG patterns associated with specific neurological conditions demonstrate consistency across populations. The 3 Hz spike-and-wave pattern characteristic of absence seizures appears similar regardless of geographic origin (Betting et al., 2006). Attention-deficit/hyperactivity disorder (ADHD) is associated with elevated theta/beta ratios across diverse populations, though prevalence and symptom expression vary culturally (Arns et al., 2013). Neurophysiological markers of sleep stages remain consistent across cultures, even as sleep practices and beliefs vary widely (Siegel, 2005).

Photobiomodulation mechanisms, involving cytochrome c oxidase activation and increased adenosine triphosphate (ATP) production, represent fundamental cellular processes operating similarly across populations (Hamblin, 2016). While skin pigmentation may affect light penetration, basic cellular responses to specific wavelengths appear

universal. Similarly, transcranial electrical stimulation's effects on neuronal excitability through membrane polarization represent basic biophysical processes that should not vary by culture (Nitsche et al., 2008).

However, while fundamental mechanisms may be universal, numerous aspects of neuroregulation are profoundly influenced by culture. Baseline physiological patterns can be shaped by cultural practices and chronic stress exposure. Individuals from cultures experiencing systemic discrimination may show chronically elevated sympathetic arousal and blunted stress reactivity, reflecting allostatic load from chronic stress (Geronimus et al., 2006). Cultural practices such as meditation, prayer, or traditional breathing exercises influence baseline EEG patterns and autonomic tone (Travis & Shear, 2010).

Interpretation and meaning assigned to physiological states vary culturally. Increased heart rate might be interpreted as anxiety in one culture but excitement or spiritual awakening in another. The experience and expression of physiological arousal is filtered through cultural schemas shaping whether sensations are perceived as problematic or normal (Hinton & Good, 2016). These interpretive differences influence whether individuals seek treatment and how they understand treatment goals.

Treatment engagement factors are heavily culturally influenced. The therapeutic alliance, crucial for adherence and outcomes, is shaped by cultural expectations about relationships, communication styles, and power dynamics. Motivation for change may be individually focused in individualistic cultures but family or community focused in collectivistic cultures. Acceptability of different feedback modalities varies based on cultural aesthetics and learning styles.

This understanding has important practice implications. Practitioners can have confidence that fundamental physiological processes targeted by neuroregulation operate similarly across cultures. A neurofeedback protocol increasing sensorimotor rhythm (SMR) and decreasing theta will have similar neurophysiological effects regardless of cultural background. However, how that protocol is explained, what motivates engagement, how progress is measured and celebrated, and how changes are integrated into daily life are all profoundly influenced by culture.

Health Disparities Framework: Understanding Structural Factors

Cultural considerations in neuroregulation cannot be separated from broader health disparities and their underlying mechanisms. Health disparities in neurological and behavioral healthcare are well-documented, with racial and ethnic minorities consistently experiencing lower access, poorer quality care, and worse outcomes (Robbins et al., 2022). These disparities reflect complex interactions of historical, social, economic, and systemic factors rather than cultural differences alone.

Saadi et al. (2017) documented striking disparities in neurological care, finding Black and Hispanic patients had markedly lower rates of outpatient neurology visits compared to White patients, even after controlling for insurance status, education, and income. These disparities were not explained by differences in disease prevalence, suggesting systemic barriers rather than differential need drive inequitable access. For neuroregulation services, often not covered by insurance and requiring specialized providers, these disparities may be even more pronounced.

Structural competency, introduced by Metzl and Hansen (2014), extends cultural competency by focusing on recognizing and addressing upstream social and institutional determinants of health. This framework shifts attention from individual cultural differences to structural factors creating and maintaining health inequities. For neuroregulation practitioners, structural competency involves understanding how insurance coverage limitations, geographic maldistribution of services, transportation barriers, inflexible work schedules, and historical redlining concentrating poverty in certain communities all create access barriers.

Insurance coverage represents a particularly significant structural barrier. Despite decades of research supporting neurofeedback efficacy, most insurance plans classify it as "experimental" without coverage. Medicare and Medicaid, disproportionately serving elderly, disabled, and low-income populations, generally do not cover neurofeedback except for specific conditions. This creates a two-tiered system where neuroregulation is available primarily to those who can afford out-of-pocket payments, typically \$1,000–\$8,000 per treatment course.

Geographic disparities compound access issues. Neuroregulation services concentrate in urban and suburban areas with higher-income populations,

creating “neurotherapy deserts” in rural areas and lower-income urban neighborhoods. The intersection of geographic and racial disparities is particularly striking in the Southeastern United States, with both the lowest neurologist density per capita and highest proportion of Black residents.

Medical mistrust, rooted in historical and contemporary discrimination and exploitation experiences, significantly affects healthcare engagement among racial and ethnic minorities. Bazargan et al. (2021) found medical mistrust was 73% higher among Black adults and 49% higher among Hispanic adults compared to White adults. This mistrust reflects collective memory of events like the Tuskegee syphilis study, forced sterilizations, and ongoing discrimination experiences in healthcare settings. For brain-based interventions potentially perceived as experimental or manipulative, mistrust may be particularly pronounced.

Therapeutic Alliance as Culturally Mediated Process

The therapeutic alliance, consistently identified as critical for treatment outcomes across interventions, is inherently influenced by cultural factors. In neuroregulation, where treatment extends over many sessions requiring active participation in clinic and home practice, relationship quality may be particularly important for adherence and outcomes.

Cultural values fundamentally shape therapeutic relationship expectations. Clients from hierarchical cultures may expect directive, authoritarian approaches from healthcare providers, viewing practitioners as experts whose recommendations should be followed without question. This expectation may conflict with collaborative approaches common in neurofeedback, where clients provide feedback about experiences and participate in goal setting. Conversely, clients from egalitarian cultures may be uncomfortable with directive approaches, expecting equal partnership in treatment planning.

Communication styles vary significantly across cultures with profound implications for information exchange, rapport building, and treatment planning. Hall’s (1976) distinction between high-context and low-context communication remains relevant. High-context communication, common in many Asian, African, and Latin American cultures, relies heavily on nonverbal cues, implicit understanding, and indirect expression. Low-context communication, typical of Northern European and

Anglo-American cultures, emphasizes explicit verbal expression and direct communication.

These differences manifest multiple ways during neuroregulation treatment. Clients from high-context cultures may not directly express disagreement or discomfort with procedures, showing reluctance through nonverbal behavior or missed appointments. They may find direct symptom questions uncomfortable, preferring to communicate distress through somatic complaints or metaphorical language. Practitioners accustomed to low-context communication may misinterpret indirect communication as resistance, poor motivation, or alexithymia.

The technical nature of neuroregulation interventions further complicates therapeutic alliance. Unlike talk therapy where the relationship itself is the primary change vehicle, neuroregulation involves complex equipment, computer interfaces, and physiological measurements potentially diminishing relational aspects. However, research suggests the therapeutic relationship remains crucial. Clients must trust practitioners to attach electrodes, interpret brain patterns, and guide neurological functioning changes, requiring significant vulnerability and trust.

Family involvement represents another culturally variable aspect. Western therapeutic models emphasize individual autonomy, confidentiality, and clear client-family boundaries. However, many cultures view health and healing as communal processes. In collectivist cultures, family members may expect presence during sessions, participation in decisions, and home practice support, creating ethical dilemmas for individually trained practitioners regarding confidentiality and consent.

The active inference model (Constant et al., 2019) provides a useful framework for understanding cultural influences on neuroregulation therapeutic relationships. Alliance building occurs through cooperative communication and mutual prediction, with practitioner and client updating models of each other through interaction. Cultural values shape “priors” or expectations clients bring, influencing interpretation of practitioner behaviors, procedures, and physiological responses during neurofeedback.

Evidence Review: Cultural Factors Across Neuroregulation Modalities

Neurofeedback and EEG Biofeedback

The literature examining cultural factors in neurofeedback reveals a striking paradox: while

practiced globally for over 4 decades, systematic investigation of cultural considerations is virtually absent. This gap is concerning given that EEG patterns, the foundation of neurofeedback assessment and training, may vary across cultural groups. Moss et al. (1985) found differences in EEG asymmetry between Japanese and Western subjects, suggesting Western-developed normative databases may not be universally applicable. Despite this early indication, the field has not pursued systematic investigation of cultural variations in EEG patterns or protocol implications.

However, while cultural practices may influence baseline EEG patterns through neuroplasticity mechanisms, fundamental neurophysiological processes underlying neurofeedback appear universal. The ability to modify brain activity through operant conditioning has been demonstrated across the limited diverse populations studied (Sherlin et al., 2011). Pathological EEG patterns, such as epileptiform activity or elevated theta/beta ratios in ADHD, show consistency across cultures (Arns et al., 2013). This suggests that while cultural factors influence engagement and implementation, core neurofeedback mechanisms operate similarly across populations.

Kelley's (1997) investigation of alpha/theta neurofeedback with a Navajo population for substance abuse treatment remains the most substantial culturally adapted neurofeedback study. This pioneering work with 19 Navajo clients demonstrated cultural adaptation's potential to enhance outcomes. Kelley reported 21% of participants maintained complete abstinence and 63% maintained partial remission at 3-year follow-up. Crucially, the alpha/theta protocol naturally aligned with traditional Navajo medicine-ways and spiritual practices. Deep states induced by training resembled traditional healing ceremonies, with emerging visual imagery interpreted through Navajo spiritual frameworks. Participants reported neurofeedback helped reconnect with traditional values and spiritual practices supporting sobriety.

This study's significance extends beyond positive outcomes, demonstrating neurofeedback need not be positioned as Western technological intervention incompatible with traditional healing but can integrate with Indigenous worldviews. The study also highlights missed opportunities, with no published replication or extension with Native American or other Indigenous populations in subsequent decades, despite high trauma and substance abuse

rates potentially benefiting from culturally adapted neurofeedback.

Eisenbarth et al. (2025) conducted the first systematic study of culturally diverse perceptions of EEG and neurofeedback research. Their mixed-methods study with 181 New Zealand participants revealed multiple barriers among diverse populations. Low awareness of EEG and neurofeedback methods was nearly universal among non-Western participants, with many expressing surprise that brain activity could be measured noninvasively or voluntarily modified. Electrode placement concerns were multifaceted, including hair disturbance worries (particularly among those with textured hair requiring significant styling), religious or cultural head-touching concerns, and gender-matched researcher preferences.

Particularly revealing were qualitative findings about emotion regulation skepticism. Some participants viewed emotions as fundamentally human experiences that shouldn't be technologically manipulated. Others worried that changing brain patterns might alter personality or cultural identity. These concerns highlight needs for careful explanation of neurofeedback capabilities and limitations, with attention to cultural values about authenticity, identity, and emotional experience nature.

Fleischman (2022) provided valuable evidence about neurofeedback effectiveness with underserved populations, though cultural factors weren't the primary focus. Their infra-low frequency neurofeedback study with over 300 clients across 20+ community agency sites demonstrated that when access barriers were addressed, diverse clients with complex presentations showed substantial improvements. The population was characterized by high trauma rates (average ACE scores of 6), multiple co-occurring disorders (average 5 diagnoses), and socioeconomic disadvantage.

Several findings have cultural implications. The remarkably low no-show rate (2% vs. typical 25–45%) suggests high engagement when services are accessible and responsive. Clients rated neurofeedback more helpful than counseling or medication, possibly because it offered nonstigmatizing, nonverbal intervention not requiring trauma discussion or cultural conflict exploration. Dramatic reductions in self-harm (79%) and arrests (70%) suggest neurofeedback addresses dysregulation patterns common among marginalized

populations experiencing chronic stress. These outcomes indicate fundamental neurofeedback mechanisms operate across diverse populations when cultural barriers are addressed.

Transcranial Electrical Stimulation

Research on cultural factors in transcranial electrical stimulation (transcranial direct current stimulation [tDCS] and transcranial alternating current stimulation [tACS]) is even more limited, with only one identified study explicitly examining cross-cultural differences. This gap is concerning given rapid tDCS research expansion and increasing home-based application interest potentially reaching diverse populations.

Martin et al. (2019) conducted groundbreaking research examining cultural influences on tDCS effects. Their study with 104 young adults (52 Southeast Asian Singaporeans and 52 Caucasian Australians) found cultural background significantly influenced both baseline social cognition and high-definition (HD)-tDCS responses. Targeting dorsomedial prefrontal cortex and right temporoparietal junction regions involved in self-other processing, baseline differences showed Southeast Asians had greater self-other integration than Caucasians, consistent with collectivistic versus individualistic cultural self-construal differences. Remarkably, anodal HD-tDCS resulted in Caucasians performing more similarly to Southeast Asians, suggesting stimulation could temporarily shift culturally influenced cognitive patterns.

These findings have profound implications for tDCS application across diverse populations. If cultural background influences baseline neural processing in targeted regions, optimal stimulation parameters may differ across groups. Protocols developed for Western populations might have different or opposite effects in populations with different baseline patterns. The study raises ethical questions about using brain stimulation to alter culturally influenced cognitive styles.

However, fundamental tDCS mechanisms involving neuronal membrane polarization and excitability changes represent basic biophysical processes operating similarly across populations (Nitsche et al., 2008). Electrical current effects on neural tissue follow universal physical laws. What varies culturally is the baseline state being modulated and resulting change interpretation. This distinction is crucial: while technology works through universal mechanisms, application must consider cultural

variations in baseline neural organization and treatment goals.

The absence of cultural acceptability research is problematic given the intervention's intimate nature. For example, tDCS involves applying electrical current through the skull to alter brain activity, potentially raising unique cultural and religious concerns. Some may view external brain activity manipulation as violating personal autonomy or spiritual integrity. Others may have specific concerns about electrical devices near the head based on consciousness, soul, or life force beliefs. tDCS equipment similarity to electroconvulsive therapy devices may evoke particular concerns among populations with psychiatric abuse or coercive treatment histories.

Photobiomodulation

The photobiomodulation literature shows rapid recent growth but reveals significant gaps addressing cultural and ethnic diversity. Recent systematic reviews and meta-analyses demonstrate efficacy for depression, cognitive enhancement, and pain management, but none examine cultural, racial, or ethnic factors potentially influencing treatment response or acceptability.

Fundamental photobiomodulation mechanisms represent universal cellular processes. Specific light wavelength interaction with cytochrome c oxidase, leading to increased ATP production and reactive oxygen species modulation, occurs in all human cells regardless of cultural background (Hamblin, 2016). Transcription factor activation and subsequent gene expression changes represent fundamental biological processes conserved across populations.

However, absence of cultural considerations is concerning given potential treatment parameter variations. Melanin content, varying significantly across racial and ethnic groups, absorbs light and could theoretically influence photobiomodulation penetration and biological effects. Despite this obvious consideration, no published studies examine whether optimal wavelengths, power densities, or treatment durations should be adjusted based on skin type or melanin content. The biphasic dose response suggests too little light has no effect while too much inhibits desired responses. If tissue optical properties vary by ethnicity, therapeutic windows might differ across populations.

Cultural acceptability remains unexplored. Light application to the head for therapeutic purposes

might be viewed differently across cultural contexts. Some cultures may be more accepting due to traditional sunlight or colored light healing practices. Others might be skeptical of claims that light penetrates the skull influencing brain function. Typical photobiomodulation device appearance often resembling LED array helmets might evoke different cultural associations.

Peripheral Biofeedback

The peripheral biofeedback literature provides somewhat more cultural factors evidence, though significant gaps remain. The modality's focus on teaching conscious autonomic control intersects with diverse mind-body practice traditions, potentially increasing acceptability for populations familiar with yoga, qigong, meditation, or contemplative practices.

Physiological processes underlying peripheral biofeedback are universal. The autonomic nervous system functions identically regardless of cultural background, with sympathetic activation increasing heart rate, peripheral vasoconstriction, and electrodermal activity, while parasympathetic activation produces opposite effects (Porges, 2011). Baroreflex, respiratory sinus arrhythmia, and other cardiorespiratory coupling mechanisms operate through conserved pathways. Gaining voluntary control over typically involuntary processes through feedback represents fundamental human nervous system learning capacity.

Feldman et al. (2016) conducted the most comprehensive culturally adapted biofeedback study, examining cognitive-behavioral psychophysiological therapy (CBPT) with HRV biofeedback for Latino adults with comorbid asthma and panic disorder. Their randomized controlled trial with 53 participants incorporated cultural adaptations including Spanish language sessions, family involvement, culturally relevant examples, addressing cultural asthma beliefs, and incorporating culturally resonant stress concepts. Both adapted CBPT and music relaxation showed improvements, with CBPT showing medication adherence advantages. Nelson et al. (2020) found HRV and end-tidal CO₂ changes partially mediated treatment effects, indicating targeted physiological mechanisms operated similarly across cultural groups despite requiring culturally adapted engagement pathways.

Beltrán-Velasco et al. (2020) documented cultural differences in psychophysiological stress responses with biofeedback protocol implications. Comparing Spanish and Colombian students revealed

significant subjective and objective stress response differences. While fundamental stress mechanisms are universal, chronic cultural and environmental factors shape baseline patterns and reactivity influencing biofeedback training. However, the ability to modify patterns through training appears consistent.

Population-Specific Patterns and Considerations

While recognizing tremendous diversity within any cultural group and avoiding stereotypes, research identifies barrier and facilitator patterns affecting different populations' neuroregulation access and engagement. These patterns reflect complex historical, cultural, social, and economic factor interactions creating unique community challenges. Importantly, these barriers affect access and engagement but don't alter fundamental physiological mechanisms.

Racial and Ethnic Minorities

Racial and ethnic minorities' healthcare experiences in the United States are profoundly shaped by historical and ongoing discrimination. Multiple disparity layers compound creating significant neuroregulation access barriers. Saadi et al. (2017) documented Black patients had 30% lower odds and Hispanic patients 40% lower odds of receiving outpatient neurology care compared to White patients, controlling for insurance, education, and income. Given neuroregulation often requires neurologist referral or collaboration, specialty care disparities create upstream barriers.

Medical mistrust among communities of color reflects ongoing discrimination experiences. Studies document Black patients receive less pain medication, are less likely referred for advanced treatments, and report frequent provider disrespect and bias. For potentially experimental or unfamiliar neuroregulation interventions, mistrust creates additional barriers. Technical neurofeedback and neurostimulation nature may seem particularly foreign or threatening to those experiencing medical exploitation.

However, when barriers are addressed and trust established, evidence suggests neuroregulation interventions are equally effective across racial and ethnic groups. Neuroplasticity, operant conditioning, and autonomic regulation mechanisms operate identically regardless of race or ethnicity. Fleischman's (2022) work with predominantly minority, low-income populations demonstrated

robust outcomes when services were accessible and culturally responsive, indicating outcome disparities often reflect access and engagement disparities rather than differential treatment effectiveness.

Language barriers significantly impact care access and quality for many ethnic minorities. While Spanish-language services have expanded, neuroregulation rarely has bilingual providers or translated materials. Technical vocabulary for explaining neurofeedback or neurostimulation is complex even in English; conveying concepts through interpreters unfamiliar with neuroscience terminology presents challenges. Many languages lack equivalent terms for *biofeedback* or *neurostimulation*, requiring creative translation.

Cultural symptom presentation and help-seeking variations influence engagement. Asian Americans tend toward somatic complaints and may avoid mental health services due to stigma and emotional restraint values. This could paradoxically make biofeedback more acceptable than psychotherapy, focusing on physiological rather than emotional processes. Without culturally informed outreach, these populations may never learn about options.

Indigenous Communities

Indigenous peoples globally face unique challenges accessing culturally appropriate healthcare, including neuroregulation services. Challenges reflect colonization, forced assimilation, and medical exploitation histories creating deep-seated Western medical intervention mistrust. The highly technological neuroregulation nature may seem particularly foreign, representing potential colonial intrusion.

Traditional Indigenous worldviews often conceptualize health fundamentally differently from biomedical models underlying neuroregulation. Many Indigenous cultures view health as physical, mental, emotional, and spiritual balance, with illness reflecting disrupted relationships with family, community, ancestors, and nature. Most neuroregulation protocols' individualistic focus may seem incomplete from relational worldviews.

However, Kelley's (1997) Navajo work suggests successful integration when approached with cultural humility and genuine collaboration. Neurophysiological changes from neurofeedback, including arousal, attention, and state regulation shifts, align with many traditional practice goals though conceptualized differently. Alpha/theta states may resemble traditional ceremony altered

consciousness states, providing technology bridges. Nonverbal neurofeedback nature may suit cultures with different communication styles or difficult-to-verbalize trauma.

Sovereignty and self-determination are critical Indigenous community considerations, recognizing tribal nations' inherent self-governance rights including health services. Practitioners should understand relevant tribal governance, health systems, and cultural protocols, potentially involving tribal council permission, traditional healer collaboration, or service adaptation to tribal priorities.

International and Immigrant Populations

International neuroregulation approach diversity reveals significant acceptance, regulation, and healthcare integration variations. While well-established in some countries (particularly Europe and parts of Asia), they remain unknown elsewhere. Immigrants may arrive from mainstream or completely unfamiliar contexts, creating varying baseline knowledge and acceptance.

Despite familiarity and acceptance differences, underlying physiological mechanisms remain constant. Stress response, autonomic regulation, and neuroplasticity operate through identical biological pathways regardless of origin. Immigrant population research shows biofeedback and neurofeedback effectiveness when language barriers are addressed and cultural adaptations enhance engagement (Feldman et al., 2016). Physiological mechanism universality means interventions developed in one country can successfully apply elsewhere with culturally adapted delivery.

Acculturation stress and immigration trauma create unique mental health needs neuroregulation might address, yet multiple barriers prevent access. Recent immigrants face practical barriers including insurance lack, limited English, healthcare system unfamiliarity, and basic needs prioritization over specialized services. Undocumented immigrants may avoid any healthcare due to deportation fear.

Socioeconomic Factors

Socioeconomic factors create perhaps the most pervasive access barriers, intersecting with race, ethnicity, and geography compounding disparities. High neuroregulation costs (\$50–\$200 per session, 20–40 sessions required) place interventions beyond low-income reach. Even with sliding scales,

total cost and time commitment may be prohibitive for those working multiple jobs or lacking paid leave.

However, socioeconomic status doesn't alter fundamental physiological processes. Learning control over physiological processes through feedback is basic human capacity operating regardless of income or education. When financial barriers are removed, as in Medicaid programs or free services, outcomes compare to affluent populations (Fleischman, 2022). This underscores that disparities are structural rather than biological, reflecting differential access rather than benefit capacity.

Insurance disparities significantly impact access. While some private plans may cover biofeedback for specific conditions, Medicaid and Medicare coverage is extremely limited. This creates paradoxical situations where populations with the highest trauma and stress-related conditions rates have the least intervention access. Neurofeedback classification as "experimental," despite decades of research, perpetuates disparities.

Synthesis and Implications

The evidence review reveals both concerning gaps and important insights about cultural factors in neuroregulation. The paucity of research across all modalities after decades of clinical practice represents a critical limitation undermining the field's inclusivity and effectiveness. However, available evidence combined with theoretical frameworks provides foundation for understanding how culture influences neuroregulation while maintaining scientific grounding in universal physiological mechanisms.

A crucial insight is distinguishing between invariant physiological processes and culturally variable implementation factors. Fundamental mechanisms including operant conditioning, neuroplasticity, autonomic regulation, and cellular photobiomodulation responses operate identically across human populations. This universality provides confidence that neuroregulation can be effective across diverse populations when cultural barriers are addressed.

However, numerous factors influencing treatment access, engagement, and outcomes are culturally shaped. These include illness explanatory models, technology comfort, communication preferences, therapeutic relationship expectations, and structural care barriers. The limited evidence available

suggests that when these factors are addressed through culturally responsive approaches, diverse populations achieve comparable outcomes.

The intersection of cultural factors with structural inequities creates compounded barriers for many populations. Medical mistrust rooted in historical and ongoing discrimination, combined with language barriers, insurance limitations, and geographic access issues, creates multiple obstacles to neuroregulation access. These structural factors require systemic solutions beyond individual practitioner cultural competence.

The therapeutic alliance emerges as a critical culturally mediated factor influencing engagement and outcomes. Cultural values shape expectations about practitioner relationships, communication styles, family involvement, and treatment goals. The technical nature of neuroregulation doesn't diminish relational importance but adds complexity to building trust across cultural differences.

Conclusion

This comprehensive examination of cultural factors in neuroregulation reveals both significant knowledge gaps and important foundations for developing culturally responsive practice. The striking absence of cultural considerations research across all neuroregulation modalities represents a critical field limitation requiring urgent attention. After decades of clinical practice, the lack of systematic investigation into how culture influences treatment engagement and outcomes undermines scientific validity and perpetuates healthcare inequities.

The theoretical frameworks presented provide essential grounding for understanding cultural influences on neuroregulation. Cultural humility's emphasis on ongoing self-reflection and power dynamic awareness, combined with cultural competence's practical knowledge and skills, creates a robust approach foundation. The health disparities framework reveals how structural inequities compound cultural factors creating multilevel access barriers. Understanding therapeutic alliance as culturally mediated process highlights relationship importance even in technically oriented interventions.

Distinguishing universal physiological mechanisms from culturally variable factors provides crucial clarity. Fundamental processes underlying neuroregulation operate consistently across human populations, offering confidence in intervention

effectiveness potential across diverse groups. However, how these mechanisms are accessed, understood, and integrated into lives varies profoundly by culture. This distinction guides practitioners in maintaining scientific integrity while adapting delivery for cultural responsiveness.

The limited available evidence suggests promising outcomes when cultural barriers are addressed. Studies with diverse populations show engagement and effectiveness comparable to majority populations when services are accessible and culturally adapted. This indicates disparities stem primarily from structural barriers rather than differential treatment response, highlighting the importance of systemic change alongside individual practitioner development.

Future research must prioritize systematic investigation of cultural factors across all neuroregulation modalities. This includes developing diverse normative databases, testing cultural adaptation effectiveness, examining implementation in community settings, and understanding how traditional healing practices might complement neuroregulation. Research must distinguish between universal mechanisms requiring preservation and variable factors requiring adaptation.

The path forward requires coordinated action across multiple levels. Individual practitioners must commit to ongoing cultural competence development while deepening understanding of physiological mechanisms. Organizations must implement equity-promoting policies and practices. Professional associations must establish cultural competence standards and support workforce diversity. Researchers must prioritize diverse population inclusion and cultural factors investigation. Policy makers must address systemic barriers through insurance reform and support for culturally responsive models.

The ultimate goal extends beyond adapting existing interventions for diverse populations to transforming the field to be inherently inclusive and culturally responsive while maintaining scientific rigor. The universality of underlying mechanisms provides foundation for inclusivity, while attention to cultural factors ensures effective access and utilization by all populations.

As neuroregulation continues evolving, cultural considerations must be central rather than peripheral. This article provides foundation for that integration, but much work remains. Through

systematic research, thoughtful practice development, and commitment to equity, the field can ensure neuroregulation benefits are available to all who might benefit, regardless of cultural background, race, ethnicity, language, or socioeconomic status.

Author Declarations

The author declares no grant support, financial interests, or conflicts of interest relevant to this submission. Artificial intelligence (AI) tools were used exclusively for technical manuscript preparation (proofreading and formatting) in this work. No AI was used for content generation, analysis, or intellectual contributions. The author assumes full responsibility for all scientific content and conclusions presented.

References

- Arns, M., Heinrich, H., & Strehl, U. (2013). Evaluation of neurofeedback in ADHD: The long and winding road. *Biological Psychology, 95*, 108–115. <https://doi.org/10.1016/j.biopsycho.2013.11.013>
- Bazargan, M., Cobb, S., & Assari, S. (2021). Discrimination and medical mistrust in a racially and ethnically diverse sample of California adults. *Annals of Family Medicine, 19*(1), 4–15. <https://doi.org/10.1370/afm.2632>
- Beltrán-Velasco, A. I., Bellido-Esteban, A., Ruisoto-Palomera, P., & Clemente-Suárez, V. J. (2020). The effect of cultural differences in psychophysiological stress response in high education context: A pilot study. *Applied Psychophysiology and Biofeedback, 45*(1), 23–29. <https://doi.org/10.1007/s10484-019-09452-0>
- Betting, L. E., Mory, S. B., Lopes-Cendes, I., Li, L. M., Guerreiro, M. M., Guerreiro, C. A., & Cendes, F. (2006). EEG features in idiopathic generalized epilepsy: Clues to diagnosis. *Epilepsia, 47*(3), 523–528. <https://doi.org/10.1111/j.1528-1167.2006.00462.x>
- Campinha-Bacote, J. (2002). The process of cultural competence in the delivery of healthcare services: A model of care. *Journal of Transcultural Nursing, 13*(3), 181–184. <https://doi.org/10.1177/10459602013003003>
- Chiao, J. Y. (Ed.). (2009). *Cultural neuroscience: Cultural influences on brain function*. Elsevier.
- Constant, A., Ramstead, M. J., Veissière, S. P., & Friston, K. (2019). Regimes of expectations: An active inference model of social conformity and human decision making. *Frontiers in Psychology, 10*, Article 679. <https://doi.org/10.3389/fpsyg.2019.00679>
- Eisenbarth, H., D'Cruz, C., Bulbulia, J. A., & Thanni, B. (2025). Culturally diverse perceptions of EEG and neurofeedback research and how to address them to reduce sampling bias. *Psychophysiology, 62*(6), Article e70077. <https://doi.org/10.1111/psyp.70077>
- Feldman, J. M., Matte, L., Interian, A., Lehrer, P. M., Lu, S. E., Scheckner, B., Steinberg, D. M., Oken, T., Kotay, A., Sinha, S., & Shim, C. (2016). Psychological treatment of comorbid asthma and panic disorder in Latino adults: Results from a randomized controlled trial. *Behaviour Research and Therapy, 87*, 142–154. <https://doi.org/10.1016/j.brat.2016.09.007>
- Fleischman, M. J. (2022). Documenting the impact of infra low frequency neurofeedback on underserved populations with complex clinical presentations. *Frontiers in Human*

- Neuroscience*, 16, Article 921491. <https://doi.org/10.3389/fnhum.2022.921491>
- Geronimus, A. T., Hicken, M., Keene, D., & Bound, J. (2006). "Weathering" and age patterns of allostatic load scores among blacks and whites in the United States. *American Journal of Public Health*, 96(5), 826–833. <https://doi.org/10.2105/ajph.2004.060749>
- Hall, E. T. (1976). *Beyond culture*. Anchor Books.
- Hamblin, M. R. (2016). Shining light on the head: Photobiomodulation for brain disorders. *BBA Clinical*, 6, 113–124. <https://doi.org/10.1016/j.bbacli.2016.09.002>
- Hinton, D. E., & Good, B. J. (Eds.). (2016). *Culture and PTSD: Trauma in global and historical perspective*. University of Pennsylvania Press.
- Kelley, M. J. (1997). Native Americans, neurofeedback, and substance abuse theory: Three year outcome of alpha/theta neurofeedback training in the treatment of problem drinking among Dine' (Navajo) people. *Journal of Neurotherapy*, 2(3), 24–60. https://doi.org/10.1300/J184v02n03_03
- Martin, A. K., Su, P., & Meinzer, M. (2019). Common and unique effects of HD-tDCS to the social brain across cultural groups. *Neuropsychologia*, 133, Article 107170. <https://doi.org/10.1016/j.neuropsychologia.2019.107170>
- McEwen, B. S. (2017). Neurobiological and systemic effects of chronic stress. *Chronic Stress*, 1, Article 2470547017692328. <https://doi.org/10.1177/2470547017692328>
- Metzl, J. M., & Hansen, H. (2014). Structural competency: Theorizing a new medical engagement with stigma and inequality. *Social Science & Medicine*, 103, 126–133. <https://doi.org/10.1016/j.socscimed.2013.06.032>
- Moss, E. M., Davidson, R. J., & Saron, C. (1985). Cross-cultural differences in hemisphericity: EEG asymmetry discriminates between Japanese and Westerners. *Neuropsychologia*, 23(1), 131–135. [https://doi.org/10.1016/0028-3932\(85\)90054-5](https://doi.org/10.1016/0028-3932(85)90054-5)
- Nelson, K. L., Matte-Landry, A., Feldman, J. M., & Lehrer, P. M. (2020). Further exploration of treatment response in Latinos with comorbid asthma and panic disorder: A brief report of HRV and ETCO2 as potential mediators of treatment response. *Applied Psychophysiology and Biofeedback*, 45(2), 67–75. <https://doi.org/10.1007/s10484-020-09454-3>
- Nitsche, M. A., Cohen, L. G., Wassermann, E. M., Priori, A., Lang, N., Antal, A., Paulus, W., Hummel, F., Boggio, P. S., Fregni, F., & Pascual-Leone, A. (2008). Transcranial direct current stimulation: State of the art 2008. *Brain Stimulation*, 1(3), 206–223. <https://doi.org/10.1016/j.brs.2008.06.004>
- Porges, S. W. (2011). *The polyvagal theory: Neurophysiological foundations of emotions, attachment, communication, and self-regulation*. Norton.
- Robbins, N. M., Charleston, L. IV, Saadi, A., Thayer, Z., Codrington, W. U. III, Landry, A., Bernat, J. L., & Hamilton, R. (2022). Black patients matter in neurology: Race, racism, and race-based neurodisparities. *Neurology*, 99(3), 106–114. <https://doi.org/10.1212/WNL.0000000000200830>
- Saadi, A., Himmelstein, D. U., Woolhandler, S., & Mejia, N. I. (2017). Racial disparities in neurologic health care access and utilization in the United States. *Neurology*, 88(24), 2268–2275. <https://doi.org/10.1212/WNL.0000000000004025>
- Sherlin, L. H., Arns, M., Lubar, J., Heinrich, H., Kerson, C., Strehl, U., & Sterman, M. B. (2011). Neurofeedback and basic learning theory: Implications for research and practice. *Journal of Neurotherapy*, 15(4), 292–304. <https://doi.org/10.1080/10874208.2011.623089>
- Siegel, J. M. (2005). Clues to the functions of mammalian sleep. *Nature*, 437(7063), 1264–1271. <https://doi.org/10.1038/nature04285>
- Tervalon, M., & Murray-García, J. (1998). Cultural humility versus cultural competence: A critical distinction in defining physician training outcomes in multicultural education. *Journal of Health Care for the Poor and Underserved*, 9(2), 117–125. <https://doi.org/10.1353/hpu.2010.0233>
- Travis, F., & Shear, J. (2010). Focused attention, open monitoring and automatic self-transcending: Categories to organize meditations from Vedic, Buddhist and Chinese traditions. *Consciousness and Cognition*, 19(4), 1110–1118. <https://doi.org/10.1016/j.concog.2010.01.007>

Received: October 6, 2025

Accepted: October 26, 2025

Published: March 31, 2026