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Addressing racial and phenotypic bias in human neuroscience methods

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Abstract

Despite their premise of objectivity, neuroscience tools for physiological data collection, such as electroencephalography and functional near-infrared spectroscopy, introduce racial bias into studies by excluding individuals on the basis of phenotypic differences in hair type and skin pigmentation. Furthermore, at least one methodology—electrodermal activity recording (skin conductance responses)—may be influenced not only by potential phenotypic differences but also by negative psychological effects stemming from the lived experience of racism. Here we situate these issues within structural injustice, urge researchers to challenge racism in their scientific work and propose procedures and changes that may lead to more equitable science.

We are at the precipice of an exciting time of discovery and innovation in human neuroscience. With increased computing power, advanced hardware and algorithms and sophisticated psychophysical paradigms, we are coming ever closer to understanding the connections between brain and behavior by non-invasive inference. What enables our field to move forward, toward both basic science and clinical goals, is the assumption that objectivity and fairness produce logical conclusions reflecting universal truths. Unfortunately, accumulating evidence suggests the opposite in human-centered science: that because of unacknowledged bias in our assumptions, a troubling focus on Western, educated, industrialized, rich and democratic (WEIRD)[1] populations and a lack of reproducibility across samples, psychological ‘facts’ are applicable only to the populations being studied.

In fact, marginalized groups—especially those who have faced historical oppression due to their race, ethnicity, gender and/or sex—are not only disproportionately excluded but have also been actively harmed by intentional and unintentional biases in medicine, technology

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Competing interests

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and even basic research[2–7]. As neuroscientists, we must be particularly sensitive to how our questions, hypotheses and research methods may introduce partiality, because neurological and psychological health is on the line. In this commentary, we sound the alarm on compounding layers of bias that contribute to documented and potential exclusion of racially and ethnically minoritized individuals in psychophysiology research. We explicitly highlight the exclusion of people who have been racialized as Black, because anti-blackness is the backbone of racism and racial bias[8,9]. As a field, we have a pivotal need to assess our methods and conduct research that directly asks: whose data are deemed 'unusable'?

Today, although most overt racial discrimination in science is condemned, biases propagate and render harm against marginalized groups by false assumptions of 'objectivity'[10], implicit discriminatory beliefs[11] and racial disparities that exacerbate these issues[12,13]. Particularly alarming is that biased research has the potential to directly feed back into society, creating a cycle that perpetuates prejudice. To be clear: race is a sociological construct rather than a biological reality[14,15]. The phenotypic differences that we consider indicators of race, such as skin color, hair texture, body composition and sweat gland density, in fact appear in the human species on a continuum that simply covaries with ancestral latitude. However, race still has meaning in our society: the collection of phenotypes and cultural indicators that we associate with one's 'race' still has power and deeply affects the lived experiences of individuals. This fact is illustrated when descendants of United States slaves (who may have mixed African, European and American ancestry) are grouped together with individuals from the continent of Africa under the term 'Black/African American' on government forms. We outline three eras in the history of the use of psychology and neuroscience tools and how understanding of phenotype and race has informed how bias has seeped into practices, especially regarding the adoption of technology.

Historical bias in science: the era of explicit exclusion

Assumptions of inherent differences between racial categories have long been a cornerstone of human-centered science, dating back to the flawed pseudoscience of phrenology and the practice of eugenics. These beliefs, fueled by racist scientific questioning, have led to oppression of racially and ethnically marginalized groups in the form of exploitation, marginalization, exclusion from power, cultural imperialism and/or violence[2,5–7,16]. Even into the late 20th century, certain subsets of the population (for example, women, LGBTQ+, Black and brown people) have been forgotten—deemed unnecessary to include or study scientifically—resulting in the exclusion of marginalized groups[6,17,18]. For example, an assumption that only men display certain mental conditions led to the underdiagnosis and/or misdiagnosis of autism and attention-deficit/hyperactivity disorder in women[19–21]. Additionally, Black women, who are further marginalized by the interaction of gender and race, are particularly absent in neuroscience research writ large[22–24]. As a result, medical mistrust has been sown in these communities, which has yet to be acknowledged and addressed systematically in healthcare and research. This exclusion of racial minorities in medicine directly harms patients[25,26] and potentially encourages the development of biased medical technologies.

‘Unusable data’ and colorblind methods: the era of ignorance

The legacy of exclusionary bias in research and medicine has lasting effects. In a world where abject racism is shamed, many adopt ‘colorblind’ thinking—assuming sameness—when scientific methodologies and technologies might be, in fact, optimized for a limited group of people. Many electrophysiological devices were not designed to handle phenotype variability, rendering a systematic erasure of data from people with darker skin and coarse, curly hair—what we call ‘phenotypic bias’. Thus, the term ‘unusable’ can be synonymous with ‘minority’ data, specifically data from Black participants. When we are ignorant to the biases in our technology, we become doomed to perpetuate those biases unknowingly. A focus on not ignoring but acknowledging and celebrating the diversity of different types of people leads to a more inclusive scientific enterprise in which people receive care based on their particular needs[27]. Below we outline two examples of technologies in our field that designate certain data as ‘unusable’.

Hair type bias: a phenotypic bias rampant in electroencephalography (EEG), which is a frequently used tool in neuroscience. The requirement of having secure, direct and long-lasting electrode-to-scalp contact led to the adoption of screening criteria that exclude individuals with specific hair characteristics, as texture and density affect electrode placement and decrease the signal-to-noise ratio. This has resulted in the exclusion of Black participants at substantially high rates[28], but the exclusion is frequently justified as a methodological limitation rather than a pivotal equity issue. In a review of 81 papers published in 2019, Choy et al.[29] found that only five included Black participants, and none of the papers clearly stated whether data from these participants were used in analyses after quality checks. Although novel EEG solutions are being developed that harness the African cultural tradition of cornrow braiding (for recommendations on how to prepare afro-textured hair and wavy hair for EEG, see ref. [28]), there are still considerable gaps in the technology for dense EEG topographies (for example, 64- and 128-channel systems).

Skin-tone bias: found in the vast field of biomedical optics, in which specific frequencies of light are shone upon biological tissues for diagnostics or neuroimaging. A failure to account for variability in skin tone, and/or an assumption that the tools will work for all skin tones, has resulted in the creation of technology that is less effective for darker skin. Optical techniques, such as functional near-infrared spectroscopy (fNIRS), rely heavily on the known scattering and absorption properties of light in human tissue, which is dependent on the density of chromophores such as melanin[30–32]. As a result, noise levels in pulse oximetry data and consumer technologies such as fitness watches are systematically higher in individuals with darker skin pigmentation due to the greater absorption of light, potentially leading to worse health outcomes, especially as Coronavirus Disease 2019 (COVID-19) treatment relies on reliable monitoring of blood oxygenation[33–35]. These issues have recently come to the forefront in academic and industry spaces, especially as activists have identified bias in facial recognition systems that are the technological bases of developing medical artificial intelligence interventions[36,37].

Lived experiences of racism: avoiding an era of negligence

After contending with the historical precedence for racial exclusion and current ignorance regarding phenotypic bias in neurotechnology, we must take proactive steps to identify and contend with the psychological consequences of racism for our data. Increasing evidence shows the effects of lived experiences on psychological processes[38–41], calling into question whether exposure to discrimination is another source of exclusion. As discussed above, the tools used can be subject to bias against certain phenotypes shared by marginalized races. However, they can also capture individual differences resulting from experiences that may co-vary with those phenotypes. For example, mental health symptoms and conditions that can arise from the experiences of racism, such as post-traumatic stress disorder (PTSD) and anhedonia, may be reflected in psychophysiology data[42,43]. As scientists, we must disentangle the source of exclusion in psychophysiology: is it indeed marginalized phenotypes; is it a mental health feature that co-varies with phenotype in our society; or is it an interaction? Do we need to simply create phenotypically inclusive neurotechnologies; do we need to address systemic racism; or do we need to do both? Although this issue exists within several modalities, we will focus the rest of our discussion on electrodermal activity (that is, sweat gland activity), an index of autonomic nervous system activation.

In laboratory-based de novo fear conditioning, a stimulus-locked skin conductance response (SCR) is considered an ‘objective’ proxy of emotional arousal and a marker of fear learning and memory[44]. To measure electrodermal activity, a pair of electrodes is typically placed on two fingers. An electrical current is passed through the electrodes; as arousal increases and the sweat glands in the hand of the participant become more active, conductivity increases[45]. However, participants are excluded from analyses if they: (1) have immeasurable skin conductance activity at baseline or (2) do not show a detectable change in SCR between conditions/stimuli (that is, the participant failed to learn the task[46,47]). These guidelines initially appear reasonable; except, Black participants are disproportionally excluded because of low baseline activity and/or are characterized as ‘non-learners’[48]. Kredlow et al.[48] reviewed five independent fear conditioning samples. These secondary analyses revealed that data from Black participants were more likely to be labeled ‘unusable’ (because of lower skin conductance levels as well as immeasurable/low responses to fear cues) and excluded compared to data from white participants.

To be clear, Black participants can appropriately discriminate between stimuli and acquire fear learning. Phenotypic differences, such as skin pigmentation, sweat gland distribution and baseline activity, have been hypothesized to affect measurement of SCR[48,49]. However, racial differences in psychological processes—stemming from lifelong exposure to racism—explain differences in SCR during fear learning. Recent work suggests that various sociocultural factors, such as negative life events, partially explain racial and ethnic differences in SCR during fear conditioning (for example, refs. [42,43]). In a formative paper, Harnett et al.[42] showed that white participants had larger threat-elicited SCRs than Black participants. This difference was attenuated after adjusting for negative life experiences, including income, neighborhood disadvantage and violence exposure. Thus, labeling Black participants as ‘non-learners’ is inherently misguided. Just as we have uncovered that

racism, and not race, drives the inequities in COVID-19 morbidity, hospitalization and mortality, perhaps it is racism, and not race, that drives this differential arousal response[50].

Methodological articles on electrodermal recordings have considered the ethical implications of continuing to use these methods without fully understanding the underlying mechanism(s) of racial differences in the signal; however, empirical work on potential mechanisms is lacking[46,51]. Kredlow et al.[52] showed that Black Americans (n = 16 out of n = 274) were less likely to discriminate between the fear and safety cues; however, they proposed that the SCR measurements of Black participants could be improved by modifying the unconditioned stimulus to include both an electric shock and a loud scream. We should not enhance fear cues to 'salvage' data from Black participants. Rather, the field should focus on testing whether electrodermal recordings have inherent phenotype biases as well as evaluating how racialized lived experiences influence psychological processes (Fig. 1).

The field (see refs. [46,52]) has largely ignored how bias in SCR, especially if differences are a reflection of lived experiences, may lead to considerable harm to individuals with the phenotypes and lived experiences associated with 'non-responders' and 'non-learners'. Information gained from these studies is used to develop interventions for psychiatric disorders. If data are biased or interpreted incorrectly, Black individuals may be misdiagnosed, underdiagnosed or inappropriately treated[52,53]. To complicate matters further, potential covariates or confounds due to the lived experience may hinder research that is specifically looking for racial group differences (for example, racial disparities in mental health outcomes). Although we have focused on SCR, many of the concerns about the sources of bias also arise in EEG (for example, 'sluggish' or attenuated brain responses can be due to anhedonia, PTSD and other mental conditions[54–56]), and other modalities may also render the data of certain groups as unusable.

Our shared responsibility toward more equitable neuroscience

Exclusion of racially and ethnically minoritized individuals under the guise of 'unusable' data occurs within the context of ongoing structural injustice against Black and brown people globally[57–59]. In a society that upholds and sees whiteness as a norm, research tools and protocols, however unintentionally, indeed perpetuate scientific oppression[58,60]. In the lack of any clear intention to produce biased results, it is easy for scientists to reject personal responsibility when publishing results that underrepresent people from racially and ethnically minoritized groups, especially when the exclusion appears methodologically justified. We need to move beyond the idea of ascribing guilt to any one person and accepting methodological limitations as a valid reason for executing biased research. Instead, we should uphold shared responsibility for addressing the outcomes of our actions within the context of structural injustice[16] (Table 1).

Individual researchers should design psychophysiology research that explicitly considers whether sources of data exclusion reflect phenotype bias and/or measures of participants' lived experiences. Implementation of post hoc statistical tests can help to determine whether demographics, including socioeconomic status and race, explain variability in psychophysiological measurements. This information is essential to differentiating

confounds (for example, phenotype bias in the tool) from co-varying and real psychological effects (for example, exposure to racism and negative life events). To achieve scientific equity, both the potential phenotype differences and differences in lived experience need to be recognized, assessed and considered. It is critical to discuss how SCR may vary by equipment, task paradigm, inclusion or exclusion of self-report measures (for example, trauma history and exposure to discrimination) and statistical approach (for example, use of standardization methods[61]). Although biomedical engineers are slowly beginning to recognize the need for and create more inclusive technologies[37,62], the onus is on us, the practitioners of psychological science, to conduct research that includes a racially and ethnically diverse sample and uses statistical techniques that disentangle these sources of bias. Ultimately, producing empirical evidence of phenotypic bias will allow funders to charge engineers to create novel biomedical solutions. In the meantime, researchers must be innovative and collaborative to achieve inclusion and equity; for example, there is now a set of EEG guidelines for coarse, curly hair (https://hellobrainlab.com/research/eeg-hair-project/).

Institutional review boards (IRBs) approve initial exclusion and inclusion criterion. This means, for example in EEG studies, IRBs have historically approved the exclusion of certain hairstyles that are culturally associated with Black populations. As the body that approves recruitment strategies, IRBs have a duty to ensure that research is scientifically sound, which, we argue, includes being equitable. IRB representatives share a responsibility to ask why racial and ethnic minorities are being excluded from recruitment and how this could be rectified. IRB personnel should receive ongoing training on biases in technology, particularly in tools used in human research, as well as offering institutionally mandated best practices.

For scientific journals, the reporting of demographics is still not a norm, although progress has been made, particularly in gender and age range reporting[63]. We know that most neuroscience studies recruit white participants[1,64]. This represents a broad ethical concern: if samples are not representative, and demographics are not reported, issues in methods will remain unexposed. The first steps publishers can take in achieving more equitable science, which has been widely discussed but not fully implemented, is to require racial demographic reporting.

If Black and brown researchers and engineers were fairly and proportionately included in the development of psychophysiology methods, it is likely that these tools would not have the same problems and oversights. Black scientists and engineers receive less funding than their white counterparts, with Black researchers' award rates for National Institutes of Health funding being only approximately 55% of those of white researchers of similar academic standing[65–67]. We echo the continual call for fair funding and educational opportunities for scholars from marginalized backgrounds. We remain adamant that we must all be proactive in promoting racial equity in science.

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References

1. Henrich J, Heine SJ & Norenzayan A Most people are not WEIRD. Nature 466, 29 (2010). [PubMed: 20595995]
2. Brandt AM Racism and research: the case of the Tuskegee Syphilis Study. Hastings Cent. Rep 8, 21 (1978).
3. Leslie C Scientific racism: reflections on peer review, science and ideology. Soc. Sci. Med 31, 891–905 (1990). [PubMed: 2259963]
4. Mohr JM Oppression by scientific method: the use of science to 'other' sexual minorities. J. Hate Stud 7, 21–45 (2009).
5. Saini A Superior: The Return of Race Science (Beacon, 2019).
6. Seydel C The missing sex. Nat. Biotechnol 39, 260–265 (2021). [PubMed: 33623158]
7. Turda M in Oxford Handbook of the History of Eugenics 62–79 (2010).
8. Dumas MJ Against the dark: antiblackness in education policy and discourse. Theory Pract. 55, 11–19 (2016).
9. Dumas MJ in Toward What Justice? (Routledge, 2018).
10. Halpin ZT Scientific objectivity and the concept of 'the other'. Women's Stud. Intl Forum 12, 285–294 (1989).
11. FitzGerald C & Hurst S Implicit bias in healthcare professionals: a systematic review. BMC Med. Ethics 18, 19 (2017). [PubMed: 28249596]
12. Johnson-Agbakwu CE et al. Racism, COVID-19, and health inequity in the USA: a call to action. J. Racial Ethn. Health Disparities 9, 52–58 (2020). [PubMed: 33197038]
13. Aleligne YK, Appiah D & Ebong IA Racial disparities in Coronavirus Disease 2019 (COVID-19) outcomes. Curr. Opin. Cardiol 36, 360–366 (2021). [PubMed: 33657019]
14. Yudell M, Roberts D, DeSalle R & Tishkoff S Taking race out of human genetics. Science 351, 564–565 (2016). [PubMed: 26912690]
15. Smedley A & Smedley BD Race as biology is fiction, racism as a social problem is real: anthropological and historical perspectives on the social construction of race. Am. Psychol 60, 16–26 (2005). [PubMed: 15641918]
16. Young IM Responsibility and global justice: a social connection model. Soc. Philos. Policy 23, 102–130 (2006).
17. García AA, Zuñiga JA & Lagon C A personal touch: the most important strategy for recruiting Latino research participants. J. Transcult. Nurs 28, 342–347 (2017). [PubMed: 27114390]
18. Wendler D et al. Are racial and ethnic minorities less willing to participate in health research? PLoS Med. 3, e19 (2005). [PubMed: 16318411]
19. Cascio MA, Weiss JA & Racine E Making autism research inclusive by attending to intersectionality: a review of the research ethics literature. Rev. J. Autism Dev. Disord 8, 22–36 (2021).
20. Gould J & Ashton-Smith J Missed diagnosis or misdiagnosis? Girls and women on the autism spectrum. Good Autism Pract. (GAP) 12, 34–41 (2011).
21. Quinn PO & Madhoo M A review of attention-deficit/hyperactivity disorder in women and girls: uncovering this hidden diagnosis. Prim. Care Companion CNS Disord 16, PCC.13r01596 (2014).
22. Thomas VG The psychology of Black women: studying women's lives in context. J. Black Psychol 30, 286–306 (2004).
23. Spates K 'The Missing Link': the exclusion of black women in psychological research and the implications for black women's mental health. Sage Open 10.1177/2158244012455179 (2012).
24. Crenshaw K Mapping the margins: intersectionality, identity politics, and violence against women of color. Stanford Law Rev 43, 1241–1299 (1991).

25. Lester JC, Jia JL, Zhang L, Okoye GA & Linos E Absence of images of skin of colour in publications of COVID-19 skin manifestations. Br. J. Dermatol 183, 593–595 (2020). [PubMed: 32471009]
26. Louie P & Wilkes R Representations of race and skin tone in medical textbook imagery. Soc. Sci. Med 202, 38–42 (2018). [PubMed: 29501717]
27. Larrazabal AJ, Nieto N, Peterson V, Milone DH & Ferrante E Gender imbalance in medical imaging datasets produces biased classifiers for computer-aided diagnosis. Proc. Natl Acad. Sci. USA 117, 12592–12594 (2020). [PubMed: 32457147]
28. Etienne A et al. Novel electrodes for reliable EEG recordings on coarse and curly hair. Annu. Inf. Conf. IEEE Eng. Med. Biol. Soc 2020, 6151–6154 (2020).
29. Choy T, Baker E & Stavropoulos K Systemic racism in EEG research: considerations and potential solutions. Affect. Sci 10.1007/s42761-021-00050-0 (2021).
30. Bashkatov AN, Genina EA & Tuchin VV Optical properties of skin, subcutaneous, and muscle tissues: a review. J. Innov. Opt. Health Sci 4, 9–38 (2011).
31. Tseng S-H, Bargo P, Durkin A & Kollias N Chromophore concentrations, absorption and scattering properties of human skin in-vivo. Opt. Express 17, 14599 (2009). [PubMed: 19687939]
32. Tseng S-H, Grant A & Durkin AJ In vivo determination of skin near-infrared optical properties using diffuse optical spectroscopy. J. Biomed. Opt 13, 014016 (2008). [PubMed: 18315374]
33. Sardar DK, Mayo ML & Glickman RD Optical characterization of melanin. J. Biomed. Opt 6, 404–411 (2001). [PubMed: 11728198]
34. Mustafa FH, Jones PW & McEwan AL Near infrared spectroscopy for body fat sensing in neonates: quantitative analysis by GAMOS simulations. Biomed. Eng. Online 16, 14 (2017). [PubMed: 28086963]
35. Phan T et al. Characterizing reduced scattering coefficient of normal human skin across different anatomic locations and Fitzpatrick skin types using spatial frequency domain imaging. J. Biomed. Opt 26, 026001 (2021).
36. Buolamwini J & Gebru T Gender shades: intersectional accuracy disparities in commercial gender classification. Proc. of the 1st Conference on Fairness, Accountability and Transparency 77–91 (PMLR, 2018).
37. Kadambi A Achieving fairness in medical devices. Science 372, 30–31 (2021). [PubMed: 33795446]
38. Carter RT, Lau MY, Johnson V & Kirkinis K Racial discrimination and health outcomes among racial/ethnic minorities: a meta-analytic review. J. Multicult. Couns. Dev 45, 232–259 (2017).
39. Carter RT et al. Race-based traumatic stress, racial identity statuses, and psychological functioning: an exploratory investigation. Prof. Psychol. Res. Pr 48, 30–37 (2017).
40. Berger M & Sarnyai Z ‘More than skin deep’: stress neurobiology and mental health consequences of racial discrimination. Stress 18, 1–10 (2015). [PubMed: 25407297]
41. Bird CM et al. Racial discrimination is associated with acute posttraumatic stress symptoms and predicts future posttraumatic stress disorder symptom severity in trauma-exposed black adults in the United States. J. Trauma. Stress 34, 995–1004 (2021). [PubMed: 33715212]
42. Harnett NG et al. Negative life experiences contribute to racial differences in the neural response to threat. Neuroimage 202, 116086 (2019). [PubMed: 31401241]
43. Martínez KG, Franco-Chaves JA, Milad MR & Quirk GJ Ethnic differences in physiological responses to fear conditioned stimuli. PLoS ONE 9, e114977 (2014). [PubMed: 25501365]
44. Knight DC, Nguyen HT & Bandettini PA Expression of conditional fear with and without awareness. Proc. Natl Acad. Sci. USA 100, 15280–15283 (2003). [PubMed: 14657356]
45. Dawson M, Schell A & Courtney C The skin conductance response, anticipation, and decision-making. J. Neurosci. Psychol. Econ 4, 111–116 (2011).
46. Lonsdorf TB et al. Navigating the garden of forking paths for data exclusions in fear conditioning research. eLife 8, e52465 (2019). [PubMed: 31841112]
47. Niles AN et al. Effects of threat context, trauma history, and posttraumatic stress disorder status on physiological startle reactivity in Gulf War veterans. J. Trauma. Stress 31, 579–590 (2018). [PubMed: 30058728]

48. Kredlow MA et al. Assessment of skin conductance in African American and non-African American participants in studies of conditioned fear. Psychophysiology 54, 1741–1754 (2017). [PubMed: 28675471]
49. Davis C & Cowles M Some sources of variance in skin conductance. Can. J. Psychol 43, 97 (1989). [PubMed: 2819600]
50. Khazanchi R et al. Patient characteristics and subsequent health care use by location of SARS-CoV-2 testing initiation in a safety-net health system.. JAMA Netw. Open 4, e2112857 (2021). [PubMed: 34100940]
51. Boucsein W et al. Publication recommendations for electrodermal measurements. Psychophysiology 49, 1017–1034 (2012). [PubMed: 22680988]
52. Kredlow MA, Orr SP & Otto MW Who is studied in de novo fear conditioning paradigms? An examination of demographic and stimulus characteristics predicting fear learning. Int. J. Psychophysiol 130, 21–28 (2018). [PubMed: 29800584]
53. Krutzinna J & Floridi L The Ethics of Medical Data Donation (Springer, 2019).
54. Parvaz MA, Gabbay V, Malaker P & Goldstein RZ Objective and specific tracking of anhedonia via event-related potentials in individuals with cocaine use disorders. Drug Alcohol Depend. 164, 158–165 (2016). [PubMed: 27226335]
55. Bioulac S, Taillard J, Philip P & Sagaspe P Excessive daytime sleepiness measurements in children with attention deficit hyperactivity disorder. Front. Psychiatry 11, 3 (2020). [PubMed: 32174847]
56. Butt M, Espinal E, Aupperle RL, Nikulina V & Stewart JL The electrical aftermath: brain signals of posttraumatic stress disorder filtered through a clinical lens. Front. Psychiatry 10, 368 (2019). [PubMed: 31214058]
57. Salter L Research as resistance and solidarity: 'spinning transformative yarns'—a narrative inquiry with women going on from abuse and oppression. J. Fam. Ther 39, 366–385 (2017).
58. Buchanan D & Badham R Power, Politics, and Organizational Change (Sage, 2020).
59. Galánn CA. et al. A call to action for an antiracist clinical science. J. Clin. Child Adolesc. Pschol 50, 12–57 (2021).
60. Benjamin R Race After Technology: Abolitionist Tools for the New Jim Code (Polity, 2019).
61. Ben-Shakhar G Standardization within individuals: a simple method to neutralize individual differences in skin conductance. Psychophysiology 22, 292–299 (1985). [PubMed: 4011799]
62. Vazquez M Engaging biomedical engineering in health disparities challenges. J. Community Med. Health Educ 8, 595 (2018). [PubMed: 31223515]
63. Rad MS, Martingano AJ & Ginges J Toward a psychology of *Homo* sapiens: making psychological science more representative of the human population. Proc. Natl Acad. Sci. USA 115, 11401–11405 (2018). [PubMed: 30397114]
64. Muthukrishna M et al. Beyond Western, educated, industrial, rich, and democratic (WEIRD) psychology: measuring and mapping scales of cultural and psychological distance. Psychol. Sci 31, 678–701 (2020). [PubMed: 32437234]
65. Erosheva EA et al. NIH peer review: criterion scores completely account for racial disparities in overall impact scores. Sci. Adv 6, eaaz4868 (2020). [PubMed: 32537494]
66. Stevens KR et al. Fund Black scientists. Cell 184, 561–565 (2021). [PubMed: 33503447]
67. Ginther DK et al. Race, ethnicity, and NIH research awards. Science 333, 1015–1019 (2011). [PubMed: 21852498]

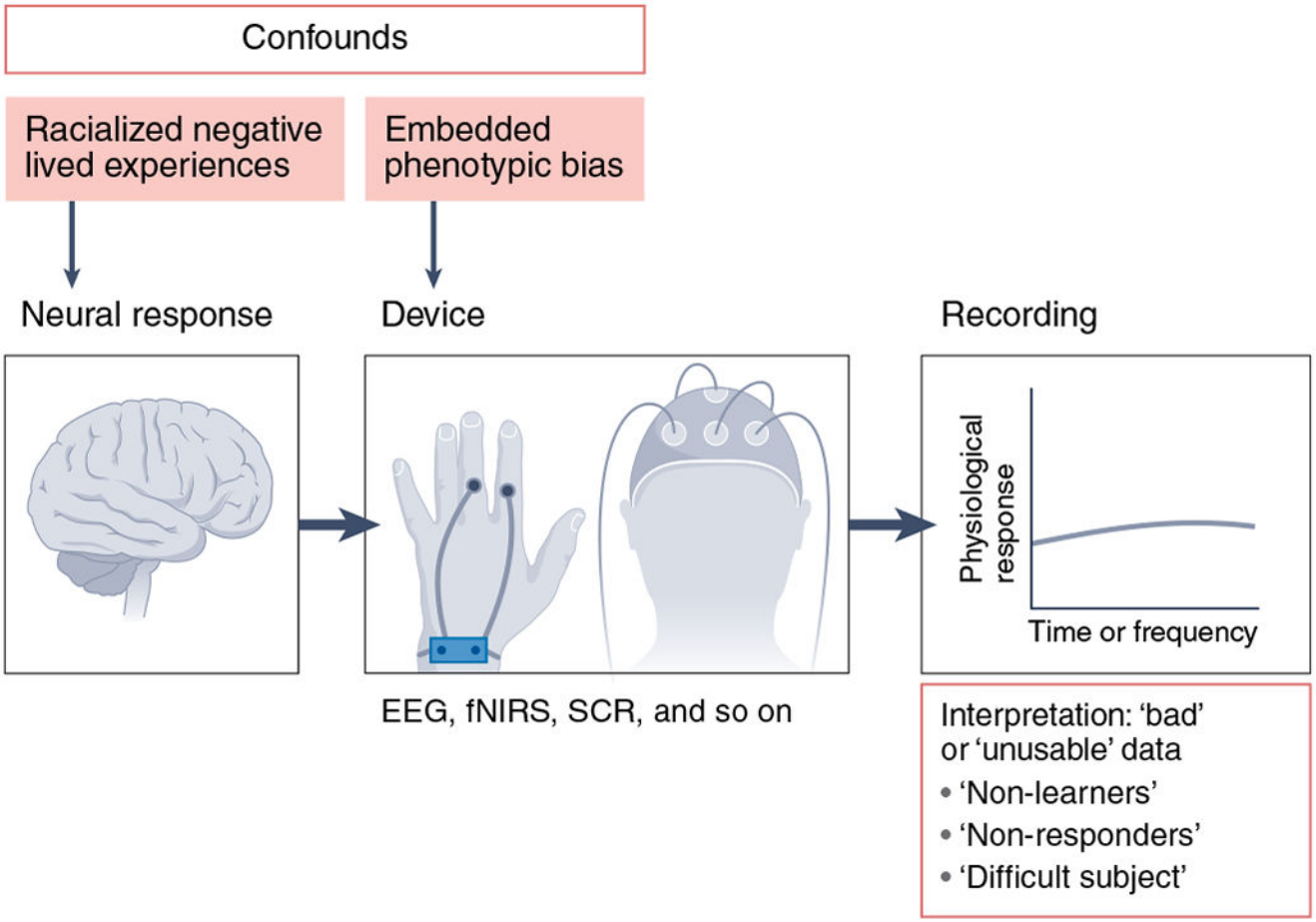

Fig. 1 |. The potential sources of racial bias in psychophysiological data collection.
Both effects of racialized negative life experiences on neural responses and embedded phenotypic bias (against darker skin and/or coarse, curly hair) in devices may influence recorded data. Historically, these confounds have not been considered, leading to the exclusion of Black participants from analyses and mislabeling participants as 'non-learners', 'non-responders' or 'difficult subjects'.

Table 1 |

Recommendations for stakeholders to combat racial injustice in human neuroscience

Steps toward more equitable human neuroscience			
Researchers	**Institutional review boards**	**Journals**	**Funding agencies**
• Use post hoc tests to explore variability in measurements. • Attempt to differentiate confounds (for example, tool phenotype bias) from co-varying and real psychological effects (for example, effects of racism-related stressors). • Report demographic information in articles.	• Ask why racial and ethnic minorities are being excluded when reviewing protocols. • Train personnel on biases in technology. • Offer institutionally mandated training on inclusive practices.	• Require and enforce demographic reporting. • When demographics are not representative, require a limitation statement within the manuscript. • Request meaningful disaggregation of data (for example, breakdown of psychophysiology measure by ethnic or racial group).	• Fund Black scientists. • Fund projects examining the effects of racialized life experiences on psychological processes. • Fund innovative and equitable method development.