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Why Sociology Matters to Race and Biosocial Science

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Abstract

Recent developments in genetics and neuroscience have led to increasing interest in biosocial approaches to social life. While today's biosocial paradigms seek to examine more fully the inextricable relationships between the biological and the social, they have also renewed concerns about the scientific study of race. Our review describes the innovative ways sociologists have designed biosocial models to capture embodied impacts of racism, but also analyzes the potential for these models normatively to reinforce existing racial inequities. First, we examine how concepts and measurements of difference in the postgenomic era have affected scientific knowledges and social practices of racial identity. Next, we assess sociological investigations of racial inequality in the biosocial era, including the implications of the biological disciplines' move to embrace the social. We conclude with a discussion of the growing interest in social algorithms and their potential to embed past racial injustices in their predictions of the future.

INTRODUCTION

Scholars have historically framed sociology and biology as opposing disciplines that take antagonistic approaches to questions of social inequality and determinism (Murray 2020). Although social scientists have incorporated deterministic logics in their racial statistics (Zuberi 2001), they have also distinguished their social explanations of racial inequality from biological explanations that assume innate racial differences. In recent decades, however, biological scientists have developed new theories and methods for studying the relationship between biology and social inequality that seek to eschew deterministic ideas (Roberts 2018). At the same time, sociologists have increasingly embraced such approaches to studying society (Bliss 2018, Conley & Fletcher 2017, Freese 2018). This sociological approach incorporates biological concepts and measures in the study of racial inequality and argues that integrating sociological and biological sciences generates a more comprehensive science. These sociologists see biosocial science as complementary to or more informative than social theories of inequality and difference alone, and as the key to proposing better solutions for health and social problems (Conley & Fletcher 2017, Freese 2018). Although biological determinism is not inevitable, our analysis demonstrates the potential for biosocial approaches to function normatively to reinforce conceptions of race as an innate and immutable fact that produces racial inequalities. We therefore highlight the critical importance of sociological critiques of and engagement in emerging bioscientific approaches to race and racism.

We divide this review into three parts. First, we examine sociological studies of new concepts and measurements of racial difference in the postgenomic era, particularly the way genetic understandings have challenged the sociological concept of race as a social construction and have affected social practices of racial identity and belonging. Our analysis then turns to the sociological investigation of racial inequality in the biosocial era. We examine how the move to embrace the social on the part of biological disciplines has led to their greater openness toward explaining social inequality, and we discuss the implications for sociology. The last section concentrates on emerging technologies of race, specifically the increasing sociological attention to the role of social algorithms in everyday life and in government control of marginalized communities. We emphasize throughout this review that sociologists must develop theories, concepts, and methods for understanding the relationship between biology and social inequality that meaningfully contest biological determinism and biological definitions of race and that accentuate social processes, hierarchies, and justice.

RACIAL DIFFERENCE IN THE POSTGENOMIC ERA

President Clinton's famous declaration that "all human beings, regardless of race, are more than 99.9% the same" might have heralded a radical change in sociological and biological studies of race (Roberts 2011, p. 50). Findings from the Human Genome Project (HGP) were supposed to settle the incessant debate surrounding race and biology. Yet what transpired in the post-HGP era was not an end to scientific research based on biological race concepts but the start of a new racial science based on genetic theories, data, and methods (Obasogie 2009, Roberts 2011).

Instead of demonstrating that race is not a natural grouping determined by genes, some population geneticists and biomedical researchers quickly turned to the 0.1% of genomic variation to identify race-based susceptibility to many complex diseases. These scientists saw race-conscious genomics as an appropriate way to address disparities in health outcomes (Bliss 2012). Social scientists, however, have been critical of the associations made between race, health, and genetics. The "molecularization of race" (Fullwiley 2007) can shift focus away from the social forces that create racial classifications and allow these categories to be (mis)understood as natural properties of human difference (Duster 2005, Roberts 2011, Zuberi et al. 2015).

Proponents in both the biological and social sciences have defended this use of genomic research by pointing to gene-environment interaction (GEI) models as a way to capture a more complete understanding of the complex causal relationships between the body and society (Freese & Shostak 2009). Yet GEI studies are not immune to slippages made between social and biological causes or to understandings of race as innate and immutable (Fujimura & Rajagopalan 2011, Shim et al. 2014). Moreover, the intense focus on race at the genetic level rapidly pushed the science well beyond health and medicine—what Duster (2015) called the postgenomic surprise. Below, we focus on sociological responses to four areas of the postgenomic challenge: genomic-based understandings of race; the genetic challenge to social constructionism of race; genetic ancestry testing and its effects on public perceptions, social meanings, and histories of racial identity; and the entwined relationships between genomic readings of race and belonging that are increasingly merging with practices of state and political sovereignty.

Genomics and the Meaning of Race

The conceptualization of race in biomedical research is an imprecise and flexible process. Following the HGP, there was a dramatic rise of genetic studies with an emphasis on race/ethnicity (Best & Byrd 2015) along with a similar increase in the conceptualization of race as a biological fact rather than as a social construction in scientific articles (Chow-White & Green 2013). Chow-White & Green's (2013) analysis of racial discourses in scientific journals showed that constructionist understandings of race often appeared in scientific publications on race and genetics in 2001, but this trend quickly reversed in 2003 as the use of biological notions of race increased dramatically. Other scholars pointed out that terms like "race" and "ethnicity" have been used interchangeably and defined inconsistently in biomedical research both before the completion of the HGP (Lee 2009) and well into the postgenomic era (Best & Byrd 2015). However, the racialization of genetics is not limited to the rise of racial taxonomies or inconsistencies in race terminology in publications. For example, the racialization of genetics is inextricably embedded in the way genetic material has been stored and categorized in biobanks—data repositories that store biological materials used for research (Lee 2015, Smart et al. 2008). Biobanks, which rely on existing racial taxonomies to organize and sort DNA samples, can operate as "political artifacts" (Lee 2015), in which the work of both sorting and mining the genetic material kept in these repositories can potentially justify and harden biologic assumptions of racial difference. Moreover, genetic understandings of race can emerge even when researchers attempt to standardize the meanings of race and ethnicity in biobanks (Smart et al. 2008).

Sociologists have also traced how these discursive practices of race arise from, and are embedded within, the making and practices of genetic science. Some geneticists have actively read race into their research, often embracing Old World referents of race to help make sense of research findings (Fullwiley 2008), while others refer to population groups to capture the complex genomic and geographical histories of individuals and ostensibly to avoid the controversy tied to the social meanings of race (Abu El-Haj 2007, Fujimura & Rajagopalan 2011, Fullwiley 2008, Shim et al. 2014, Yudell et al. 2016). Yet ancestral or geographic population measures are not always able to escape the "tenacity of race" (Fujimura & Rajagopalan 2011, p. 5). A related field, precision medicine, has been championed as a way to help eliminate not only racial health disparities but also the need to use racial categories in biomedical research (Bonham et al. 2016). However, the US Food and Drug Administration's approval of the first race-based pharmaceutical, BiDil, which the agency considered an exemplar of the move toward personalized medicine (Bonham et al. 2016, Obasogie 2009), illustrates how the biological definition of race and politics of racial identity complicate such optimistic medical visions (Bliss 2013, Duster 2005, Kahn 2012, Lee 2012, Roberts 2011, Sankar & Kahn 2005).

The construction and adoption of new technoscientific practices in postgenomic science do not automatically depart from older racial taxonomies (Duster 2015, Roberts 2011, Zuberi et al. 2015). Far from obstructing scientific practices, such plasticity in racial categorizing and racial meanings has helped produce and facilitate scientific authority in the genomic sciences (Panofsky & Bliss 2017). Fujimura & Rajagopalan (2011, p. 7) analyzed the development and use of new statistical software in genome-wide association studies (GWAS), which was designed to avoid reading race into genomic findings, and found that the software's utility may be limited by "genome geography." That is, the practice of locating the origin of specific groups in geographical regions via DNA makes it difficult to untangle race, population, and genetic ancestry in the research. Similarly, Shim and colleagues (2014) demonstrated that some genetic scientists actively produce sociocultural understandings of racial homogeneity and heterogeneity situationally, as a way to yield more scientifically relevant understandings of complex diseases. Some scientists they studied used racial categories to help construct suitable study populations. Other scientists used notions of racial sameness or difference as a better way to conceptualize other types of biomedical differences, such as behavior or diet, which may influence disease etiology (Shim et al. 2014).

A Challenge to Social Constructionism

In contrast to sociologists who critique genomic definitions of race, a small number of sociologists are incorporating genomic understandings of race in their research and suggesting that genomic research can open new avenues toward understanding, revising, and challenging race as a social construction. In 2012, several sociologists advanced a theoretical synthesis of genomic and sociological approaches that accepts the claim that genetic clusters within human population structures are consistent with dominant racial classifications, "without diminishing the social character of their context, meaning, production, or consequences" (Shiao et al. 2012, p. 68). They asserted that there exists a biological—and, therefore, more objective—measure of race that underlies sociological constructs of race. Under this approach, sociologists borrow a biological definition of race from population genomics and then apply sociological theories and methods to analyze the social implications of this genetic category.

In 2014, *Sociological Theory* devoted an issue to the debate generated by the Shiao et al. (2012) article. Fujimura et al. (2014) pointed out the errors in Shiao et al.'s reading of the genomic science and reiterated the evidence refuting the genomic definition of race. Morning (2014) presented a searing criticism of claims to genomic objectivity and defended the important role sociologists play in understanding how both race and genomic science operate in society. After discussing the multiple subjective decisions researchers make in conducting genetic clustering studies, Morning (2014, p. 190) concluded, "our depictions of the genetic structure of human populations are themselves so culturally conditioned that it would be a mistake to conclude that they represent objective biological measurements that are any less a human artifact than folk taxonomies." There is no biological race for genomic researchers to discover. Social constructionism "is already quite capable of accounting for new (and not-so-new) claims about race and biology" (Morning 2014, p. 190).

Genetic Ancestry and the Politics of Identity

The increasing public acceptance of genetic understandings of health and social life goes hand in hand with the marketization of identity (Bliss 2013) as a booming industry specializing in direct-to-consumer genetic genealogy has emerged (Bolnick et al. 2007, Lee 2013, Roberts 2013). Recent social science literature, employing both quantitative and qualitative methods, has examined consumers' experiences with genetic ancestry testing and the growing public

anticipation and acceptance of genomic understandings of health and difference (Byrd & Ray 2015, Hochschild & Sen 2015, Morin-Chassé et al. 2017, Nelson 2016, Panofsky & Donovan 2019, Phelan et al. 2013, Roth & Ivemark 2018, Shim et al. 2018, Yaylaci et al. 2019). Nelson (2016) explained that genealogical technologies transform the way consumers understand, or want to understand, their racial histories. African Americans, in particular, have turned to ancestry testing as part of broader reconciliation projects that aim to mend the ruptures caused by enslavement and subsequent forms of racism (Nelson 2016). These consumers incorporate test results into a complex process of "affiliative self-fashioning"—a social translation of genetic findings "from the biological to the biographical" (Nelson 2008, p. 775). However, Nelson also made clear that this translation process does not negate the risk that genomic understandings can reinforce a biologized interpretation of racial identity (Nelson 2016, Roberts 2011). Panofsky & Donovan (2019) identified a different kind of reconciliation project in their study examining how white nationalists' interpretations of their genetic ancestry results reshape norms, attitudes, and hierarchies of whiteness. They showed that white nationalists who received upsetting results from genetic ancestry tests developed repair strategies that resulted in flexible reinterpretations of racial boundaries to redeem their existing sense of white identity.

Roth & Ivemark (2018) found that the racially diverse participants in their study did not accept genetic ancestry test results as given. The researchers' genetic options theory, in contrast to a genetic deterministic account of identity, explained how consumers choose selectively from the estimates according to their own identity aspirations and social appraisals. Consumers may not envision their genetic ancestry results as direct evidence of their racial identity, but white participants in the study aspired to new racial identities more readily and in ways that reinforced their race privilege. Thus, researchers must still be aware of the problematic understandings of racial identity, belonging, and privilege that remain viable through these discursive readings of genetic ancestry. To help researchers capture the social impact of genetic technologies, Yaylaci et al. (2019) developed the Genetic Essentialism Scale for Race, which can be employed in sociological investigations to demonstrate how beliefs about genetic ancestry can reinvigorate essentialist understandings of race difference. Participants in Shim et al.'s (2018) study, however, overwhelmingly accepted, and were satisfied with, their genetic ancestry results. The participants in the study were women who self-identified their race as African American, Hispanic, Asian American/Pacific Islander, or Alaskan Native. Interestingly, all these women stated that the genetic ancestry results, while interesting, had no impact on the existing ways that they conceived their racial identity. That is, while these women regarded the test results as informative, they were less convinced that such genetic readings of identity would displace the "cumulative, personal, familial, and social life experiences" that shaped their racial identities (Shim et al. 2018, p. 58). Overall, these findings suggest that the public's understandings of genetic ancestry testing are not necessarily provoking new racial identities, but instead are being interpreted unevenly through existing socio-political and personal logics of identity and kinship.

Genetic Classifications and Immigration Policy

Another type of genealogical identification has been taking place in the context of race and immigration. DNA testing has emerged as a technology of family reunification in more than twenty countries (Heinemann & Lemke 2014). In Germany, these practices often restrict the definition of family to biological ancestry, to the detriment of immigrant groups whose own meanings of family extend beyond biological kinship (Heinemann & Lemke 2014). Similarly, US government officials, tasked with reuniting families affected by recent family separation practices, have turned to genetic matching using Rapid DNA (Farahany et al. 2019)—a newly approved

automated technology able to drastically cut the time for a DNA match to less than two hours (US FBI 2017). Immigrant rights groups have challenged this DNA identification practice due to consent and privacy concerns with respect to the minors (Silva 2018). Moreover, governments deploy such technoscientific tools not only to unite families but also to separate and criminalize families deemed to be fraudulent (Miroff 2019). Thus, "assessments of [DNA] test results are not merely an evaluation of scientific assertions but rather social and political claims about what kinds of bodies can make demands on the nation" (Lee & Voigt 2020, p. 436).

RACE IN THE BIOSOCIAL ERA

The most basic understanding of the term "biosocial" implies a fluid and multidirectional interaction between social and biological factors (Meloni et al. 2016, Müller et al. 2017, Pitts-Taylor 2016). Shifts in genetics research from candidate genes to GEIs, and now epigenetics, exemplify new efforts to capture embodied impacts of social life on health. Similarly, social neuroscience has replaced the view of the brain as static with one that captures its plastic nature. Thus, biosocial science treats the gene and the brain as dynamic, unfixed determinants of health and social behavior.

While the emerging biosocial science provides a more compelling picture of causality than past iterations, sociologists continue to deliberate the accuracy, utility, and ethics of these biosocial models, especially their potential to engender biologically deterministic explanations of social life (Bliss 2018, Freese 2018, Roberts 2018). Our assessment of biosocial science follows the few sociological reviews that have focused directly on the question of race and racism (Goosby et al. 2015, Meloni 2017). Against the continued threat of the biologization of race, these reviews note how social scientists have developed biosocial models that address inequalities in health without attributing an innate characteristic to race or generating deterministic readings of racial inequality.

We start with a review of the innovative biosocial measures of racism that sociologists have developed to investigate experiences of stigma and discrimination, as well as biosocial theories to explain disparate health and social outcomes. Health outcomes have been the most common focus of biosocial science but not the only outcomes to which sociologists have applied biosocial thinking. Hence, the second part of this section discusses biosocial investigations of crime and violence. Given the racialized sociocultural interpretations of social behaviors like crime or intelligence, and the historically racist, sexist, and classist findings from biological research on social behaviors, contemporary biosocial research raises serious questions as to how sociologists can better evaluate and develop biosocial models, especially as these knowledges are translated into social policies.

Embodying Racism

W.E.B. Du Bois, who pioneered the first academic challenge to biodeterministic explanations for racial gaps in health, recognized that the sources of health inequities were unequal social and political conditions (Morris 2015). In 1899, Du Bois (1899, p. 160) wrote: "Particularly with regard to consumption, it must be remembered that the Negroes are not the first people who have been claimed as its particular victims; the Irish were once thought to be doomed by that disease—but that was when Irishmen were unpopular." His point was to push back against the crude explanations of health disparities that focused on seemingly innate differences between racial groups and instead concentrate on the impacts of social inequity—in particular, racialized social practices that structure unequal life chances. Following Du Bois's tradition, sociologists today are at the forefront of developing investigations that analyze how inequities in wealth, housing, incarceration, and education produce health disparities (Boen 2019, Harris & McDade 2018, Lee et al. 2014, Schnittker et al. 2011, Sewell 2016, Williams et al. 2019, Williams & Mohammed 2013).

Utilizing novel measures of structural racism—political participation, employment status, educational attainment, and judicial treatment—Lukachko and colleagues (2014) found that blacks living in states with high levels of structural racism were more likely to report past-year myocardial infarction than those living in low–structural racism states. A more recent study found evidence that higher education may buffer the biological effects of discrimination, measured as allostatic load, for African American women, while even lower levels of discrimination were associated with high allostatic load for African American women with lower education (high school or less) (Allen et al. 2019). Moreover, experiencing racial discrimination may have profound biological effects from a young age. Perceived discrimination by African American youth (aged 10–15) has been correlated with elevated blood pressure and C-reactive protein (Goosby et al. 2015), which mirrors similar findings in African American adult populations (Boen 2019, Lewis et al. 2010).

A number of recent sociological studies have focused on racially segregated neighborhoods as a key social factor in explaining racial health inequities and have examined the ways these neighborhoods affect health outcomes throughout the life course (Williams & Mohammed 2013, Williams et al. 2019). Residential segregation—resulting from the forcible exclusion of black people from white neighborhoods by private terror, government housing policies, and state-sponsored legal mechanisms, such as restrictive covenants—remains a powerful mechanism of persistent racial disadvantage in the United States (Massey & Denton 1993, Rothstein 2017). Merging data from the 1994 Home Mortgage Disclosure Act and Neighborhood Change Database with data from the Project on Human Development in Chicago Neighborhoods, Sewell (2016) found a connection between the dual mortgage market, residential segregation, and childhood health inequalities. Research has also demonstrated a correlation between living in neighborhoods with high rates of police violence against African Americans and increased risk for poorer mental health and illnesses such as diabetes (Bor et al. 2018, Sewell 2017, Sewell et al. 2016).

Similarly, Sampson & Winter (2016) graphically showed the racial ecology of lead poisoning by empirically mapping the link between the spatial isolation of African Americans in segregated neighborhoods and the prevalence of lead poisoning in Chicago. Using the term "toxic inequality," they confirm what black activists have charged as environmental racism for decades: Predominantly black neighborhoods comprise the vast majority of neighborhoods in the top quintile of Chicago's lead toxicity rates in each year from 1996 through 2012. Lead poisoning of black children, they conclude, is "a form of biosocial stratification" (Sampson & Winter 2016, p. 279). Concentrating on the relationship between discrimination and telomere length (a biomarker of aging health), Massey and colleagues (2018) directly demonstrated how this form of biosocial stratification impacts individuals at the biological level. They found that shorter telomere length was associated with spatially concentrated disadvantage in both white and African American mothers and make clear that such biological differences must be interpreted through the existing sociological literature on racial segregation, which disproportionally disadvantages African American populations. Rather than posit that biological differences in genes, brains, or cells produce social disparities, these biosocial models create the opportunity to show the materialization of structural racism, that is, to examine how racism gets under the skin.

Researchers have also gone a step further using epigenetic studies to show how deleterious effects of racial inequality can be intergenerationally transmitted (Goosby & Heidbrink 2013, Landecker & Panofsky 2013). Epigenetic research captures how the social environment influences gene function or expression, which in turn affects physiological and behavioral outcomes (Landecker & Panofsky 2013). These studies help to explain how disparate racial outcomes that appear to be inherited can result from social factors rather than gene sequences. A seminal study on epigenetics and race (Kuzawa & Sweet 2009) examined the disproportionately high rates of

low birth weight in African American populations to offer a conceptual model linking maternal stress during pregnancy to a higher risk of cardiovascular diseases in adult offspring. Researchers have also found evidence that epigenetic modifications in genes related to breast cancer may contribute to altered gene expression in African American and European American older adult women (Wang et al. 2012). Reviews have indicated an epigenetic relationship between long-term stress and chronic pain experienced by African American adults (Aroke et al. 2019), as well as higher susceptibility to psychiatric disorders among Native Americans (Brockie et al. 2013).

Scholars herald social epigenetics as having the potential to transform social science by incorporating more deeply the reciprocal causality of biological and social processes into sociological research concepts and methods (Chung et al. 2016). Moreover, all of these new epigenetic models of health make clear the socially constructed character of race (Meloni 2017). Yet even as they avoid deterministic understandings of race, they may open a new route toward biologizing racial inequality by making deleterious epigenetic processes seem normal, self-perpetuating, and inevitable (Mansfield & Guthman 2015, Roberts 2018). Such epigenetic explanations for disparate racial outcomes may help reinforce rather than eliminate the social inequities that produced them by directing interventions to the biological processes, further pathologizing and regulating the bodies of socially marginalized individuals (Roberts 2012, 2018).

Moreover, deploying biosocial evidence to advance claims for better social conditions begs another set of questions: Will researchers need to continue monitoring telomere lengths, cortisol levels, or brain functioning in order to validate efforts for social change? Will biological tests be required to substantiate not only the causes and harms of social inequality but also their solutions? Therefore, sociologists must continue to take seriously the potential that soft heredity claims—less deterministic interpretations of heredity that take seriously environmental influences on inheritance—will be read through biologizing scientific practices as they are translated into social policies (Meloni 2017). As the biosocial increasingly shapes scientific understandings of racial inequality, sociologists play a critical role in insisting on substantive social, not individualized biological, interventions in biosocial stratification.

The Social Brain and Race

In another take on the embodiment of discrimination, social neuroscientists have emphasized the novelty of neuroimaging to see where prejudicial discourses about and experiences with race materialize into neural changes (Amodio 2014, Kubota et al. 2012). This biosocial framing of embodied racism focuses on the perpetrators rather than the victims of bias. These researchers study the biological indicators in the brains of (mostly white) individuals who engage in discriminatory actions and thoughts, instead of the biological impacts of structural inequality on the brains of marginalized individuals. Building off of Allport's (1954) work on prejudice, this research traces the formation of racial attitudes and behaviors to neurobiological structure and function. Thus, neuroscientists are optimistic that "seeing pictures of the brain may lead people to understand that their own race-based perceptions have the capacity to change and shape who they themselves are, in ways never before thought possible" (Eberhardt 2005, p. 189).

Neurobiological research has linked brain activations in the amygdala (an area associated with emotions) to the way individuals initially evaluate racial faces or cues (Kubota et al. 2012), finding greater activation in this area when individuals view faces of out-group members. Other studies found a significant interaction between race and perceived skin tone, suggesting that darker skin tones may trigger an automatic negative response as individuals try to process racial identity (Ronquillo et al. 2007). Additionally, research has also identified the fusiform face area (FFA) as significant to the ability to detect racial identity (Hughes et al. 2019). For example, one recent

neuroimaging study successfully predicted the race of the faces (defined as either black or white) viewed by study participants with higher levels of pro-white implicit biases from their recorded brain patterns in the FFA (Brosch et al. 2013). According to the authors, because unique neural patterns may be linked to an individual's score on the implicit association test, neuroimaging can potentially be used to predict or detect differences in implicit bias.

One immediate drawback to these studies is that they focus almost exclusively on white participants' biases toward African Americans; in fact, studies have been less conclusive when they assess out-group bias in nonwhite racial groups (Kubota et al. 2012). Moreover, these studies seem to be unable to detect significant brain differences for explicit racial behaviors. These shortcomings raise important questions about the translation of these neuroscientific knowledges into sociological understandings of racism, and the potential for anatomical or neurocognitive understandings of racism to overlook the normative and embedded role of racism in our society—how racial socialization may impede researchers' ability to detect biased brain functioning as abnormal. In addition, neuroscientists are framing the brain not only as a decoder for racial discourses and ideologies but also as the site to intervene upon to change individuals' potential racist actions. One study even suggested that propranolol—a common beta-blocking drug prescribed to treat high blood pressure and other cardiovascular health problems—be used to treat implicit racial bias (Terbeck et al. 2012). The blood pressure pill was said to blunt implicit racial biases in the study's sample—although the drug had no effect on individuals' explicit racial biases (Terbeck et al. 2012). Although most social neuroscientists recommend psychological interventions, such as individuation and intergroup contact (Kubota & Phelps 2015), to help attenuate implicit biases, the suggestion of a pharmaceutical solution underscores the troubling potential to medicalize racism as a disease in need of a cure (Gilman & Thomas 2016, Kahn 2017), jeopardizing structural and systematic attempts to dismantle it and to nullify its detrimental impacts on society.

Genetics, Race, and Educational Attainment

Some social scientists have advocated the use of biosocial models to capture the way genetic differences affect educational attainment (Asbury & Plomin 2013, Domingue et al. 2015, Herd et al. 2019, Qu et al. 2018) and to improve pedagogical practices (Youdell 2016). Others have questioned assertions that new biosocial explanations for educational achievement can avoid old pitfalls associated with the study of intelligence and race—and pointed to new ways these explanations can obscure structural barriers to educational equity (Martschenko et al. 2019, Roberts 2018). Proponents of gene-based studies of educational attainment have acknowledged these challenges and have been quick to distinguish their research from heredity studies that incorporated biologically deterministic understandings of race or inequality (Freese 2018, Herd et al. 2019). Herd and colleagues (2019) recently advanced a sociocontextual perspective with the aim of helping to better explain the relationships between gender and educational attainment using polygenic risk scores. Their perspective insists on the need to view genetic influences of educational attainment within a context of history, life course, and social forces, and rejects adding race to such models due to its social nature. However, it is not clear how gender—a social construct, as well—differs from race as a suitable focus for biosocial investigations.

Beyond genetics, scientists using biosocial models focused on the brain are investigating the relationships between race and educational attainment. Using structural neuroimaging, a technique that captures the brain's anatomical composition and volume, Qu et al.'s (2018) biopsychosocial approach explicitly suggested that smaller hippocampus volume (an area associated with learning) uniquely predicted better educational attainment in Mexican American youth. The authors acknowledged that it is unclear why lower hippocampal volume predicts educational outcomes in

Mexican American populations, given that lower brain volumes are usually associated with a decrease in cognitive functioning. Moreover, they showed that parental cultural association predicts educational attainment just as well.

Scientists have also designated the brain as a site for biosocial research on the impact of socioeconomic inequality. The growing neuroscience of poverty literature examines how the experience of poverty during childhood manifests as neural changes in the brain, producing anatomical and functional effects that hinder cognitive abilities (Hackman & Farah 2009, Noble et al. 2015). Pitts-Taylor (2019, p. 672) criticized this research by pointing to its "biosocial determinism" that allows for fluid causality yet "elevates biological explanations for social problems while attributing biological conditions to social causes." By theorizing damaged brain function as the biological conduit that transfers structural inequities into lower educational achievement, the neuroscience of poverty can obscure how multiple forms of discrimination directly and systematically impose impediments and deny opportunities to poor children, especially poor black children (Roberts 2018). To be clear, most neuroscientists studying biosocial impacts have tried to be more agnostic toward race. That is, as with other projects in social neuroscience, which we discuss below, researchers attempt to operate in a race-neutral manner. Nevertheless, this race-neutral framing of social experiences (e.g., poverty) or social behaviors (e.g., educational attainment or crime) through biosocial research can render the research incapable of fully grasping the complex social effects of race and racism, and some have noted that race-neutral brain research can obscure the impact of structural racism and discrimination (Rollins 2020).

The Biosocial Criminal and Race

Novel DNA forensic technologies are often depicted as more efficient than traditional crime solving techniques—a "silent witness" (M'charek 2008, p. 521)—that may even reduce racial bias in the criminal justice system. However, governments may apply such technologies to existing sociocultural practices of race without scrutiny, thereby threatening to provide a scientific justification for racially discriminatory law enforcement procedures within a racially subordinating criminal justice system (Duster 2004, 2006a; M'charek 2008; Ossorio & Duster 2005; Rollins 2018; Sankar 2010).

Beyond forensics, new biosocial developments have fueled a resurgence of biological research on crime, which is also renewing criminology's controversial history of criminalizing race through biological logics. Biosocial criminology is at the forefront of this move in the social sciences. Biosocial criminology is an emerging subdiscipline of sociologists and criminologists that argues for genetics and neuroscientific research on violence to improve existing social theories of crime (Beaver 2009). Unlike the embodying racism approaches outlined above, this criminological framework views biomarkers as the causal underpinnings of criminal behavior rather than the effects of either criminality or the social environment upon offenders. Social scientists who advocate for biosocial models of crime have criticized biosocial criminology's methodological dependency on heritability models of causation (Burt & Simons 2014). Other critiques have focused on the epistemological foundations of biosocial criminology, demonstrating that the subdiscipline tends to reduce crime to a "nonsocial object" (Carrier & Walby 2014, p. 21) that decontextualizes the dynamic social properties of crime.

Biosocial criminology, with few exceptions (e.g., Barnes 2018), treats race as both a biological variable and a semiautonomous predictor of crime. For example, one group of researchers attributed higher rates of shooting and stabbing behaviors among African American males to their propensity to carry a rare MAOA allele (Beaver et al. 2014). More egregiously, a 2015 biosocial criminology article claimed that certain phenotypes like narcissistic traits and lower

intelligence are more "moderately to highly heritable" in African American populations and that "the possibility exists that these phenotypes are somehow embedded in the genetic architecture of race or. . .they emerge under environmental conditions that Blacks more likely experience" (Wright & Morgan 2015, p. 69).

Interestingly, biosocial criminologists generally acknowledge the social construction of race. In fact, Wright & Morgan (2015) claimed to be agnostic on the question of the biological nature of race. However, a recent sociological study explained that many of these biosocial criminologists employ social constructionism as a back door to reinsert antiquated biologic notions of race (Larregue & Rollins 2019). Although biosocial criminologists acknowledge the social construction of race, they maintain that race also has a biological character, which allows them to treat race as a useful predictor of criminal activity. Biosocial criminology, then, is a clear indication that biosocial framings can be (mis)used to reconstitute deterministic ideas about racial propensities for social behavior.

US-based geneticists and neuroscientists studying crime have tried to avoid any hint of race-related connections to their work, insisting that their investigations are race-neutral and do not seek to explain racial patterns in offending. These scientists acknowledge the troublesome past of biological studies on crime and race, and unlike biosocial criminologists, they envision the biosocial criminal as a postracial being (Andrews & Metzl 2016). Brain researchers try to manage inconvenient facts like race in the lab (Fallin et al. 2018) and instead focus on the basic neurobiological factors of crime, creating a means of solving racial inequalities without having to deal directly with politically sticky issues of race and racism (Rollins 2020). The race-neutral biosocial approach differs from biosocial criminology, but it also departs from sociological thinking about the embodiment of discrimination and fails to capture the role of structural inequality. The sociological problem raised by these studies is not a direct route from biosocial science to the biologization of race. Rather, the problem is that, by relying on already racialized social data, like police reports or arrest records, this seemingly race-neutral biosocial science can build in existing racist social structures and biases. As these knowledges move beyond the lab, they will be used by existing social institutions that already operate along their own color-blind logics of crime (Alexander 2012). Far from drawing attention to racial inequalities, this science is more likely to legitimize increased focus on individual bodies and minds rather than larger structural issues in law enforcement policies. Thus, the risk sociologists must address is not the general biologization of crime, but the ways that these seemingly race-neutral knowledges may reinforce, if not exacerbate, existing regimes of control and punishment enforced by the criminal justice system (Duster 2006b, Roberts 2010, Rollins 2020).

FUTURE DIRECTIONS: TECHNOLOGIES OF RACE

Sociologists who study the embodiment of racial inequality rely on advanced technologies, such as GWAS and neuroimaging, that promise to enhance their ability accurately to identify and measure the causes and effects of racial disparities. Scientific and biomedical innovations are hybrid technoscientific developments, which simultaneously reassemble and fuse together scientific, technological, and social forms of knowledge (Clarke et al. 2010). Therefore, the sociological understanding of intersections between race and science today requires investigating the social infrastructures that empower racialized technoscientific practices.

In this last section, we turn to the growing use of algorithmic tools by researchers, state agencies, and private businesses as another way that race and racial inequality can be built into seemingly neutral practices of science. As discussed above, social scientists have been attentive to the way racial meanings shape, and are shaped by, technological developments in health and medicine.

Sociologists have also linked race to the digital divide that creates and maintains social disparities in the ownership and use of, and proficiency in, technologies (Nelson et al. 2001). More recent research revealing the racialized impacts of the Internet (Daniels 2013, Nakamura & Chow-White 2011) and robotics (Benjamin 2019, Sparrow 2020) indicates that algorithmic models risk a different form of bias stemming from the social inputs that produce harmful outputs for those included in digitized systems.

Today's algorithms are not fixed codes. Instead, they operate as a semiautonomous set of rules that are fundamentally emergent (Lazer 2015). Breakthroughs in machine learning have allowed algorithmic systems to learn from data and automate data analysis in order to make more precise predictions (Molina & Garip 2019) when paired with biological technologies like neuroimaging and GWAS. Social scientists increasingly employ speed and power algorithms for their own big data problems in the hope to better develop a "science of society. . .that would study society at scale" (Lazer & Radford 2017, p. 26). Moreover, algorithms are vital to our everyday social engagements. These tools power our Internet searches and social media feeds, and governments and corporations increasingly turn to social algorithms as more efficient techniques to make automated predictions about health, crime, and general life chances (Lazer 2015, Obermeyer et al. 2019).

Race can be reconstituted in digital form, what Nakamura (2007) termed the digital racial formation. Algorithms can help confirm and amplify racist ideologies like white supremacy on the Internet (Daniels 2018), and they have further blurred the lines between crime, belonging, and citizenship, as states use technosecurity systems that digitize racial identities and continually reconfigure these identities as "an unstable assemblage of corporeal, digital and discursive elements" (Skinner 2020, p. 77). In this way, these technologies can reduce the complex meaning of race to racialized characteristics that operate as a "template of datafied performances, a 'feature' as opposed to a set of historically and culturally grounded subjective experiences" (Cheney-Lippold 2017, p. 29). Thus, racialized meanings, structures, and conduct can be built in to these complex calculations (Benjamin 2019), seamlessly automating inequality (Eubanks 2018) in society.

Although programmers may not intend racialized outcomes, such results do not arise by chance, as there is evidence that they can be tweaked to modify expected performances. For example, Noble (2018) exposed the way Google searches readily yield racist and pornographic representations of black women and girls. Yet an identical Google search for "black girls" produced less sexualized depictions of black girls after programmers changed the algorithmic codes and suppressed pornographic representations (Noble 2018). Moreover, sociologists have questioned whether tweaking algorithms can eliminate the racism that is already structured in the data collected and objectives pursued by state agencies—an indication that the social impacts of algorithms are not limited to apparent forms of racialization (Benjamin 2019, Roberts 2019).

Algorithms are increasingly used in public and private spheres to enumerate, predict, and potentially rectify aspects of social life, as they shape policing practices and eligibility for services like loans, health care, and public assistance (Benjamin 2019, Eubanks 2018, Noble 2018, Obermeyer et al. 2019). Advocates of these technologies argue they make more objective decisions than human actors alone. Social scientists, however, have revealed how algorithmic tools can build in existing racial inequalities, performing a subtler or color-blind (Bonilla-Silva 2006) form of racism. Moreover, the ubiquity of coding schema, along with proprietary rights to them, makes it difficult to examine exactly how and when algorithmic calculations may produce discriminatory outcomes. For example, Obermeyer et al.'s (2019) recent study showed that a commercial algorithm used by insurers to predict health risks inadvertently reproduced racial health inequities. The researchers, who gained access to the underlying ingredients used to form the algorithm, found that, because the algorithm predicted cost of care as a proxy for patients' health needs, it failed to account for

inequalities in actual illness. Instead, the tool produced similar risk scores for black and white patients even though black patients were sicker on average, owing to lower amounts spent on black patients' care.

Similarly, government officials have claimed that algorithms can enable them to avoid racially biased policing practices by focusing on geospatial risk and vulnerabilities instead of individuals (Caplan & Kennedy 2016). However, analyses of digitized policing practices have revealed that they compute higher risk scores for African Americans than other groups at risk for crime (Angwin et al. 2016). One potential way race works its way back into these assessments is through the problematic data fed into computer systems (Zou & Schiebinger 2018). Law enforcement agencies rely on arrest records and police reports, which reflect racialized and discriminatory practices themselves, as informative sources of data (Hao 2019). The focus on "places, and not people," then fails to acknowledge the sociohistorical dynamics that create and maintain already racially segregated neighborhoods (Ferguson 2019). Predictive tools often rely on proxies for race, such as marital and criminal history, neighborhood, and employment status, that combine to reproduce racialized outcomes even when race is omitted from the algorithms (Roberts 2019). In this way, mathematical computation based on uncritical data mining ostensibly sanitizes problematic policing data and helps divert attention from the unjust practices that helped compile the metrics in the first place.

The seemingly race-neutral function of algorithms can coalesce with existing practices of inequality to strengthen these practices in society—what Benjamin (2019) called a "New Jim Code." Detroit's Project Green Light, a facial surveillance system that allows law enforcement to interface with cameras around the city in real time and build databases of faces caught on camera, enrolls African Americans disproportionately into its visual database and targets them through policing surveillance tactics (Garvie & Moy 2019). As this example shows, algorithmic codes can operate as malleable platforms that facilitate digital epidermalization (Browne 2015) or technological redlining (Noble 2018) practices of racial surveillance. Biometric technologies like facial recognition can make predictions based on phenotypic differences, without ever directly considering an individual's race as a risk factor.

Addressing built-in racism in artificial intelligence will require efforts beyond traditional bioethics (Benjamin 2019). Zou & Schiebinger (2018) have urged computer scientists to collaborate with social scientists, legal scholars, and experts in humanities to develop novel approaches to these technoscientific developments. Reassessing the dependency on problematic data should be a starting point in these collaborative efforts. Yet even if we can get algorithms to perform in a fairer way, this may not address their use by state institutions, like police, public assistance, and child welfare departments, that already function in racially oppressive ways. Roberts (2019) illustrated how the expanding carceral state structures its use of predictive digital technologies in both law enforcement and social welfare programs in particular ways to reinforce an unjust, unequal, and undemocratic political order—calling for a radically different relationship between technology and politics that rejects technological reproduction of past injustices and facilitates envisioning social change.

Thus, avoiding bias may not be as simple as deracializing data through collaborations between social scientists and technicians alone. The use of predictive technologies reminds us that the emerging biosocial paradigms exist alongside other, more static representations of biology and identity. Collaborative efforts between science and social science must engage with the state and, according to Browne (2015, p. 116), necessitate the formation of a "critical biometric consciousness" that involves informed public debate, accountability by the state and the private sector, and understanding "access to one's own body data and other intellectual property that is generated from one's body data" as a human right.

CONCLUSION

A rapidly emerging biosocial science is breaking down the perceived antagonism between biological and sociological approaches to social inequality. Both biological and social scientists increasingly view emerging modes of scientific inquiry that investigate the interaction between social and environmental influences on health and social behaviors as a more informative way to understand and address social inequalities. This review examines how sociologists are approaching the conceptualization of race and racial inequality in this cutting-edge biosocial science. Sociological assessments of these scientific practices show that a complex mix of sociocultural and biologic assumptions and refutations about race remain infused in genomic, neuroscientific, and other biosocial research practices. We explore sociological studies of new concepts and measurements of racial difference in the postgenomic era, particularly the way genetic understandings have challenged the sociological concept of race as a social construction and have affected social practices of racial identity and belonging. We also analyze the implications for sociology of the biological disciplines' incorporation of social factors and openness toward explaining social inequality. On the one hand, sociologists are developing innovative biosocial measures of racism to investigate experiences of stigma and discrimination, as well as biosocial theories to explain disparate health and social outcomes—how racism gets embodied. On the other hand, some biosocial investigations of crime and violence depart dramatically from this sociological paradigm and perpetuate deterministic explanations for social behavior and inequities, even when race is not mentioned. We show that biosocial studies of the impact of social inequities on epigenomes and brains, which aim to eschew deterministic assumptions, can also help reinforce rather than eliminate the social inequities by directing interventions to biological processes. Despite the purported equal integration of biological and social explanations, this research can still employ race as a biological category, overemphasize the biological contributions to social inequalities, and obscure the role of structural racism in producing racial disparities.

Finally, we discuss sociological critiques of the growing role of predictive algorithms in discriminatory corporate practices and in government control of marginalized communities. Sociologists are at the forefront of revealing the ways technoscientific decision making by state agencies and private companies reconstitutes race in digitized form and builds past racial discrimination into predictions of the future. In this case, the naturalization of race is embedded in programmable mathematical formulas and computer codes that are ubiquitously present in everyday technologies and practices.

Our analysis does not conclude that biological determinism is inevitable any time biological sciences or biotechnologies approach social problems. Instead, it demonstrates the potential for such technoscientific models and practices, especially in relation to race, to suggest seemingly stable and unidirectional explanations of causation. Today's biosocial science, while designed to be more open and plastic, can privilege measurable biological vulnerabilities and visual susceptibilities at the expense of its potential to explore social relationships, processes, and meanings. The problem is not technological usage per se, but its ability to obscure ethical uncertainties and structural forces and to reconstitute problematic sociocultural assumptions that researchers relied upon uncritically to execute biosocial research and/or biometric surveillance.

The tenacity of race (Fujimura & Rajagopalan 2011) and the postgenomic surprise (Duster 2015), which threaten to undermine scientific discovery and innovation as well as hinder social change, concern not only the questions of domination and determinism but also ideals of freedom and flexibility that are uncritically afforded to biosocial research (Reardon 2012). Reardon (2012, p. 27) persuasively argued that "exclusion, disempowerment and possible new forms of racism arise not as researchers seek to dominate their subjects, but as they create new scientific and

ethical practices intended to free them." These assumptions and uncertainties are key reasons that bioscientific knowledges can continue to reinforce longstanding social inequities based on race, gender, class, disability, and citizenship. Rather than cede the study of social inequality to biological approaches, sociologists must continue to develop theories, concepts, and methods for understanding the relationship between biology and social inequality that meaningfully contest biological determinism and biological definitions of race. Moreover, instead of automatically assuming that a focus on the social will engender an antiracist or democratic science, sociologists should reinvigorate Du Bois's vision of antiracism in science that contests unjust social hierarchies and power and centers social processes and justice.

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