Testing Common Misconceptions about the Nature of Human Racial Variation

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Abstract

Race is a hot-button topic in American society, but one that needs to be addressed in the biological science curriculum. This paper examines how college students in a large introductory course came to understand race through the exploration of four key concepts about the nature of human biological and genetic variation. Using clicker data collected from four courses (n = 296), change in starting and ending understanding of content was compared using paired t-tests and mean difference scores. Results indicate statistically significant improvement in student understanding of common fallacies of the "biological race concept" after a single exposure to content.

Key Words: *race; racism; social sciences; natural science.*

Introduction

Scientific understanding of the human genome and the nature of human biological variation is expanding rapidly. Out of pace with this growth is the general public's understanding of such concepts (Bates, 2005; Condit, 2001; Condit et al., 2004; Haga et al., 2013; Lanie et al., 2004; Petty et al., 2000; Smerecnik et al., 2008). As a result, college classrooms have become important spaces in which to address popular misconceptions. Among the most dangerous of myths about the nature of human variation is the "biological race" concept. In short, the biological race concept posits that significant genetic and physical (i.e., phenotypic) differences define racial groups, not culturally specific and personal interpretations of these biological features (e.g., see Fuentes, 2012). This concept "naturalizes" perceived racial features and behavior instead of recognizing that race is best explained by complex social, economic, and political forces acting over the past several hundred years (Goodman et al., 2012; Hartigan, 2010; Sussman, 2014; Yudell, 2014). Among the natural and social sciences, with few exceptions (e.g., see Burchard et al., 2003; Risch et al., 2002; Shiao et al., 2012), it is widely accepted that definitions utilizing a biological framework for racial differences do not reflect scientific data.

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Faculty often shy away from complex or controversial topics in courses when time and resources may compete with a need to cover large amounts of course content. In the course of my 11-year teaching career, I have often struggled to determine an appropriate amount of coverage of this topic and have been left wondering if students fully understand such concepts. Although many blame textbooks for student misconceptions about race (Donovan, 2015; Edgar & Hunley, 2009; Morning, 2009), faculty should also determine best practices for teaching these concepts in the classroom, given that anywhere between 20 percent (Baier et al., 2011) and 30 percent (Burchfield & Sappington, 2000) of students never read assigned materials. Likewise, a steady number of biology majors are moving on to medical and health professions where such concepts are "fuzzy" (e.g., Fujimura & Rajagopalan, 2011; Graves, 2011). In fact, MCAT practice tests and training manuals continue to confuse race as a category with some biological basis. As such, our classrooms have become important spaces in which to address both the misconceptions and the implications of these "myths" about human biological variation.

From In-Class Assignment to Research Project

In my own course, I wanted to know how well students understood basic concepts about the nature of human biological and genetic variation as it pertains to race, especially given that this was the first science course many of them had in college. Using website materials and a video developed by the American Anthropological Association (Goodman et al., 2012; Mukhopadhyay et al., 2014),

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I developed a set of four questions dealing with common misconceptions about the nature of human biological and genetic variation in relation to human racial variation. The overarching misunderstanding lies in the notion that phenotypic variation mirrors underlying genetic variation (see Baker, 1997, for a review of why this is false), making the biological variants we see as racially specific produced by underlying genetic differences between racial groups. As a result, students and the public commonly fall into "folk beliefs" about the nature of human variation (see, e.g., Gravlee, 2009; Omi, 2010; Smedley & Smedley, 2005). The common misconceptions (from Goodman et al., 2012; Mukhopadhyay et al., 2014) explored in this paper are that:

1. **Individual traits (like skin color *or* hair color) can be used to reliably distinguish people by race:** The assumption is that human phenotypic variants (e.g., skin color) are discontinuous, therefore, different racial "types" (e.g., white vs. black) can be easily determined via clearly distinguished trait "types" (e.g., light skin vs. dark skin).
2. **Combinations of traits (like skin color *and* hair color) can be used to reliably distinguish people by race:** The assumption is phenotypic variants covary so that certain "racial" traits are always found together (e.g., particular skin colors and hair colors).
3. **There are more biological/genetic differences between people of different races than between people of the same race.** This concept is predicated on misunderstanding of the differences between race and genetic ancestry as well as the fact that people equate visible, phenotypic differences with underlying genetic differences.
4. **Racial differences are best explained by biology, not culture or society:** Because people can "see" differences in phenotypic traits across racial groups, there is the assumption that such variation reflects underlying genetic variation, *not* social or cultural variation in human perceptions of phenotypic variation.

Using data from an in-class assessment, this paper explores how student understanding of the above concepts changed between exposures and which concepts were most pervasive.

○ Materials

Wright State is a mid-sized (~14,000 undergraduate), open-enrollment regional university located in Dayton, Ohio. This paper examines data collected from 296 undergraduate students in a large-enrollment (60 to 100 students), general education, natural science course surveying the field of biological anthropology. Participants were primarily non-science majors (92%), white (59%), and female (58%). Few of the students enrolled in this course had taken other anthropology or biology courses, and in exit evaluations most identified their initial reason for taking the course as a means to obtain a required science credit. Data were collected over a two-year period in four courses (one per term), using a real-time polling response system (Turning Point$_{TM}$ or TopHat$_{TM}$). This dataset was part of an in-class assessment and therefore represents a convenience sample; its secondary use in this paper has been approved by Wright State University's Social and Behavioral Science IRB panel.

○ Methods

Study Objectives

The purpose of the present study was to explore how well college students understand the concept of race by exploring the following questions:

- Which concepts do students struggle to understand?
- How did student understanding of each concept change between exposures and was change significant?

Data Collection

Each term students were asked to evaluate four, binary response statements, presented in Table 1. The first three questions, in different ways, assess common misconceptions about human variation that lead people to view races as biologically rooted categories: (1) that the physically observable differences we equate with race can be matched to specific genetic differences, (2) that racial variants are "discrete" variants, (3) that racial traits co-vary, and (4) that

Table 1. Polled questions.

Q1: Are there individual (biological) traits that can be used to define a racial group?
• Incorrect response (score = 0): Yes, there are single biological traits (such as skin color or eye shape) that can be used to distinguish one racial group from another.
• Correct response (score = 1): No, there is too much overlap between racial groups to use a single biological trait (like skin color or eye shape) to distinguish one racial group from another.
Q2: Are there groups of (biological) traits that collectively can be used to define a racial group?
• Incorrect response (score = 0): Yes, when several traits are combined they can be used to distinguish one racial group from another.
• Correct response (score = 1): No, there is no combination of traits that can be used to distinguish one racial group from another.
Q3: Are there more biological differences between racial groups *or* between individuals within a single race?
• Incorrect response (score = 0): There are more biological differences between two racial groups.
• Correct response (score = 1): There are more biological differences between individuals within a single race.
Q4: Is race biologically or culturally based?
• Incorrect response (score = 0): Race is based on biological differences among racial groups, as opposed to cultural perceptions of such differences.
• Correct response (score = 1): Race is based on cultural perceptions of differences among racial groups, as opposed to biological differences among such groups.

people of the same race are more genetically similar. The first three questions confirmed whether students truly understood *why* race was not a biologically rooted category, and the final question allowed for an assessment of the students' overall understanding of what race is. It has been extensively documented that people who reject the biological race concept (Q4) often still ascribe to one or more of the specific fallacies of race as biology (Q1, Q2, Q3) (e.g., Hong et al., 2009; Kang et al., 2015; Plaks et al., 2012; Williams & Eberhardt, 2008).

On day one, students were polled before viewing the first 50 minutes of "Race: The Power of an Illusion" (Episode 1, "The Differences Between Us") as a pre-test (E_0) (Adelman, 2003). This popular video was produced as part of the American Anthropological Association's program "Race: Are we so different?" (Goodman et al., 2012) and covers the development of the race concept in America, the misuse of race in research, and the core biological fallacies of race (as described in the introduction). Afterward, students were polled again (E_1).

The same day students attended a two-hour lab where they were shown a series of photos and asked to assign a "race" and to describe specific physical features used to categorize each individual. Through sharing of data among members of their lab group (which are rarely consistent), students were challenged to "prove" there are individual traits or trait combinations that can be used to reliably assign individuals to racial groups. A final reflective portion asked students to use these results to explain to a friend why racial differences have no basis in biology. Upon completion of lab, students were not polled.

On day two, students received a 50-minute lecture debunking the core myths of the biological race concept. In some cases, students were polled before the start of the class (i.e., post-lab and a day later), but this practice was not consistent across terms; therefore, this comparison is not included. At the conclusion of the lecture, the final polling (E_2) was conducted.

Data Analysis

Two tests were performed (in SPSS) to test student understanding. First, to track change in understanding, sample means and 95 percent confidence limits were calculated separately by term for each exposure and each question; however, because of overlap in the confidence limits for sample means across the four terms, all data were pooled for the final comparison (see results below) to increase sample sizes and for ease of comparison. Second, to test whether change in understanding was significant, *t*-tests were calculated for pairs of exposures (E_0 to E_1, E_1 to E_2, and E_0 to E_2). Mean differences (with standard deviations) were also estimated to explore the magnitude of change between exposures. Unfortunately, even after pooling data, small sample sizes did not allow for an evaluation of which content (video or lab/lecture) most influenced student understanding.

○ Results

Change in Understanding

Table 2 presents the sample means and associated 95 percent confidence intervals by question and exposure (with sample sizes). Because the data are binary, the mean also represents the proportion of students who correctly answered each question. Note that sample sizes varied by exposure (E_0 to E_2) and question (Q1 to Q4) due to technology issues, student tardiness or absence from class, and/or students forgetting their clickers or phones.

Before exposure to content (E_0), students appeared to believe that multiple biological traits can be used to divide people into distinct racial groups (Q2), with slightly better understanding that single traits cannot be used to define races (Q1), that there is more biological variation among members of the same race (Q3), and that races are culturally variable categories (Q4). After first exposure (E_0 to E_1), student understanding increased 16 to 32 percent, depending on question, and after second exposure (E_1 to E_2) did not change more than 6 percent (Q3 showed no change). Still, given the overlap in confidence limits for individual exposures, students appear to have understood all concepts equally well, once exposed to the course materials (i.e., by E_1).

Significance of Change in Understanding

Although the means reported above reflect students' average understanding of each concept by exposure, they do not indicate whether there was significant change in understanding after each exposure (i.e., between E_0 and E_1, or between E_1 and E_2). Table 3 presents the results of the paired *t*-test including the mean difference between starting and ending understanding (E_0 and E_2), between pre-exposure and first exposure (E_0 and E_1), and between first and second exposures (E_1 and E_2), by question. Note that E_0 to E_2 includes some students who were not present for the first exposure (E_1) and therefore is a combined sample of students with one or two exposures.

There was a statistically significant change in understanding of concepts after the first exposure for all questions (E_0 to E_1), with no strong change in understanding after the second exposure (E_1 to E_2). In general, change in understanding was positive (i.e., percentages of students answering the question correctly increased) except for the second exposure for Q1. Students exhibited similar changes in understanding (mean difference) that single biological traits are not effective in assessing racial differences (Q1), that there is greater biological variation within a single racial group than across all racial groups (Q3), and that racial differences are not explained by biological

Table 2. Sample means, 95% confidence intervals by question and exposure.

Question	Mean E_0 ± 95% CI	Mean E_1 ± 95% CI	Mean E_2 ± 95% CI
Q1	0.76 ± 0.06 (*n* = 188)	0.93 ± 0.04 (*n* = 142)	0.85 ± 0.05 (*n* = 122)
Q2	0.42 ± 0.07 (*n* = 195)	0.74 ± 0.06 (*n* = 219)	0.78 ± 0.06 (*n* = 219)
Q3	0.71 ± 0.06 (*n* = 197)	0.87 ± 0.05 (*n* = 220)	0.87 ± 0.05 (*n* = 223)
Q4	0.68 ± 0.06 (*n* = 205)	0.84 ± 0.05 (*n* = 219)	0.90 ± 0.04 (*n* = 221)

E_0 = pre-exposure, E_1 = post-video, E_2 = post-lecture and lab

Table 3. Paired *t*-test, mean difference, and significance of change.

Question	Exposures	*n*	Mean difference (SD)	*t*-value
Q1	$E_0 - E_1$	121	0.18 (0.43)	4.67***
	$E_1 - E_2$	112	−0.54 (0.35)	−1.62
	$E_0 - E_2$	152	0.13 (0.53)	2.90**
Q2	$E_0 - E_1$	185	0.33 (0.60)	7.44***
	$E_1 - E_2$	174	0.40 (0.50)	1.07
	$E_0 - E_2$	155	0.38 (0.61)	7.82***
Q3	$E_0 - E_1$	188	0.18 (0.50)	4.79***
	$E_1 - E_2$	178	0.39 (0.36)	1.46
	$E_0 - E_2$	162	0.18 (0.52)	4.37***
Q4	$E_0 - E_1$	194	0.17 (0.48)	4.77***
	$E_1 - E_2$	176	0.51 (0.42)	1.62
	$E_0 - E_2$	168	0.22 (0.54)	5.28***

Note: E_0 = pre-exposure, E_1 = post-video, E_2 = post-lecture and lab.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$ (two-tailed test).

differences and are instead explained by cultural differences (Q4). The fallacy that multiple biological traits can consistently be used to predict race (Q2) showed the greatest magnitude of positive change in understanding of all concepts.

○ Discussion

It is clear that students in this course were capable of changing their minds about race as biology but that work is still needed to address certain key concepts about the "biological race" myth. As results indicate, the idea that we cannot use suites of biological traits to reliably assign individuals to racial groupings (Q2) was a sticking point. Despite an overall 38 percent change in understanding (E_0 to E_2), only 74 percent (E_1) to 78 percent (E_2) of students could recognize the fallacy presented in Q2, as opposed to the 84 percent to 90 percent of students who recognized the fallacies presented in Q1, Q3, and Q4. These findings are to be expected. In casual conversation and from qualitative responses on labs and in-class reflective assignments, students often remarked it is "obvious" that single traits do not define racial groups. In contrast, most students still struggled with their assumptions that "racial traits" covary because phenotypic traits (what we can see) are more varied than our underlying genes. These visible differences allow students to feel they are certain in how they combine traits to determine racial differences, as long as they are allowed to choose the traits. The challenge for students lies in fully conceptualizing why the differences they see are subjective and, therefore, not consistent from person to person (Goodman et al., 2012).

This study found a statistically significant change in students' understanding of four common misconceptions about race after a single exposure to content (E_0 to E_2), with no significant change after a second exposure (E_1 to E_2). These results, therefore, suggest that a single exposure to content might lead to a significant change in understanding. Although these results could be unique to the particular course being studied, it is worth reconsidering common arguments against teaching (especially sensitive) concepts for which there is not adequate time. Likewise, the first exposure for students in this study was a video; therefore, those who are not yet comfortable teaching about these sensitive topics could opt to use this resource and have students complete a reflective activity in lieu of a lecture and/or in-class discussion.

It is promising that students exhibited similar rates of understanding that race is a "cultural" construct and specific details of why race is not biologically rooted. Still, there is a tendency for students to assume that, if race is *not* biological, it is not real (e.g., Omi, 2010). Though not tested in the present study, students in this course go on to explore racism and its effects once the common myths have been debunked. For example, students examine how racism affects health in terms of differential access to healthcare (e.g., Rylko-Bauer & Farmer, 2002), elevated stress levels (e.g., Madrigal et al., 2009), and even doctors' perceptions of their patients (e.g., Hoffman et al., 2016), but not because of innate biological differences in susceptibility to disease (e.g., Goodman, 2000). A discussion of the differences between genetic ancestry and race can also illustrate why genes do matter in health, but are not linked to "races" of people (Yudell et al., 2016). Hubbard (in press) provides a complete overview of the approached used.

While controversial topics can be a challenge to incorporate into introductory courses, considerable research suggests this is an excellent time to do so given that: (1) problem-based examples and socially relevant applications of materials promote better understanding of science (Kesselman et al., 2015); (2) engaging students in critical thinking activities enhances citizenship and challenges students to consider applications of the materials learned in class (Kolstø, 2001); (3) this topic reinforces key concepts in biology such as the nature of genetic variation, while debunking common myths based on lived experience (Fuentes, 2012); (4) such discussions promote and support diversity in the STEM classroom (e.g., Hodson, 1993; Johnson, 2007); and

(5) faculty who share personal struggles with racism can connect to students through shared experiences (e.g., Olitsky, 2007).

Limitations and Areas for Future Research

The present study examines student understanding of core concepts about human biological and genetic variation that negate the concept of "biological races" in an introductory natural science course. The present dataset did not allow an exploration of how specific content (e.g., video or lecture) influenced understanding of each concept. Additionally, because data were collected immediately prior to content exposure, "true" starting understanding is not known. Subsequent first-day polling in the same course show that starting percentages for all four questions are lower; therefore, the significance of change reported here may be conservative. Future research could explore: (1) pre-exposure knowledge (e.g., other coursework on the subject), (2) the effects of variables such as student rankings, GPA, and/or attendance, (3) long-term retention of such information, or (4) qualitative responses during lab.

○ Why You Should Teach About Race

One course cannot serve to debunk all aspects of one of the most pervasive scientific misconceptions in our society; however, one course can serve as a catalyst for continued learning. Although it is not possible to fully address the historical events that have led humans to very recently develop such ideas or to address all aspects of systemic racism in an introductory biology course, this introduction can be the starting point for students to consider how race affects society and motivate them to explore such ideas further. As noted earlier, those teaching pre-med or health science courses can use health-based examples to impart the importance of exploring such topics in the future. In this course, the inclusion of race made the classroom "safe" for discussions of diversity and challenged students to recognize that biological science has real-life, important applications. Based on comments through student evaluations, students of color were also more likely to report feeling more comfortable in the classroom because these issues were addressed. It is critical that biologically based college courses begin to explicitly debunk the core tenets of the biological race concept and eliminate public perceptions that racial behaviors are innate, as the sensitive topics we avoid in the classroom become the significant problems we avoid in our communities.

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