

Cross-Sectional and Longitudinal Disparities in STEM Career Aspirations at the Intersection of Gender, Race/Ethnicity, and Socioeconomic Status

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Analyzing the nationally representative High School Longitudinal Study of 2009 (HSLs:09), this study examined the cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status (SES). Results indicated that female, Black, Hispanic, and low SES students were less likely to show, maintain, and develop an interest in STEM careers during high school years. Compared with White boys from higher SES background, girls from all racial/ethnic and SES groups, as well as Black and Hispanic boys from lower SES groups, consistently had lower rates of interest, persistence, and developing an interest in STEM fields.

Keywords: adolescence; career aspiration; intersectionality; longitudinal studies; observational research; regression analyses; STEM disparities

Attracting young talents from all sociodemographic backgrounds to participate in science, technology, engineering, and mathematics (STEM) fields has been a national priority of the United States for ensuring equity and diversity in STEM workforce while maintaining a competitive edge in the global economy (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011). Recent statistics, however, showed that women, Blacks and Hispanics, and youth with lower socioeconomic status (SES) continue to be seriously underrepresented in STEM education and occupations (National Science Foundation, 2017). Prior research has demonstrated that STEM career aspirations in adolescence were one of the primary determinants of disparities in STEM degree attainment (Legewie & DiPrete, 2014; Tai, Liu, Maltese, & Fan, 2006), an important qualification for entering STEM professions. Adolescents' career aspirations have also been found to be fluid over time (Creed, Tilbury, Buys, & Crawford, 2011; Rojewski, 1997). Curiously, little attention has been paid to the research on the (in)stability of STEM career aspirations among young students, which could be a critical early indicator for monitoring and addressing the disparities in STEM education and employment.¹

This study fills the gap by investigating the cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and SES using the

nationally representative High School Longitudinal Study of 2009 (HSLs:09; $n = 20,242$; for more information about the sample and sociodemographic measures, see Appendix A). In the first two waves of the HSLs:09 (in early 9th grade and late 11th grade), students who reported the occupation they expected to have at age 30 in life and physical science, engineering, mathematics, architecture, or information technology industries were identified as having *STEM career aspirations* (a dichotomous variable). Among students who aspired to STEM careers in early 9th grade, those who maintained their aspirations through late 11th grade were identified as *persisters*. Among those students who were not interested in a STEM career in early 9th grade, those who turned their interest to STEM jobs were identified as *emergers*. We estimate linear probability models to quantify the magnitudes of sociodemographic differences—raw gaps at the population level—in STEM career aspirations. All estimates were weighted by corresponding cross-sectional or longitudinal analytic weights (i.e., W1STUDENT and W2W1STU) provided by the National Center for Education Statistics (NCES) such that the results can be generalized to the population of first-time 9th graders in the United States in fall 2009. When

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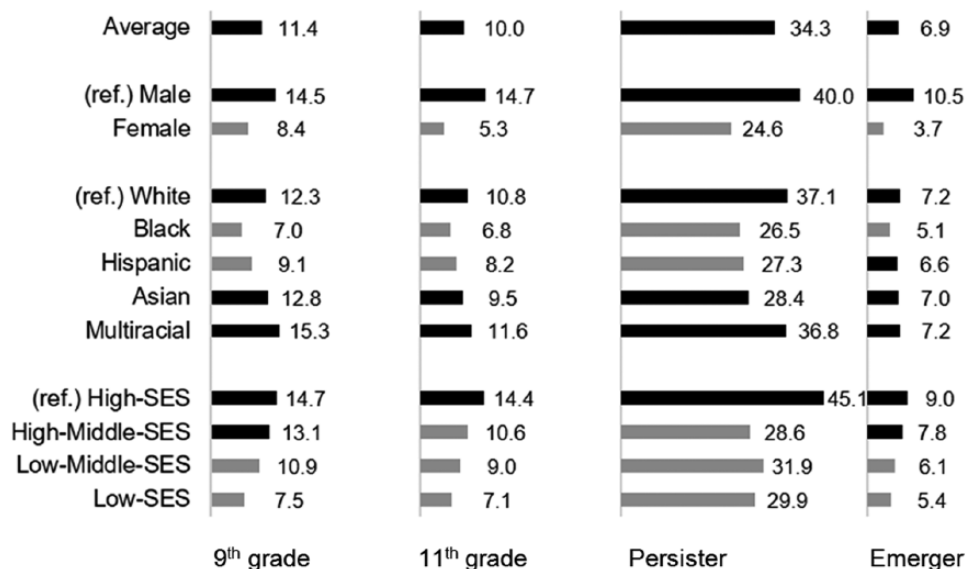


FIGURE 1. *Disparities and changes in STEM career aspirations among high school students by gender, race/ethnicity, and socioeconomic status (%)*.

Note. Black bars indicate no statistically significant differences from the reference groups, whereas gray bars indicate statistically significant differences from the reference groups ($p < .05$). ref. = reference group; SES = socioeconomic status.

determining the significance of the group differences, robust standard errors were computed and used to address potential heteroscedasticity.

Singular Disparities by Sociodemographic Groups

Among first-time 9th graders in fall 2009, only about 11.4% of students were interested in pursuing a STEM career upon entering high school (see Figure 1). The percentage declined slightly to 10.0% for the same cohort of students after they spent their first three years in high school. Of those who aspired to a career in STEM in early 9th grade, only about 34.3% maintained their interest until late 11th grade (or persisters). Interestingly, about 6.9% students (or emergers) who initially did not aspire to STEM careers developed an interest three years after enrolling in high school. Although the persistence and emergence rates are fairly low, the absolute numbers of nonpersisters (unweighted 1,272 out of 1,988) and emergers (unweighted 1,132 out of 14,941) are more or less identical, which explains the quite stable rates of STEM career aspirations among high school students over time.

As shown in Figure 1 (for regression estimates, see Appendix Table B1), considerable cross-sectional and longitudinal disparities in STEM career aspirations existed among gender, racial/ethnic, and SES groups. Gender and SES gaps in STEM career aspirations appear to be widening over time, whereas the racial/ethnic gaps seem to be closing. At the beginning of 9th grade, about 14.5% of boys and 8.4% of girls were interested in a STEM career (a 6.1% gap). At the end of 11th grade, the corresponding percentages were 14.7% and 5.3%, suggesting that the gender gap grew to 9.4 percentage points. The growing gender gap resulted from the lower percentage of persisters (24.6%) as well as the lower percentage of emergers (3.7%) among girls throughout the first three years of high school. For boys, the corresponding percentages were 40.0% and 10.5%.

Although racial/ethnic disparities in STEM career aspirations were more complex, three notable patterns emerged. First, the rates of interest in STEM professions dropped slightly for all racial/ethnic groups (ranging from 0.9% for Hispanics to 3.7% for multiracial students), except for Blacks. Second, Black and Hispanic students consistently had significantly lower rates of interest (both in early 9th grade and late 11th grade) and persistence in STEM professions. At the end of 11th grade, for example, while 10.8% of Whites, 9.5% of Asians, and 11.6% of multiracial students aspired to a career in STEM, only 6.8% of Blacks and 8.2% of Hispanics did. Third, interestingly, among those who previously were not interested in STEM fields, students from all racial/ethnic backgrounds, except Blacks (5.1%), gained interest in STEM jobs at a similar rate (about 7%) after spending three years in high school.

The patterns of SES disparities were clear and quite consistent across multiple indicators of cross-sectional and longitudinal STEM career aspirations. Students with lower SES were less likely to aspire to a STEM career at the start and toward the end of high school. In late 11th grade, for instance, while about 14.4% of high SES students aspired to pursue a career in STEM, only 10.6% of high-middle SES, 9.0% of low-middle SES, and 7.1% of low SES students did. From a longitudinal perspective, students from the two lower SES groups—low-middle and low SES groups—had significantly fewer persisters (31.9% and 29.9%) and emergers (6.1% and 5.4%) than their high SES peers (45.1% and 9.0%, respectively).

Intersectional Disparities by Sociodemographic Groups

When examining the intersection of gender, race/ethnicity, and SES, the picture of disparities in STEM career aspirations among high school students is expected to be even more complicated, both cross-sectionally and longitudinally. To simplify and achieve sufficient statistical power for multigroup comparisons,

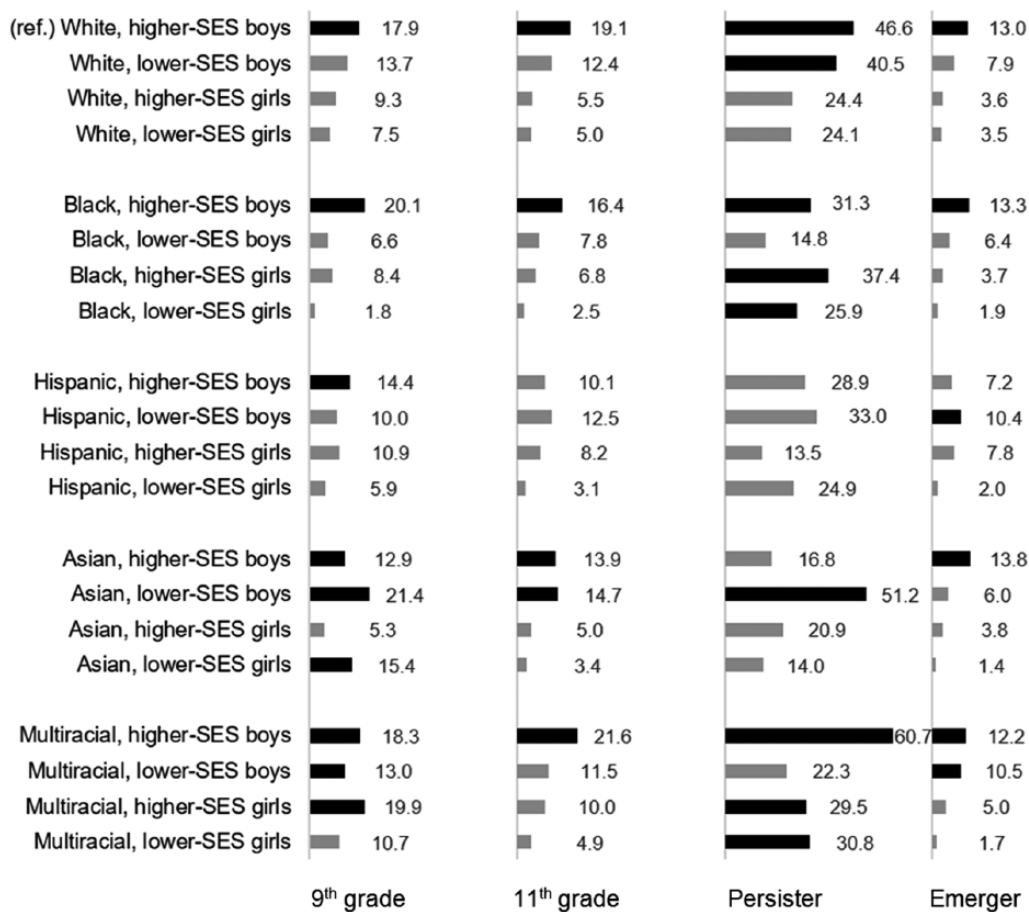


FIGURE 2. *Disparities and changes in STEM career aspirations among high school students at the intersection of gender, race/ethnicity, and socioeconomic status (%)*.

Note. Black bars indicate no statistically significant differences from the reference groups, whereas gray bars indicate statistically significant differences from the reference groups ($p < .05$). ref. = reference group; SES = socioeconomic status.

we constructed only two SES groups—higher SES (combining high and high-middle SES) versus lower SES (combining low and low-middle SES)—to intersect with two gender groups and five racial/ethnic groups, creating 20 gender-by-race/ethnicity-by-SES subgroups (Appendix Table B2 reports sample sizes for each intersectional group used for analyses of each outcome).

The gaps in STEM career aspirations between White, higher SES boys (reference group for this second set of analyses) and some of their counterparts from other intersectional groups were strikingly large and widening over time (see Figure 2; Appendix Table B3 reports regression estimates). For example, while 17.9% of White boys from higher SES families aspired to a career in STEM upon entering high school, only 1.8% of Black girls from lower SES families did (a 16.1% gap). From high school freshman to junior year, the gaps in STEM career aspirations between White boys from higher SES households and girls from all racial/ethnic groups, regardless of their SES, on average grew by 6.6 percentage points. In terms of persisters, whereas nearly half of White boys from higher SES families (46.6%) who initially had a career interest in STEM maintained their interest, only about 14.0% of Black boys from lower SES group, Hispanic girls from higher SES group, and Asian girls from lower SES group did.

For Whites, the patterns of cross-sectional and longitudinal disparities in STEM career aspirations across gender and SES groups were prominent and consistent. In particular, higher SES boys reported the highest rates of all four indicators of STEM career aspirations, followed by lower SES boys, higher SES girls, and lower SES girls. No clear-cut patterns emerged when analyzing the differences in STEM career aspirations across gender and SES groups for Black, Hispanic, Asian, and multiracial students. Nevertheless, several findings deserve mention. First, compared with their White counterparts (interracial but intragender and intra-SES comparisons), higher SES boys from Black, Asian, and multiracial groups showed similar levels of STEM career aspirations in nearly all indicators, except that higher SES boys from the Hispanic group reported lower levels of career aspirations in STEM in those indicators. Second, compared with their White high SES peers (intra-gender but interracial and inter-SES comparisons), Asian boys, though raised in lower SES households, had comparable rates of STEM career aspirations, unlike Black, Hispanic, and multiracial boys from lower SES families who consistently had significantly lower rates of all four indicators. Third, compared with White higher SES boys, girls from Black, Hispanic, Asian, and multiracial groups, regardless of their SES, had significantly lower rates of almost all four indicators of STEM career aspirations in high school.

Discussion

This study makes a number of practical, theoretical, and methodological contributions to the STEM literature. It is the first to document the disparities and changes in STEM career aspirations among high school students by gender, race/ethnicity, and SES, using a nationally representative sample. The cross-sectional findings indicate that traditionally STEM-underrepresented groups including female, Black, Hispanic, and low SES students reported significantly lower levels of career interest in STEM upon entering and toward the end of high school. Longitudinally, they are also less likely to maintain their aspirations (persisters) or develop an interest (emergers) in STEM careers during the first three years of high school. The intersectional analyses reveal that girls from all racial/ethnic and SES groups as well as lower SES boys from both Black and Hispanic groups consistently had significantly lower rates of interest (both in early and late high school), persistence, and developing an interest in STEM fields. Taken together, these results highlight that to tackle the enduring STEM diversity and equity issues, it is pressing to develop and maintain career interests in STEM for adolescents from underrepresented groups, particularly those who have dual or triple underrepresented statuses.

Our results also demonstrate the prevalence of instability of STEM career aspirations among adolescents from all sociodemographic backgrounds. In the research literature, students' STEM career aspiration, sometimes operationalized as "intent to major in STEM," is one key construct (often serves as a predictor or a proximal outcome) of most motivational theories such as expectancy-value theory (e.g., Lauermann, Tsai, & Eccles, 2017; Riegle-Crumb, Moore, & Ramos-Wada, 2011) and social cognitive career theory (e.g., Lent et al., 2003; Mau, 2003) that are widely used in research on and intervention for career development and disparities in STEM choices. Our empirical findings on the instability and volatility of STEM career aspirations point to a critical need for conceptualizing and measuring STEM career aspirations over time as a time-variant disposition. In turn, such construct can serve as dynamic motivational factors to better understand and monitor the disparities in STEM participation among young students.

Moving beyond conventional inequality comparisons that are typically based on singular or dual sociodemographic characteristics, this study represents the first large-scale analysis examining the disparities and changes in STEM career aspirations at the intersection of gender, race/ethnicity, and SES. In contrast to the "additive" approach where individuals' social statuses are each analyzed separately and their advantages or disadvantages are viewed as increasing with the addition of each status, our intersectional approach illustrates and highlights the unique cross-sectional and longitudinal disparities in STEM career aspirations among young students, created by the integration of multiple social statuses. Future research should explore how social systems and contexts shape these intersectional inequalities over time (Alexander, Johnson, & Kelley, 2012; Núñez, 2014), which will offer informative evidence for policymaking or designing interventions that can improve the STEM participation of particularly underrepresented subpopulations (e.g., Black lower SES girls and Hispanic lower SES boys).

NOTES

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¹Two previous studies explored the stability and volatility of career aspirations in STEM over time among young students (Mau, 2003; Sadler, Sonnert, Hazari, & Tai, 2012). Analyzing the National Educational Longitudinal Survey of 1988, Mau (2003) documented that only 22% of eighth graders who aspired to science and engineering (SE) professions retained their career aspirations six years later. Mau's analyses further showed that boys were more likely than girls to persist in their SE career aspirations, whereas no significant differences among racial/ethnic groups were observed. In a recent study, Sadler et al. (2012) analyzed the changes in STEM career interests during high school among about 6,000 college students and found that the percentage of boys interested in a STEM career remained stable at about 40%, while the rate declined from 15.7% to 12.7% for girls. For male students, the stability of STEM career aspirations was a result of offsetting numbers of those who gained and lost interest in STEM. For female students, the exit rate was higher, yet the entrance rate was lower than their male counterparts. Although their findings are informative, the two studies are limited in many ways. Mau's analysis used a sample of students attending secondary schools three decades ago, and his constructed SE category excluded the professions of mathematics and technology, which are popular STEM fields recently. Sadler and colleagues studied a cohort of postsecondary students from 34 institutions with retrospective measures. The generalizability of their findings was limited, and their estimates were likely to be subjected to retrospective bias.

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Appendix A

Sample and Sociodemographic Measures

The data source of this study is the High School Longitudinal Study of 2009 (HSLS:09), conducted by the National Center for Education Statistics (NCES). HSLS:09 began with a nationally representative sample of ninth graders in fall 2009 (21,444 students from 944 schools) and followed them through postsecondary education. The sample involves students from different sociodemographic backgrounds, defined by gender (male or female), race/ethnicity (White, Black, Hispanic, Asian, multiracial, or other), and SES (divided into four quartiles based on a composite score of parental education, occupations, and income). Black included African American; Hispanic included Latino (all Hispanic respondents were placed in the Hispanic category regardless of race); other race/ethnicity included American Indian or Alaska Native, Pacific Islander or Native Hawaiian. Race categories excluded Hispanic origin. Our analytic sample is restricted to first-time 9th-graders, whose information on their career aspirations is available in at least one of the two survey rounds ($n = 20,242$).

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Table B1
Disparities and Changes in STEM Career Aspirations Among High School Students by Gender, Race/Ethnicity, and Socioeconomic Status

	9 th Grade		11 th Grade		Persister		Emerger	
	<i>n</i> = 19,633		<i>n</i> = 17,421		<i>n</i> = 1,988		<i>n</i> = 14,941	
	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>
Panel 1: Gender								
Male (<i>ref.</i>)	.145	(.005)	.147	(.006)	.400	(.020)	.105	(.006)
Female	−.061***	(.007)	−.094***	(.007)	−.154***	(.032)	−.068***	(.007)
Panel 2: Race/ethnicity ^a								
White (<i>ref.</i>)	.126	(.004)	.111	(.004)	.374	(.018)	.073	(.003)
Black	−.053***	(.010)	−.040***	(.010)	−.106†	(.061)	−.021*	(.009)
Hispanic	−.032**	(.009)	−.026*	(.011)	−.098*	(.047)	−.006	(.012)
Asian	.005	(.018)	−.013	(.014)	−.087	(.075)	−.002	(.011)
Multiracial	.030	(.021)	.008	(.013)	−.003	(.069)	.000	(.010)
Panel 3: Socioeconomic status								
High (<i>ref.</i>)	.148	(.007)	.144	(.007)	.453	(.028)	.090	(.006)
High-middle	−.016	(.011)	−.038***	(.010)	−.165***	(.042)	−.012	(.008)
Low-middle	−.038***	(.010)	−.054***	(.009)	−.132**	(.041)	−.029**	(.008)
Low	−.072***	(.009)	−.073***	(.011)	−.152**	(.049)	−.036***	(.010)

Note. *ref.* = reference group (intercept in regression). Each column of each panel reports results from a regression model estimating the mean differences among specific sociodemographic groups. Data were weighted to be generalizable to the population of 9th-grade students in 2009 in the United States. Robust standard errors are reported in parentheses.

^aThere were a small number of students (*n* = 250) whose racial status was identified as “other,” including non-Hispanic American Indian, Alaska Native, Native Hawaiian, and Pacific Islander. They were included in the regression models as a separate group but the results are not reported here.

†*p* < .1. **p* < .05. ***p* < .01. ****p* < .001.

Table B2
Sample Size by Sociodemographic Characteristics and STEM Career Aspirations

	9 th Grade		11 th Grade		Persister		Emerger	
	<i>n</i>	Yes	<i>n</i>	Yes	<i>n</i>	Yes	<i>n</i>	Yes
Gender								
Male	9,793	1,459	8,646	1,355	1,290	538	7,066	782
Female	9,840	797	8,775	540	698	178	7,875	350
Race/ethnicity ^a								
White	11,038	1,357	9,885	1,133	1,204	461	8,438	646
Black	1,892	170	1,692	142	149	44	1,471	87
Hispanic	3,164	311	2,724	238	266	72	2,368	164
Asian	1,550	179	1,390	169	155	54	1,199	110
Multiracial	1,749	218	1,536	189	198	79	1,296	109
Socioeconomic status								
High	5,134	735	4,746	683	668	295	3,966	371
High-middle	5,022	583	4,442	508	516	171	3,827	329
Low-middle	4,856	550	4,248	411	472	155	3,656	247
Low	4,621	388	3,985	293	332	95	3,492	185
Intersectional groups ^a								
White, higher SES boys	3,258	592	2,938	573	526	246	2,330	312
White, lower SES boys	2,264	335	1,976	255	282	112	1,636	136
White, higher SES girls	3,216	286	2,943	197	253	70	2,637	125
White, lower SES girls	2,300	166	2,028	108	143	33	1,835	74
Black, higher SES boys	402	67	370	53	60	20	299	33
Black, lower SES boys	544	53	486	45	44	11	402	27
Black, higher SES girls	393	32	353	27	28	11	318	14
Black, lower SES girls	553	18	483	17	17	<10	452	13
Hispanic, higher SES boys	415	55	362	56	48	18	307	38
Hispanic, lower SES boys	1,144	120	960	103	103	33	817	68
Hispanic, higher SES girls	467	50	420	38	47	10	360	28
Hispanic, lower SES girls	1,138	86	982	41	68	11	884	30
Asian, higher SES boys	497	65	455	79	60	18	382	60
Asian, lower SES boys	275	53	237	41	44	20	189	21
Asian, higher SES girls	516	40	468	36	32	11	424	22
Asian, lower SES girls	262	21	230	13	19	<10	204	<10
Multiracial, higher SES boys	453	82	405	82	77	43	318	38
Multiracial, lower SES boys	417	46	356	51	37	13	302	38
Multiracial, higher SES girls	436	46	389	35	43	14	343	21
Multiracial, lower SES girls	443	44	386	21	41	<10	333	12
Number of observations	19,633		17,421		1,988		14,941	

Note. SES = socioeconomic status. NCES requires the rounding of unweighted sample size numbers to the nearest 10 that provides disclosure protection while giving the reader a sense of the “power” of the underlying sample.

^aThere were a small number of students ($n = 250$) whose racial status was identified as “other,” including non-Hispanic American Indian, Alaska Native, Native Hawaiian, and Pacific Islander.

Table B3
Disparities and Changes in STEM Career Aspirations Among High School Students at the
Intersection of Gender, Race/Ethnicity, and Socioeconomic Status

	9 th Grade		11 th Grade		Persister		Emerger	
	<i>n</i> = 19,633		<i>n</i> = 17,421		<i>n</i> = 1,988		<i>n</i> = 14,941	
	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>	<i>b</i>	<i>SE</i>
White, higher SES boys (<i>ref.</i>)	.179	(.009)	.191	(.010)	.466	(.030)	.130	(.009)
White, lower SES boys	-.037**	(.012)	-.063***	(.013)	-.062	(.048)	-.047***	(.012)
White, higher SES girls	-.081***	(.011)	-.132***	(.011)	-.223***	(.044)	-.090***	(.010)
White, lower SES girls	-.099***	(.011)	-.137***	(.011)	-.226***	(.055)	-.091***	(.010)
Black, higher SES boys	.027	(.040)	-.023	(.032)	-.154	(.099)	.007	(.032)
Black, lower SES boys	-.108***	(.018)	-.109***	(.021)	-.319***	(.071)	-.062**	(.023)
Black, higher SES girls	-.090***	(.025)	-.119***	(.024)	-.093	(.150)	-.089***	(.018)
Black, lower SES girls	-.156***	(.011)	-.162***	(.013)	-.208	(.184)	-.107***	(.012)
Hispanic, higher SES boys	-.030	(.034)	-.086**	(.025)	-.178†	(.107)	-.054*	(.023)
Hispanic, lower SES boys	-.074***	(.016)	-.062*	(.025)	-.137†	(.072)	-.022	(.027)
Hispanic, higher SES girls	-.065*	(.027)	-.105***	(.023)	-.332***	(.074)	-.048*	(.024)
Hispanic, lower SES girls	-.115***	(.014)	-.156***	(.013)	-.218*	(.105)	-.106***	(.011)
Asian, higher SES boys	-.045	(.029)	-.048	(.027)	-.299***	(.062)	.012	(.029)
Asian, lower SES boys	.040	(.048)	-.040	(.046)	.045	(.143)	-.066**	(.021)
Asian, higher SES girls	-.121***	(.017)	-.137***	(.019)	-.258*	(.102)	-.088***	(.019)
Asian, lower SES girls	-.020	(.060)	-.153***	(.018)	-.327**	(.099)	-.112***	(.012)
Multiracial, higher SES boys	.009	(.029)	.029	(.033)	.140	(.086)	-.004	(.028)
Multiracial, lower SES boys	-.044	(.031)	-.072**	(.025)	-.244**	(.091)	-.021	(.026)
Multiracial, higher SES girls	.025	(.070)	-.087**	(.026)	-.172	(.147)	-.076***	(.018)
Multiracial, lower SES girls	-.067**	(.024)	-.138***	(.021)	-.159	(.123)	-.109***	(.011)

Note. SES = socioeconomic status; *ref.* = reference group (intercept in regression). Data were weighted to be generalizable to the population of 9th-grade students in 2009 in the United States. Robust standard errors are reported in parentheses.

^aThere were a small number of students (*n* = 250) whose racial status was identified as “other,” including non-Hispanic American Indian, Alaska Native, Native Hawaiian, and Pacific Islander. They were included in the regression models as a separate group but the results are not reported here.

†*p* < .1. **p* < .05. ***p* < .01. ****p* < .001.