WHAT CAN WE LEARN ABOUT DIVERSITY FROM STATISTICS ON ACOUSTICS?

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Concerns about diversity in the acoustics community have recently led to the formation of the Committee on Diversity in Acoustics (CDA). The CDA held its first meeting on May 21, 2009, at the 157th Acoustical Society of America (ASA) meeting in Portland, Oregon. This committee was formed to explore and propose activities designed to attract members of underrepresented groups to the profession of acoustics and to encourage underrepresented members to join the ASA.[1] At that meeting, the CDA held a joint session ("Diversity Issues in Education in Acoustics") with the Education Committee. We presented this information as a talk at the session and are pleased to share our findings more broadly through *Acoustics Today*. We will examine both gender and ethnic diversity in fields traditionally associated with acoustics, and we will compare our findings with ASA demographics where available.

"Is this low representation among women simply a reflection of the academic disciplines associated with ASA members?"

Gender diversity in acoustics

A profile of the ASA membership reports that 15.2% of ASA members are women.[2] We ask, "Is this low representation among women simply a reflection of the academic disciplines associated with ASA members?"

Less than one-sixth of the members of ASA report that the subject of their highest degree is acoustics. Table 1 shows the data for the fifteen academic fields that are most commonly listed as the subject of the member's highest degree. These fields account for over 92% of all ASA members. The top four fields, which account for almost 60% of the membership, are academic areas that have traditionally exhibited small numbers of women earning degrees relative to men.[4] As the data in Table 2 reveal, most of these fields awarded more than 15% of their degrees to women. We use a three-year average to smooth out any year-to-year variability in small fields, and we look at the most recent data (2005 through 2007) and data from ten years earlier to look for changes over time. We see that the representation of women in physics and engineering has increased in the last ten years, but it is still low compared to other subjects.

Almost all of these fields exhibit an increase in the proportion of women earning degrees between 1995–97 and 2005–07, but there is quite a bit of variation across fields, from a low of 11 to 12% in mechanical engineering to a high of about 95% in audiology. We take a weighted average of the proportion of all degrees awarded to women (weighted by percent of ASA membership[6]) and find that about 32% of the

Table 1: Subject of Highest Degree of ASA Members[3]

Subject of Highest Degree	Percent of Members
Physics	17.7
Acoustics	15.7
Electrical Engineering	14.1
Mechanical Engineering	11.2
Psychology	6.4
Speech	5.3
Other Engineering	5.2
Audiology	4.7
Linguistics	3.0
Math / Computer	2.8
Physiology	1.6
Architecture	1.5
Oceanography	1.3
Geophysics	1.1
Music	1.0
Other Fields	7.4

Table 2: Percent of All Degrees Awarded to Women, by Subject, 1995–1997 & 2005–2007[5]

	% of All Degrees Awarded to Women	
Subject	1995 – 1997	2005 – 2007
Physics	17.4	22.2
Acoustics	17.4	22.2
Electrical Engineering	12.4	15.5
Mechanical Engineering	11.3	12.7
Psychology	72.9	77.7
Speech	62.8	66.2
Other Engineering	21.5	24.7
Audiology	94.1	95.3
Linguistics	67.1	69.3
Math / Computer	35.2	27.6
Physiology	48.6	56.2
Architecture	38.3	44.5
Oceanography	33.8	43.2
Geophysics	33.8	43.2
Music	49.3	46.5
Other Fields	56.0	58.8

degree recipients in these fields in the 1995–97 time period were women; by 2005–07, it had increased to almost 36%. Thus, we would expect about one-third of ASA members to be women. However, given that less than one-sixth of ASA members are women, perhaps we are overlooking other factors that can explain this discrepancy.

The age distribution of ASA's members might explain the low representation of women in ASA. Over one-half of the members of ASA are 50 years old or older. We would expect the graduates from 1995–97 to have an average age between thirty-five and forty years old and those from 2005–2007 to be between twenty-five and thirty, on average. Only 9% of ASA members are under age 30 (the 2005–07 graduates); 18% are between 30 and 39. Just as the proportion of women earning degrees increased from the mid-1990s to the mid-2000s, it also increased in the years prior to the mid-1990s. So, the proportion of the older ASA members who are women would be less than one-third.

Adjusting for the age distribution of the membership reduces the proportion of members expected to be women to about 23%. The age distribution apparently explains some of the difference between the proportion of ASA members we would expect to be women and those that *are* women; however, there is still a fairly significant gap between the 23% women we expect to find and the 15% women that we do find.

Are we overlooking other factors that could account for this apparent disparity? Yes, most ASA members have earned an advanced degree, and a lower proportion of women earn advanced degrees rather than bachelor's degrees. About two-thirds of ASA members have earned a doctorate; 18% have a master's degree, and about 11% hold a bachelor's degree as their highest degree. Table 3 shows the proportion of women earning degrees in the various fields by highest degree for 1995–97 and 2005–2007. In almost every case, the proportion of women earning doctorates in a subject is lower than the proportion earning bachelor's degrees. While the numbers are closer to parity in the more recent data, we see that the trend persists—fewer women than men earn higher degrees.

Table 4 shows the percent of all degrees awarded to women by subject area after adjusting for the degree distribution of ASA members. For physics, for example, the 14.7% of degrees awarded to women is a weighted average of the proportion doctorates, master's, and bachelor's degrees awarded to women using the degree distribution profile of ASA members. We see that almost every data point in Table 4 is lower than the corresponding data shown in Table 2. (The data in Table 2 have not been weighted by highest degree.) Perhaps accounting for both the age distribution and the highest degree distribution among ASA members will explain the seemingly low representation of women.

However, adjusting by subject, by age distribution, and by highest degree suggests that about 19% of ASA's members should be women. Only 15.2% are women. Is it possible that this remaining difference is just noise and not significant?

A statistical test for the difference between two proportions suggests that this difference is significant. In fact, the statistical test suggests that there is almost no chance that this difference is just noise; the p-value is less than 0.01. If we randomly selected 7,000 people (the approximate number of members in ASA) from a pool of people who mirrored ASA's membership with respect to age, highest degree, and subject of highest degree, we would get 15.2% females (or fewer) less than twice in $1*10^9$ draws.

Although the difference is statistically significant, it should be noted that our analysis uses only U.S. degree recipients. However, some ASA members have earned their degrees abroad. In addition, about one-third of ASA members reside outside the U.S. and only a small number of these members will have earned degrees in U.S. Since we are using data from U.S. institutions only, we cannot account for the international segments—neither the international degree recipients nor the international members—in this analysis. This is a source of error that our analysis cannot reduce.

This analysis also does not tell us the reasons for the lower than expected representation of women in ASA. Perhaps women with degrees in these disciplines are less likely to go into acoustics than into other fields, and the ASA membership is just a reflection of

Table 3: Percent of by Subject & Highest Degree, 1995 – 97 & 2005 – 2007[7]
All Degrees Awarded to Women,
by Subject & Highest Degree, 1995 – 97 & 2005 – 20077

	% of Degrees Awarded to Women			
Subject	1995 – 1997		2005 – 2007	
	Doctorate	Bachelor's	Doctorate	Bachelor's
Physics	13.3	19.0	18.3	22.3
Acoustics	13.3	19.0	18.3	22.3
Electrical Engineering	10.0	12.1	14.6	13.3
Mechanical Engineering	7.5	11.6	12.7	12.6
Psychology	65.6	73.3	72.5	77.6
Speech	57.1	62.3	57.9	65.8
Other Engineering	14.4	23.1	23.7	24.5
Audiology	77.5	94.2	85.7	95.9
Linguistics	53.2	70.5	61.8	69.0
Math / Computer	19.7	34.2	24.7	26.3
Physiology	41.6	80.0	47.6	60.4
Architecture	31.9	35.5	42.3	43.7
Oceanography	22.6	35.6	37.4	42.8
Geophysics	22.6	35.6	37.4	42.8
Music	44.0	49.9	48.1	49.1
Other Fields	40.1	55.3	49.4	57.5

Table 4: Percent of All Degrees Awarded to Women Adjusted to Reflect Highest Degree Distribution in ASA Membership, 1995 – 1997 & 2005 – 2007[8]

	% of All Degrees Awarded to Women	
Subject	1995 – 1997	2005 – 2007
Physics	14.7	20.0
Acoustics	14.7	20.0
Electrical Engineering	10.9	15.4
Mechanical Engineering	8.6	12.8
Psychology	67.9	74.4
Speech	59.7	61.8
Other Engineering	16.5	24.3
Audiology	82.6	88.9
Linguistics	57.7	64.6
Math / Computer	23.4	26.0
Physiology	48.6	49.8
Architecture	34.1	42.9
Oceanography	26.0	39.7
Geophysics	26.0	39.7
Music	46.3	48.9
Other Fields	44.8	52.3

this larger trend. Or does something discourage women from joining ASA, remaining in ASA or, conversely, attract men to ASA in higher numbers than expected?

The Women in Acoustics committee (WIA) was created in 1995. In 1990, five years before the committee was established, less than 10% of ASA members were women; however, women's representation among sub-groups (as defined by the technical sub-group to which a member belongs) varied greatly from the 1% of the members of Engineering Acoustics who were women to the 28% of Speech Communication who were women. Five years after WIA was created, 13.5% of ASA members were women. Women constituted about 4% of the members of the Engineering Acoustics sub-group and one-third of the membership of the Speech Communication sub-group.[9] While the 33% representation of women in Speech Communication looks good relative to women's representation among all members, it is well below the proportion of women earning degrees in speech.

One of the goals of WIA is "to encourage the recruitment of female colleagues to become and remain members of the Society."[10] The data suggest that, while progress has been made, there is still much work to be done.

Ethnic diversity in acoustics

In our questions about the representation of women in acoustics, we examined whether or not the proportion of women among the ASA membership mirrored that of women receiving degrees in subjects traditionally associated with acoustics; we did not explicitly consider the question of whether or not the proportion of women in these fields should mirror that of society. The ASA does not currently maintain data on the ethnicities of its members, so we cannot conduct a comparison between the ethnicities of degree recipients and ASA members as we did with the gender data.

When considering ethnic diversity, we ask a different question: "Does the ethnic diversity in acoustics reflect the ethnic diversity of the population?" Of course, in posing this question, we implicitly assume that the profession should mirror the population as a whole.

The examination of ethnicity in any international organization is complicated by the fact that ethnicity is a *national* construct, but the ASA is an international organization with approximately 30% of its membership residing outside the U.S. At the same time, that does not mean that we should not consider ethnic diversity at all; it means that the issue is very complex. We only have data on the ethnicities of U.S. citizens and permanent residents graduating from U.S. universities; this does not account for the ASA members outside the U.S.[11]

The data we will use to examine this issue also come from the National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS). Ethnicity is collected for U.S. citizens and permanent residents only. As shown in Figure 1, over 60% of doctoral degree recipients in some subjects typically associated with acoustics are foreign nationals attending U.S. schools as temporary residents of the U.S. Temporary residents account for a large portion of the doctorates in physics and the two engineering specialties; ethnicity data is not available for temporary residents. A high proportion of ASA members report their highest degree is in physics (including acoustics), electrical engineering, and mechanical engineering, and a high proportion

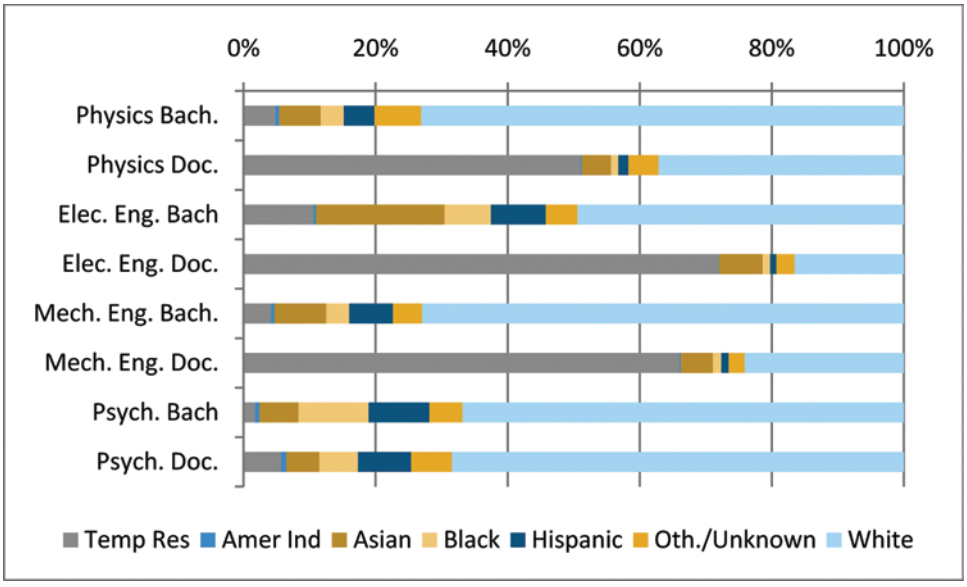

Fig. 1. Residency and Ethnicity of Degree Recipients in Selected Subjects: 2005–2007.

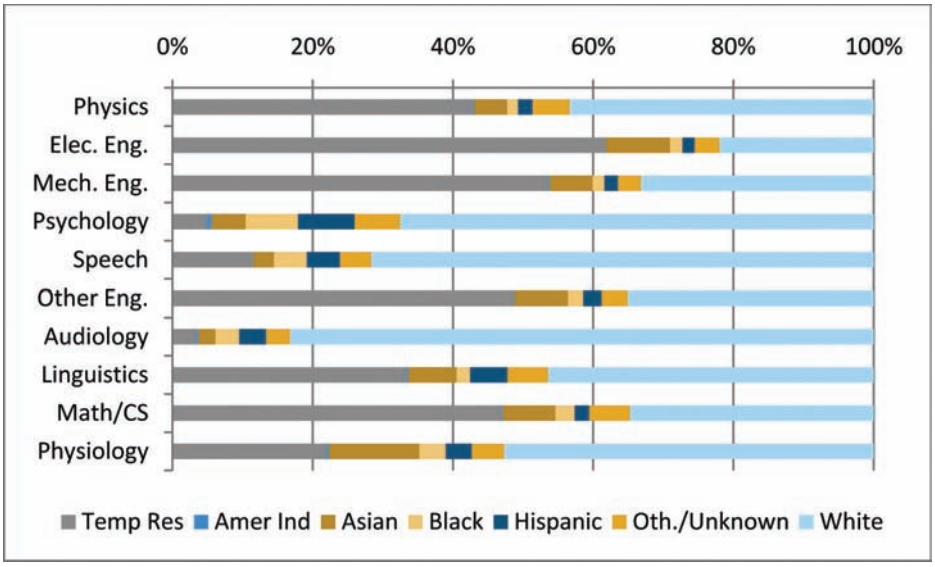

Fig. 2. Residency and Ethnicity of Degree Recipients in Selected Subjects, Weighted by Highest Degree to Reflect ASA Membership, 2005–2007.

of ASA members have earned doctorates. Given the high proportion of temporary residents among doctoral degree recipients in physics and engineering, we calculate that about 40% of the degree recipients whose characteristics match the ASA membership profile (by highest degree and subject) are foreign nationals. Thus, we have ethnicity data only for about 60% of the degree recipient pool.

Figure 2 shows the residency and ethnicities of degree recipients in subjects traditionally associated with acoustics for 2005–2007; these data have been weighted by highest degree to reflect the degree distribution among ASA members. We see that the proportion of temporary residents varies widely by subject.

If we consider only U.S. citizens and permanent residents earning degrees in these subjects, we can examine the ethnicities of these degree recipients. Figure 3 includes only U.S. citizens in selected fields in 2005–2007. The difference between Figures 2 and 3 is that foreign students have been removed from Figure 3.

These data can be further combined to examine ethnic diversity among degree recipients whose profile matches the ASA membership profile by highest degree and by academic subject area.[12] As seen in Figure 4, the proportion of whites among U.S. citizens receiving degrees in the subjects consistent with the ASA membership profile (as first shown in Table 1) decreased between 1995-97 and 2005-07; that is, this group became more diverse.[13] In addition, the proportion of degree recipients who were U.S. citizens or permanent residents also fell from 70% in the earlier time frame to 62% in the latter. Figure 5 provides a further breakdown of the non-white U.S. citizens and permanent residents who received degrees. We see that the proportion who are Asian decreased, while the proportion who are Black and Hispanic increased.

Since we are using data which includes U.S. degree recipients, we will compare the ethnic diversity in acoustics to the diversity within the U.S. population as a whole. In Figure 6, we see that Blacks and Hispanics are greatly underrepresented in fields traditionally associated with acoustics. American Indians are also underrepresented, and Asians are overrepresented.

U.S. ethnicity data are from the American Community Survey and are not limited to degree holders.[14]

We have examined ethnic diversity among U.S. degree recipients in subject areas that match the ASA membership profile, weighting for both the subject area and the highest degree distribution among ASA members. In doing so, we see that Blacks and Hispanics are underrepresented when compared to the U.S. population as a whole. This suggests that the Committee on Diversity in Acoustics (CDA) should work with the entire membership of the ASA to increase the representation of these groups in acoustics if its goal is to have a membership that reflects the diversity in the U.S. population.

Many ASA members reside outside the U.S., and a discussion about ethnic diversity in other countries requires a different language. According to the World Factbook, among the ethnic groups in Germany are German, Turkish, Greek, Italian, Polish, Russian, Serbo-Croation, and Spanish. In the United Kingdom, the white ethnic groups include English, Scottish, Welsh, and Northern Irish; other ethnicities comprise Black, Indian, Pakistani, and more.15 Since almost 70% of ASA members are from the U.S., the CDA will likely focus on U.S. diversity initially. Since ethnic diversity is not a phe-

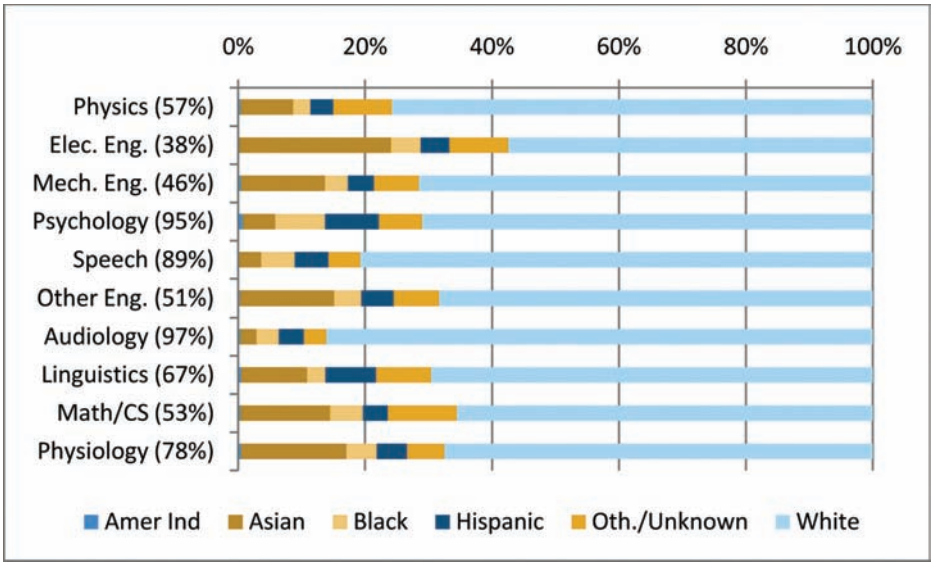

Fig. 3. Ethnicity of U.S. Citizens and Permanent Residents among Degree Recipients in Selected Subjects, Weighted by Highest Degree to Reflect ASA Membership, 2005–2007.

(Numbers in parentheses indicate the percentage of degree recipients in that field who are U.S. citizens or permanent residents.)

nomenon limited to the U.S. only, international members should consider ways to increase ethnic diversity in acoustics in their own countries.

Diversity in acoustics

Acoustics as a discipline is rich in academic diversity, drawing from arts, sciences, humanities, social sciences, and medicine. However, the data presented here indicate that there is still work to be done with respect to women, Blacks, and Hispanics; these are all underrepresented groups in acoustics.[16] In addition, women are underrepresented within the membership of the Acoustical Society of America. Future comparisons with existing data can be used to measure the effectiveness of these committees; however, the effectiveness of these committees depends on the actions of every member. AT

References and notes

1 See http://acosoc.org/diversity/Diversity.html for more information about the CDA.

2 Taken from the Profile of Society Membership of the Acoustical Society of America, http://asa.aip.org/prof_members.html, accessed May 19, 2010, and adjusted for non-respondents.

3 Profile of Society Membership of the Acoustical Society of America, http://asa.aip.org/prof_members.html, accessed May 19, 2010.

4 See, for example, http://www.aip.org/statistics/trends/highlite/other/womenbach.htm, accessed May 19, 2010.

5 National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS) Degree Completion Surveys, accessed through National Science Foundation's WebCASPAR (https://webcaspar.nsf.gov/), accessed April 14, 2010.

6 This weighted average is computed as $\%\ women\ in\ acoustics = \Sigma_f * \%\ ASA\ members_f$ where f represents the academic fields first shown in Table 1.

7 National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS) Degree Completion Surveys, accessed through National Science Foundation's WebCASPAR (https://webcaspar.nsf.gov/), accessed April 14, 2010.

8 Data from National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS) Degree Completion Surveys, accessed through National Science Foundation's WebCASPAR (https://webcaspar.nsf.gov/), accessed April 14, 2010, and adjusted using ASA member-

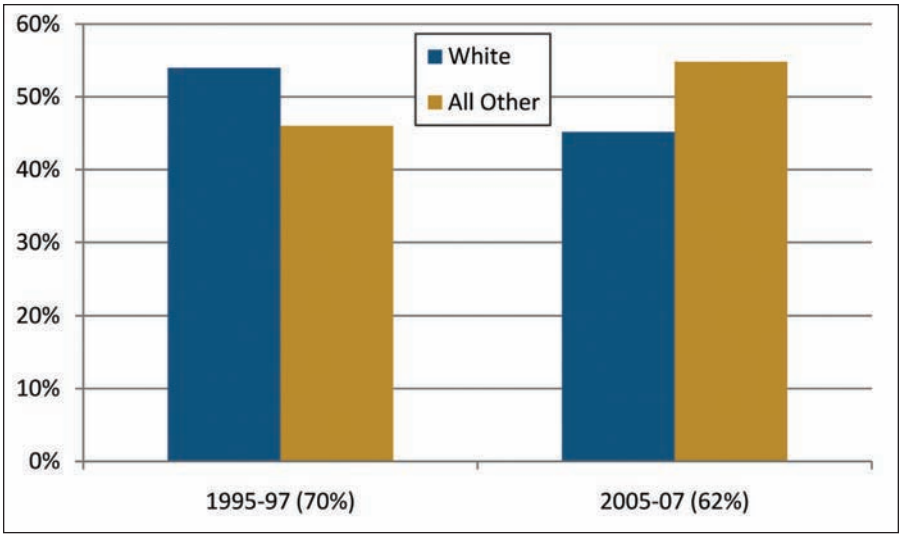

Fig. 4. Ethnicity of U.S. Citizens and Permanent Residents among Degree Recipients in Selected Subjects, Combined and Weighted by Highest Degree to Reflect ASA Membership Profile.

(Numbers in parentheses indicate the percentage of degree recipients in that field who are U.S. citizens or permanent residents.)

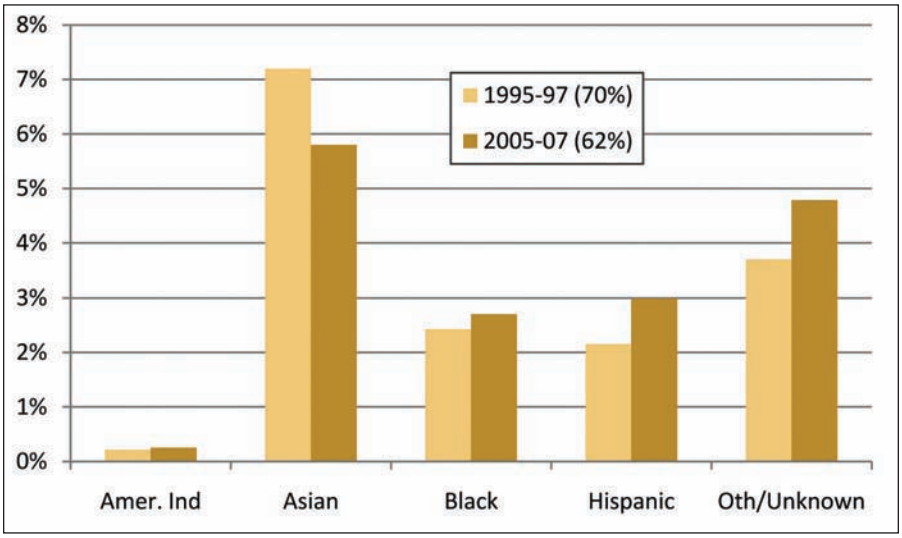

Fig. 5. Ethnicity of Non-White U.S. Citizens and Permanent Residents among Degree Recipients in Selected Subjects, Combined and Weighted by Highest Degree to Reflect ASA Membership Profile.

(Numbers in parentheses indicate the percentage of degree recipients in that field who are U.S. citizens or permanent residents.)

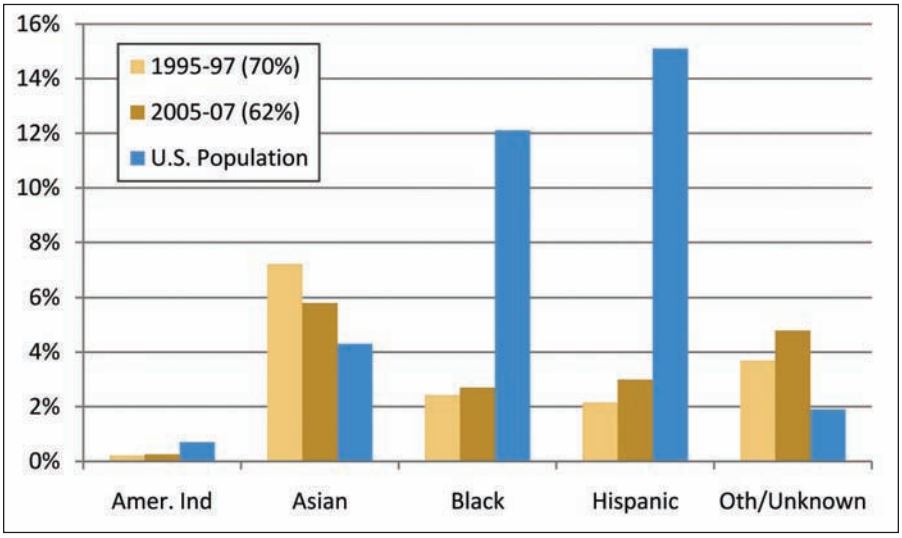

Fig. 6. Ethnicity of Non-White U.S. Citizens and Non-White U.S. Citizens and Permanent Residents among Degree Recipients in Selected Subjects.

(Numbers in parentheses indicate the percentage of degree recipients in that field who are U.S. citizens or permanent residents.)

ship profile data for highest degree, Profile of Society Membership of the Acoustical Society of America, http://asa.aip.org/ prof_members.html, accessed May 19, 2010.

9 The Women in Acoustics' website contains historical data on the number of women in the Acoustical Society of America. See http://www.acoustics.org/WIA/stats.htm, accessed May 21, 2010.

10 See http://www.acoustics.org/WIA/about.htm, accessed May 21, 2010.

11 The data available from Profile of Society Membership of the Acoustical Society of America, http://asa.aip.org/prof_members.html, accessed May 19, 2010, do not allow us to disaggregate international ASA members from U.S. resident members.

12 As with our weighting when examining women in acoustics, we continue to weight by subject area and by highest degree to match the ASA membership profile.

13 We use these two time frames because the data were not collected by detailed academic subjects prior to 1995. Just as the proportion of women in acoustics increased during this time frame, we see that the more recent group is more diverse with respect to ethnicity. We would expect the graduates from even earlier periods to be less diverse.

14 Data from the American Community Survey (ACS) Demographic and Housing Estimates, 2006-2008, http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=01000US&-qr_name=ACS_2008_3YR_G00_DP3YR5&-ds_name=ACS_2008_3YR_G00_&-_lang=en&-_sse=on, accessed June 2, 2010.

15 Data from The World Factbook, https://www.cia.gov/library/publications/the-world-factbook/index.html, accessed July 8, 2010.

16 Ethnicity data is for U.S. citizens and permanent residents only, so these comparisons hold only for the U.S. membership of the ASA.

Appendix

Data used to plot figs. 1–6

	Temp Res	Amer Ind	Asian	Black
Physics Bach.	4.9%	0.6%	6.3%	3.5%
Physics Doc.	51.0%	0.2%	4.4%	1.1%
Elec. Eng. Bach	10.6%	0.4%	19.5%	7.0%
Elec. Eng. Doc.	72.0%	0.1%	6.6%	1.1%
Mech. Eng. Bach.	4.2%	0.5%	7.8%	3.5%
Mech. Eng. Doc.	66.1%	0.2%	4.9%	1.3%
Psych. Bach	1.7%	0.7%	5.9%	10.6%
Psych. Doc.	5.7%	0.7%	5.0%	5.9%

Data for Fig. 1

	Temp Res	Amer Ind	Asian	Black	Hispanic
Physics	43%	0.2%	4.8%	1.5%	2.1%
Elec. Eng.	62%	0.1%	9.1%	1.8%	1.7%
Mech. Eng.	54%	0.2%	6.1%	1.7%	1.9%
Psychology	5%	0.7%	4.9%	7.5%	8.1%
Speech	11%	0.2%	3.1%	4.7%	4.7%
Other Eng.	49%	0.2%	7.6%	2.2%	2.6%
Audiology	3%	0.3%	2.5%	3.4%	3.8%
Linguistics	33%	0.3%	6.9%	1.9%	5.3%
Math/CS	47%	0.2%	7.5%	2.8%	2.1%
Physiology	22%	0.4%	13.0%	3.7%	3.7%

Data for Fig. 2

	1995-97 (70%)	2005-07 (62%)
White	54%	45%
All Other	46%	55%

Data for Fig. 4

	1995-97 (70%)	2005-07 (62%)
Amer. Ind	0.2%	0.3%
Asian	7%	6%
Black	2%	3%
Hispanic	2%	3%
Oth/Unk	4%	5%

Data for Fig. 5

	1995-97 (70%)	2005-07 (62%)	U.S. Population
Amer. Ind	0.2%	0.3%	0.70%
Asian	7%	6%	4.30%
Black	2%	3%	12.10%
Hispanic	2%	3%	15.10%
Oth/Unk	4%	5%	1.90%

Data for Fig. 6

	Amer Ind	Asian	Black	Hispanic	Oth /Unk	White
Physics (57%)	0.2%	4.8%	1.5%	2.1%	5.3%	43.4%
Elec. Eng. (38%)	0.1%	9.1%	1.8%	1.7%	3.6%	22.0%
Mech. Eng. (46%)	0.2%	6.1%	1.7%	1.9%	3.3%	33.2%
Psychology (95%)	0.7%	4.9%	7.5%	8.1%	6.5%	67.5%
Speech (89%)	0.2%	3.1%	4.7%	4.7%	4.5%	71.6%
Other Eng. (51%)	0.2%	7.6%	2.2%	2.6%	3.7%	35.1%
Audiology (97%)	0.3%	2.5%	3.4%	3.8%	3.4%	83.2%
Linguistics (67%)	0.3%	6.9%	1.9%	5.3%	5.8%	46.4%
Math/CS (53%)	0.2%	7.5%	2.8%	2.1%	5.8%	34.8%
Physiology (78%)	0.4%	13.0%	3.7%	3.7%	4.6%	52.7%

Data for Fig. 3

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