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# Gender Representation in the Vision Sciences: A Longitudinal Study

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**Understanding the current status and historical trends of gender representation within a research field is an important component of fostering a diverse and inclusive scientific community. Here, we report on the gender representation of a large sample of the vision science research community—the attendees of the Annual Meeting of the Vision Sciences Society (VSS). Our analysis shows that the majority of scientists at all career levels in our sample are male. This imbalance is most pronounced for the senior scientists, whereas predoctoral students are nearly balanced between the genders. Historically, the gender imbalance was larger than it is at present, and it has followed a slow-but-steady trend toward gender parity over the past decade. A longitudinal analysis based on tracking individual attendees shows a larger dropout rate for female than male predoctoral trainees. However, among the trainees who continue in the vision science field after graduate school, evidence suggests that career advancement is quite similar between the genders. In an additional analysis, we found that the VSS Young Investigator awardees and the abstract review committee members reflect substantial gender imbalances, suggesting that these recognitions have yet to catch up with the greater gender balance of the rising generation of junior vision scientists. We hope that this report will encourage awareness of issues of diversity in the scientific community and further promote the development of a research field in which all talented scientists are supported to succeed.**

## Introduction

Men and women do not tend to be equally represented in scientific research careers. The characterization and potential causes of this imbalance have been heavily addressed within and between the boundaries of traditional research fields, such as mathematics and life sciences (e.g., Ceci, Ginther, Kahn, & Williams, 2014; Kaminski & Geisler, 2012; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012; Sheltzer & Smith, 2014). For example, it has been shown that in the academic setting, women are underrepresented in mathematically intensive fields, such as engineering, computer science, and physics, while in social and life sciences, the representation is more balanced (Ceci et al., 2014).

We were interested in investigating the gender representation among researchers in the vision sciences—a multidisciplinary field that encompasses scientists with different departmental affiliations and a range of research interests that touch on issues related to biological vision. We wanted to determine the current gender makeup of the vision sciences community and whether it has been changing over time. We also wanted to examine if there are differences between males and females in career trajectory from a graduate student to an independent researcher. For example, are there gender differences in the drop out of individuals (i.e., pipeline leakage)? What percentages of male and female trainees continue their career in science and reach independence?

To address these questions, we examined the records of attendees of the Annual Meeting of the Vision Sciences Society (VSS). VSS is one of the most prominent conferences in the field and has been bringing together a large group of vision science researchers for over a decade. Thus, we considered VSS attendees to be a suitable sample of the vision sciences community for addressing our research questions. Here, we describe the gender composition of VSS attendees at different career stages, which are reflected in different levels of conference registration (predoctoral, postdoctoral, and regular) and we report how this composition has been changing over time. Furthermore, by tracking individual attendees, we are able to examine and compare career trajectories for a subset of male and female attendees.

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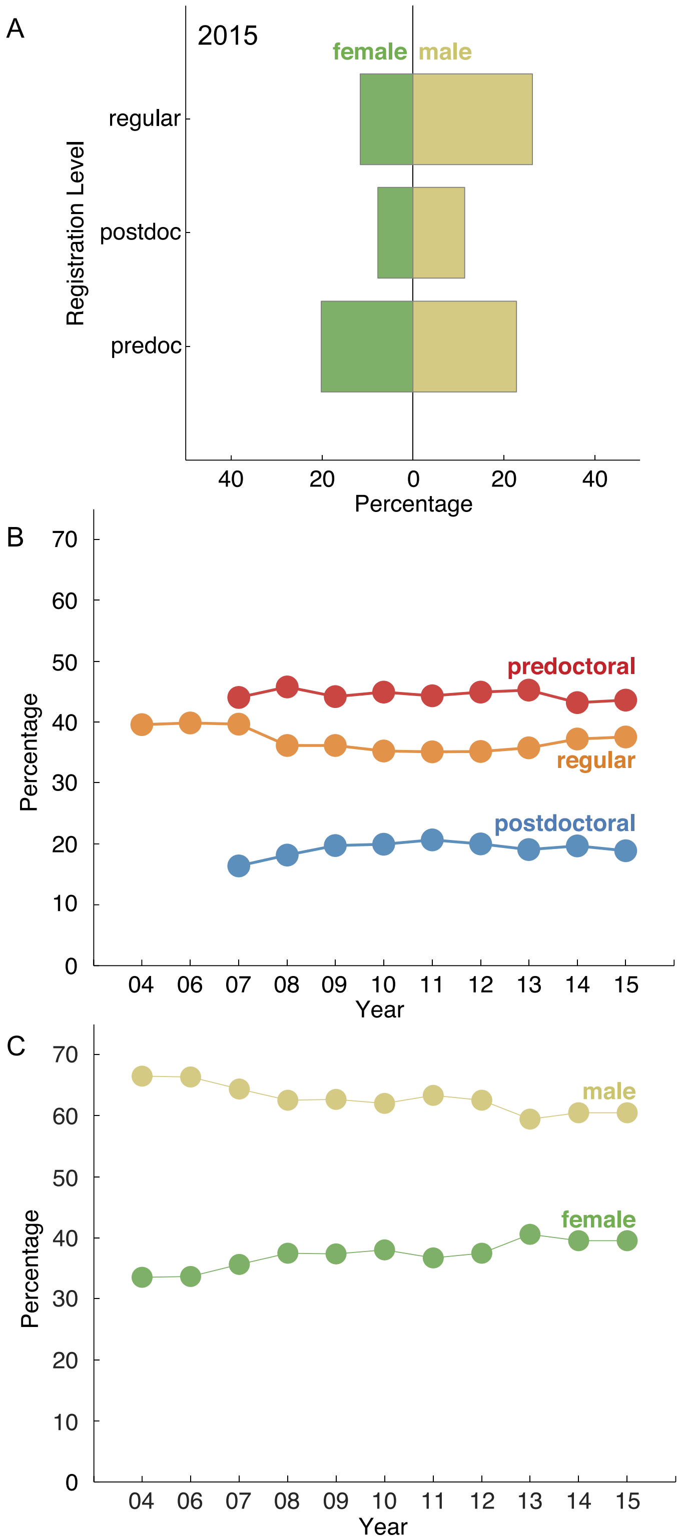


Figure 1. (A) VSS population pyramid for the 15th Annual Meeting (2015). The percentage of male attendees (in yellow) and female attendees (in green) are shown for each registration level (*y*-axis). (B) Distribution of attendees by registration level across years. For each year (2004, 2006–2015) the percentage of attendees at each registration level are plotted (predoctoral in red, postdoctoral in blue, regular in orange). (C) Distribution of attendees by gender across years. For each year, the percentage of male attendees is shown in yellow and the percentage of female attendees is shown in green.

We believe that it is important to directly examine the issue of gender representation in the vision sciences for several reasons. First, advancement in science should be based on merit. If we accept that men and women are equally capable of (and interested in) advancing vision-related research (Halpern et al., 2007), then we would expect balanced representation and career advancement at equal rates across genders. If the representation and career advancement are not balanced, it is worthwhile to examine the potential underlying causes. Second, a scientific community will be best positioned to tackle complex problems if it is composed of people with a diversity of backgrounds. Any systematic exclusion that is not based on research quality—whatever the cause—can only hinder progress toward a common goal. Finally, equal support and recognition of the achievements of men and women in the vision science field provides role models and encourages capable and motivated trainees of both genders.

## Results

In Figure 1A, we summarize the gender makeup of the VSS attendees for the most recent meeting (2015) with a population pyramid. The pyramid describes the VSS population in terms of registration level and gender. VSS attendees must register in one of three categories: regular, postdoctoral, or predoctoral. We assume that attendees that register in the regular category are active independent researchers, while predoctoral and postdoctoral attendees are trainees. We therefore assume that regular attendees have advanced farther in their career development than postdoctoral attendees, who are continuing their training and have not yet obtained an independent research position.

Several characteristics of the community are clearly noticeable. First, the majority of attendees are at the predoctoral level (43%), as compared to the postdoctoral (19.1%) and regular (37.9%) levels. Second, the majority of attendees are male at all levels, although at the predoctoral level the difference in the number of male and female attendees is small and approaches parity (22.8% vs. 20.2%). Finally, a comparison across all gender and career levels indicates that male regular members constitute the majority of the VSS community (26.3%). These general characteristics hold across all years we analyzed. An icon accompanying our report and Figure S1 in the supplement show population pyramids for each of the 11 years included in the analysis. Note that data from 2005 were unavailable, and that prior to 2007 pre- and postdoctoral attendees were combined and categories cannot be directly compared.

The vision sciences community has been growing steadily since the Society and the annual meeting were established 15 years ago. We were interested in investigating whether and how the structure of the community has been changing as VSS grows over the years. Figure 1B shows the percentage of attendees at each registration level across years. Even though the total number of participants has increased by more than a factor of two (from approx. 900 to nearly 2,000, see Table A1 in Appendix), the percentage of attendees at each registration level has remained remarkably stable. Figure 1C shows the gender distribution across years when all registration levels are combined. In all years, the majority of VSS attendees were male and the difference in the number of male and female attendees is pronounced. However, the gender gap has been gradually decreasing: the percentage of female attendees increased significantly from 2004 to 2015 (33.5% vs. 39.5%; $\chi^2(1) = 8.62$; $p < 0.01$).

We further explored how the gender balance changed across years within each registration category. Figure 2 contains the percentage of male and female attendees for predoctoral (A), postdoctoral (B), and regular (C) levels separately. This analysis shows that the gender gap is the smallest at the predoctoral level, in which the percentages of male and female participants in recent years (2013–2015) approaches equality. Although the gap is clearly the largest at the regular level, there is a notable steady increase in the number of female attendees relative to male in this category, even if gradual.

Figure 2D summarizes these data in the form of male-to-female attendee ratios for each year and registration level. In the postdoctoral category, this ratio fluctuated without showing a clear trend, but in both the predoctoral and regular categories there was a decrease in the gender ratio across years. In the predoctoral category, male-to-female ratios changed from 1.27:1 in 2007 to 1.13:1 in 2015. Although these two ratios did not differ significantly, $\chi^2(1) = 1.18$, $p = 0.3$, the linear correlation revealed a significant change over the years, $r = 0.78$, $p < 0.05$. In the regular category, the change was more marked: while there were 3.18 males for each female attendee in 2004, this ratio decreased to 2.27:1 in 2015, $\chi^2(1) = 4.92$, $p < 0.05$; $r = 0.91$, $p < 0.001$.

One of the goals of our study was to estimate the percentage of trainees in the vision sciences who become independent researchers and to investigate whether these numbers differ across genders. The studies that investigate gender differences in science careers typically focus on academic milestones and have previously compared the percentages of male and female trainees who receive a PhD within a certain time period to the percentages of male and female assistant professors 5–6 years later (Ceci et al., 2014). The data about the number of awarded PhDs and attained assistant professorships was not available to us; therefore, we developed an analysis more appropriate for our dataset that followed similar logic and took advantage of our ability to track individual conference attendees across years.

For each conference year, we recorded the number of male and female trainees (i.e., attendees at either the pre- or postdoctoral level) for whom, based on our records, this was the first VSS meeting they attended. We then computed the percentage of these trainees who subsequently registered as regular members (which we take to indicate that they became independent researchers). We aggregated these data into three cohorts, each representing a different generation of trainees (2004–2006, 2007–2010, 2011–2014; see Figure 3A). Overall, the percentage of first-time trainees who became regular members is the highest for the first generation (2004–2006; 31%), as these trainees had the longest time to reach independence. In contrast, only 2% of trainees in the most recent generation (2011–2014) became regular members so far. Presumably, most of them are still continuing with their pre- or postdoctoral training. Across all three generations, the percentage of trainees who become regular members is larger for male than for female attendees; however, this difference is small and not significant: +4.6% in the first, +2.5% in the second, and $< +1\%$ in the third; all $\chi^2(1) < 3$; *ns*. Table A2 shows the number of male and female trainees in each group; the Methods section describes in further detail how we tracked individual attendees across years.

In a second longitudinal analysis, we investigated the career development of one generation of vision scientists from the earliest stage. We focused on predoctoral attendees only—a category that consists primarily of graduate students. We asked what percentage of male and female predoctoral attendees do not continue an active research career (i.e., only appear in conference rosters as a predoctoral attendee), and what percentage of predoctoral attendees become independent researchers (i.e., register in subsequent years as a regular member). We limited this analysis to the second generation of attendees (2007–2010). However, we did not require that an individual's first attendance to the conference occur in this range, only that they were registered as a predoctoral attendee at some point during these years. Before 2007, predoctoral and postdoctoral researchers were registered as a single category and we

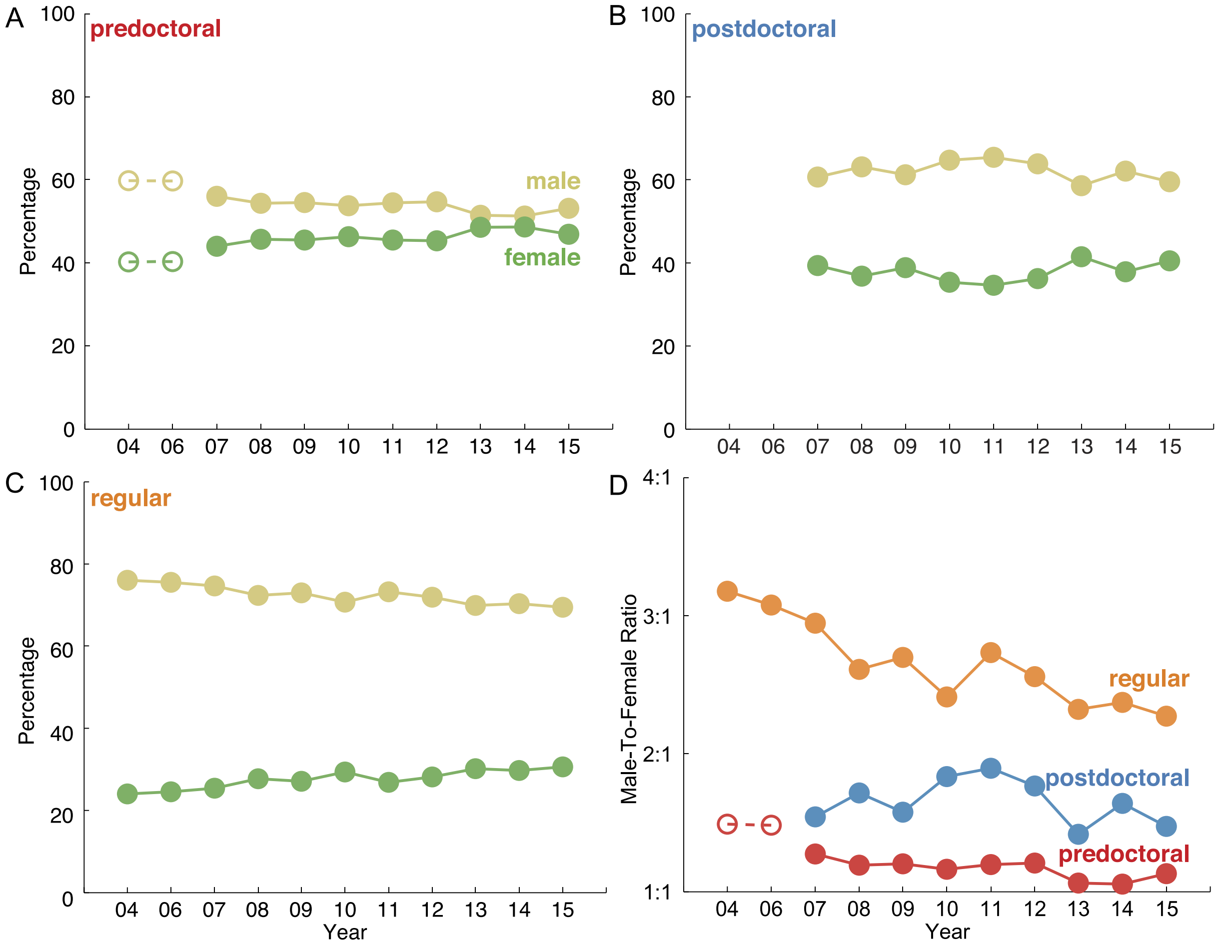


Figure 2. (A–C) Change in gender distribution within different registration levels. Percentage of male (yellow) and female (green) attendees is shown for predoctoral (A), postdoctoral (B), and regular attendees (C). (D) Male-to-female ratios across years. Predoctoral level is shown in red, postdoctoral in blue, and regular in orange. Pre-2007 data for the pre- and postdoctoral registration level, as a single category, are shown as dashed lines in panels (A) and (D), for reference.

were not able to distinguish between them; limiting the analysis to 2010 left a reasonably long time (at least 5 years) to monitor the career progress.

Figure 3B shows the percentage of these predoctoral trainees who became regular members: 10.2% of males and 9% of females. Our analysis suggests that a majority of predoctoral researchers do not pursue a career in vision science research after graduating and that the percentage of those who drop out at the graduate (or undergraduate) level is significantly larger for female than for male attendees. Only 27% of female predoctoral attendees from the 2007–2010 cohort return to the conference as a postdoctoral or regular attendee, as compared to 36.2% of male attendees, $\chi^2(1) = 15.97$; $p < 0.001$. Note, however, that some of these attendees may still be at the predoctoral level in 2015. Interestingly, out of those attendees who continue their career in vision science (i.e., subsequently register at levels other than predoctoral), males and females reach independence in similar proportions: 33.5% of female and 28% of male attendees have registered at regular level, $\chi^2(1) < 2$; *ns*.

Because the total number of attendees who transitioned from predoctoral to regular registration level was fairly small (90 male, 67 female) it was feasible to verify each attendee carrier stage using their professional profiles available online and establish what type of independent position they obtained (Figure 3B). We identified three broad classes of independent positions: tenure-track (assistant or associate professor, or equivalent), researcher (research professor, researcher in industry or government agency), and instructor (teaching fellows and visiting assistant professors). We found that the distribution of male and female predoctoral-turned-regular attendees across these three categories is essentially identical. Among 67 female attendees, 52 (77.6%) had tenure-track positions, 10 (14.9%) were researchers, and 3 (4.5%) were instructors. Among 90 male attendees, 70 (77.8%) had tenure-track positions, 15 (16.7%) were researchers, 4 (4.4%) were instructors. We were not able to either verify or precisely categorize the position of two females and one

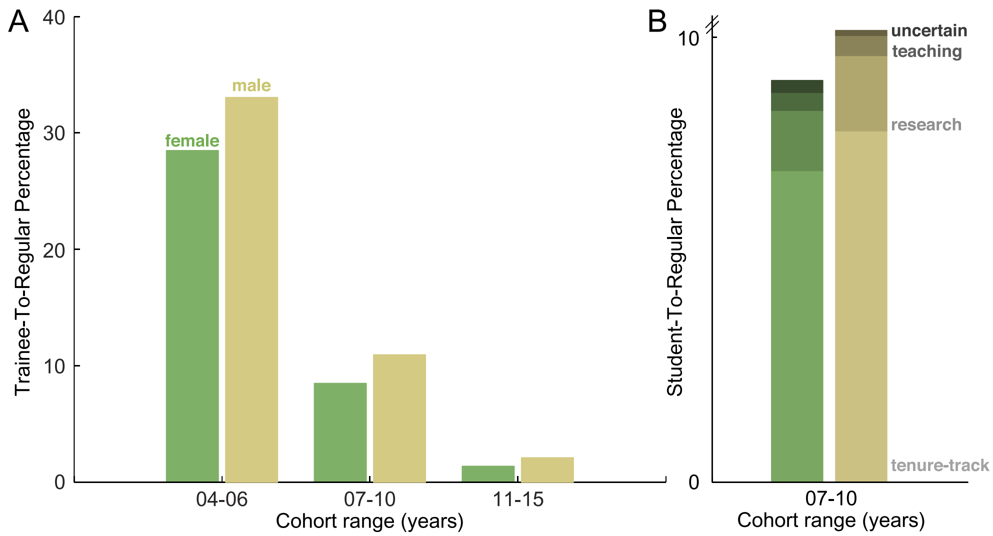


Figure 3. (A) Percentage of trainees (pre- and postdoctoral) who became regular members for three generations of vision scientists. The percentage of first-time trainees who registered as regular members in subsequent years is aggregated across years for each generation and shown separately for male attendees (yellow) and female attendees (green). The *x*-axis indicates the range of years included in each generation (i.e., the cohort range). The total number of attendees included in each generation is 953 (2004–2006), 1,650 (2007–2010), and 1,853 (2011–2015). (B) Percentage of predoctoral attendees from the 2007–2010 cohort who became regular members, and the type of academic position they have obtained. The total number of student attendees in the cohort is 1,628.

male. Note that the percentages in Figure 3B are shown relative to the entire cohort size.

We also conducted a broad-strokes comparison of universities in which male and female attendees from this generation held tenure-track positions in terms of how research-intensive they are. To do so we relied on the rankings provided by U.S. News & World Report (U.S. News & World Report, Best Global Universities Rankings, 2014) and Times Higher Education (Times Higher Education, World University Rankings 2014–15, 2014), which rate PhD-granting universities worldwide in terms of their research activity (extent and impact) and overall academic quality. We found that male and female attendees from this generation attain positions in top research universities in similar proportions: 60% of male and 54% of female tenure-track attendees had a position at a university that appeared on the list of top 400 institutions worldwide in one or both ranking systems.

## Discussion

Our analyses showed that gender imbalance in the VSS community does exist, but that it has been steadily decreasing across both the junior and senior conference attendees. Interestingly, we did observe a larger dropout rate for female than male trainees after they obtain their doctoral degree. However, when we compared the career progression of those trainees who continue in the vision science field after graduate school, we found essentially no difference between males and females. One possible interpretation of these findings is that, in the vision sciences, women are less likely to choose to pursue an academic career after they receive a PhD (see also, Ceci et al., 2014; Martinez et al., 2007). Our analyses suggests that, if they do choose to continue, they have equal chances to succeed in establishing an independent research career as their male colleagues.

Another possible interpretation of our findings (and one that was suggested to us by an anonymous reviewer) is that the larger dropout rate for female trainees might reflect that women have more difficulties in obtaining a postdoctoral position than men. If this were the case, those women who do advance might on average be more qualified than men with similar positions, creating a systematic gender bias in career advancement. Careful and systematic examination of the factors that influence decisions to leave an academic career after obtaining a PhD will be required to distinguish between these interpretations.

The conference registration rosters, however, cannot tell the whole story. Another way to examine gender representation within a field is to look at whether males and females are recognized equally for their achievements. To address this question, we analyzed the gender composition of a subset of attendees who have been singled out for the VSS awards and committees.

We used gender information available in our dataset to investigate whether the gender representation within different award categories reflects the overall representation in the vision science community. We analyzed two award categories: Student Travel Award "for excellent contributions from graduate students" (Vision Sciences Society, VSS 2015 Student Travel Awards, 2015) and Young Investigator Award (YIA), given to "an outstanding visual scientist who received an advanced degree within the past 10 years" (Vision Sciences Society, Elsevier/VSS Young Investigator Award, 2015). The Davida Teller Award for exceptional contributions to vision science is awarded only to women.

Our analysis reveals that Student Travel Awards are well-balanced across genders. These awards are given to multiple student attendees per year (20 yearly after 2007). On average, 56.5% of yearly awards were given to men in the period 2007–2015 ($SD = 8.3\%$), and the yearly percentages reflect the balance of male and female predoctoral attendees well, particularly for the period of 2011–2015 (see Figure S2 in the supplement). In contrast, one YIA is given each year. So far, only one out of nine awardees was a woman.

We also observed a discrepancy in the percentages of male and female members who serve on the abstract review committee relative to the percentages of male and female regular members. Out of 69 scientists who served as abstract reviewers for the 2015 meeting, only 11 (15.9%) were female (Vision Sciences Society, 2015 Review Committee, 2015; information on the reviewing committees from previous years was not available online). According to the VSS website, the abstract committee "is composed of accomplished visual scientists representing a broad range of specialty areas and methodological approaches" who are appointed by the VSS Board for a one-year renewable term (Vision Sciences Society, 2015 Review Committee, 2015). If we assume then that the reviewing committee is recruited each year from the ranks of typical regular conference attendees, we can then compare the observed gender ratio in the committee to the expected ratio for a random sample. We found that in 2014, women constituted 29.7% of regular attendees, nearly twice as much as their participation in the reviewing committee in the following year (2015). Even in 2004, the earliest year for which we have attendance records, women constituted 25% of regular attendees. At the time of this report, the abstract review committee membership roster was updated online for 2016. The number of committee members increased to 76, but the percentage of female reviewers remained unchanged (12 or 15.8%) (Vision Sciences Society, Abstract Review Committee, 2016).

Thus, examinations of both the YIA recipients and the abstract review committee suggest substantial gender imbalance. From the current analysis, however, it is not possible to pinpoint why this imbalance occurs. Are similar numbers of men and women asked to serve on the abstract review committee, yet women are more likely to decline? Are men and women nominated for the YIA at equal rates, or are the nominations themselves biased? Taken collectively, our analyses suggest that at the level of YIA recipients and the abstract committee, the relative inclusion of men and women has yet to catch up with the greater gender balance of the current generation of vision scientists.

One alternative way to analyze gender balance within a field is to examine the percentages of men and women in different types of conference presentations (e.g., symposia, talks, or posters). Although the information about the relative participation of men and women across presentation types is available (via cross-referencing conference programs with our records of attendee gender), we did not have the information about the number of men and women who have requested a talk or proposed a symposium. Without this information, we could neither compute gender success rates nor examine whether there are gender differences in preference for one type of presentation over another (poster vs. talk). Both of these questions are interesting and could provide additional insight about gender balance in the vision community, and we hope to address them in our future studies.

### Looking forward

As a multidisciplinary community, the group of vision science researchers cannot be assumed to follow the demographic trends of any single traditional scientific field. Thus, it is important to explicitly gauge the current and historical gender balance among vision scientists, and monitor these trends going forward. Better understanding of the relationship between gender and career progression should be part of a larger effort of supporting and encouraging a diverse group of talented scientists to pursue complex research questions such as those posed in vision science.

## Methods

### Data collection

Conference registration rosters for 11 annual VSS meetings (2004, 2006–2015) were obtained from the conference administrators. The data from year 2005 were not available. We used the information in the rosters to determine career stage and gender for each attendee in each conference year following the methods we describe below. All data analysis procedures were approved by the Institutional Review Boards at Stanford University, Dartmouth College, and the University of Pennsylvania, and were in accordance with the World Medical Association Declaration of Helsinki.

## Determining attendee gender

According to convention, we use the term gender to denote the social, rather than biological, role of an individual (Deaux, 1985). Three different strategies were used to determine the gender of the conference attendees. Each strategy relies on the idea that an individual communicates gender via both direct and indirect cues, and necessarily excludes those individuals who chose not to outwardly specify their gender.

### *Self-reported gender*

Since 2012, conference attendees had the option to voluntarily report their gender as part of their profile. The self-reported gender data was available for 43.3% of attendees (2,921 people total). When self-reported gender information was provided, we considered it to represent the "ground truth."

### *First-name gender*

In some cases, it is possible to determine an attendee's gender with a high level of confidence based on first name. To do this, we used a publically available database and application programming interface (API) called Genderize.io (https://genderize.io). Genderize provides the probability of an individual's gender given the first name, based on the frequency with which user profiles on major social networking websites contain a particular name-gender combination. For example, at the time of this report, the name "Peter" occurs in the Genderize database 4,373 times, and 100% of the time the gender is male. In comparison, out of the 1,628 occurrences of the name "Robin," only 59% are female, suggesting that this name is gender-ambiguous. We used the API to query the first name of each attendee who had a single first name or a hyphenated dual name (e.g., Jean-Paul; dual names that are not hyphenated, such as Lisa Marie, are unsupported). We computed the binomial confidence interval on the name's gender, and retained matches for which the lower end of the 95% confidence bounds was equal to or greater than 80%. Under this criterion, 72% of all attendees (4,861 people total) could be assigned gender.

### *Online profile gender*

After determining gender based on self-report and Genderize, there were still 15.2% of the attendees (1,024 total) with unknown genders. For these remaining attendees we relied on information publicly available online to determine gender. We did this by entering an attendee's first and last name and their affiliation at the time of most recent attendance into the Google search engine and searching the results for professional websites that contained matching information. If we found a professional website that either contained a photo or used gender pronouns, we recorded the attendee's gender. Using this method, we assigned gender to approximately another 10% of attendees, leaving only 5.8% (393) of attendees without any gender information.

### *Validation*

By combining and cross-validating all three approaches, we hoped to minimize the effect of any biases inherent to a particular approach. For example, cultural differences in the frequency of dual names would prove problematic for Genderize, but can be compensated for using online profiles. We validated the Genderize results against self-reported data for the subset of attendees for which information from both sources was available (2,055 people total). The two methods agreed in 99.3% of the cases, suggesting that our Genderize-based method for assigning attendee gender has high accuracy. To test the reliability of the online profile approach, two independent judges (the two authors) both performed the online search for a subset of attendees. The agreement between the two judges in these cases was high (99.3%; 136 out of 137 instances in which the gender was determined by both judges). The remaining attendees were only handled by one judge. A subset of the attendees for whom gender was determined using the Genderize API was also categorized based on their online profiles, with the Genderize data withheld. The agreement of these two methods was high (97.7%; 291 out of 298 cases for which both methods provided gender information). When the methods disagreed, we relied on self-report data (if available) or online profile data verified by both judges.

## Determining attendee career stage

Conference attendees register based on their self-reported career stage. From 2007 onward, this could be one of three options: predoctoral, postdoctoral, or regular. Prior to 2007, predoctoral and postdoctoral attendees were grouped into a single registration category (student/postdoctoral).

In the initial years of the meeting, conference staff, journal representatives and commercial exhibitors were also included in conference rosters, sometimes as a separate registration category (labeled Staff, VSS, or Exhibitor). Because we wanted to limit our analysis to researchers, we excluded from further analysis any attendee who at any point registered under one of these categories.

In some cases, information about the attendee's registration level was not available in the conference rosters. For all years except 2006, there were only a few (if any) such cases. In 2006, however, the information about the registration level was missing for all nonmember attendees (approx. 7% of attendees that year). To make the datasets as complete as possible, we filled the missing registration level information by using the information from the surrounding years (if available). For example, if an attendee was in the regular category in 2004, we assumed that they were also in this category in 2006. If an attendee was a student in both 2004 and 2007, we assumed that they were also a student in 2006. If reliable information from surrounding years was unavailable, the two authors independently judged an attendee's missing registration level based on information publicly available online (personal or professional profiles, lab websites, CVs; following the same general strategy used when searching for gender data). When both authors agreed, this information was used (52 such cases). The attendees for whom information about registration was still missing (24 attendees in year 2006, 4 in 2007) were excluded from further analysis.

## Year-by-year analysis

Our analysis only included those attendees who were researchers and for whom the information about both the registration level and gender were available. For each conference year we analyzed, Table A1 shows the number of total registered attendees; the number of staff, publisher, and exhibitor representatives that were excluded from the analysis; and the number of researcher-attendees for whom registration or gender information was not known (and were therefore excluded). In the Results section, all numbers are computed relative to the total number of attendees included in the analysis (percentage of these attendees relative to the whole population of researchers for a given year is also shown in Table A1).

We have no reason to believe that any of our methods for assigning attendee gender or registration are biased against any particular category. We therefore assume that, if gender and registration data were available for the excluded attendees, these would distribute across categories in similar proportions and would not significantly change our results.

In the course of our analysis we also identified several individuals for whom the changes in registration status across years deviated from the expected progression—from predoctoral to postdoctoral to regular (e.g., a postdoctoral researcher registered as a regular member one year and as a postdoctoral member the following year). For each such attendee, we used the information publicly available online to verify their career status in a given year and, if needed, we corrected their registration status to reflect their actual career stage at that time. We also discovered that lab research assistants who are at the predoctoral level but are not graduate students occasionally register as regular attendees. We were able to identify and correct some, but likely not all, such cases. It is also possible that, contrary to our assumption, some of the attendees who register at the regular level are not independent researchers, but at a different career stage that does not qualify as pre- or postdoctoral (e.g., lab technician or computer programmer). We expect, however, that the number of such attendees is quite small, as is the number of remaining predoctoral attendees that are registered as regular attendees.

## Tracking individual attendees

One goal of our analysis was to track the attendance of unique individuals over different years of the conference. Because VSS members are not assigned unique identifies (e.g., member ID number), we developed a method for assigning such a number for each individual attendee. Given the size of the VSS conference population, we assumed that we could track individual attendees across years based on their first and last names with a reasonable level of accuracy. We implemented the following strategies to minimize errors in this method.

First, to avoid conflating two individuals with the same first and last name, we searched the dataset for instances in which the same name appeared multiple times in one year. In these few cases, we used professional online profiles to determine the separate identities of the two individuals and assign them each a different unique ID. This method necessarily fails to catch cases in which different individuals with the same name attended during different years. We reasoned, however, that there would be a relatively small number of such cases and they would be nearly impossible to identify.

Second, we wanted to avoid incorrectly categorizing a single individual as multiple different people due simply to minor changes in format in which they entered their name during the registration process (e.g., with or without accents or capitalization). To avoid this error, all non-Roman characters were converted to the closest Roman letter. We also manually identified and corrected a number of year-to-year name inconsistencies. One additional concern was that the apparent pipeline leakage for woman might be falsely inflated by the fact that women are more likely to change their surname. We identified and corrected two such instances, but it is possible that there were additional instances that we were not able to find. After implementing these strategies, we assigned a unique number to each ostensible unique individual that attended VSS during the period we analyzed.

For each individual attendee, the resulting dataset indicated in which years they attended the meeting and what their career stage was at the time (continual attendance across years was not required). We used this dataset for our longitudinal analyses in which we tracked the career progression of the subset of attendees who were trainees in the early years of the conference (see Figure 3). Note that it was not possible to examine career progress that is not reflected in the registration level, such as advancement from assistant to associate to full professorships.

One clear limitation of our analysis based on tracking individual attendees lies in the fact that it excludes all pre- and postdoctoral trainees who stop attending VSS, even though some of them may continue an active research career but prioritize other conferences. For example, those who specialize in neuroscience might choose to attend the Society for Neuroscience (SfN) or Computational and Systems Neuroscience (Cosyne) meetings rather than VSS, while those that are more clinically oriented might choose the Association for Research in Vision and Ophthalmology meeting (ARVO). Similarly, attendees who attain positions outside the United States might be more likely to prioritize international meetings that are geographically closer (e.g., European Conference on Visual Perception or the Asia-Pacific Conference on Vision). In the present analysis, we assume that this kind of sample attrition affects male and female trainees at equal rates.

While our current dataset necessarily restricts our knowledge of an individual's career progression to those who repeatedly attend VSS, further longitudinal research will help verify whether the tendencies we have measured can be observed in the long run and in larger samples of the vision research community.

*Keywords: vision science, gender representation, longitudinal analysis*

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# Appendix

| Conference year | No. of registrants | No. of staff and exhibitors | No. of researchers | Registration unknown | Gender unknown | % analyzed |
|---|---|---|---|---|---|---|
| 2004 | 890 | 0 | 890 | 0 | 76 | 91.46 |
| 2006 | 1,297 | 3 | 1,294 | 24 | 109 | 90.03 |
| 2007 | 1,489 | 22 | 1,467 | 4 | 90 | 93.59 |
| 2008 | 1,432 | 35 | 1,397 | 0 | 71 | 94.92 |
| 2009 | 1,631 | 6 | 1,625 | 0 | 87 | 94.65 |
| 2010 | 1,807 | 7 | 1,800 | 0 | 78 | 95.67 |
| 2011 | 1,798 | 5 | 1,793 | 0 | 75 | 95.82 |
| 2012 | 1,883 | 2 | 1,881 | 0 | 41 | 97.82 |
| 2013 | 1,819 | 1 | 1,818 | 0 | 22 | 98.79 |
| 2014 | 1,945 | 1 | 1,944 | 0 | 10 | 99.49 |
| 2015 | 1913 | 1 | 1912 | 0 | 21 | 98.90 |

Table A1. Number of attendees for each conference year. For each conference year, we report the total number of: registrants in the conference roster, nonresearcher attendees (staff, publishers, exhibitors), researcher-attendees, researchers for whom registration level was unknown, and researchers whose gender was unknown. In 2006, four attendees were missing both registration and gender information, and they are counted in both the Registration unknown and Gender unknown columns. The last column shows the total number of researchers (in %) included in the analysis (i.e., those whom both gender and registration data were available).

| | 2004–2006 | | 2007–2010 | | 2011–2014 | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| First-time trainees | 563 | 390 | 905 | 745 | 966 | 887 |
| First-time trainee-to-regular | 186 | 111 | 99 | 63 | 20 | 12 |

Table A2. Number of first-time trainees who become regular members for three generations of vision scientists. Row 1 shows the total number of male and female trainees who registered for the first time during this period. Row 2 shows the number of those trainees who later return to the conference as regular members (see also Figure 3A).