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WIMIR: AN INFORMETRIC STUDY ON WOMEN AUTHORS IN ISMIR

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ABSTRACT

The Music Information Retrieval (MIR) community is becoming increasingly aware of a gender imbalance evident in ISMIR participation and publication. This paper reports upon a comprehensive informetric study of the publication, authorship and citation characteristics of female researchers in the context of the ISMIR conferences. All 1,610 papers in the ISMIR proceedings written by 1,910 unique authors from 2000 to 2015 were collected and analyzed. Only 14.1% of all papers were led by female researchers. Temporal analysis shows that the percentage of lead female authors has not improved over the years, but more papers have appeared with female co-authors in very recent years. Topics and citation numbers are also analyzed and compared between female and male authors to identify research emphasis and to measure impact. The results show that the most prolific authors of both genders published similar numbers of ISMIR papers and the citation counts of lead authors in both genders had no significant difference. We also analyzed the collaboration patterns to discover whether gender is related to the number of collaborators. Implications of these findings are discussed and suggestions are proposed on how to continue encouraging and supporting female participation in the MIR field.

1. INTRODUCTION

Music Information Retrieval (MIR) is a highly interdisciplinary field with researchers from multiple domains including Electrical Engineering, Computer Science, Information Science, Musicology and Music Theory, Psychology, and so on. Perhaps due to the strong representation from the technical domains, the MIR field has been dominated by male researchers [12]. Responding to this trend, supporting female researchers has emerged as an important agenda for the MIR community. Since 2011, "Women in MIR" (WiMIR) sessions have been organized in order to identify current issues and challenges female MIR researchers face, and to brainstorm ideas for providing more support to female MIR researchers. The ses-

sions have been well attended by both female and male participants every year, and a number of initiatives have been started for ensuring the inclusion of female researchers in various leadership roles such as session chairs, conference and program chairs, reviewers and meta-reviewers, as well as ISMIR board members. In addition, a mentorship program targeted for junior female mentees has recently been established.¹

While we continue encouraging young female students to enter the field, we lack a solid understanding of where our current female researchers come from, what their research strengths are, who they collaborate with and what their impact has been in the field. This makes it difficult to establish a mentoring relationship between these young researchers and established scholars, which has been identified as being critical for increasing the representation of female scholars and retaining them in the field. As an effort to provide useful empirical data to support such initiatives, this paper reports an informetric study analyzing the publication, authorship and citation patterns of female researchers in the context of the ISMIR conferences.

2. RELATED WORK

2.1 Informetric Studies in MIR

A few studies in MIR have used citation analysis (examining publication and citation counts, and co-citation patterns) and co-authorship analysis to measure the impact of individual papers or authors and understand the patterns of publication. Lee, Jones, and Downie [12] conducted a citation analysis of ISMIR proceedings from 2000 to 2008, aiming to discover how the publication patterns have changed over time. They were able to identify the top 22 authors with the largest number of distinct co-authors, distinguish the commonly used title terms reflecting the research foci in the ISMIR community, and reveal the increasing co-authorship among the MIR scholars. Lee and Cunningham [13] specifically examined 198 user studies in MIR and analyzed the overall growth, publication and citation patterns, popular topics, and methods employed. They found that overall the number of user studies increased, but not the ratio of user studies published in ISMIR proceedings over time. Additionally, they were able to identify a few strong networks



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¹ <http://www.ismir.net/wimir.html>

of co-authorship based on universities and labs, and also found that many of the studies heavily focused on experiment and usability testing. Another study by these authors [4] applied informetric methods to investigate the influence of ISMIR and MIREX research on patents, through citation and topic analysis. The results showed evidence of strong links between academic and commercial MIR research. Very recently, Sordo et al. [18] analyzed the evolution of topics and co-authorship networks in the ISMIR conference, and found larger groups with more variability of topics made more impact to the field.

Notwithstanding the significance of these studies in measuring the status and impact of the field, there has not been any study focusing on the gender disparities in MIR research. The role of gender in scholarly research and academic career has been a long standing topic in many fields, as briefly summarized in the next subsection.

2.2 Female Authors and Scholarly Research

Although there is abundant research showing that female researchers are as devoted as male researchers in the goal of discovery [17][19], women researchers are underrepresented in almost all disciplines, especially in science, technology, engineering, and mathematics (STEM) [15]. In a recent study, Sugimoto et al. [11] analyzed 5,483,841 articles published over the period 2008-2012, from the Web of Science database with over 27 million authorships. They found that only 30% of the authors were female, but surprisingly female authors dominated in some countries, such as Latvia and Ukraine. Kosmulski [10] studied publication patterns of scholars in Poland and found that female scientists in Poland published less than their male counterparts. However, an examination of yearly statistics reveals a trend moving towards gender equalization in recent years. Another study by Aksnes et al. [1] analyzed the publications of 8,500 Norwegian researchers from all disciplines. Findings showed that female researchers published significantly fewer papers than their male counterparts, but the difference in citation rate was not as salient. They also found that among the most productive researchers, women perform as well as men do. Female researchers were even found to be more highly cited than male researchers in physical sciences, including computer science, informatics, and engineering. Conversely, a study of gender-based citation patterns in the field of International Relations [14] found that women were cited significantly less than men, even after controlling for variables including tenure status, institution, and year of publication. This discrepancy was identified as partly due to gender-based self-citation patterns (where men tend to self-cite more than women) and to a tendency for men to cite other men proportionately more than women—perhaps indicating that social networks can have an impact on citation practices.

3. DATA COLLECTION AND PREPROCESSING

Two sources were used to collect the titles of ISMIR papers and their authors: the ISMIR online proceedings and the ISMIR conference web pages. First, bibliographic records of papers published between 2000 and 2011 were

downloaded from the Cumulative ISMIR Proceedings database¹, which supports export in CSV format. Records for papers published between 2012 and 2015 were collected by crawling the program webpages of the conferences since they were only included in dblp², which does not provide a function for exporting multiple records. The crawled raw HTML pages were then parsed with regular expressions, to extract titles and author names.

3.1 Standardization and Deduplication of Names

The downloaded author names needed to be standardized in several aspects. First, some names were inverted with the last name first. Second, some authors varied the form of their name across multiple papers (e.g., including or omitting middle name initials). Third, diacritic letters in names were occasionally replaced by English letters. Besides manual inspection of these cases, we also made use of OpenRefine³, a tool for data cleansing and exploration, to help identify similar forms of names. Once different forms of a same name were identified, we kept the most frequently used version and removed others as duplicates.

3.2 Author Gender Identification

We manually determined and labelled the gender of each author based on their names. Some first names are exclusively or almost exclusively used for one gender (e.g., *Susan*, *Marie*, and *Yumi* are female names by convention). Some names are almost exclusively attributed to males in one language but to females in another language (e.g., *Rene* is a male name in French but a female name in English). In these cases, we tried to determine the gender of authors, taking into account their cultural origin. However, many first names are androgynous, especially Chinese names whose English written forms represent the pronunciations rather than the meanings, which makes determining the gender of those names difficult. To address that, we relied on our collective knowledge of ISMIR authors and we used the affiliation information to search for these authors on the Web. Nevertheless, this did not allow us to assign genders to all authors. The last step was to send a call through the ISMIR mailing list to ask the community to help determine the gender of the authors we could not identify. We also directly contacted a few authors and labs when possible. In the end, we were able to determine the gender of 1,863 (97.54%) out of a total of the 1,910 unique authors on the list.

3.3 Citation Counts

Google Scholar (GS)⁴ was used as the source of citation data for this study, since ISMIR proceedings are not indexed in Web of Science (WoS) or Scopus, the two other main sources of citation data for scholarly works. Studies have shown that GS coverage had grown substantially since its launch [21] and now even surpasses WoS coverage in certain disciplines, including Computer Science

¹ <http://www.ismir.net/proceedings/>

² <http://dblp.uni-trier.de/db/conf/ismir/index.html>

³ <http://openrefine.org>

⁴ <https://scholar.google.com/>

[7]. It also indexes a wider variety of academic sources, including more books, conference papers, and working papers than WoS [8]. As a result, GS has been considered as a reliable source of citation data and an adequate alternative to WoS for research evaluation [7][8]. Since GS does not offer a function for exporting multiple records at once, we used Publish or Perish¹, an open source software tool, to retrieve the citation data for ISMIR papers.

3.4 Limitations

As mentioned previously, we relied on name convention to determine the gender of a large proportion of the authors. It is possible that some of the authors from one gender had a first name more traditionally attributed to the other gender and have thus been mislabelled. Moreover, a high proportion of the 2.56% (48) of authors whose gender could not be determined are of Chinese origin. Therefore, Chinese authors are underrepresented in our dataset. Moreover, our work only focuses on two genders (i.e., male and female) based on name convention and no other gender identity. It is possible that some of these authors identify as neither male nor female and we are not able to represent that information in our analysis.

The use of GS brings additional limitations. Although GS is considered by researchers an adequate source of citation data for research evaluation, it still has some weaknesses. Research shows that the database contains many errors such as duplicates and false positive citations [21] which can potentially inflate the number of citations, but we have no reason to believe that this would affect male- and female-led papers differently. Finally, ISMIR workshops were not consistently indexed in GS, and thus we had no citation data for 35 papers.

4. RESULTS

4.1 Number of Authors and Publications

There are 1,910 unique authors who published at least one paper in ISMIR proceedings from 2000 to 2015. The gender information of 1,863 (97.54%) authors was identified. Among the identified authors, 274 (14.71%) were female and 1,589 (85.29%) were male. There were 1,610 papers published over the years. Among them, 389 papers (24.2%) had female co-authors, 227 (14.1%) had female first authors, compared to 1,188 (73.8%) papers without any female authors and 1,362 (84.6%) led by male authors. While the number of female authors did increase over time, the total number of ISMIR papers and male authors also significantly increased [12]. Figure 1 shows the percentage of papers with male and female first authors over the years as well as those with and without female authors. There is virtually no improvement over the years in terms of the proportion of papers led by female authors, but more papers with female co-authors appeared in recent years (2014 and 2015).

Figure 2 compares the number of papers led by female versus male researchers in histograms. The most proliferate female and male researchers had led almost

equal number of papers, with 13 papers by Jin Ha Lee (female) and 12 by Xiao Hu (female) compared to 14 by Meinard Müller (male). This demonstrates a similar pattern to the finding in [1] that the most productive women and men researchers perform equally well.

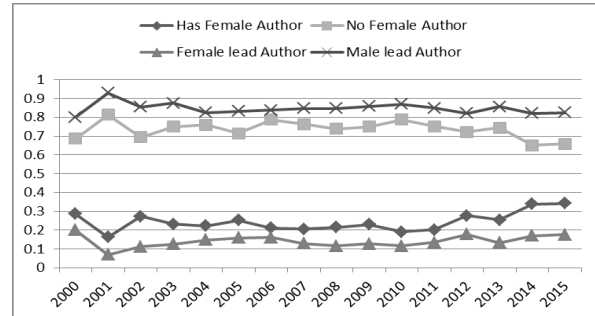


Figure 1. Proportion of ISMIR papers by each gender.

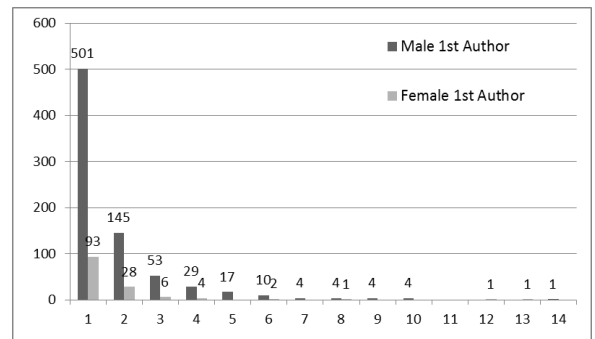


Figure 2. Number of ISMIR papers led by each gender.

4.2 Institutions and Disciplines of Female Authors

The 227 papers with female first authors (including single authored papers) were analyzed to identify the institutions and disciplines of the first authors at the time of publication. Table 1 shows the institutions with the largest number of such papers. The ranks of the top three institutions were in fact earned by their female students, as no female researchers with permanent positions in these institutions has led an ISMIR paper. This is evidence of a strong contribution that female students made to the field, supporting the importance of fostering the growth of junior female researchers through mentorship programs.

Institutions	Number of papers
University of Illinois	12
Queen Mary University of London	10
McGill University	9
University of Washington	9
Indiana University	8
University of Waikato	8
University of Southern California	7
Fraunhofer IDMT	6
Goldsmiths, University of London	5
Pompeu Fabra University	5
Stanford University	5
Utrecht University	5

Table 1. Institutions with the most papers of first female authors.

¹ <http://www.harzing.com/resources/publish-or-perish>

Table 2 lists the most frequent disciplines of female authors who led ISMIR papers. The discipline information was obtained from the departments of the female first authors' affiliations as written in the papers. The disciplines were cleaned up such that closely related ones were combined. For example, "Computer Science and Informatics" was combined with "Computer Science", and "Audio and Speech Processing" was combined with "Electrical Engineering". The most popular discipline is Computer Science, following by Library and Information Science and Music Technology. The latter two were interdisciplinary fields which historically had stronger female representations [16]. When looking at Tables 1 and 2 together, papers from some top ranked institutions were contributed from authors in Library and Information Science (University of Illinois, University of Washington) or Music Technology (Queen Mary University of London, McGill University), rather than the Engineering disciplines predominant in the field. The results indicate that it can be promising to try to foster more female contributors to ISMIR from these disciplines.

Discipline	Number of papers
Computer Science	87
Library and Information Science	44
Music Technology	40
Electrical Engineering	18
Musicology and Music Theory	12

Table 2. Top disciplines of first female authors.

From the affiliations of the female authors, we identified the geographic locations of the authors, as shown in Table 3. Unsurprisingly, most of them were in North America and Europe, in accordance with the fact that most labs in the MIR field are located in these areas. These are followed by Asia and Pacific region with 39 papers led by female authors. Promoting international collaborations between regions with more established and reputable research facilities and other emerging but less developed regions can be a fruitful approach for fostering female researchers in the field. Sugimoto et al. [11] also advocated international collaboration as "it might help to level the playing field" (p.213). This observation may also be related to a study by Ferreira [6] which reported that a steady growth of PhD dissertations written by female in the U.S. was observed, but the increase was attributed to international female research students who came from other parts of the world including Asia. Although further studies are warranted to verify whether this trend also holds for ISMIR authors, in our dataset we did observe circumstantial evidence in that many female author names with Asian origins were based at institutions in Europe or North America.

4.3 Co-authorship

Among all the papers led by female and male authors, the average number of co-authors is 2.69 and 2.86, respectively. A two-sample unequal variance t-test reported a non-significant difference between the two ($p = 0.289$). Figure 3 illustrates the co-authorship trend over the years.

In general, papers led by authors in either gender tend to have an increasing number of co-authors.

Continent	Number of papers
North America	96
Europe	90
Asia	28
Oceania	11
South America	2
Total	227

Table 3. Continents of female leading authors.

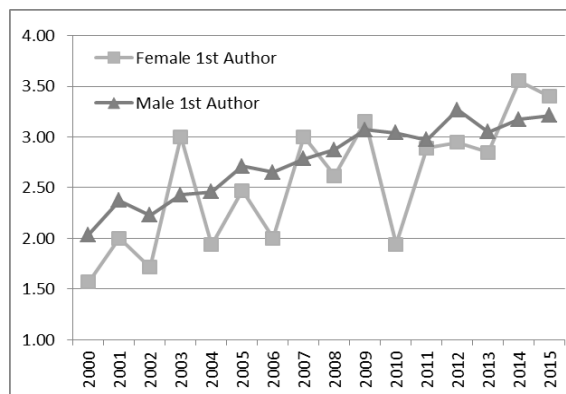


Figure 3. Number of co-authors per paper (2000-2015).

There were 214 single authored papers: 35 (16.3%) of them written by female authors and 179 (83.7%) by males. This percentage of 16.3% is lower than what was reported in [20] in which they found that 26% of single-authored papers published in the JSTOR network databases since 1990 were contributed by female authors. In our dataset, 22 (8.0%) of female authors had single-authored one or more ISMIR papers, whereas 129 (8.1%) of male authors had done so. The results indicate that both female and male authors reach out for collaborations, perhaps due to the interdisciplinary nature of the MIR field. In addition, similar percentages of female and male authors opted to write single authored papers.

We also conducted social network analysis (SNA) on the co-authorship networks of female researchers and their collaborators, to find out with which authors the female researchers most frequently collaborated. Figure 4 shows the network graphs (generated by using the NodeXL SNA tool [8]). The graphs' nodes represent researchers who were grouped into clusters by using the Clauset-Newman-Moore clustering algorithm [3], such that the authors who often collaborated with each other were grouped into a single cluster. The size of a node is proportional to the number of papers written by the researcher. Figure 4 contains nine clusters, each of which has at least five female authors. Each female author in the graphs is represented by a node of diamond shape and the name is marked with an asterisk. In each graph, the names of authors with the most co-authors are labelled.

As shown in Figure 4, some clusters contain multiple female authors with a relatively high number of publications, such as the one with Jin Ha Lee, Xiao Hu and Sally Jo Cunningham, as well as the one with Rebecca

Fiebrink, Catherine Lai, etc. This can probably be attributed to the research groups these authors were affiliated with, as this result corresponds to the pattern observed in Table 1: the two clusters match to the research groups in University of Illinois and McGill University, respectively. Other clusters shown in this figure also reflect re-

search groups such as the Music Technology Group in Pompeu Fabra University (the cluster with Emilia Gomez) and Utrecht University (the cluster with Anja Volk). This pattern once again verifies the importance of having research labs or groups that can foster the growth of female researchers.

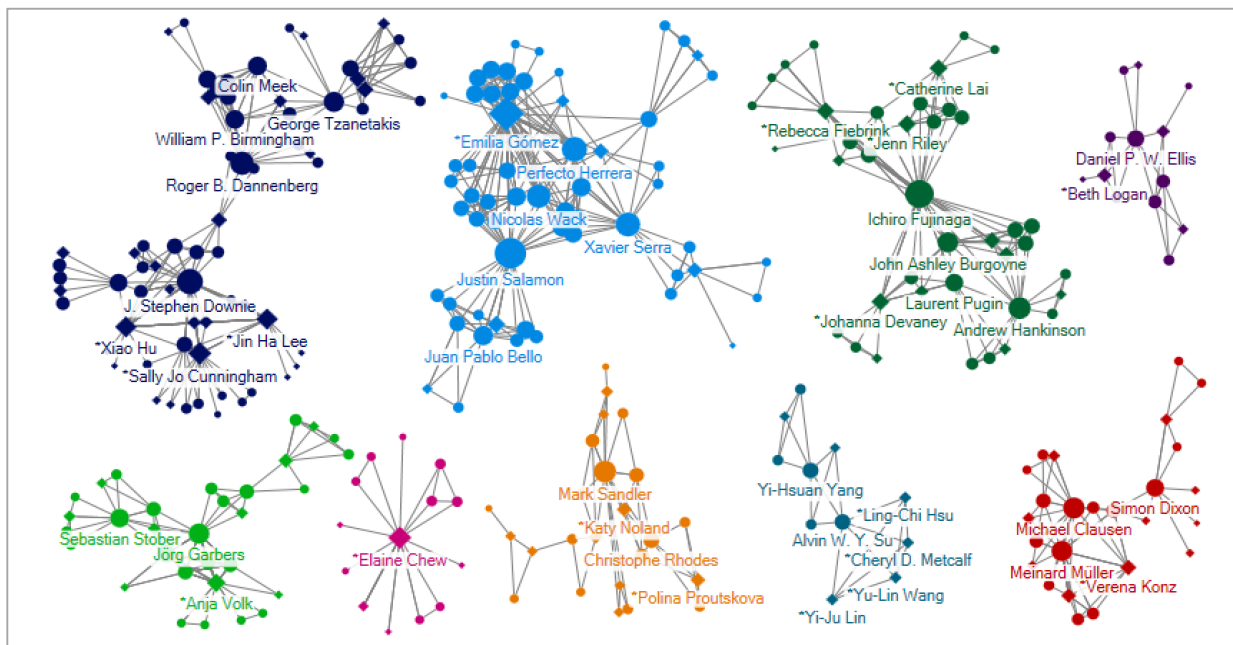


Figure 4. Co-authorship networks of ISMIR female authors (groups with at least five female authors are presented)

4.4 Citation analysis

The average citation count of all papers with female researcher as the leading authors is 34.30. Although this number is lower than that of papers with male leading authors (43.26), the difference was not significant ($p = 0.259$). When considering citation counts of single-authored papers, the difference is even smaller: 22.25 versus 25.27 for female and male authors, respectively.

Figure 5 shows the comparative distribution of papers led by female and male authors by number of citations. A chi-square independence test shows that the two distributions are very similar ($\chi^2 = 11.124$, $df = 8$, $p = 0.195$). The proportion of papers with no citation is the same for both groups (9%). The proportion of highly cited papers (papers cited more than 100 times) is also very similar, representing 10% of female first-authored papers and 9% of male first-authored papers.

These results indicate that the scholarly impact of authors in both genders is similar. Although previous studies found that the difference between citation rates for male- and female-led papers was smaller than that between publication rates [1], it is unusual to see no significant difference on citation rate between genders. The large scale study by Sugimoto et al. [11] found there were fewer citations for papers with female being sole author, first author or last author than in cases where a man was in one of these roles. As Sugimoto and her colleagues worked with more than 5 million of papers across all dis-

ciplines, it is an encouraging result that such gender disparity in scholarly impact as measured by citation counts is not significant in MIR.

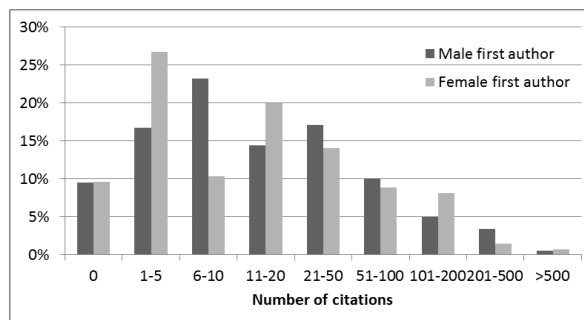


Figure 5. Distribution of female and male-led ISMIR papers by number of citations.

4.5 Topics

Topic analysis was conducted with the titles of the papers, to identify the topics female authors tended to pursue. Both single terms (unigrams) in the titles and combinations of two consecutive terms (bigrams) were extracted. To combine different forms of the same word prefix, the Porter stemmer was used. Stop words were also eliminated, as was the word “music” as it is related to all papers in ISMIR. The most frequently used title words (unigrams) are presented in Table 4. For comparison purposes, the table includes the top title words for six paper

categories: all papers, papers with female lead authors, papers with at least one female author (but not the lead), papers with no female authors, papers with male lead authors, as well as papers written by teams of all female authors. As such, there are overlapping papers between the “Female 1st” and “All Female” categories, and between the “Female non-1st” and “Male 1st” categories.

The first five columns in Table 4 show similar words such as “audio”, “retriev” (retrieval), “classif” (classify). One exception is the female non-1st author category that contains terms such as “detect”, “evalu” (evaluation), and “record”, which suggests that female researchers collaborated with male to work on key detection and evaluation. Several terms from all female teams are quite different from those in other categories (e.g., “digit”, “user”, “kei” (key) and “evalu”), which suggests that areas in which female authors worked together include user studies, key detection and evaluation.

As single words may bear limited semantics, we also extracted bigrams from the paper titles of the aforementioned six categories of gender authorship. Bigrams are two consecutive words which are often phrases, and thus may provide more meanings than unigrams. As listed in Table 5, the differences of bigrams across paper categories are even more obvious than those of unigrams. Papers with all female authors were most likely to be on audio key finding, digital libraries, melody extraction, and user studies. Papers led by female authors were more

likely to focus on melody similarity, mood classification, retrieval systems, corpus and data sources, as well as cross-cultural issues. In contrast, male researchers were more likely to write about Markov model, audio signals, audio features, and Web-based approaches. These differences in focus may reflect the distribution of representation of women in Computer Science and Engineering, where proportionately more women in those fields focus on Human-Computer Interaction (e.g., user studies, cross-cultural issues, digital libraries) rather than signal processing (e.g., audio signals, audio features) [2].

All	Female 1 st	Female non-1 st	All male	Male 1 st	All Female
audio	audio	retriev	audio	audio	inform
retriev	retriev	audio	retriev	retriev	retriev
inform	inform	classif	model	similar	digit
automat	classif	inform	featur	featur	similar
classif	similar	analysi	similar	classif	user
similar	model	detect	analysi	automat	audio
featur	automat	evalu	automat	inform	kei
analysi	polyphon	record	inform	analysi	evalu
recognit	song	system	classif	system	extract
polyphon	featur	feature	system	recognit	find

Table 4. Most frequent words in paper titles (terms unique to female authors are bolded).

All	Female 1 st	Female non-1 st	All male	Male 1 st	All Female
content-bas	inform_retriev	inform_retriev	content-bas	content-bas	inform_retriev
polyphonic_audio	genr_classif	polyphon_audio	audio_signal	non-negativ	audio_kei
real-tim	melod_similar	genr_classif	markov_model	polyphon_audio	digit_librari
non-negativ	classif_us	audio_record	web-bas	audio_signal	kei_find
markov_model	content-bas	auditori_model	audio_feature	markov_model	melodi_extract
audio_feature	mood_classif	base_transcrib	audio_us	audio_feature	understand_user
audio_signal	retriev_system	classif_us	audio-bas	web-bas	
audio_fingerprint	comput_model	corpus-bas	polyphonic_audio	audio_record	
audio_record	cross_cultur	data_sourc	audio_record	audio_us	
automati_chord	machin_learn	digit_imag	score_inform	audio-bas	

Table 5. Most frequent bigrams in titles of papers (terms unique to female authors are bolded).

5. CONCLUSION AND FUTURE WORK

Overall our findings show both positive and negative aspects related to gender balance issues in MIR. While it is discouraging that the participation of female authors has hovered around 10-20% throughout the history of ISMIR without much improvement over time, we also see that the most prolific authors of both genders are similarly productive and papers led by both genders are cited at similar rates. Our analysis highlights the importance of the role of mentorship through co-authoring papers and also being part of the same labs or research groups for increasing the number of female scholars in the field. International collaborations connecting female researchers in less represented regions with more established groups can be a promising approach. In addition, we may encourage and attract female contributors from interdisciplinary disciplines historically with better female representations such as Information Science and Music Tech-

nology. Promoting research in these areas (whether by male or female authors) has also been identified as an important step forward for the field of MIR [5][12]—it is crucial to the development of usable, effective music systems that we understand our users and their needs, and work to create new systems that integrate with both technological and social infrastructures.

In order to conduct a more accurate informetric study in the future, it would be useful for the ISMIR program committee to collect gender information during the paper submission process directly from the authors. This will not only allow us to obtain a more accurate representation of the ISMIR community, but also enable the analysis on paper rejection rates in terms of gender. We also recommend the gathering of gender and research focus data for program committee members, to examine the possible effect of gender in the gatekeeping aspect of entry to the ISMIR community.

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