2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

Linguistic Analysis of Letters of Recommendation for Physics Residency Program Applicants

Elizabeth L. Covington, PhD[1], Kelly A. Wallace, PhD[2], Jessica Fagerstrom, MEd, PhD[3], Benjamin S. Rosen, PhD[1], Meera Tewari[1], Sharareh Koufigar, MS[3] and Krithika Suresh, PhD[1], (1)University of Michigan, Ann Arbor, MI (2)Medical University of South Carolina, Charleston, SC (3)Department of Radiation Oncology, Fred Hutchinson Cancer Center, University of Washington, Seattle, WA

ABSTRACT

Purpose: Determine if linguistic differences are present in letters of recommendation (LOR) for applicants to medical physics residency programs (MPRPs).

Methods: Three MPRPs provided letters from applicants in 2019-2021. Letters were analyzed using the Linguistic Inquiry and Word Count (LIWC) software to determine percentage of words in LIWC categories and custom dictionaries for technical/research skills and personality. Letters were classified by applicant gender (AG), letter writer gender (LWG), and letter writer academic rank (LWR). For each LIWC category, linear mixed effects models with a random effect for applicant were used to assess differences in mean word use by AG, LWG, and LWR. Interaction terms between AG and LWG, and between AG and LWR were used to investigate effect modification.

Results: Analysis was performed on 714 letters for 173 applicants. There were more male letter writers (LWs) overall (598 (84%) male versus 113 (16%) female). There was no significant difference in the distribution of LWG by AG (p = 0.15). Several linguistic features showed significant differences by AG. Words associated with conflict (p=0.017) and friend (p=0.028) had higher mean usage for male applicants, while words related to wellness (p=0.002) and social referents (p=0.005) had higher mean usage for female applicants. A significant interaction between LWG and AG was observed for positive tone (p=0.006), with female LWs using more positive tone words for male compared with female applicants. Letters by full professors were more likely to have linguistic features of work (p=0.001), lifestyle (p=0.002), and tech (p=0.018), while assistant professors were more likely to have features of skill/knowledge (p=<0.001) and social behavior (p=0.002). There were no statistically significant interactions between LWR and AG.

Conclusions: Linguistic features showed significant differences between AG, LWG, and the LWR. Discussion of methods to mitigate linguistic bias, such as standardization or bias training, could improve LOR.

CONTACT

Elizabeth L. Covington, Ph.D.
Department of Radiation Oncology
University of Michigan
ecoving@umich.edu

INTRODUCTION

Letter of recommendation in academic medicine have shown bias where linguistic descriptors, word count, and raising doubt vary between male and female applicants and other applicant charactersitics[1,2]. This is the first study to analyze letters of recommendations for physics residency applicants for linguistic bias.

METHODS AND MATERIALS

- Letters from three medical physics residency programs (MPRPs) were analyzed using the Linguistic Inquiry and Word Count (LIWC) software to determine percentage of words in LIWC categories and custom dictionaries, as shown in Table 1, for technical/research skills and personality.
- National Match System (NMS) IDs were used to ensure that applicants were analyzed once and not duplicated between institutions.
- Letters were label by the applicant gender (AG), letter writer gender (LWG), and letter writer academic rank (LWR).
- For each LIWC category, linear mixed effects models with a random effect for applicant were used to assess differences in mean word use by AG, LWG, and LWR. Interaction terms between AG and LWG, and between AG and LWR were used to investigate effect modification.

Table 1. Example of custom dictionary used in linguistic analysis (adapted from Chapman et al[1]).

Domain	Words/Phrases
Grindstone	hardworking, hard-working, hard worker, tenacious, deliberate, work ethic, productive, efficient, self-starter, self starter, go-getter, go getter, self-motivated, self motivated, tenacity, deliberately, productivity, efficiency, motivated, motivation
Standout	standout, best, leader, leadership, exceptional, outstanding, star, superstar, impressive
Desirability	keep, recruit, stay, rank, match, top 1%, top 5%, top 10%, top echelon
Research	research, publications, funding, PhD, Ph.D., scientist, first-author, grant, thesis, dissertation, oral presentation, ASTRO, high-impact, podium, abstract, investigator, translational, lead-author, patent, manuscript, article, conference, AAPM, publication, funded, first author, grants, poster, presentations, high impact, lead author
Skill/ Knowledge	skillful, finesse, knowledgeable, fund of knowledge, technical, technique, skilled, skills, quality assurance, QA, quality improvement, quality control, treatment planning, code, coding, programming, scripting, commissioning, commission, modeling
Communal/ Friendly	likable, team player, friendly, easy-going, enthusiastic, enthusiasm, agreeable, caring, nice, pleasant, kind, kindness, warm, warmth, endear, endearing, cheerful, polite, smile, modest, humble, genuine, collaborative, upbeat, liked easygoing, easy going, personable
Social/ Familial	work-life balance, children, child, couple, wife, husband, family, nontraditional, mature, kid, spouse, caregiver, son, daughter
Introverted Personality	reserved, shy, introverted, sensitive, quiet

RESULTS

There were 714 letters written for 173 candidates, with a median of 3 letters per candidate. A summary of characteristics applicants and letter writers is shown in Table 2. Several linguistic features showed significant differences by AG (Figure 1, Table 3), LWG (Figure 2, Table 4), and LWR (Figure 3).

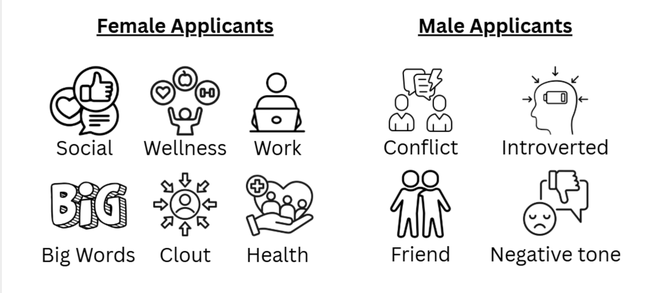

Figure 1. Significant linguistic features by gender of applicant

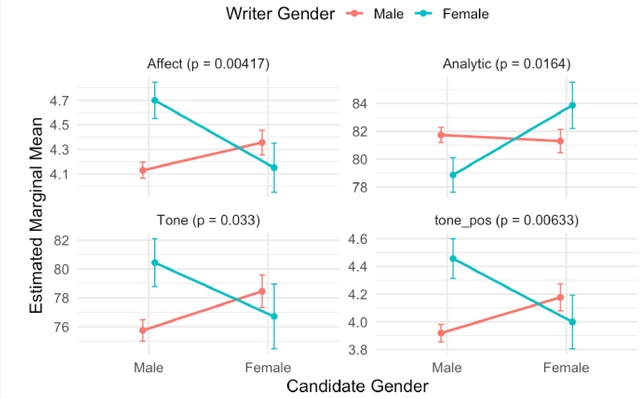

Figure 2. Linguistic features showed significant interaction effects between candidate and writer gender.

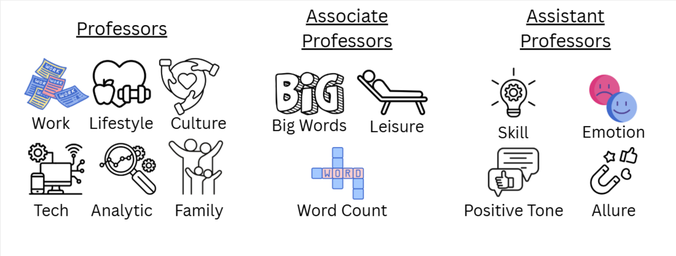

Figure 3. Significant linguistic features by rank of the letter writer

Table 2. Summary of characteristics by Candidate gender (n = # of total letters, % = percentage of total letters)

Characteristic	Overall N = 714[1]	Female N = 212[1]	Male N = 502[1]	p-value[2]
Writer gender				0.15
Female	113 (16%)	40 (19%)	73 (15%)	
Male	598 (84%)	171 (81%)	427 (85%)	
Unknown	3	1	2	
Writer rank				0.12
Assistant Professor	108 (17%)	26 (14%)	82 (19%)	
Associate Professor	173 (28%)	60 (33%)	113 (26%)	
Professor	341 (55%)	95 (52%)	246 (56%)	
Unknown	92	31	61	

[1] n (%)
[2] Pearson's Chi-squared test

Table 3. Significant linguistic features by gender of applicant

Feature	Direction	p-value
Wellness	Female > Male	0.002
Social Referent	Female > Male	0.005
Big Words	Female > Male	0.005
Clout	Female > Male	0.016
Work	Female > Male	0.024
Social	Female > Male	0.029
Achieve	Female > Male	0.037
Health	Female > Male	0.050
Physical	Female > Male	0.050
Conflict	Male > Female	0.017
Friend	Male > Female	0.028
Introverted Personality	Male > Female	0.025
Negative tone	Male > Female	0.044

Table 4. Significant linguistic features by gender of the letter writer

Feature	Direction	p-value
Positive tone	Female > Male	0.016
Affect	Female > Male	0.016
Moral	Female > Male	0.018
Grindstone	Female > Male	0.038
Tech	Male > Female	0.012
Big Words	Male > Female	0.024
Work	Male > Female	0.026
Lifestyle	Male > Female	0.033
Research	Male > Female	0.036
Culture	Male > Female	0.043
Standout	Male > Female	0.046

DISCUSSION/CONCLUSION

Significant differences in linguistic features by AG, LWG, and LWR were observed. There were also significant interactions between AG and LWG, with female writers having a more positive tone for male applicants. There were no statistically significant interactions between LWR and AG. Methods for reducing bias, such a standardization or bias training, should be discussed for ensuring equity across letters of recommendation for medical physics residency programs.

REFERENCES

1. Florence E. Turrentine, Caitlin N. Dreisbach, Amanda R. St Ivany, John B. Hanks, Anneke T. Schroen, Influence of Gender on Surgical Residency Applicants' Recommendation Letters, Journal of the American College of Surgeons, Volume 228, Issue 4,2019,Pages 356-365.e3,ISSN 1072-7515, https://doi.org/10.1016/j.jamcollsurg.2018.12.020.
2. Chapman BV, Rooney MK, Ludmir EB, De La Cruz D, Salcedo A, Pinnix CC, Das P, Jagsi R, Thomas CR Jr, Holliday EB. Linguistic Biases in Letters of Recommendation for Radiation Oncology Residency Applicants from 2015 to 2019. J Cancer Educ. 2022 Aug;37(4):965-972. doi: 10.1007/s13187-020-01907-x. Epub 2020 Oct 27. PMID: 33111188; PMCID: PMC7591242..

© Poster Template by Genigraphics® 1.800.790.4001 www.genigraphics.com