

Understanding Algorithmic Bias in Job Recommender Systems: An Audit Study Approach

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Personalized Recommendation


- A tool to alleviate information overload problem.
- Personalized recommendation:
 - ① Support human decisions on discovering and selecting new and relevant item.
 - ② Mass applications in online markets. [link](#)
- Internet job boards:
 - ① In US 2021, 8.85 million jobs were posted online by employers; more than half of the job seekers prefer finding job online. [link](#)

Personalized Recommendations

Today's Recommendations For You

Here's a daily sample of items recommended for you. Click here to [see all recommendations](#)

LOOK INSIDE!






Even Faster Web Sites: Performance (Paperback) by Steve Souder
★★★★★ (7) \$23.10
[Fix this recommendation](#)

Any Category Algorithms B
Graphic Design Microsoft

NETFLIX Watch Instantly Just for Kids Instant Queue Personalize

Angela, welcome to your very own Netflix homepage!
Based on your ratings, we've filled it with personalized suggestions **JUST FOR YOU**.
The more you rate, the better we get at giving you suggestions you'll love.

Top 10 for Angela



Movies Popular on Netflix

STORIES YOU MIGHT LIKE ? 10 of 10



White House Is Hoping Jon Stewart Can Help Them Out With The 9/11 Responders Bill
[Like](#) 234 [Jon Stewart](#)



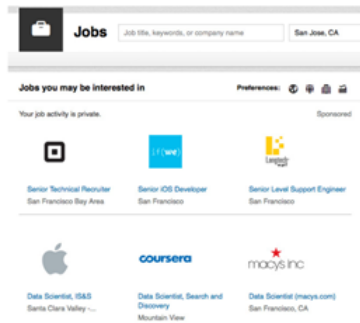
Ozzy Osbourne: 'I'm Getting Sick Of Lady Gaga'
[Like](#) [Madonna](#)



New York Times Sues N.Y.P.D. on Access to Information
[Like](#) [New York Times](#)

Job Boards

- Job board is not only an information aggregation and displaying site.
- Job recommender systems generate a list of job positions that satisfy a job seeker's desire and interest.



Job Recommender System

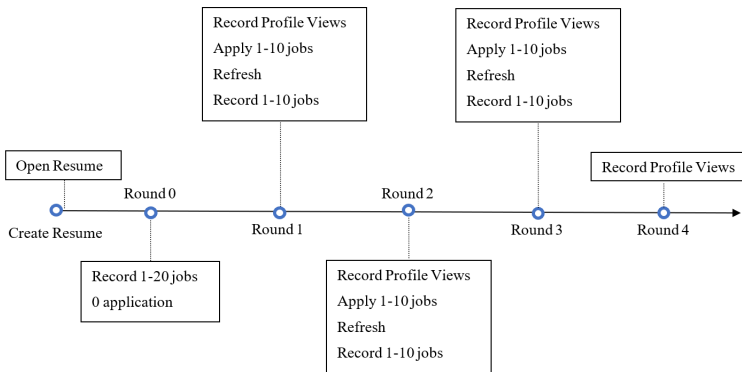
- Apply recommendation algorithms to labor markets.
 - ① worker's characteristics and behaviors, and the match between the worker and the job.
- Pros: Improve job-worker match.
- Cons: Fairness of the job recommendation algorithms;
Reinforce gender and other stereotypes.
- **Research Questions:** Whether, to what extent, and how job board algorithms systematically treat male and female job seekers differently?

Design

- An algorithm audit study.
- Selection of job types (35)
 - 1 Sample size
 - 2 Job's gender type: female-dominated, gender-balanced, and male-dominated jobs.
 - 3 Hierarchy level: entry level, mid-level and high level.
 - 4 E.g. software engineer in the Internet industry
- Resume:
 - 1 Match the job's requirements.
 - 2 Young (3 years exp), older (13 years exp).
- Platforms: Top 4 Chinese online job boards.
- Location: Beijing, Shanghai, Shenzhen and Guangzhou.
- In total, $35 \times 4 \times 4(\text{city}) \times 4(\text{websites}) = 2240$ resumes created.

Implementation

- Paired (male and female) profiles are designed to follow identical application strategies.
- Naïve users who click into and send resume to the top listed recommended jobs.



Results

- 12.3% of job recommendations are gender-specific.
- Compare job characteristics: Only-to-male jobs have

	(1)	(2)	(3)
	Posted Wage	Education	Experience
Male	2,616**	0.0466	0.1666***
	(1,240.305)	(0.031)	(0.028)
N	20,321	22,245	22,245
R ²	0.620	0.374	0.382

- $\approx 1.8\%$ average current wage, 2.1% average experience.

Words and Gender Stereotype

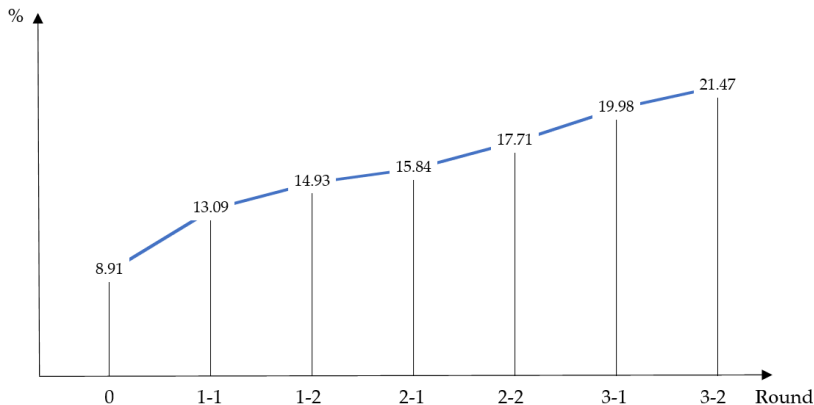
	Female Words	Male Words
Skills	listen, speak, write, documentation, data, chat tools, cooperation, communication, assist, negotiation, administrative, collect	decision-making, planning, engineering, independent, leadership, charge, supervise, design
Work Timing and Location	eight-hour working, flexible, weekly break, regular hour	nightwork, work overtime, long travel
Benefits	marriage leave, maternity leave, parental leave, social security, maternity insurance, medical insurance	commission, stock, allowance, reward, meal, shuttle, commute friendly, injury insurance
Company	training, atmosphere	public company
Other Qualifications	certificate, new grad, non-experience	science engineering, no crime history
Personality, Age, and Appearance	careful, patient, active, outgoing, generous, punctual, figure, temperament, facial	self-motivated, pressure, innovative, entrepreneurial

The color intensity indicates the femaleness (red) and maleness (blue) consistency with gender stereotypes from literature and two survey results. [back](#)

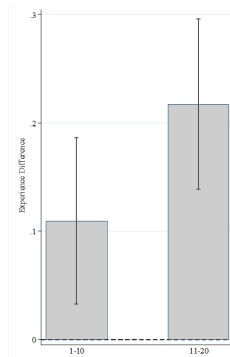
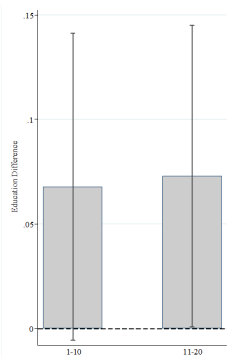
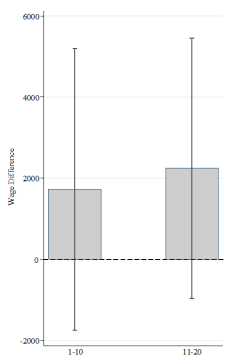
Drivers of Gender Bias

- ① Gender request in job ads.
 - Filter out gender mismatch recommendations (jobs with gender request $< 1\%$ in 2018).
- ② Content-based recommendations may play a role from results on words.
 - Gender (related keywords) are used to define 'similar' workers and match worker and job.
 - Words in gender specific job are related with gender stereotype. [link](#)
- ③ Item-based collaborative filtering can enlarge the gender bias.
 - Recommend jobs similar to histories.
 - Compare ads before and after application. [link](#) [link](#)
- ④ Hiring agents' feedback.
 - Use hiring agents' behaviors to predict preferences on workers.
 - Number of views on profiles. [link](#)

Difference Rate by Rounds



Before and After Application

[back](#)

Views from HR

- Y is the number of gender-different recommended jobs per 100 recommendations in gender pair.
- $ViewT$: the number of views of two applicants in gender pair.

	(1)	(2)	(3)	(4)
ViewT	0.0310*** (0.003)	0.0310*** (0.003)	0.0308*** (0.003)	0.0313*** (0.008)
Age		Yes	Yes	Yes
Job Gender Type			Yes	Yes
Job Board				Yes
N	1,031	1,031	1,031	1,031
R ²	0.336	0.336	0.345	0.366

Related Literature

- Gender differences in job search
 - ① Where, and how, do people look for jobs? (Eriksson and Lagerström, 2012; Flory et al., 2015; Card et al., 2016...)
 - ② Which job vacancies does a worker get to see before deciding where to apply?
- Audit study in gender discrimination (Booth and Leigh, 2010; Cediey and Foroni, 2008; Kline et al., 2022)
 - ① How employers respond to job applications from identical men versus women?

Related Literature

- Algorithm audits
 - ① focus on e-commerce sites or Facebook jobs (Ali et al 2019, Hannak et al., 2014, Lambrecht et al, 2019)
- Algorithm fairness
 - ① Advertisement delivery, criminal courts, mortgage approval, health care (Lambrecht and Tucker, 2019; Fuster et al., 2020; Bartlett et al., 2021; Obermeyer et al., 2019...)
- Algorithms in worker recruitment
 - ① Algorithmic decision tools in employees selection (Hoffman et al., 2018; Li et al., 2020)
 - ② Algorithms design of resume search engines (Chen et al., 2018)

Summary

- An algorithm audit study of job recommendation algorithms
 - ① widespread use, but almost no attention among labor studies.
 - ② workers **cannot** apply to jobs they don't see.
- Key findings:
 - ① 12.3 percent of recommended jobs are seen only by (identical) male or female resumes
 - ② Only-to-male recommendations offer modestly higher wages and demand more experience
 - ③ Recommended jobs strongly reinforce common gender stereotypes
- Driven by three processes:
 - ① content-based matching (gendered words in the job ad match the resume)
 - ② item-based collaborative filtering (based on application history)
 - ③ hiring agents' reactions to previous male and female application

Thank you

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