

# JOB RECOMMENDATION RECSYS SUMMER SCHOOL 2023

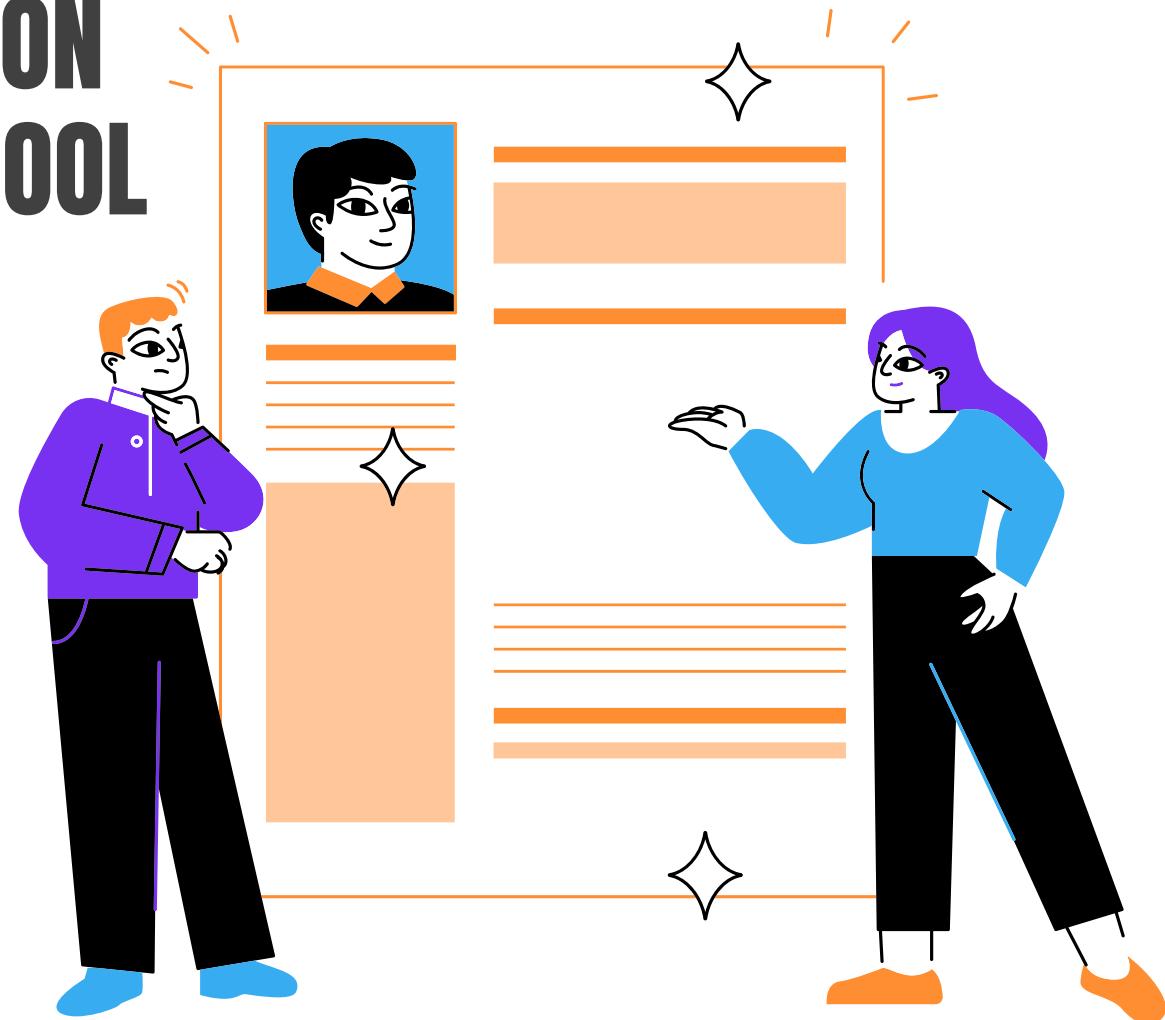
## MESUT KAYA

**Postdoc @AAU**

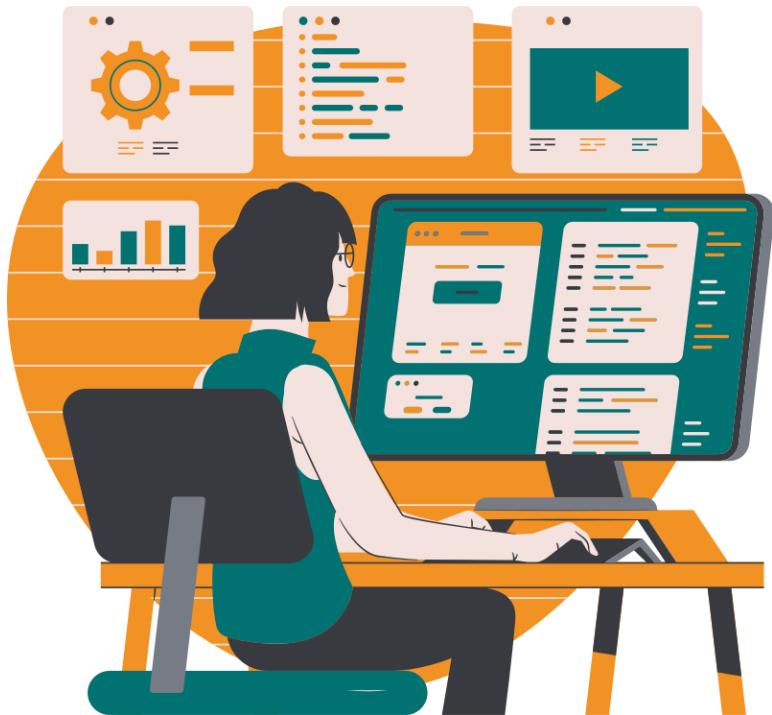
[mkaya@ikp.aau.dk](mailto:mkaya@ikp.aau.dk)



@kayaa\_mesutt



# OVERVIEW



**Introduction to Job Recommendation Problem**

**Case Study: JobMatch Project**

**Understanding Recruiter's Search Behaviour**

**Talent Recommendation**

**Evaluating Talent Recommendation Algorithms**

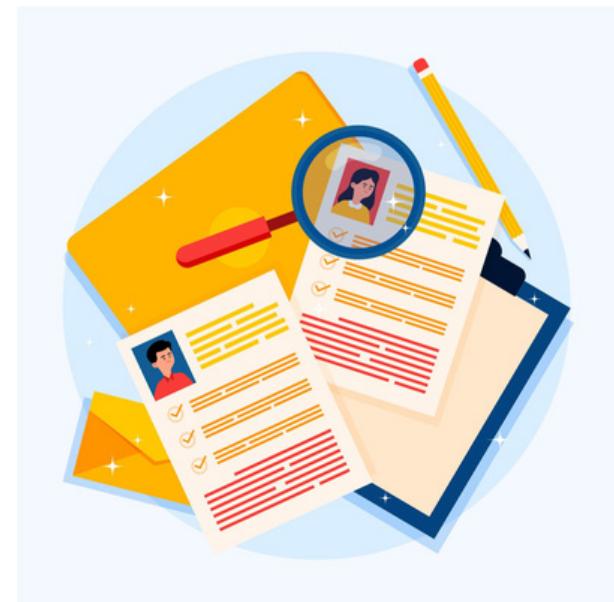
**Lessons Learned**

# JOB RECOMMENDATION

## PERSON-JOB FIT



Job opening



Resume

# Recommending relevant jobs to job seekers



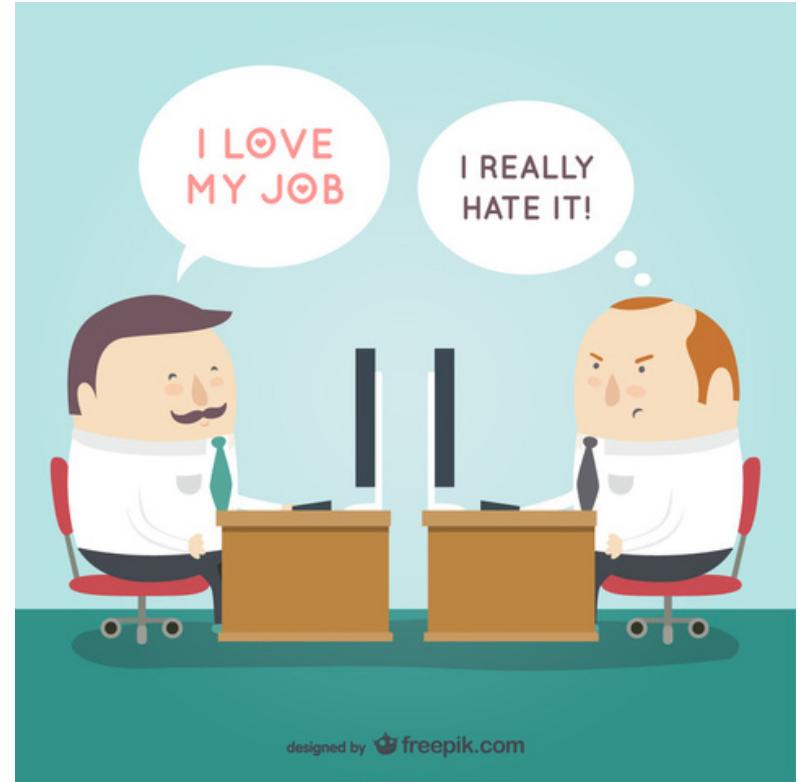
# Recommending relevant job seekers to open job positions



# Earlier Approaches



**Collaborative Filtering**



**Content-based**

# Representation Learning



$d = \{t_1, t_2, \dots, t_m\}$

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Textual data source

$h_u = \{\vec{d}_{i1}, \vec{d}_{i2}, \dots, \vec{d}_{in}\}$

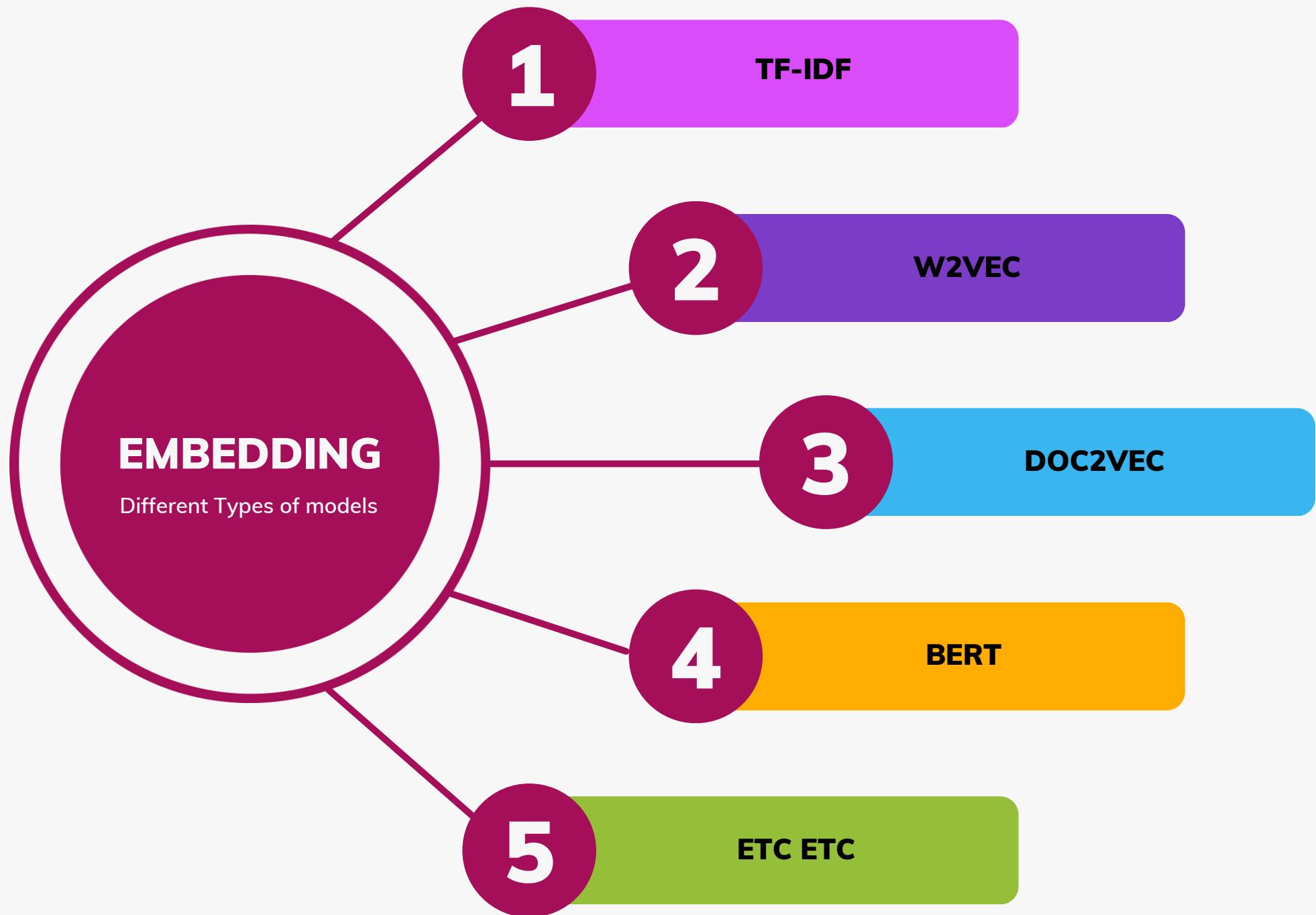
$h_i = \{\vec{d}_{u1}, \vec{d}_{u2}, \dots, \vec{d}_{ul}\}$

Interaction data

Embedding Model

0.21 | 0.93 | 0.01 | 0.12 | ...

0.34 | 0.73 | 0.41 | 0.02 | ...





You are a Python Developer with a solid experience in Web development and can manage projects.

You easily adapt in a new environment and speak French and English





# JobMatch Project

A 3-year research project is now trying to crack the code of matching jobseekers with the right jobs. The project is supported by Innovation Fund Denmark with 7 million Dkr.



# Understanding Recruiters' Search Behaviour



# Contextual Inquiry



# Search in CVs

1

[See manual](#)

sales supply chain

Choose job titles

Search

Enter work location (e.g. postcode or city)

Choose category/categories

Reset

## Filter your search

2

### Following company

 Testfirma

### Education level

At least

Maximum

### Work experience (years)

10 Maximum

### Management experience (years)

5 Maximum

### Salary expectations

40,000 kr. Maximum

60,000 kr.

### Tags

Found 1,845 users.

[Contact CVs](#)[Clear CVs](#)[Sent me](#)

4

**Language skills** English**Management experience** 5+**Notice period** 1 month notice**Salary expectations** 40,000 kr.–60,000 kr.**Search among** Online CVs + followers**Search term** sales supply chain**Special groups** Full-time**Work experience** 10+[Create CV Agent](#)

## Advanced

3

### Language skills

 English

### Minimum language proficiency

### Notice period

1 month notice

### Employment / groups

 Full-time

### Search among

Online CVs + followers

### Saved searches

[View all your searches](#) →

## Experienced Supply Chain Management Professional

**Job wishes:** Supply Chain Director, Category Manager, COO, Director and 6 others**Latest job:** Owner and founder ( [REDACTED] )**Geography:** [REDACTED]**Education:** Graduate Diploma in Business Administration) – HD 2. Supply Chain Management ([REDACTED])**Salary expectations:** DKK 40-50,000**Work experience:** 24 years**Conditions of employment:** Full-time and temp**Management experience:** 20 years

Experienced Supply Chain Management Professional – with extensive international leadership experience from Strategic Sourcing, Procurement, Supply Chain Management, Product Portfolio Management, Business & Product Development and leading global international teams.

... one of the best managers within Supply Chain and Procurement in [REDACTED] ...  
... PROFILE I am an Experienced Supply Chain Management Professional with a solid ...

[supply shipment](#)[Experienced Supply Chain Management Professional](#)[Global Supply Chain Jobs](#)

ABC

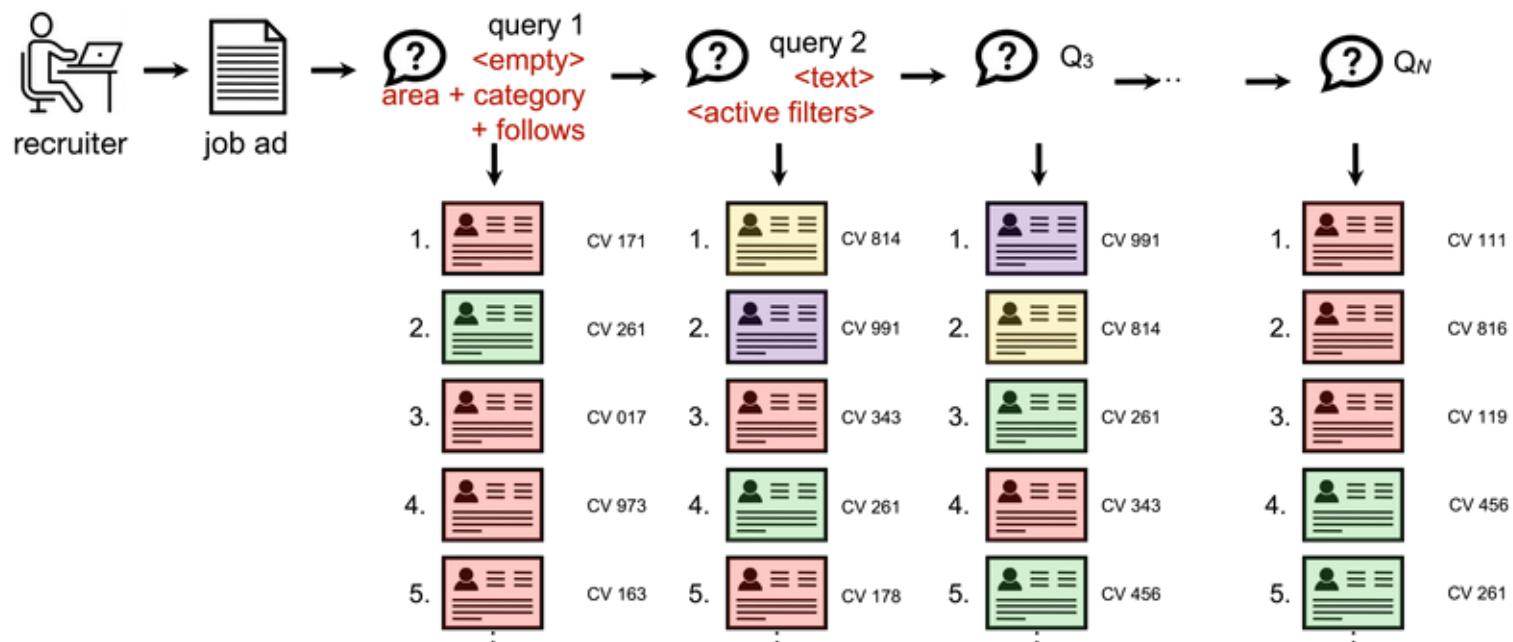
+ 134 others

 [REDACTED]

## Supply Chain, Procurement and Logistics Specialist

**Job wishes:** Business Development, Key account, Procurement, Sourcing and 2 others**Latest job:** Head of Supply Chain, Procurement and Logistics ([REDACTED])**Geography:** [REDACTED]**Education:** Cand. merc. [REDACTED]**Salary expectations:** DKK 50-60,000**Work experience:** 10 years**Conditions of employment:** Full-time**Management experience:** 5 years

I am a hardworking and ambitious [REDACTED]-year-old with specialty in International Business, Supply Chain, Procurement and Logistics. I have experience in working in a dynamic environment, where pace and overview are decisive elements. You will get a dedicated, hardworking and social employee with a theoretical and practical background within Business Administration, Supply Chain and International Business. I will be able to contribute with positive energy, new ideas, new



# Interviews with Recruiters



## Introduction

- Ask their consent for the interview
- Learn about their recruitment experience, which industry etc.

## Searching & filtering candidates

- How they decide which **search terms** and **filters** to use, **how long** this search process took,
- How many **query reformulations** they went through
- How their inspection of the search results changed their perception of their search terms and search criteria.

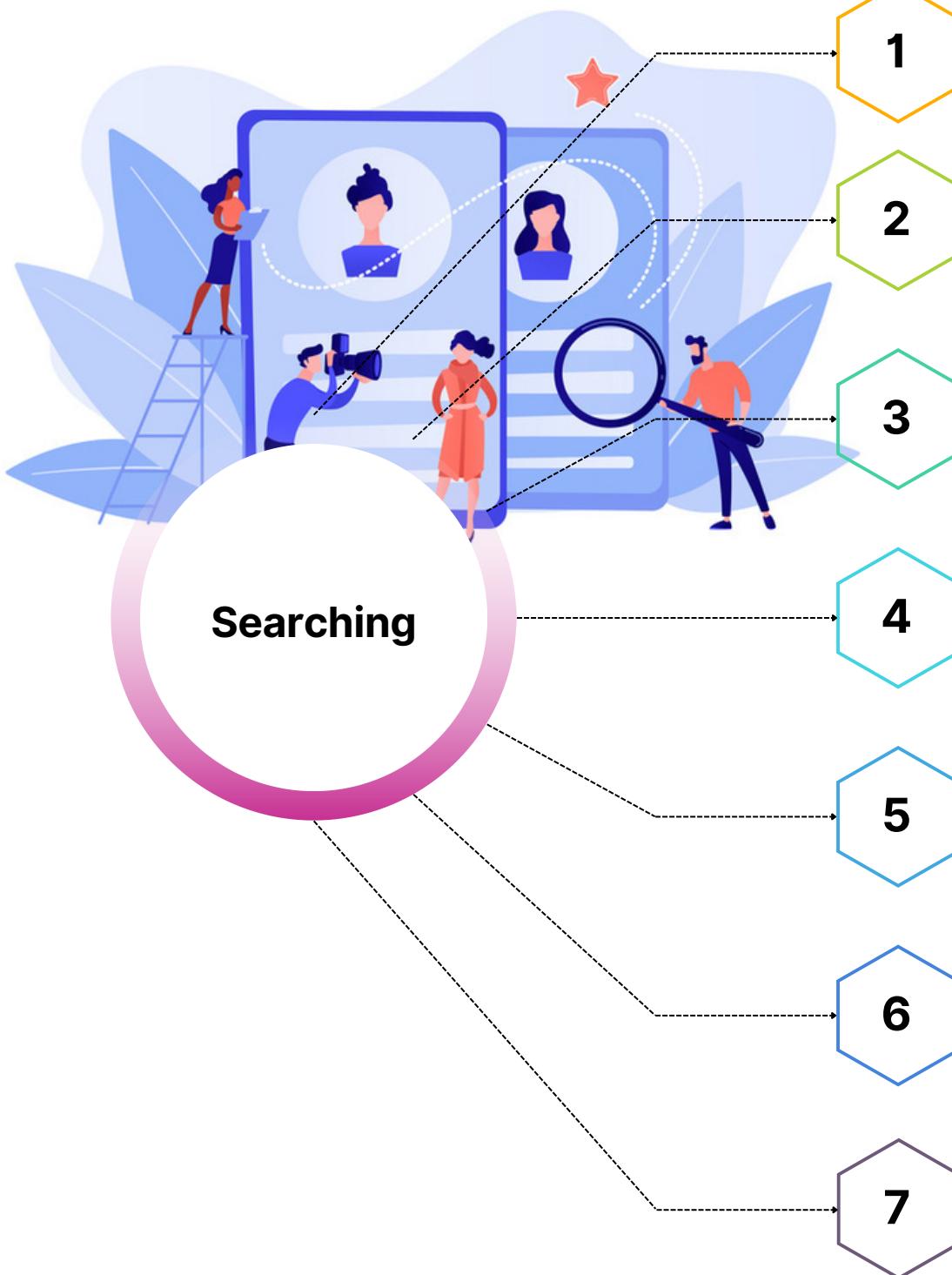
## Shortlisting Candidates

What information about jobs and CVs was used by the participants to determine whether a candidate was relevant

## Contacting Candidates

- Whether and to what degree the messages are personalized before they are sent out,
- which aspects of the job or CVs are highlighted in these messages
- whether participants use personal templates or company-wide templates





## INITIAL RESULT LIST

inspect the top of this initial list based on matching **location** and **category** filters to get a feel for the type and the number of candidates that the search engine returns.

## TOO FEW RESULTS

**divergent** search behavior, e.g., by removing pre-filled locations or job categories, or using wildcard operators to increase recall

## TOO MANY RESULTS

adjust queries to converge on a smaller set of search results by **adding more specific keywords or job titles**

## LOCATION

The auto-generated location in the location search bar is usually left in place by our participants and rarely altered

## KEYWORD SEARCH

participants tend to go from basic 'quick-and-dirty' search to using more advanced search operators -> **Searching as learning**

## JOB TITLES

Searching for job titles was done by some of the participants. Some think that job title is as important as knowledge, skill and ability.

## JOB CATEGORIES

Job categories were not as popular with the participants as the other search bars. Due to their automatic assignment



## SALARY

While some recruiters only set a maximum salary level, others insisted on setting both minimum and maximum salary level expectations to uncover the relevant candidates.

## MANAGEMENT EXPERIENCE

typically only use it filter if it is explicitly mentioned in the job posting, similar to work experience

## COMPANY FOLLOW FILTER

Filter the CVs that shows interest in the company to find more relevant candidates.

## LANGUAGE

They use it only if the job posting explicitly states the language as requirement.

## EMPLOYMENT TYPE

for jobs for jobs that are not full-time positions, such as part-time positions, freelancing or student jobs

## EDUCATION LEVEL

Used if explicitly mentioned, similar to language, management experience, work experience.



## NUMBER OF RELEVANT CVS

most recruiters aim for a shortlist of around 20 relevant candidates before they move on to the contacting phase.

## SKILL, KNOWLEDGE, ABILITY

The most important relevance criteria when assessing the relevance of a candidate for the position are whether they match the required knowledge, skills and abilities stated in the job posting.

## PAST WORK EXPERIENCE

participants would contrast the most recent positions a candidate has held to the required skills to better be able to determine whether the candidate really possesses those skills

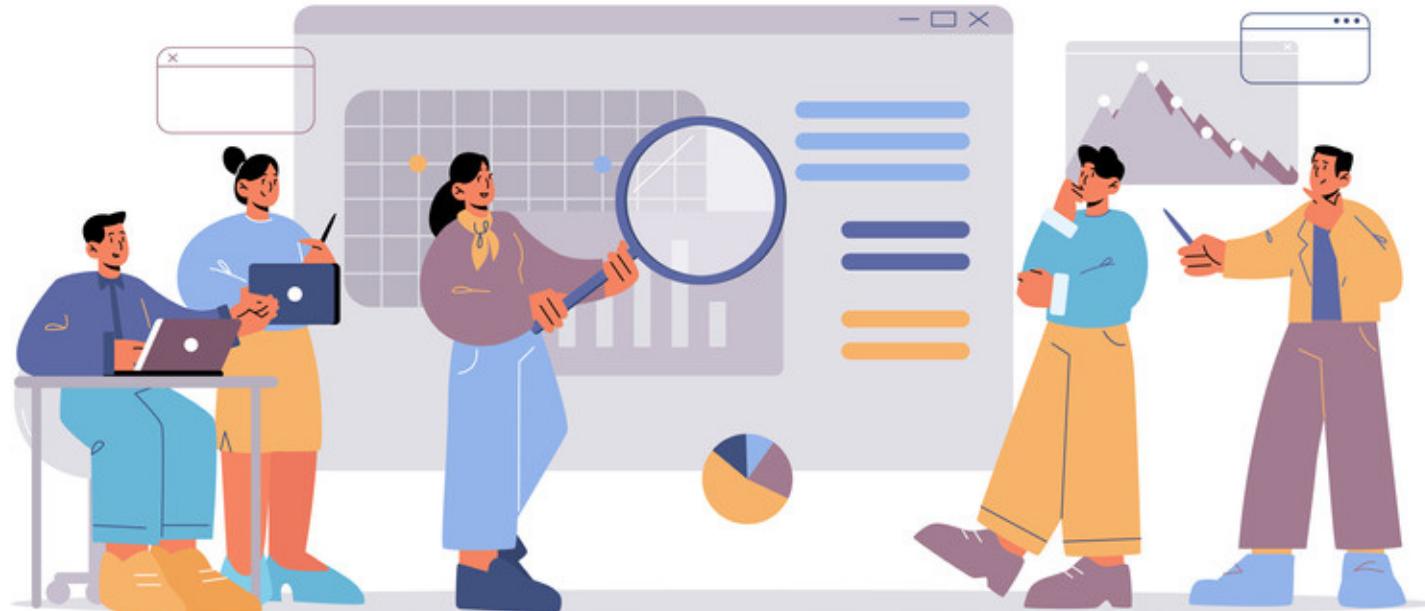
## LOCATION

it has a strong influence on whether candidates will be interested in applying for a job.

## OTHER INFORMATION

When necessary, participants would check unstructured personal CVs that are included as PDFs, although this was not common due to this taking more time to assess

# Search Log Analysis



# Research Questions

1

## RECRUITMENT TASKS

What characterizes the recruiters' search behavior for different types of recruitment tasks?

2

## SEARCH BEHAVIOUR OVER TIME

How does recruiters' search behavior change over the course of a search session?

3

## SUCCESS RATE

What influences the success rate of a search session (**the number of positive responses** by job seekers after being matched)?

4

## EFFECT OF PANDEMIC

How has the pandemic influenced the success rate of recruiters?

5

## CONTEXTUAL INQUIRY

How do the results of the contextual inquiries align with our search log analysis?

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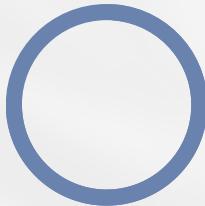
[★ ★ ★](#)[Add tag](#)[Add comments](#)

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# Search Log Data



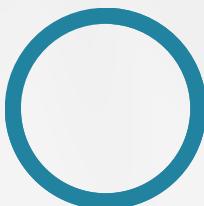
## Matching

a cheaper, short-term service where recruiters spend at most 60 minutes



## Recruitment

a more expensive, long-term service

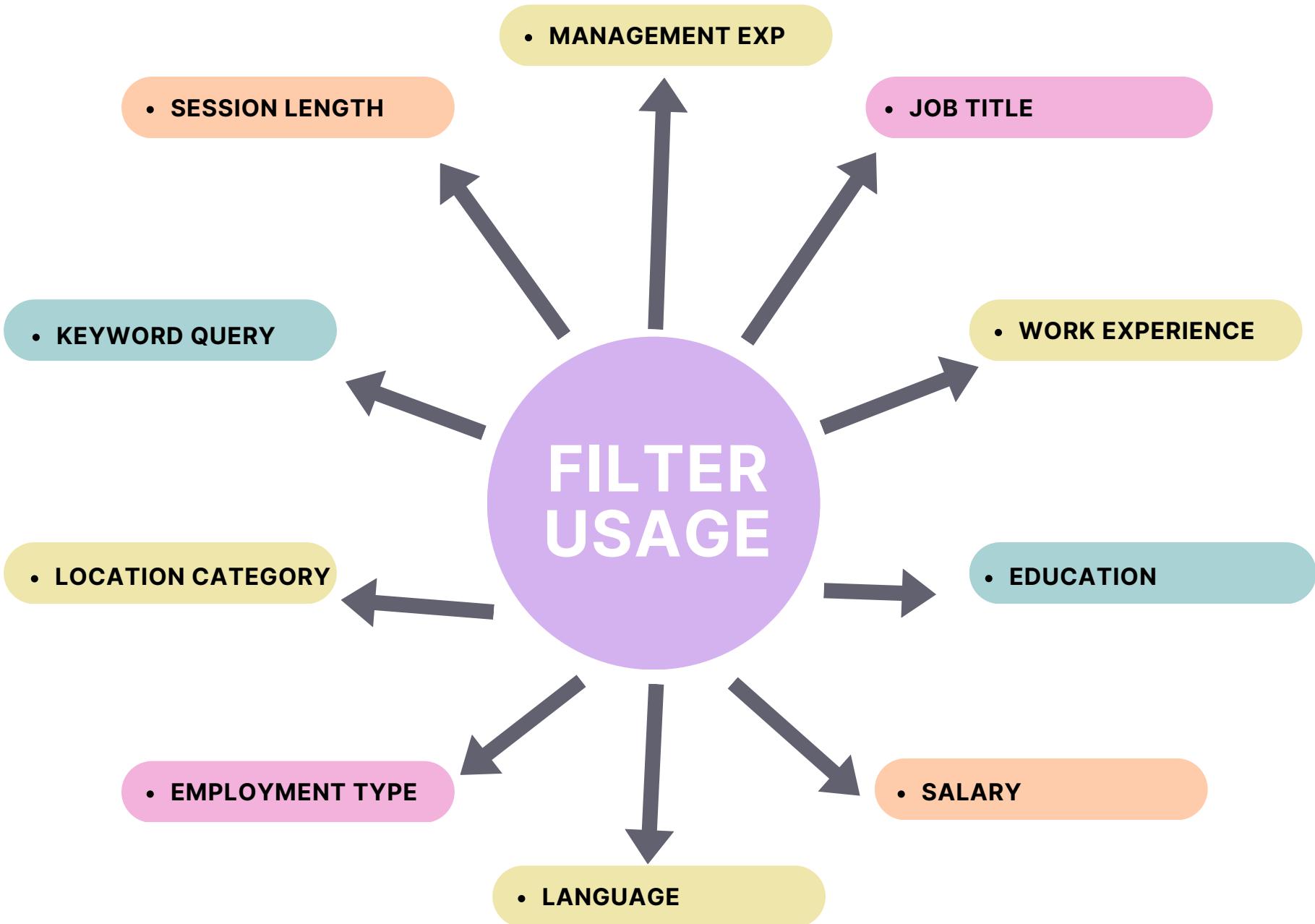


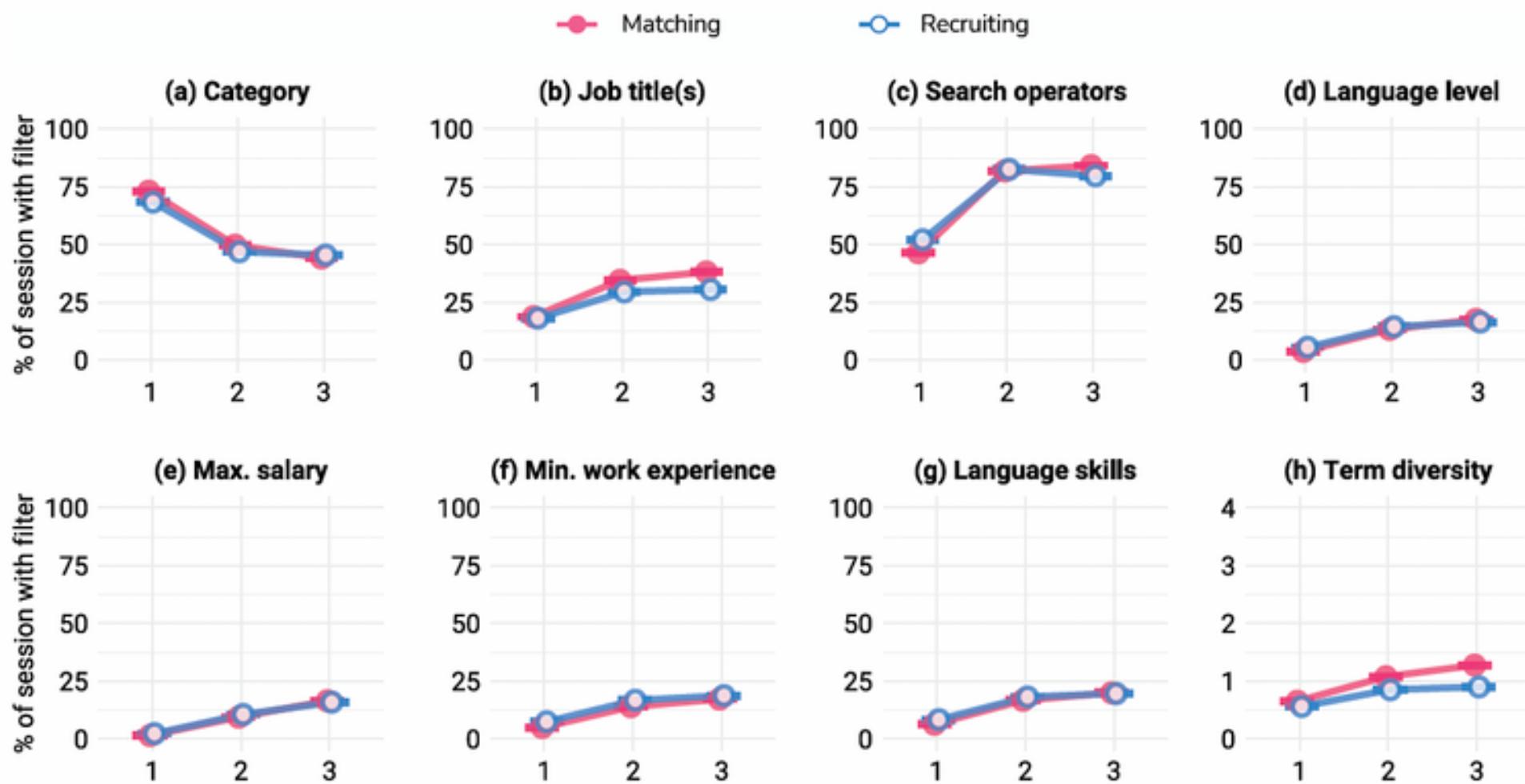
## Stats

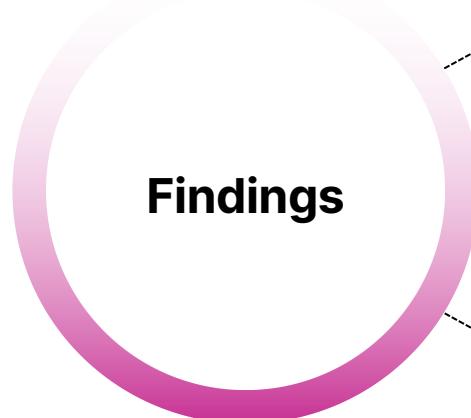
**157,046** unique search tasks performed by Jobindex recruiters in the period of September 2016 to November 2021.

# Search Stage Partitioning









1

2

3

4

5

## TALENT SEARCH IS COMPLEX

Formulating multiple complex and diverse queries along with the use of different filters in search sessions that can last several hours.

## MATCHING VS RECRUITMENT

Not much difference

## EARLY SEARCH STAGES

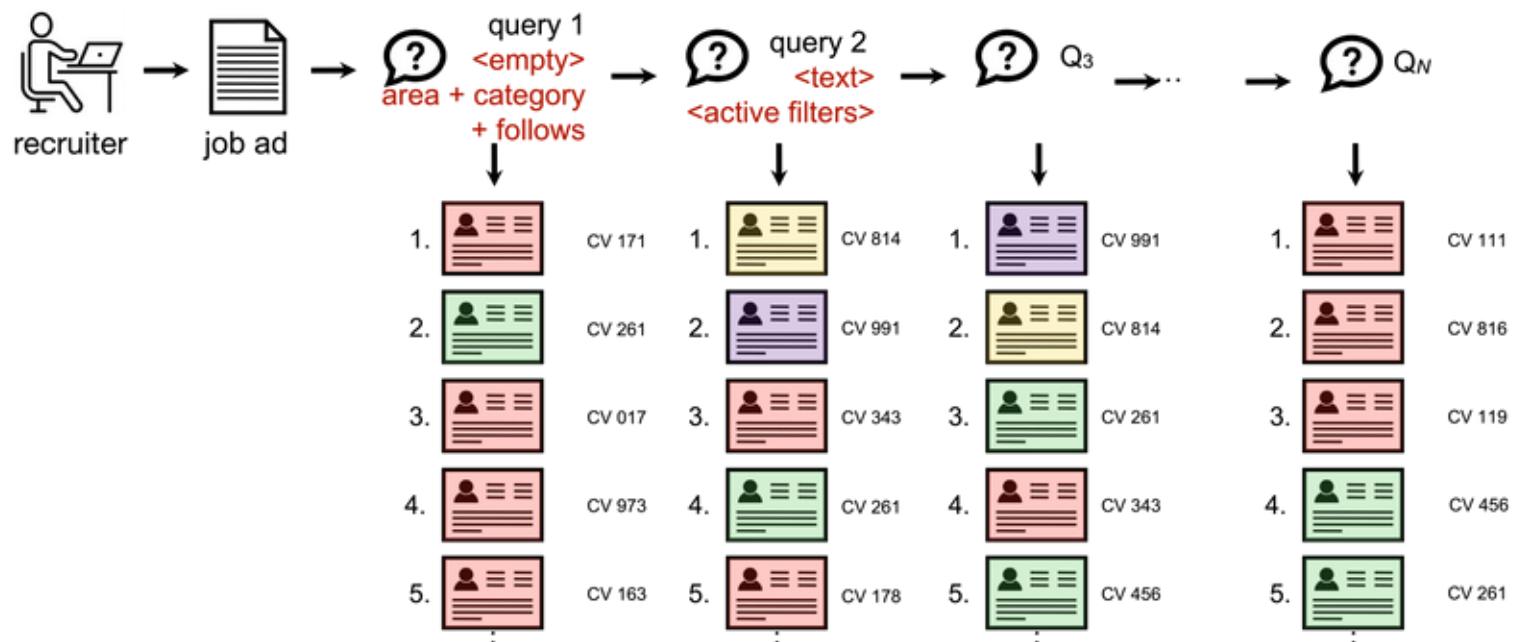
in the early stages recruiters learn from the job posting which **requirements, skills** and **abilities** relevant candidates are required to possess.

## LATER SEARCH STAGES

As their search task progresses, recruiters **increase their use of filters, formulate longer queries with more diverse query terms and advanced search operators**

## LEARNING AS SEARCHING

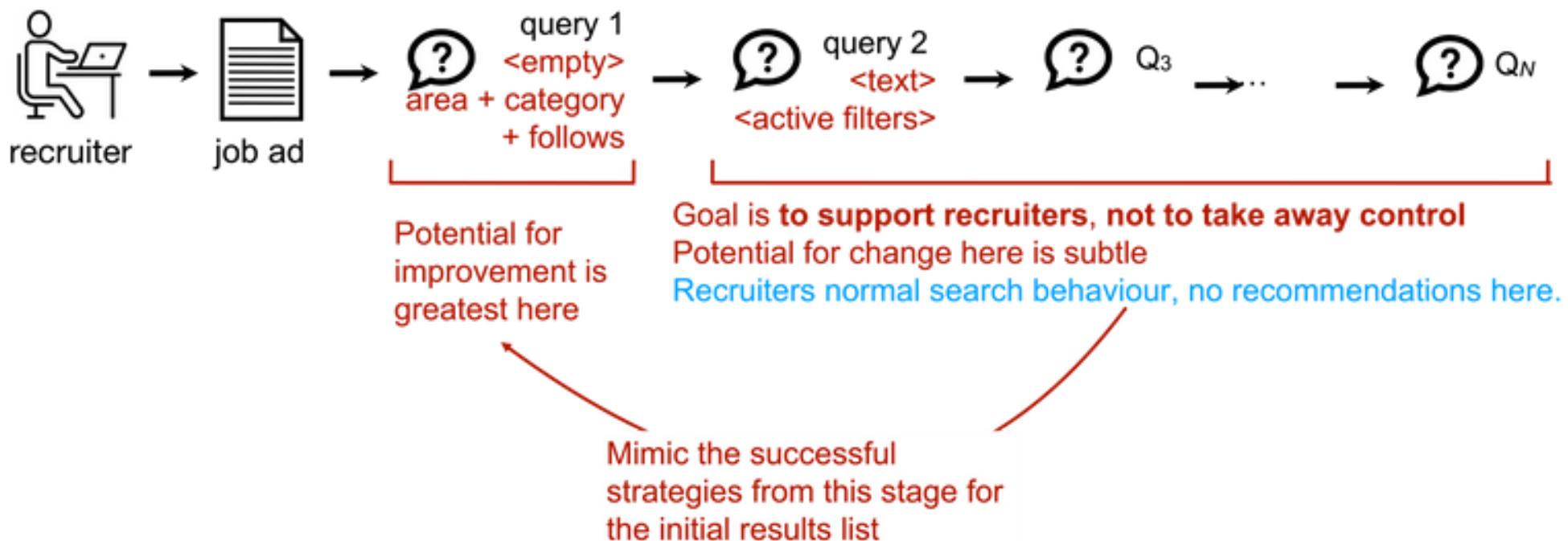
for each new job posting, recruiters gradually learn how to search more effectively as their search session progresses, something confirmed by our earlier work



# TALENT RECOMMENDATION

## Recommendations

What are we trying to improve?



# JobMatch - Recommender Prototypes

## 1st Prototype

w2vec embeddings using  
job title only

## 2nd prototype

use historical interaction  
as additional info

## Current prototype

Fine tune Bert, using  
other features.

03

02

01



- Compare embeddings based solely on job titles to embeddings of full-text description of resumes and job postings.



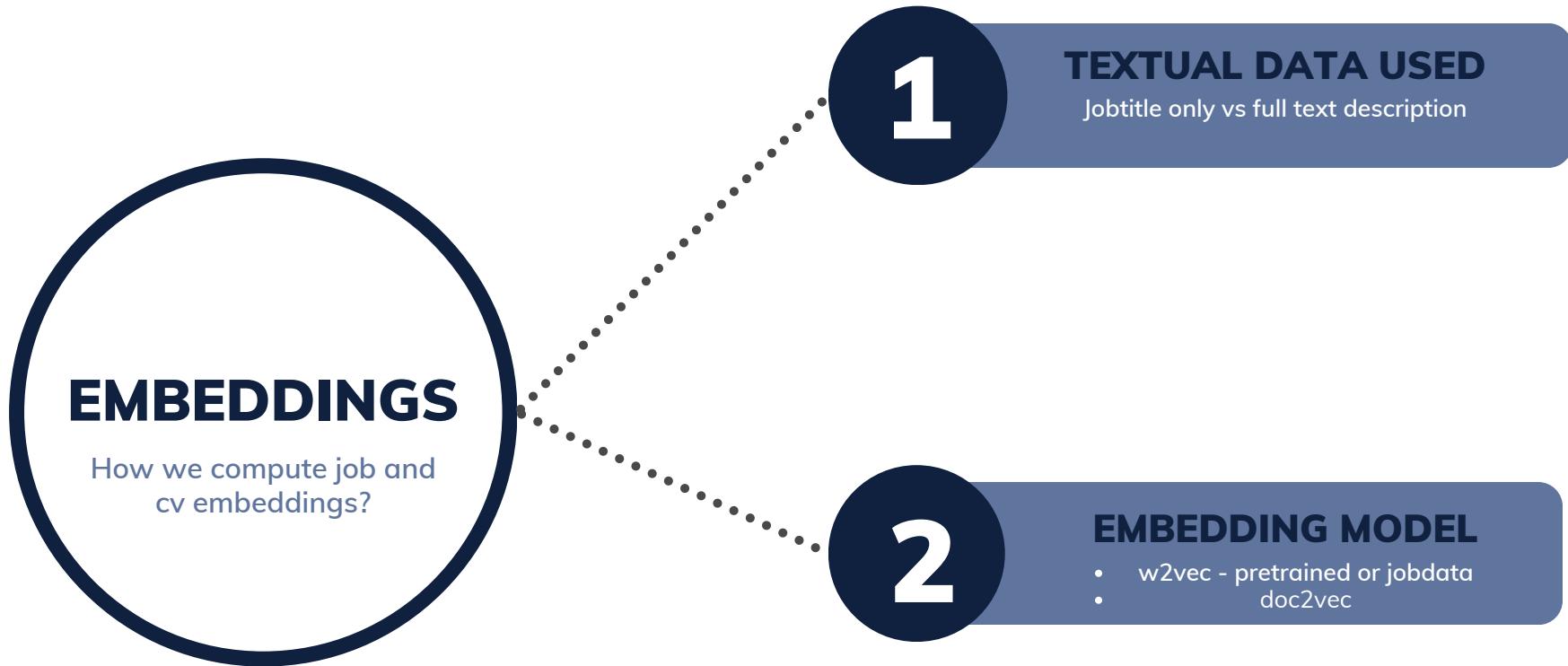
$d = \{t_1, t_2, \dots, t_m\}$

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Textual data source

Embedding Model





**Recommendation Task:** given a ‘reference’ vector that is the representation of a user  $u$  (i.e., job postings)—to find the top- $N$  similar vectors among item vectors (i.e., job seekers).

KEEP VECTORS ON **SOLR** and PERFORM VECTOR SEARCH

- Compare embeddings based solely on job titles to embeddings of full-text description of resumes and job postings.



$$d = \{t_1, t_2, \dots, t_m\}$$

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$$h_i = \{\vec{d}_{u1}, \vec{d}_{u2}, \dots, \vec{d}_{ul}\}$$

Interaction data

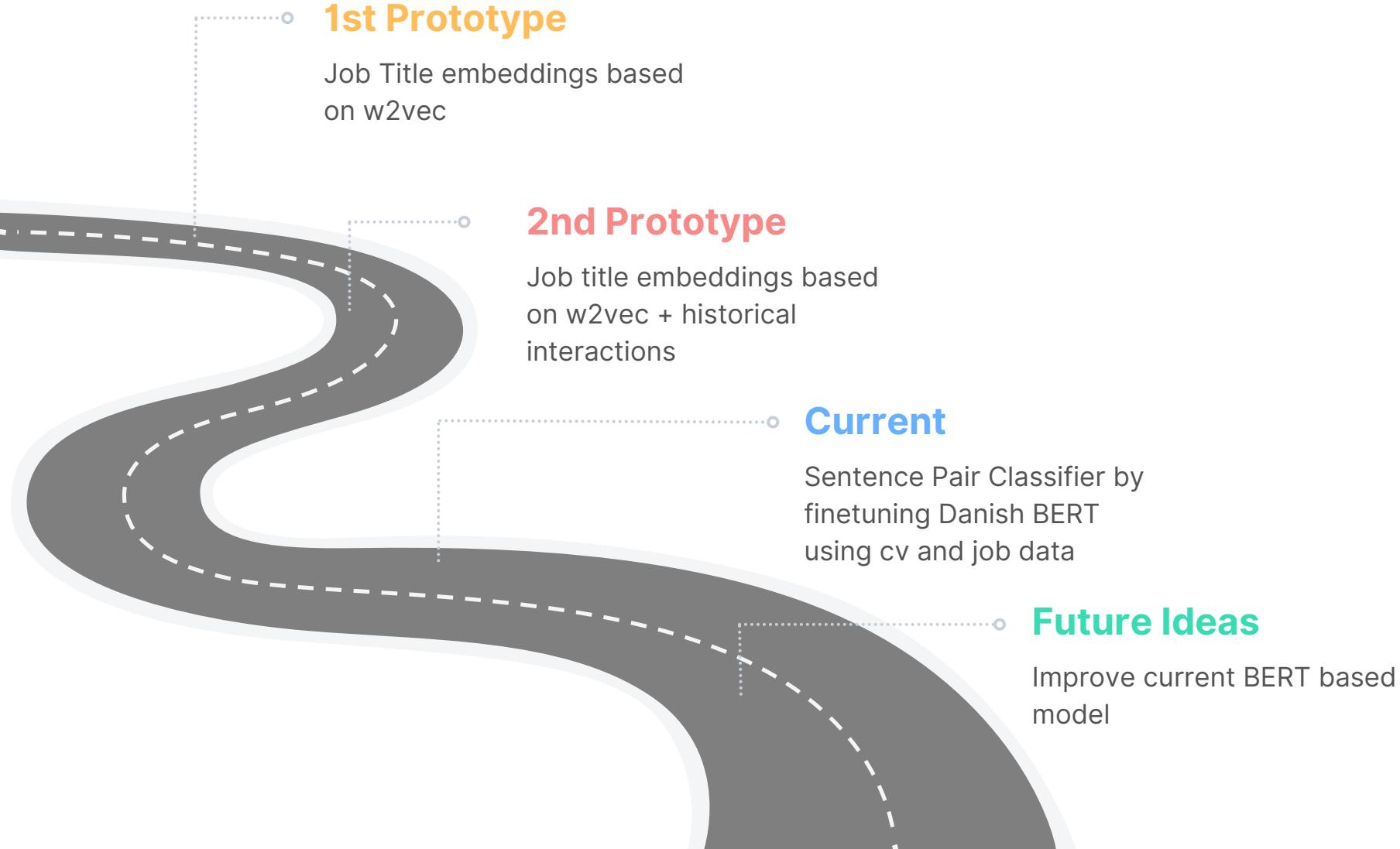
Embedding Model



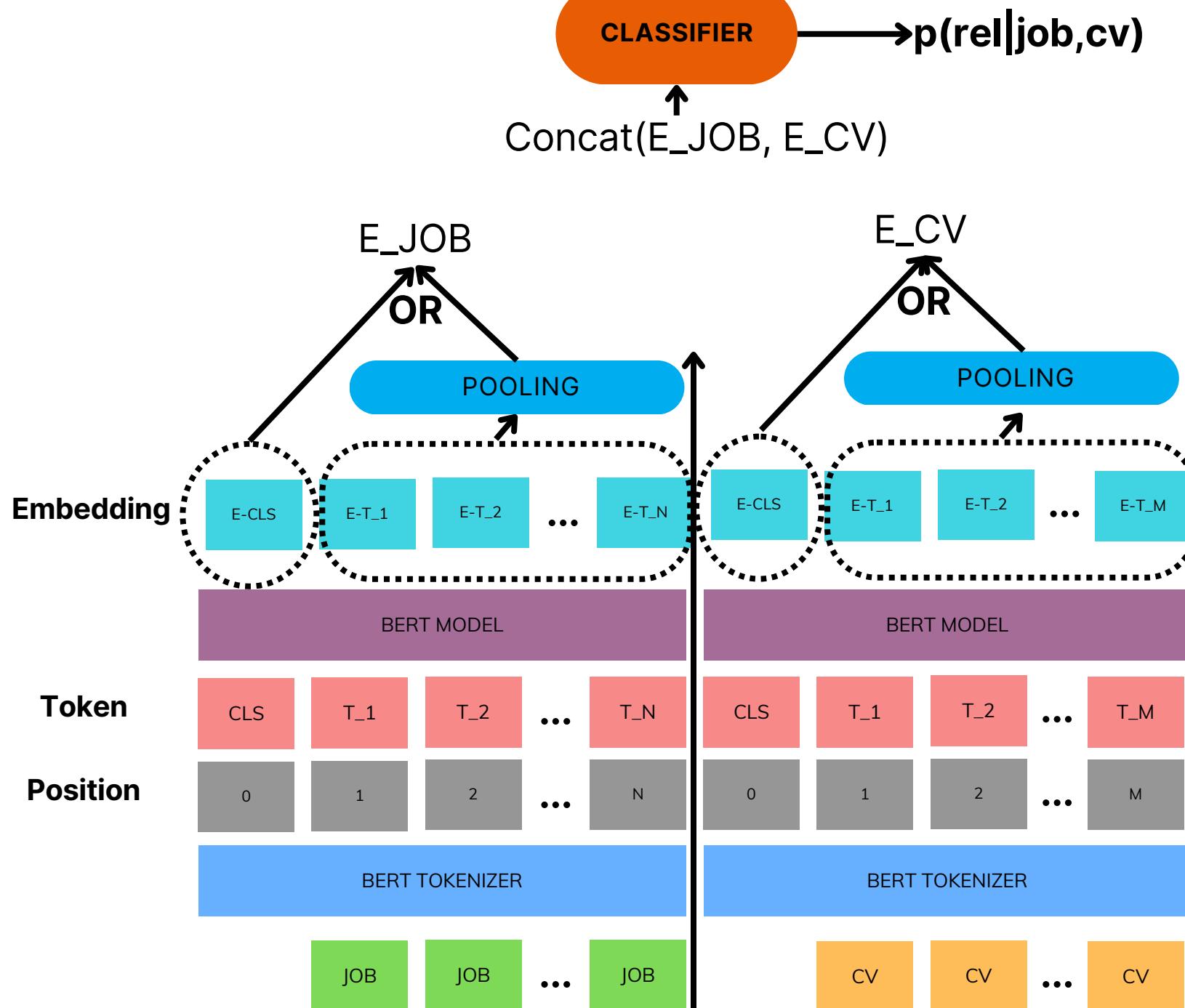
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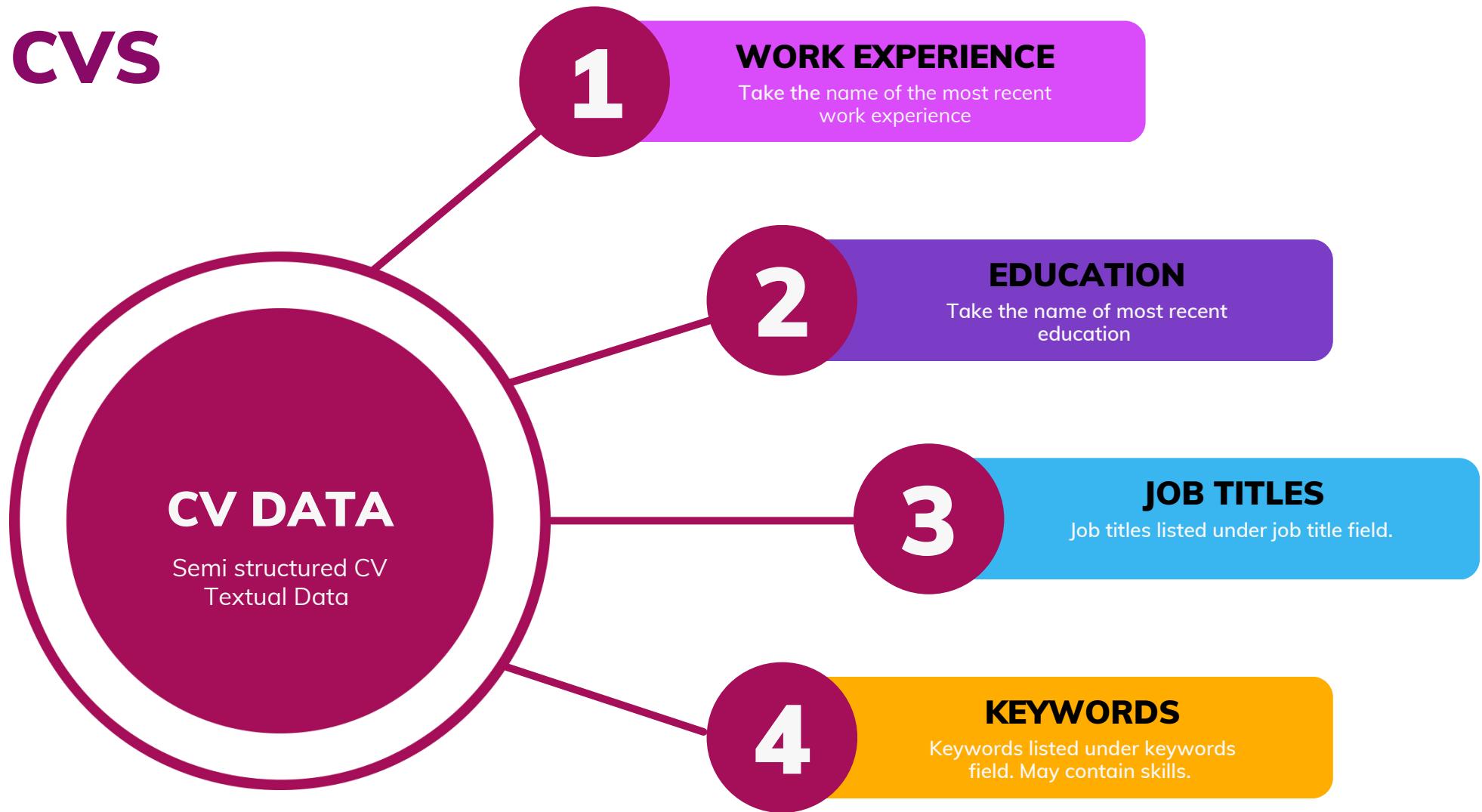
# Recommender Prototype Process



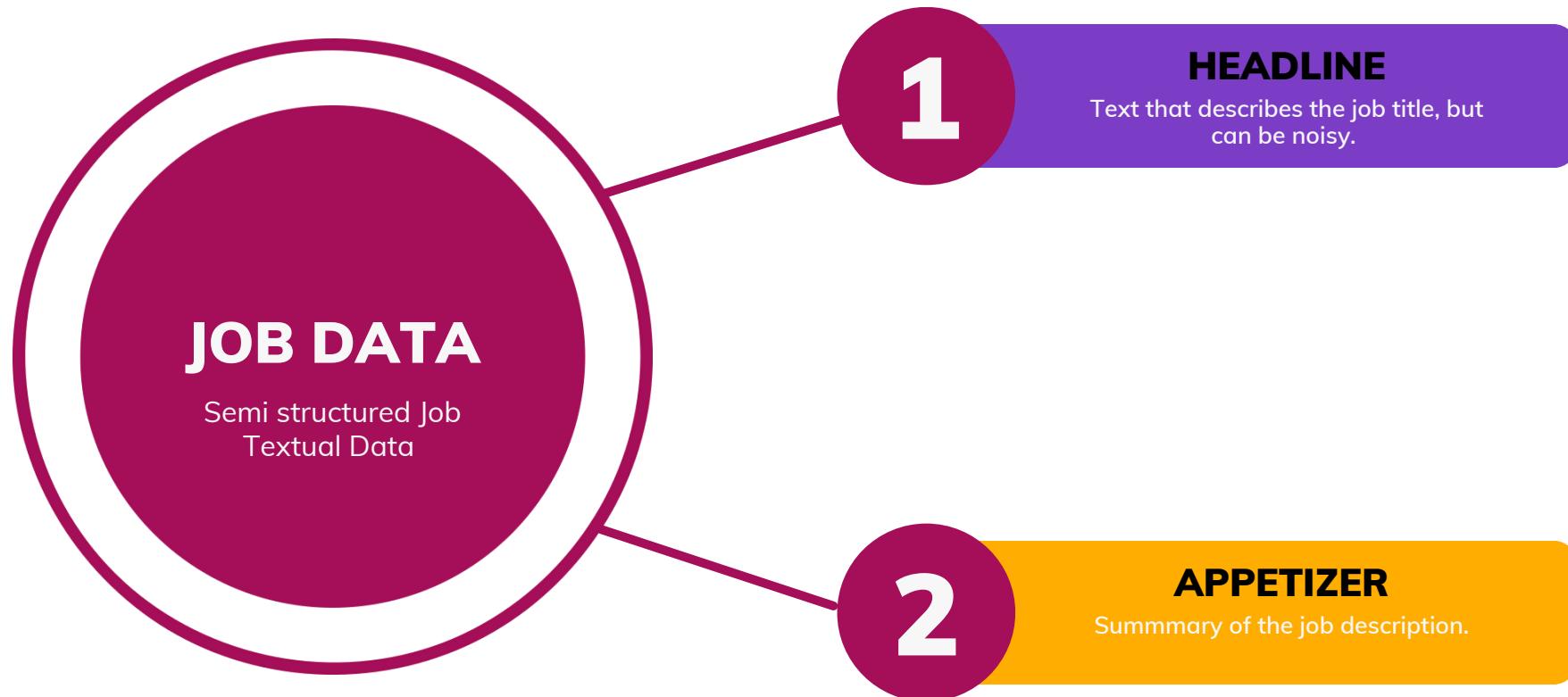
# Sentence-BERT for Job Cv Match



# CVS



# JOBS



# Next Sentence Prediction with BERT OR Sentence Pair Classification

Sentence 1

Sentence 2

Next Sentence?

I am going outside.

I will be back after 6.

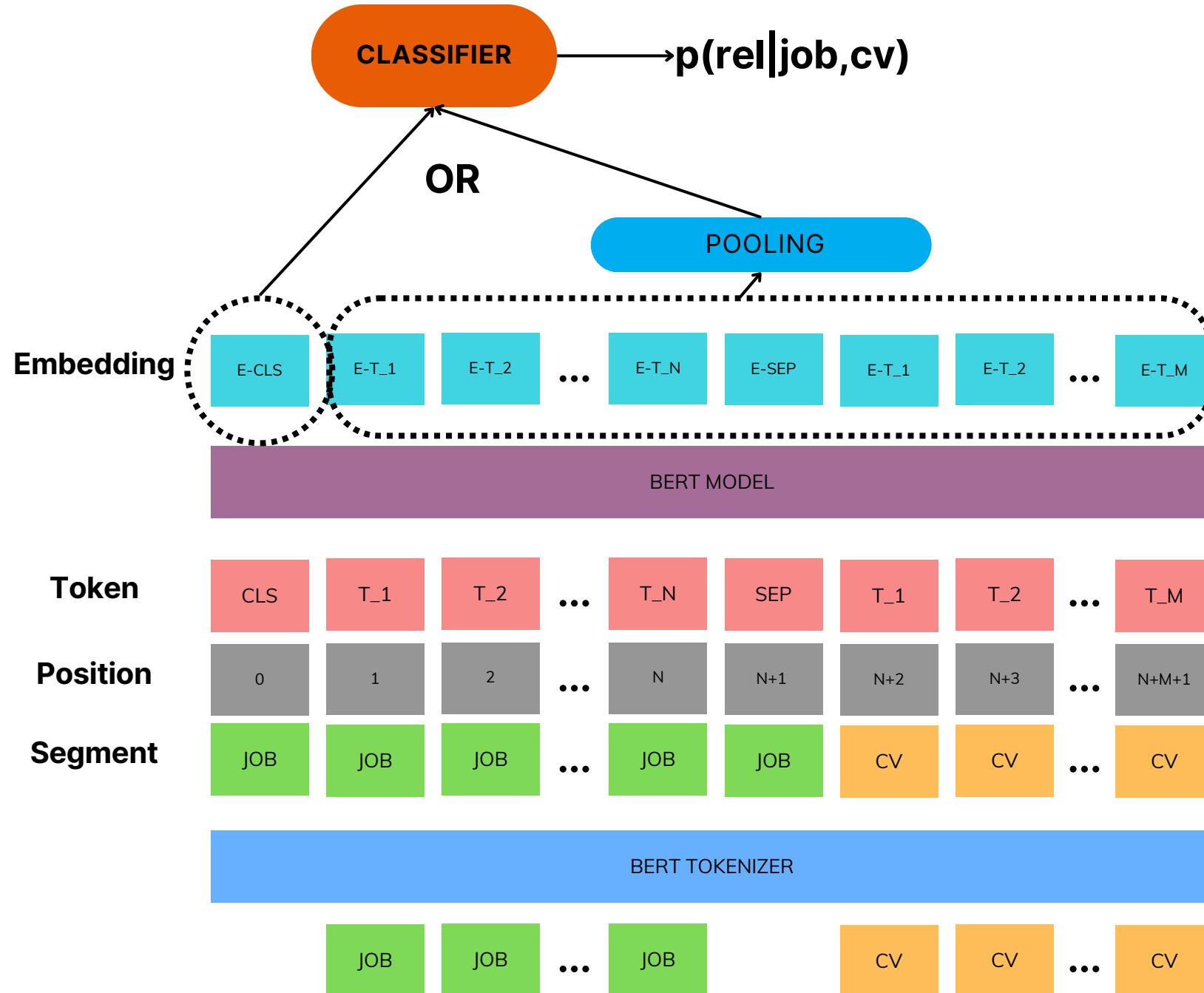
YES

I am going outside.

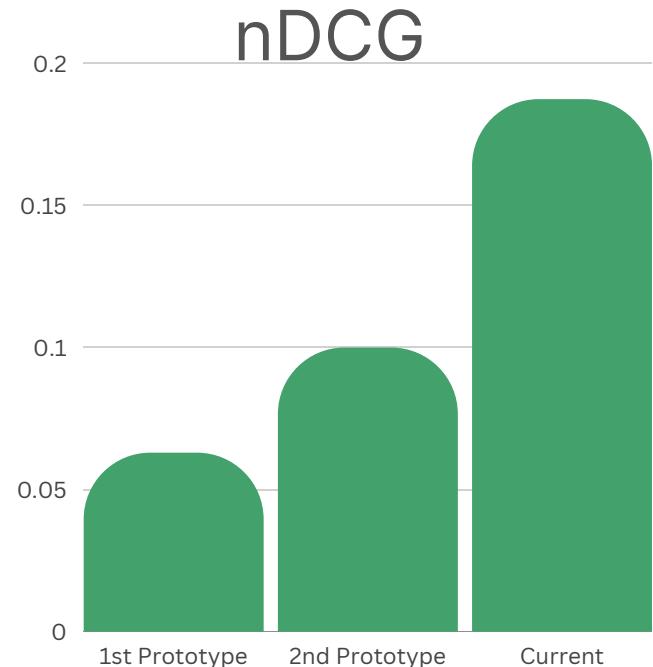
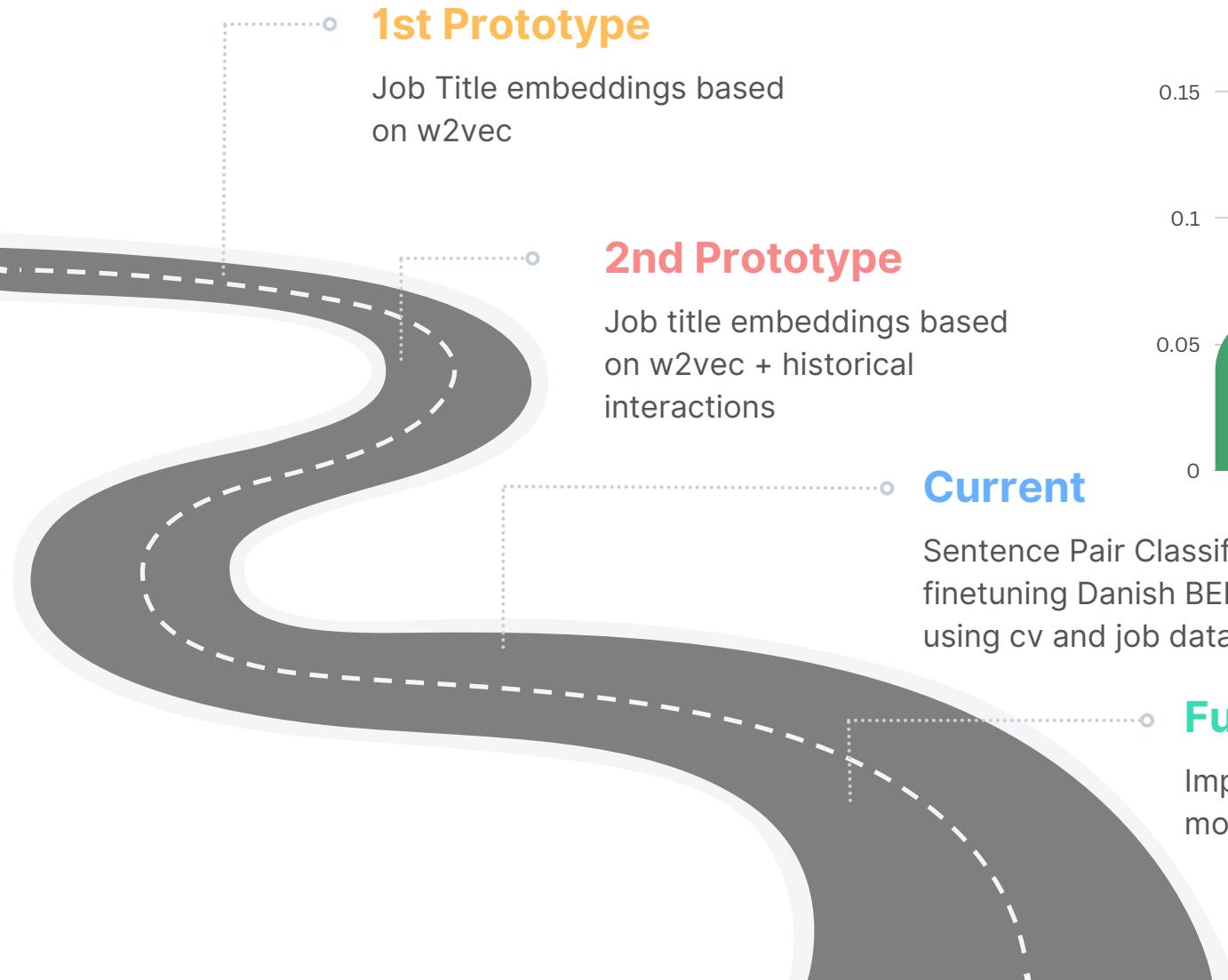
You know nothing John Snow.

NO

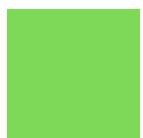
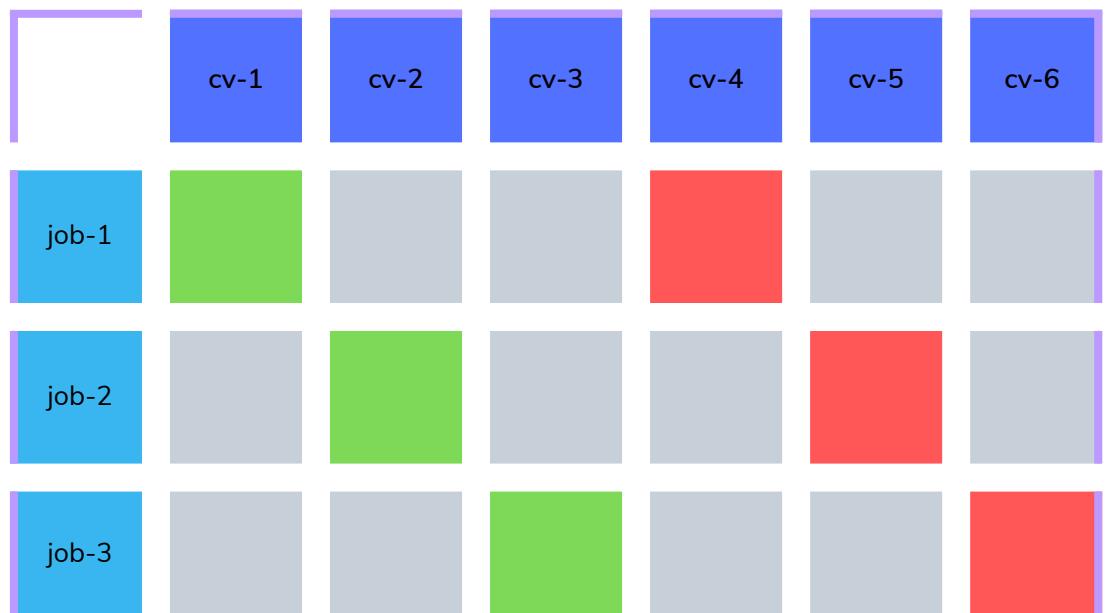
# Sentence Pair Classification for Job Cv Match



# Recommender Prototype Process



# Negative Sampling



relevant (job, cv) pair  
positive sample

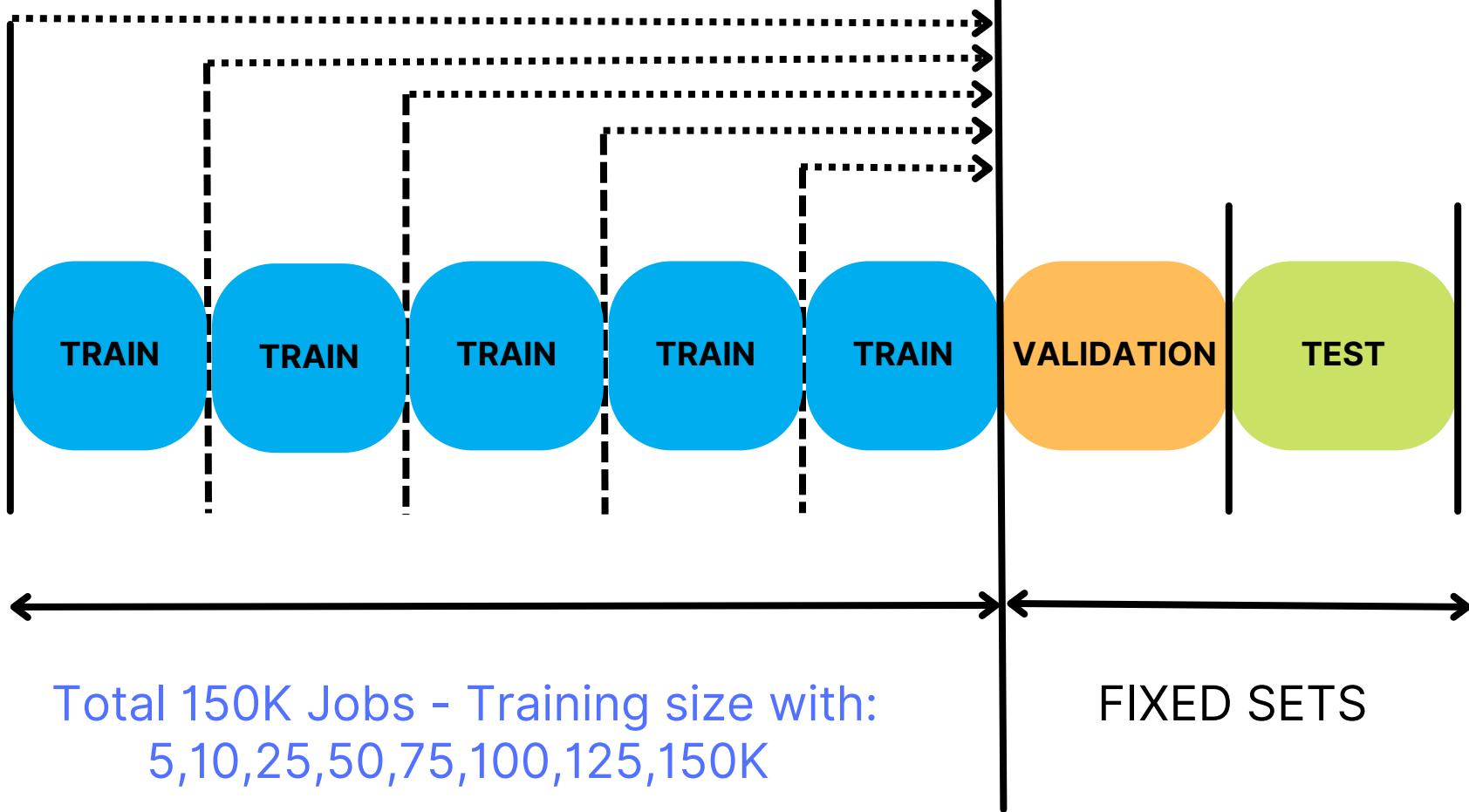


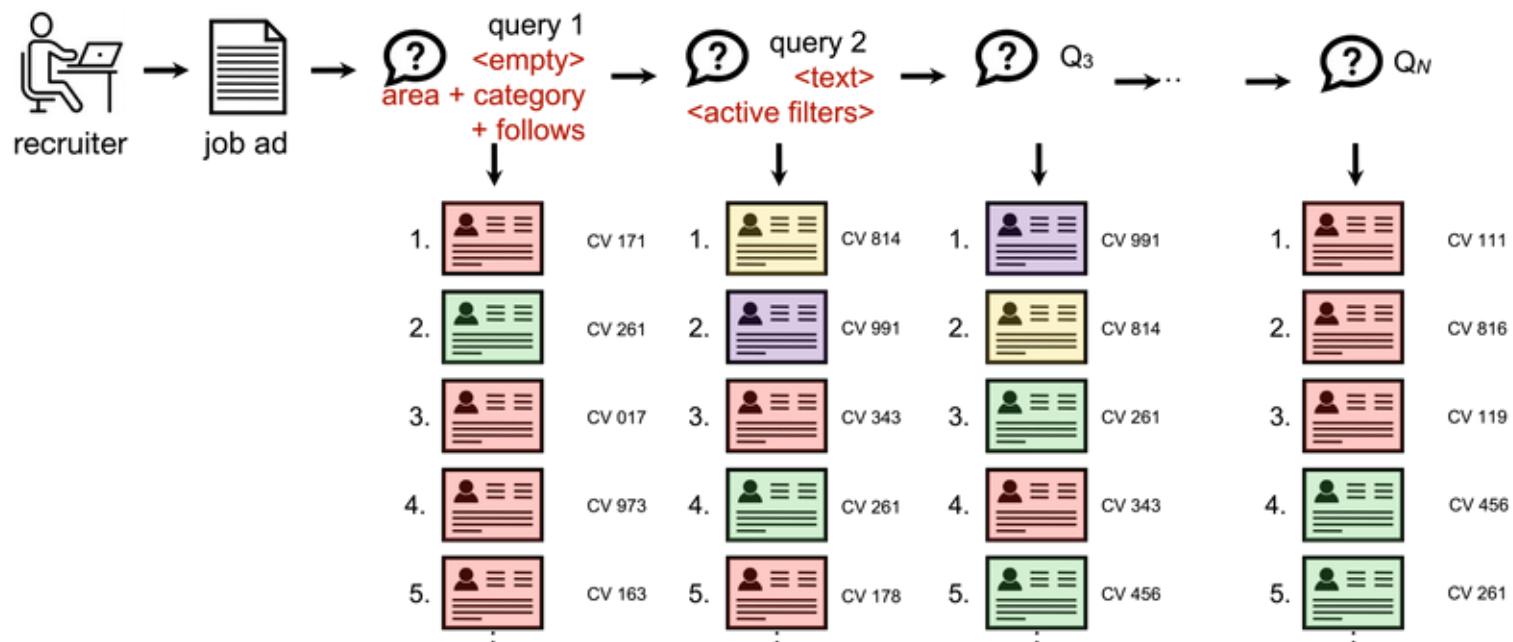
irrelevant (job, cv) pair  
hard negative sample



irrelevant (job, cv) pair  
random negative sample

Varying number of training instances are used to train model, split is done via timestamp of the jobs



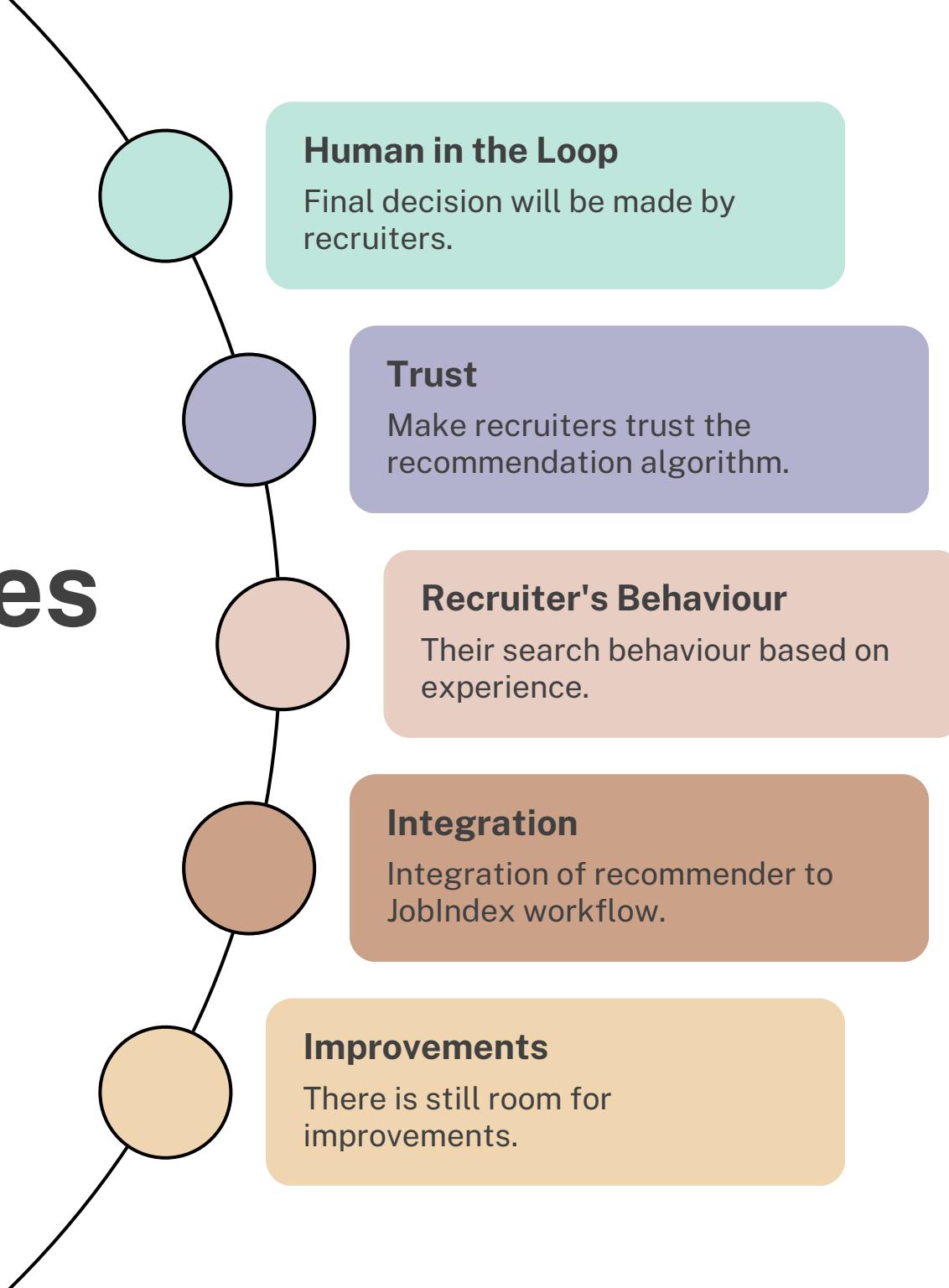


# Recommendations

## What are we trying to improve?



# Challenges





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[@kayaa\\_mesutt](https://twitter.com/kayaa_mesutt)