



A Lightweight Transformer for Next-Item Recommendation

RecSys 2022

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Multi-headed Attention Recommender System

MARS: A lightweight transformer model powering recommendations using **only customer browse** for inference.

Based off SASRec (Kang & McAuley 2018)

It is trained on **customer-item interactions only** - i.e. viewed items and ATC/ordered items (if they exist for a customer), **in the order** they were interacted with.

([link for video](#))

Rugs / Area Rugs

This Just In
Our Favorite Rugs

Shop This Sale

Sponsored

\$47.00 \$99.99
★ ★ ★ ★ ★ (3392)

\$43.99 \$69.00
★ ★ ★ ★ ★ (1745)

\$55.99 \$62.99
★ ★ ★ ★ ★ (1301)

Sort by Recommended

Area Rugs
Over 500,000 Results

| Image | SKU Type | Sort Type | Product Name | Price Range | Rating | Shipping |
|-------|-------------------|-----------|---|--------------------|------------------|--------------------|
| | Sale | +11 Sizes | Malha Indoor / Outdoor Area Rug in Gray by Latitude Run® | \$39.99 - \$269.99 | ★ ★ ★ ★ ★ (1249) | Free Shipping |
| | Sponsored Skus | +9 Sizes | Liddle Abstract Area Rug in Ivory/Granite by Trent Austin Design® | \$48.99 - \$749.99 | ★ ★ ★ ★ ★ (255) | Free Fast Delivery |
| | Default Solr Sort | +1 Size | Lachapelle Ikat Flatweave Indoor / Outdoor Area Rug in Espresso by Laurel Foundry Modern Farmhouse® | \$69.99 - \$72.99 | ★ ★ ★ ★ ★ (751) | Free Shipping |
| | Sale | +38 Sizes | Ironia Oriental Area Rug in Cream/Navy by Bungalow Rose | \$23.99 - \$369.99 | ★ ★ ★ ★ ★ (6451) | Fast Delivery |

Sponsored

Offline evaluation

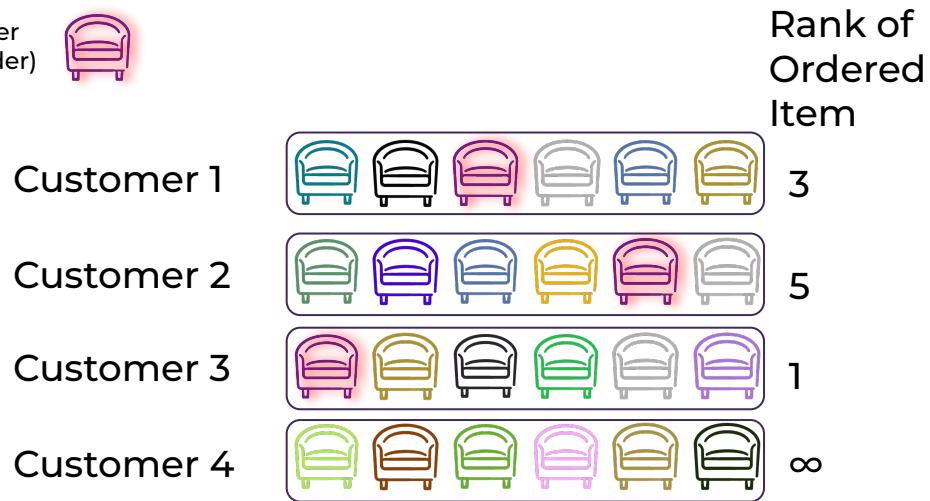
For our purposes - one right answer (**next order**), everything else is wrong

In theory you can use next-ATC, next-view, even all future orders etc.

Standard metrics:

- Recall (position-agnostic)
- nDCG (logarithmic positional discount)

Correct answer
(i.e. actual order)

(mean) Recall@6:

$$\frac{1 + 1 + 1 + 0}{4} = 0.75$$

$$\mathbf{DCG} = \sum_k^N \frac{2^{rel_k} - 1}{\log_2(k+1)} = \sum_k^4 \frac{1 \text{ if right else } 0}{\log_2(k+1)}$$

$$\text{(mean) nDCG@6: } \frac{\frac{1}{\log_2(3+1)} + \frac{1}{\log_2(5+1)} + \frac{1}{\log_2(1+1)} + 0}{4} = 0.47$$

Offline evaluation looks good...

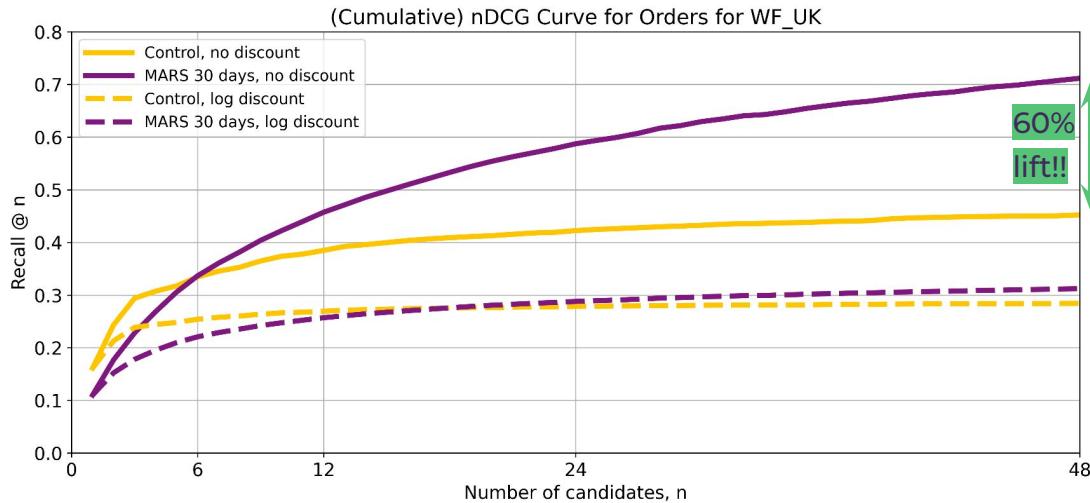
We show 48 results per page, so a very natural metric for us is **Recall@48** or **nDCG@48**.

Recall@48 prediction: **Win**

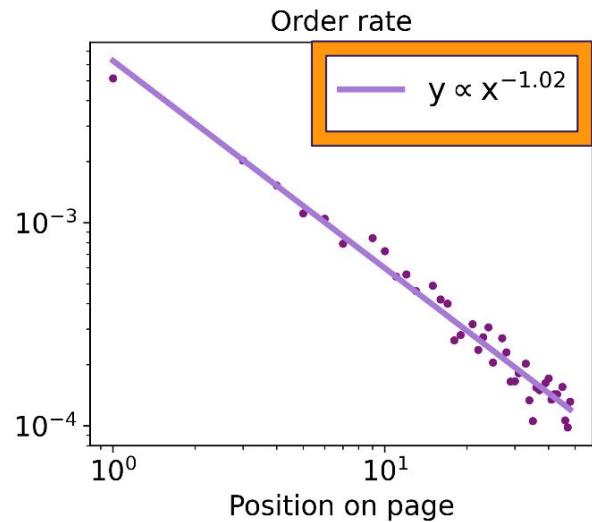
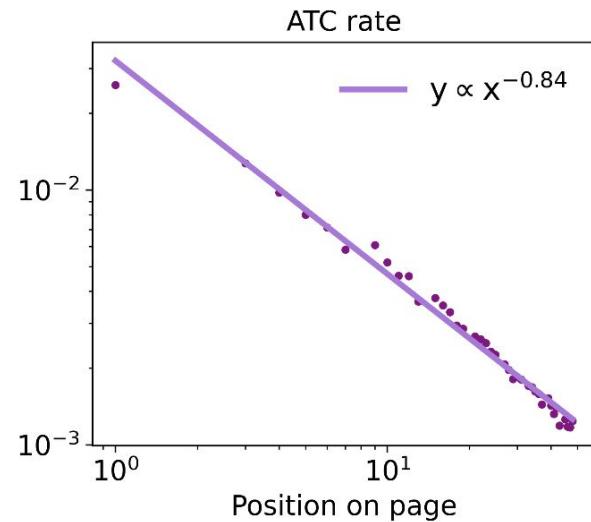
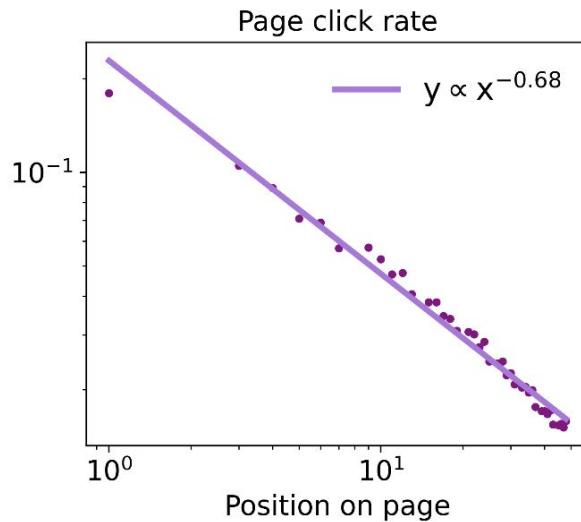
\log_2 nDCG@48 prediction: **Win**

=> Do an A/B test

But the test for WF_UK failed... orders actually **significantly dropped** by >1%.



Determining positional effects empirically

**nDCG**

$$\frac{\frac{1}{\log_2(3+1)} + \frac{1}{\log_2(5+1)} + \frac{1}{\log_2(1+1)} + 0}{4} = 0.47$$

nDCGe

$$\frac{\frac{1}{3^{1.02}} + \frac{1}{5^{1.02}} + \frac{1}{1^{1.02}} + 0}{4} = 0.38$$

Applying empirical discount

Now we can see that the empirical discount rate of $x^{-1.02}$ actually shows control beating MARS.

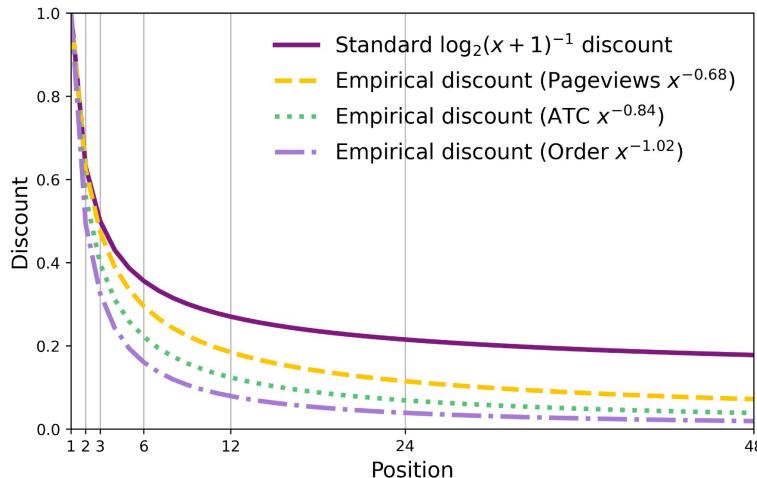
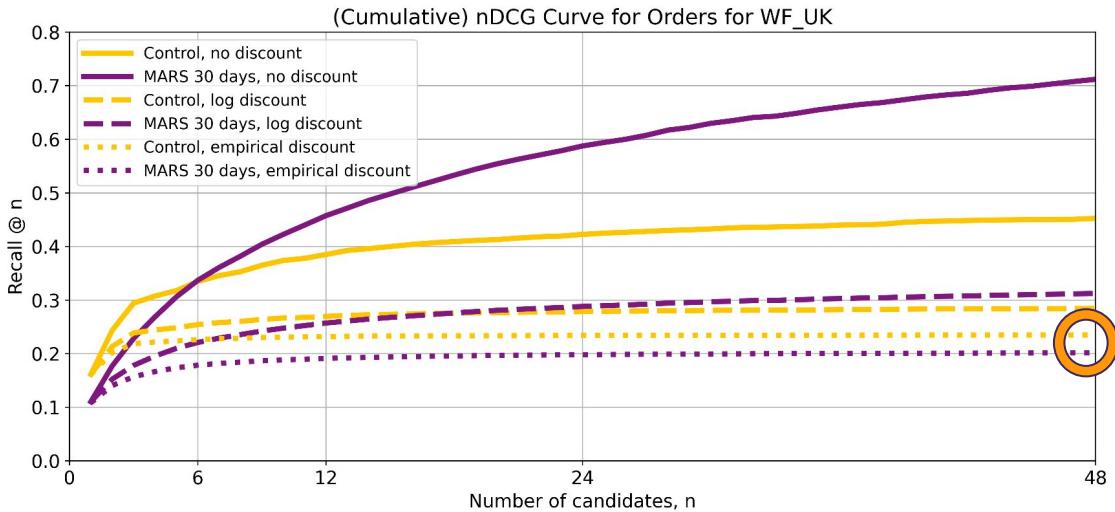
True A/B test result: **-1% CVR**

Recall@48 prediction: **Win**

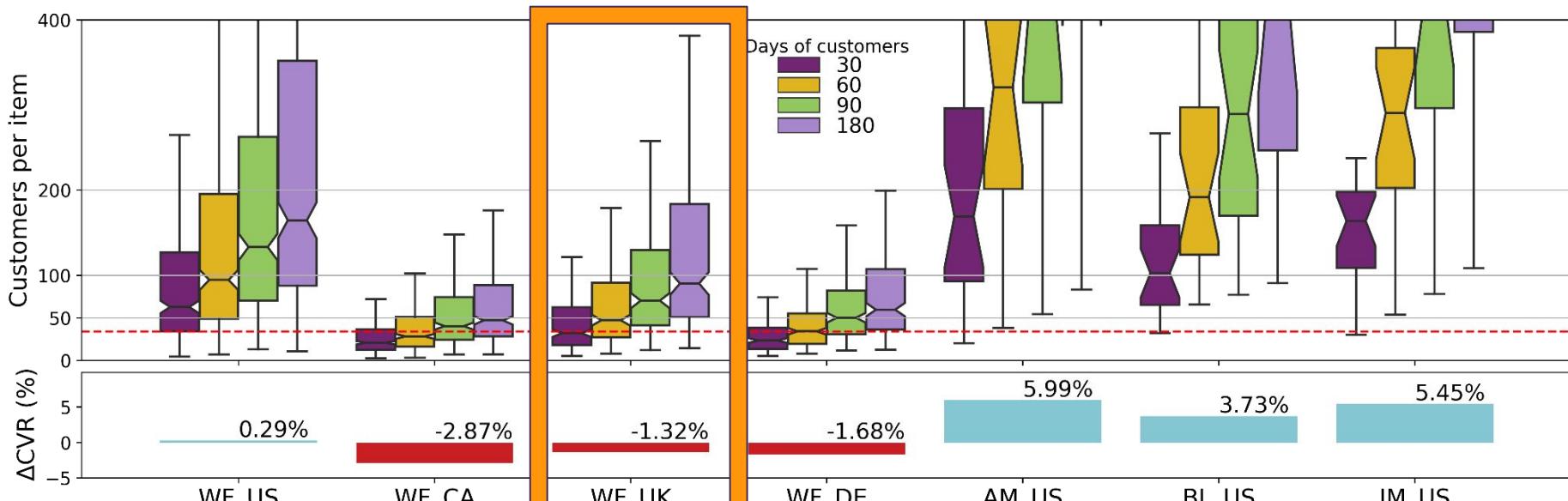
$\text{Log}_2 \text{nDCG}$ @48 prediction: **Win**

$x^{-1.02} \text{nDCG}_e$ @48 prediction: **Loss**

The **standard log₂ discount** is too small to account for our real, observed positional effect.



Data thinness is very correlated with A/B test result



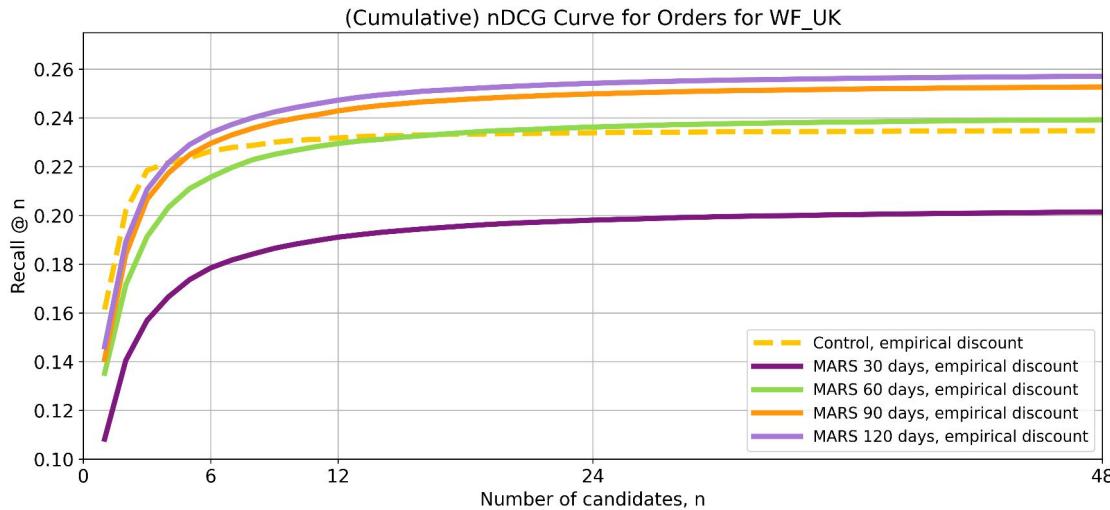
- US stores account for 80% of revenue so the test was an overall win, but we would love to see all stores winning
- Data thinness is different for each store

Increased training data

The benefit of adding more training data eventually saturates

- although we can keep increasing the performance, this also increases training time ~linearly.

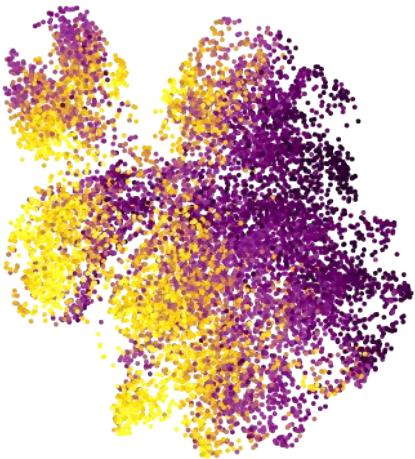
More importantly, we can see 90 days gives a very clear lift of (order-discounted) $nDCG_e@48$ of ~25%.



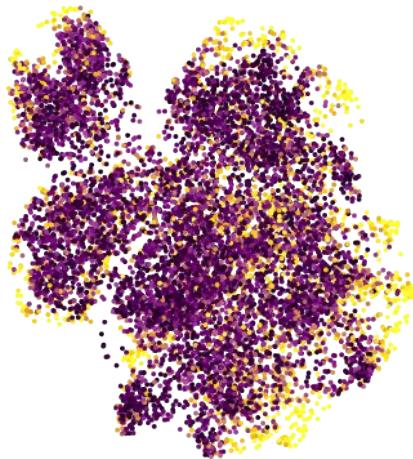
When we A/B tested again using 90 days of training data, CVR for WF_UK **increased 2.4%**!

Learned Item Embeddings - Sofas

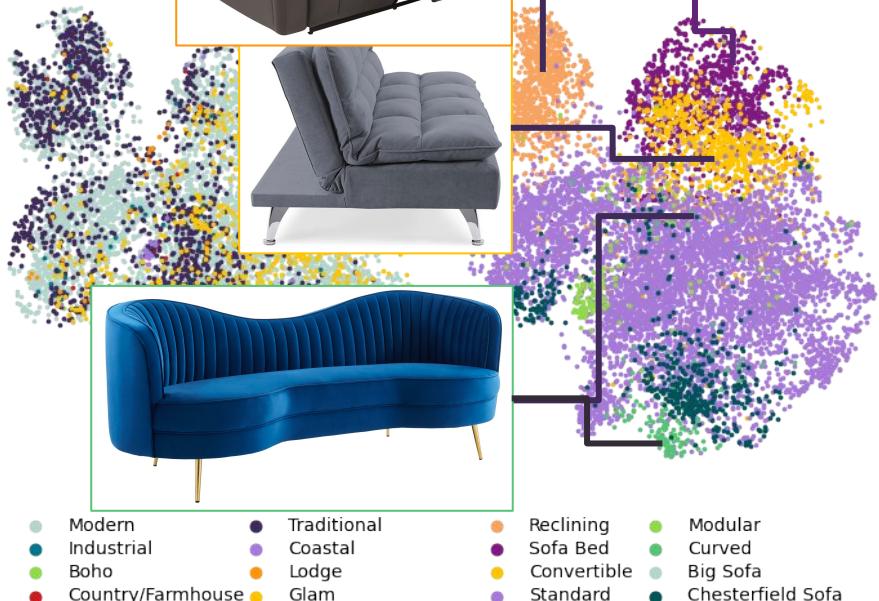
(a) Price



(b) Popularity

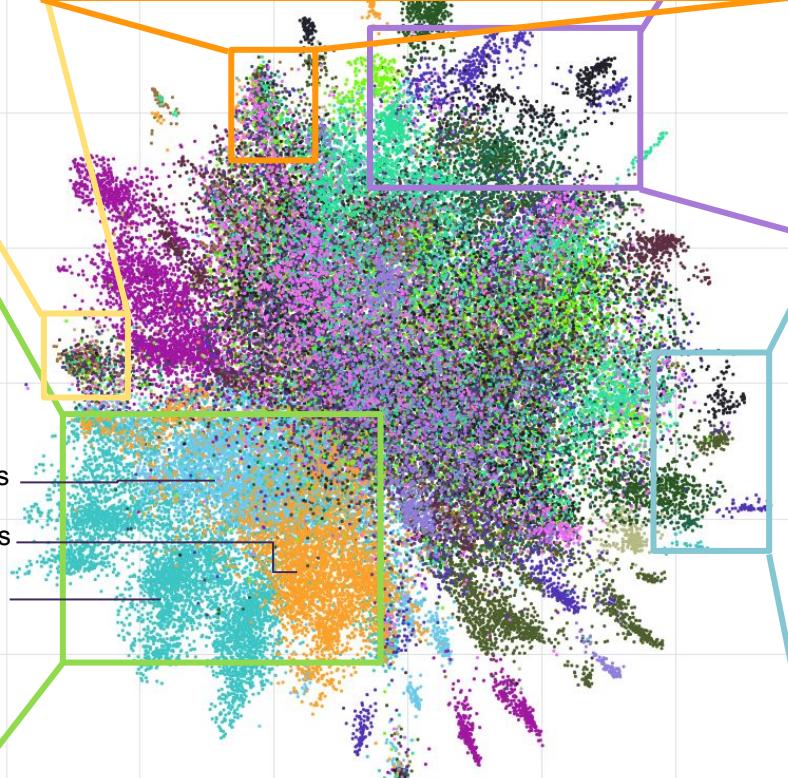
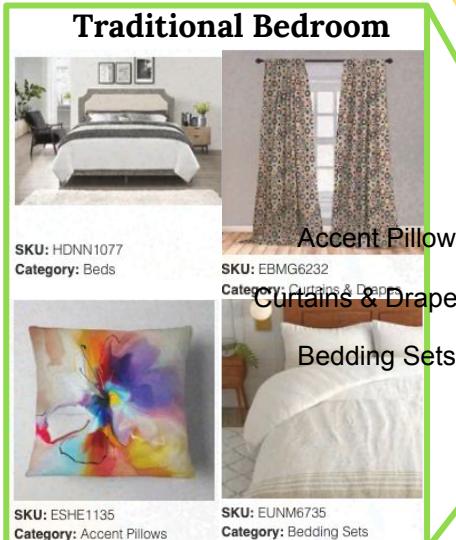


(c) Style



Interpreting MARS

- Accent Pillows
- Bedding Sets
- Wall & Accent Mirrors
- End Tables
- Desks
- Curtains & Drapes
- Sofas
- Accent Chairs
- Beds
- Dining Chairs
- Coffee & Cocktail Tables
- Bar Stools
- Dining Tables
- TV Stands & Entertainment
- Dining Table Sets
- Nightstands
- Dressers & Chests
- Office Chairs



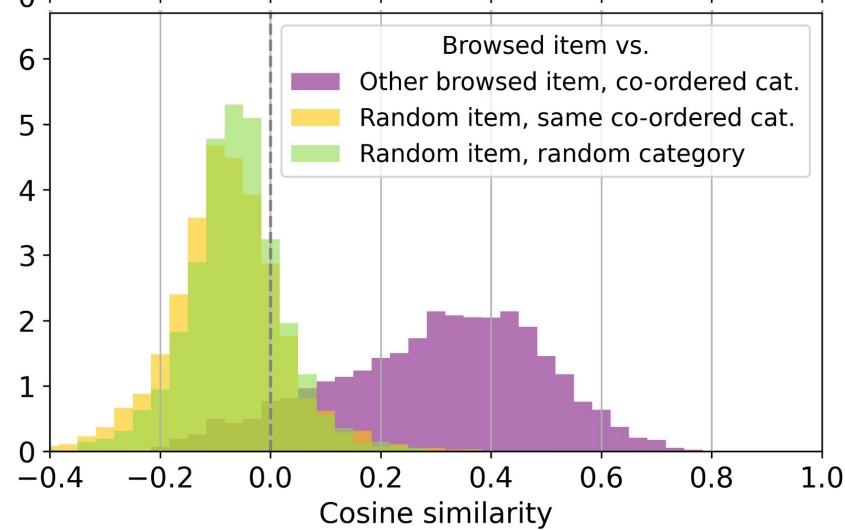
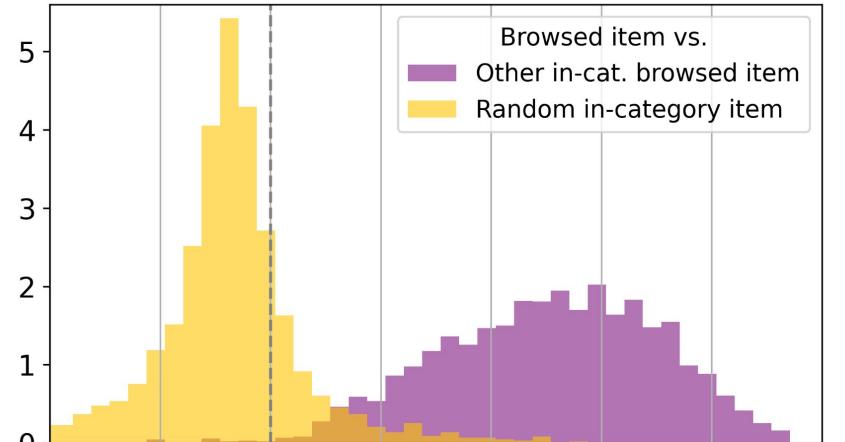
Do these attributes carry across furniture types?

We see high similarity between browsed items for both in-category and cross-category* browse.

Here, we remove the category signal from the embeddings as we want to exclude the effect of categories themselves being overall similar.

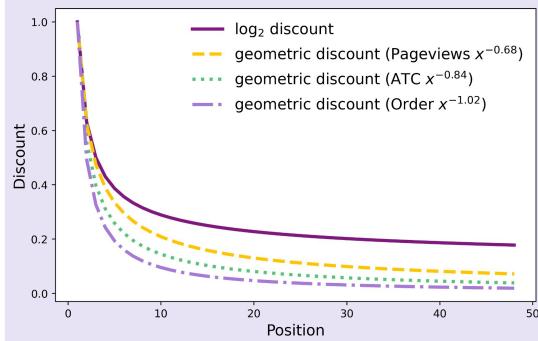
*Commonly co-ordered category e.g.

- Nightstands and beds
- Sofas and coffee tables



Summary of learnings

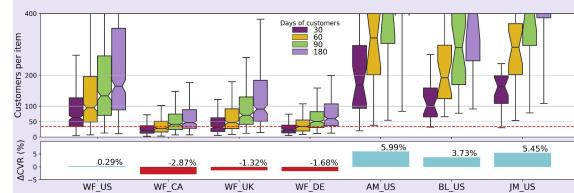
Empirically find discount rate



... using historic interaction data by position



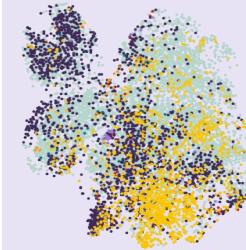
Account for data thinness



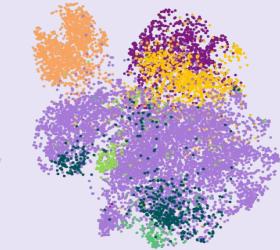
... by tracking average number of customers viewing each item

Simplicity

(c) Style



(d) Functionality



Legend for sofa styles and functionalities

... putting the **implicit** in **simplicity**

