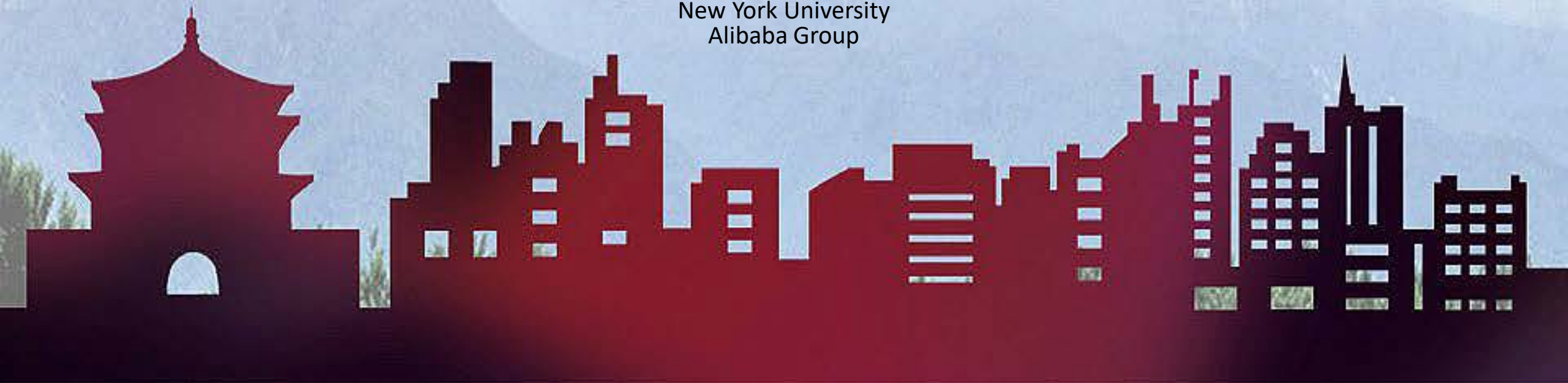


# Understanding Echo Chambers in E-commerce Recommender Systems

Yingqiang Ge\* Shuya Zhao\* Honglu Zhou  
Changhua Pei Fei Sun Wenwu Ou Yongfeng Zhang

Rutgers University  
New York University  
Alibaba Group



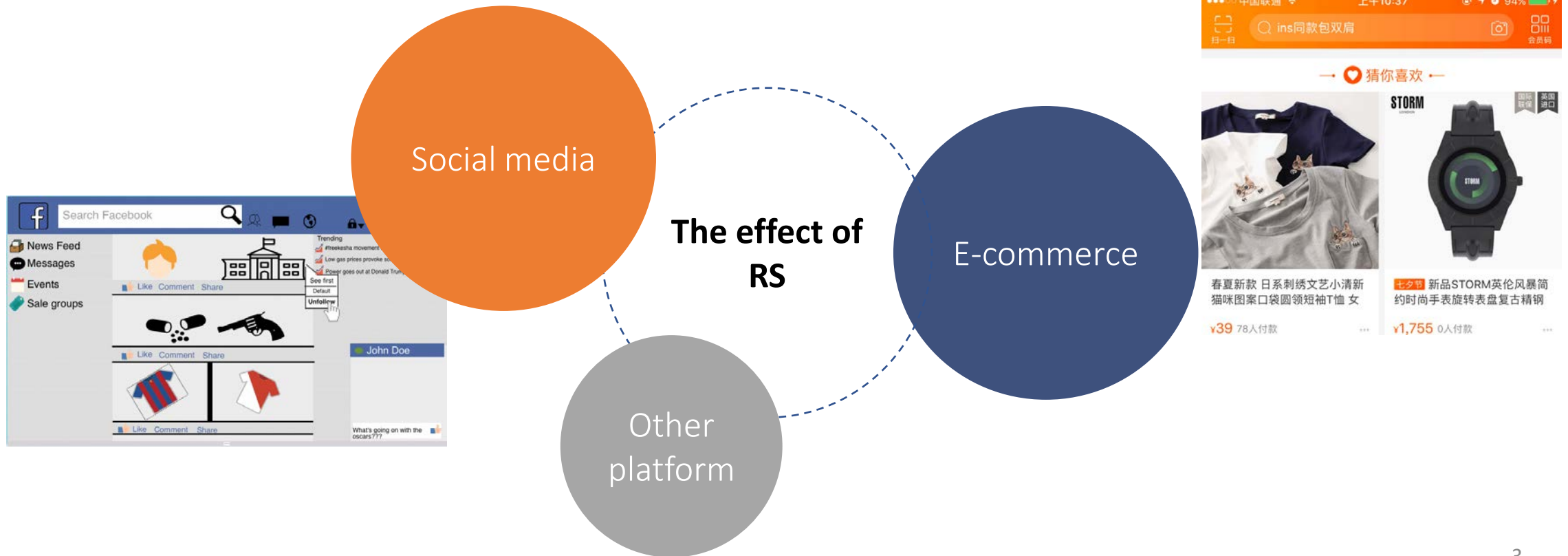
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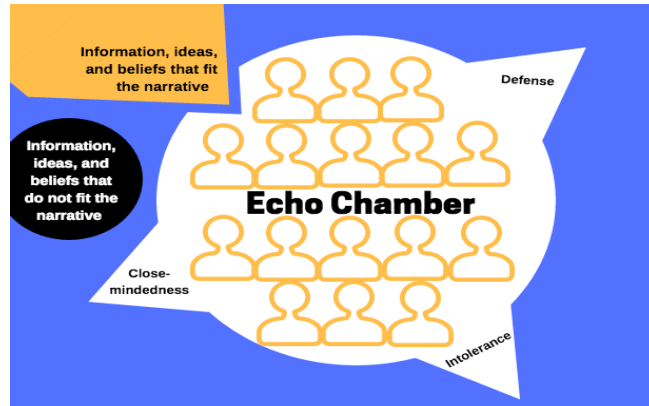


# Motivation

There are growing concerns about how the recommendations influence user preferences and behaviors, e.g. how RS leads to Echo Chamber, in various platform, especially E-commerce. We aim to analyze the echo chamber phenomenon and its potential cause, narrowed exposure of items, in Alibaba Taobao.



# Motivation



**Echo chamber** is the effect of user interests being reinforced through repeated exposure to similar contents.



**Filter bubble** is the effect of recommenders making users isolated from diverse content and trapped in an unchanging environment.

# Challenges

User actions in **E-commerce** are different from that in online media.

- Diverse products and versatile user preferences.
- Indirect interactions between users and the platforms through the recommendations.

	User interests	Interaction
E-commerce	Diverse	Indirect
Social Media	Positive or Negative	Direct

Tab.1 E-commerce vs Social media.

# Methods

- Separate users based on whether they take recommendations offered by the platforms: **Following Group** and **Ignoring Group**.
- Examine the effect of Recommender System at the **population level** via two questions:
  - 1. Does the recommender system, to some extent, reinforce user click/purchase interests?
  - 2. If user interests are indeed strengthened, is it caused by RS narrowing down the scope of items exposed to users?

# Methods

## ➤ RQ1: Reinforcement in User Interests

1. K-means clustering
2. Select optimal clustering setting:

- Hopkins Statistic:

$$H = \frac{\sum_{i=1}^M t_i^D}{\sum_{i=1}^M s_i^D + \sum_{i=1}^M t_i^D}$$

- Bayesian Information Criterion (BIC).

$$BIC = \sum_{i=1}^K n_i \left( \log \frac{n_i}{N} - \frac{n_i D \log 2\pi \Sigma}{2} - \frac{D(n_i - 1)}{2} \right) - \frac{K(D+1) \log N}{2}$$

3. Measure clustering validity indexes.

Internal validity index: Calinski-Harabasz (CH)

$$CH_K = \frac{SSB_K}{SSW_K} \cdot \frac{(N-K)}{(K-1)}$$

External validity index: Adjusted Rand Index (ARI)

$$ARI = \frac{\sum_{ij} \binom{n_{ij}}{2} - [\sum_i \binom{p_i}{2}] \sum_j \binom{q_j}{2} / \binom{N}{2}}{\frac{1}{2} [\sum_i \binom{p_i}{2} + \sum_j \binom{q_j}{2}] - [\sum_i \binom{p_i}{2}] \sum_j \binom{q_j}{2} / \binom{N}{2}}$$

# Methods

## ➤ RQ2: change in content diversity

1. Average pairwise Euclidean distance of item embeddings: content diversity.

$$distance_{v_i, v_j} = \sqrt{\sum_{d=1}^D (v_i^d - v_j^d)^2}$$

2. Measure average of content diversity in each user group.



# Dataset

Dataset	Statistic	Numerical Values
Click Log	Num of click logs	7,386,783
	Num of users	7,477
	Num of items	2,686,591
Purchase Log	Num of purchase logs	98,135
	Num of users	3,557
	Num of items	71,973
Browse Log	Num of browse logs	6,225,301
	Num of users	7,417
	Num of items	5,077,268

Tab. 2 Statistic of experiment data.

	Click	Purchase	Browse
#Interactions	100	10	200

Tab.3 Length of blocks.

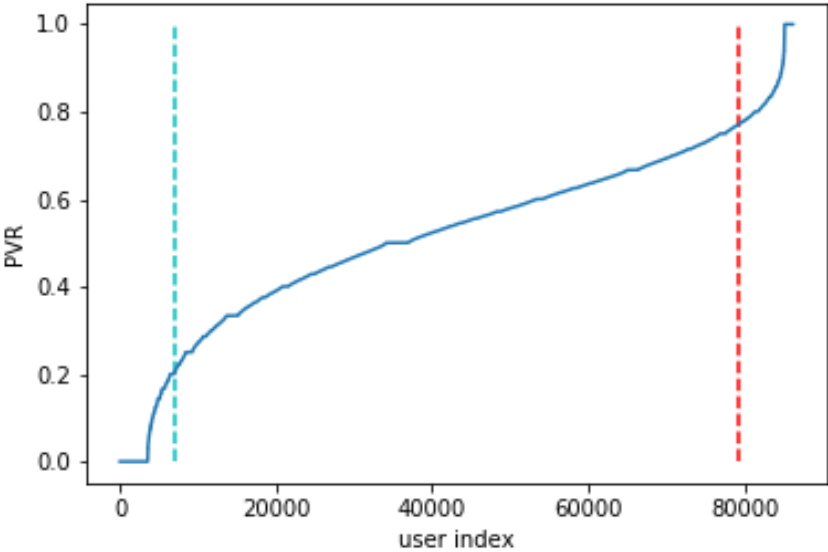


Fig 1. Classify user groups based on Page review ratio (PVR).

	Click	Purchase	Browse
Following group	5,025	2,099	5,507
Ignoring group	2,452	1,458	1,910
All users	7,477	3,557	7,417

Tab.4 Statistic of each user group.

# Experimental Results: Clustering tendency

Action	User type	Amount	First Block	Last Block	P-value
Click	All users	4904	0.7742	0.7713	4.33e−9
	Following	2452	0.7756	0.7746	3.05e−2
	Ignoring	2452	0.7728	0.7680	1.53e−21
	Between-group p-value	4904	1.58e−8	2.88e−28	
Purchase	All users	2916	0.7264	0.7279	1.41e−2
	Following	1458	0.7223	0.7248	1.25e−6
	Ignoring	1458	0.7305	0.7310	0.27
	Between-group p-value	2916	2.65e−28	1.02e−24	

Tab. 5 Hopkins Statistic.

# Experimental Results: K-selection

	$K^*$	$K^*-5$	$K^*+5$
Click Following	24	19	29
Click Ignoring	20	15	25
Purchase Following	11	6	16
Purchase Ignoring	9	4	14

Tab. 6 The range of the number of clusters.

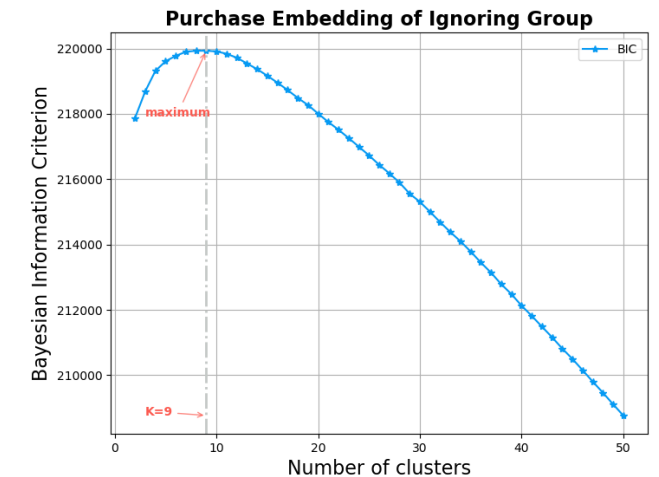
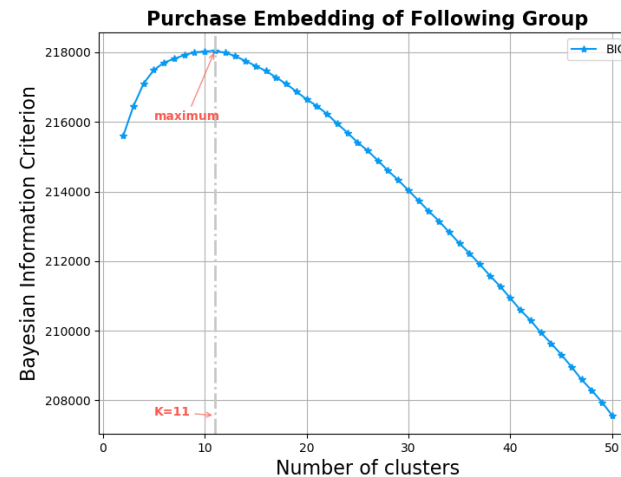
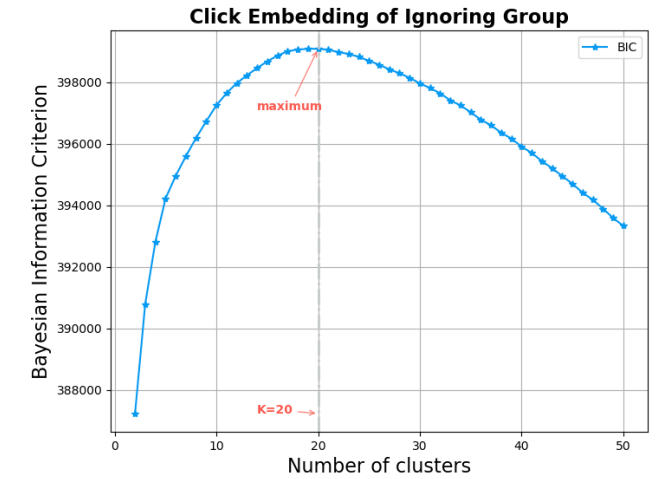
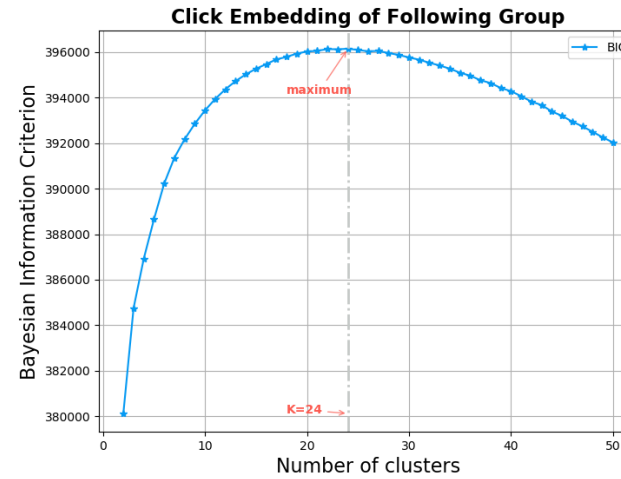


Fig. 2 Bayesian Information Criterion (BIC).

# Experimental Results: RQ1

	Click			Purchase		
	Following	Ignoring	P-value	Following	Ignoring	P-value
$k^* - 5$	53.50	58.14	$3.62e-41$	41.76	52.72	$6.94e-60$
$k^* - 4$	52.21	56.51	$2.10e-39$	39.30	47.35	$3.54e-56$
$k^* - 3$	51.12	54.95	$1.58e-40$	37.30	43.41	$1.44e-50$
$k^* - 2$	50.10	53.54	$4.79e-35$	35.60	40.21	$3.50e-48$
$k^* - 1$	49.19	52.02	$7.64e-31$	34.13	37.70	$7.47e-39$
$k^*$	48.22	50.73	$4.29e-28$	32.74	35.45	$3.55e-29$
$k^* + 1$	47.17	49.38	$9.78e-22$	31.34	33.62	$3.96e-24$
$k^* + 2$	46.45	48.00	$3.92e-15$	30.09	32.06	$8.70e-23$
$k^* + 3$	45.74	46.89	$8.67e-11$	28.88	30.54	$4.99e-19$
$k^* + 4$	44.78	45.69	$1.36e-7$	27.78	29.14	$2.69e-18$
$k^* + 5$	44.05	44.62	$2.61e-4$	26.97	28.00	$4.78e-14$
AVE	48.41	50.95	$5.97e-32$	33.26	37.29	$1.06e-46$

Tab. 7 Decreases in Calinski-Harabasz scores (CH).

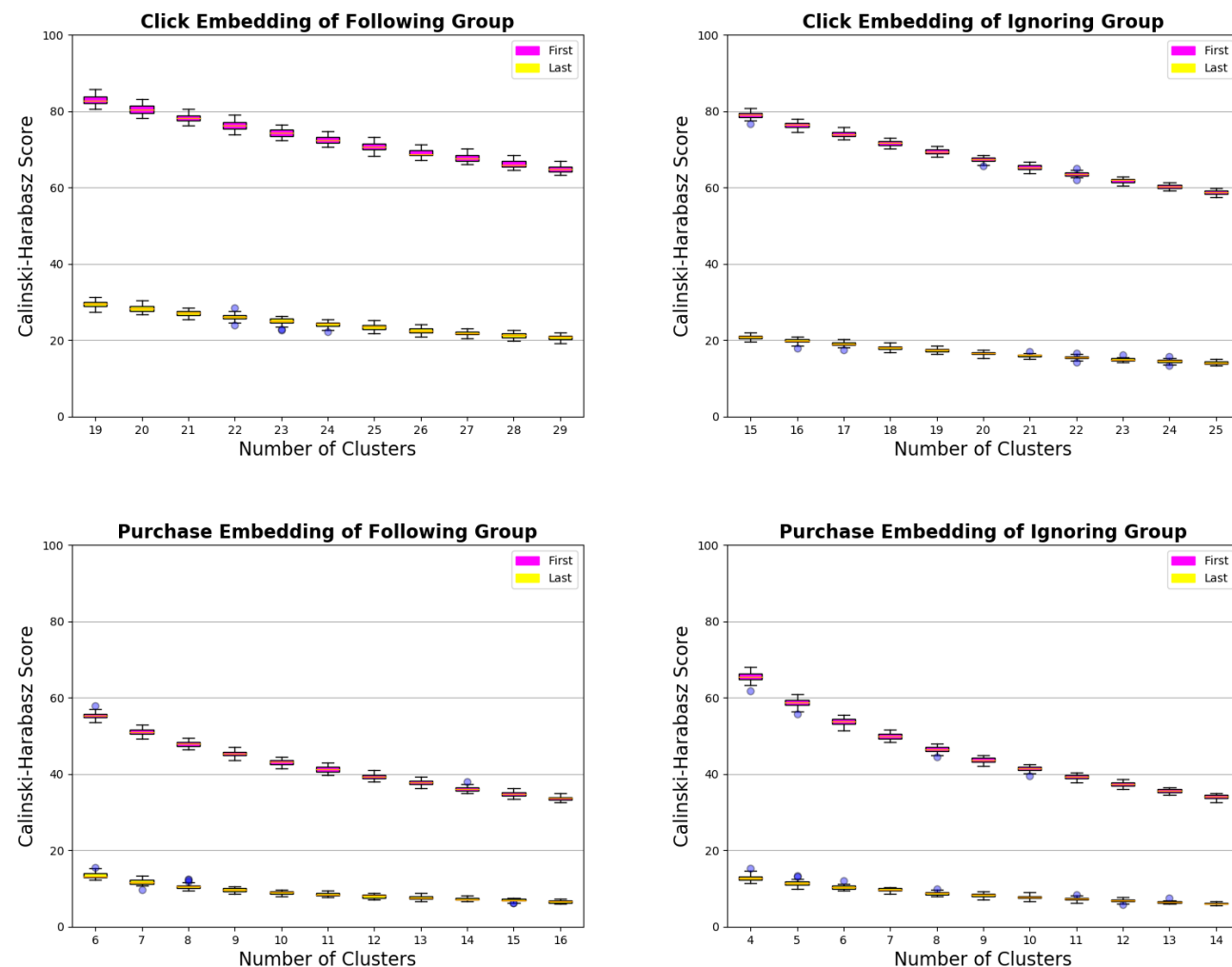


Fig. 3 Calinski-Harabasz scores

# Experimental Results: RQ1

	Click			Purchase		
	Following	Ignoring	P-value	Following	Ignoring	P-value
$k^* - 5$	0.1136	0.0877	$1.34e-33$	0.0969	0.0829	$3.70e-8$
$k^* - 4$	0.1099	0.0856	$1.85e-32$	0.0825	0.0677	$1.67e-10$
$k^* - 3$	0.1060	0.0829	$1.23e-33$	0.0725	0.0686	$2.77e-2$
$k^* - 2$	0.1040	0.0811	$4.19e-34$	0.0697	0.0712	0.35
$k^* - 1$	0.0996	0.0780	$2.88e-32$	0.0639	0.0650	0.52
$k^*$	0.0974	0.0756	$5.52e-32$	0.0615	0.0635	0.23
$k^* + 1$	0.0949	0.0734	$4.49e-41$	0.0585	0.0634	$9.17e-4$
$k^* + 2$	0.0929	0.0717	$1.62e-33$	0.0555	0.0598	$4.12e-3$
$k^* + 3$	0.0900	0.0698	$1.13e-35$	0.0524	0.0583	$1.88e-5$
$k^* + 4$	0.0890	0.0687	$1.10e-39$	0.0511	0.0552	$1.48e-3$
$k^* + 5$	0.0871	0.0670	$4.20e-34$	0.0489	0.0510	0.13
AVE	0.0986	0.0765	$2.28e-51$	0.0648	0.0642	0.53

Tab. 8 Adjusted Rand Index (ARI).

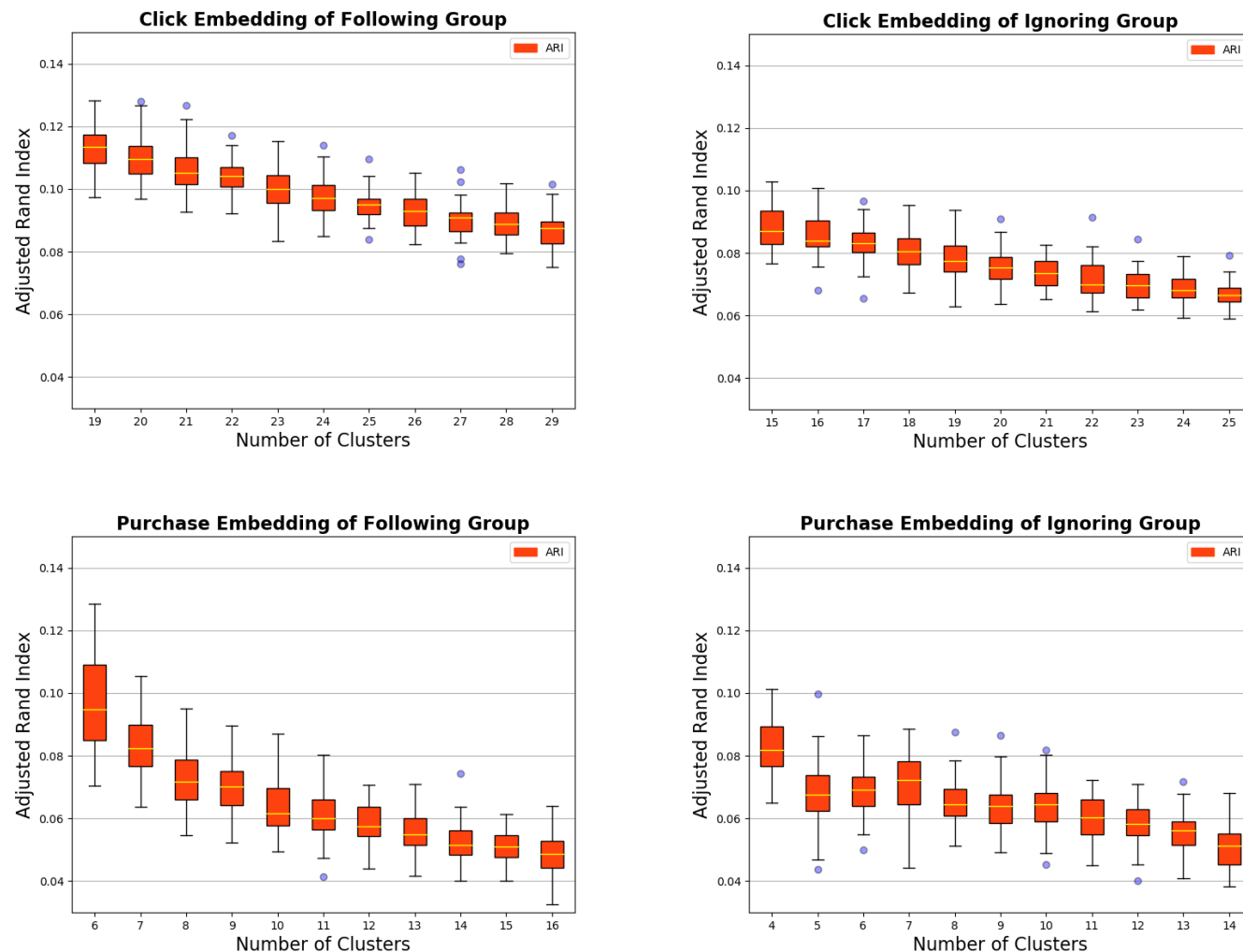


Fig. 4 Adjusted Rand Index .

# Experimental Results: RQ2

	Amount	First	last	Within-group p-value
All users	3820	1.0969	1.0937	6.10e-11
Following group	1910	1.0945	1.0882	1.95e-20
Ignoring group	1910	1.0992	1.0989	0.67
Between-group p-value	3820	2.13e-12	2.16e-56	

Tab. 9 The content diversity of Recommended items.

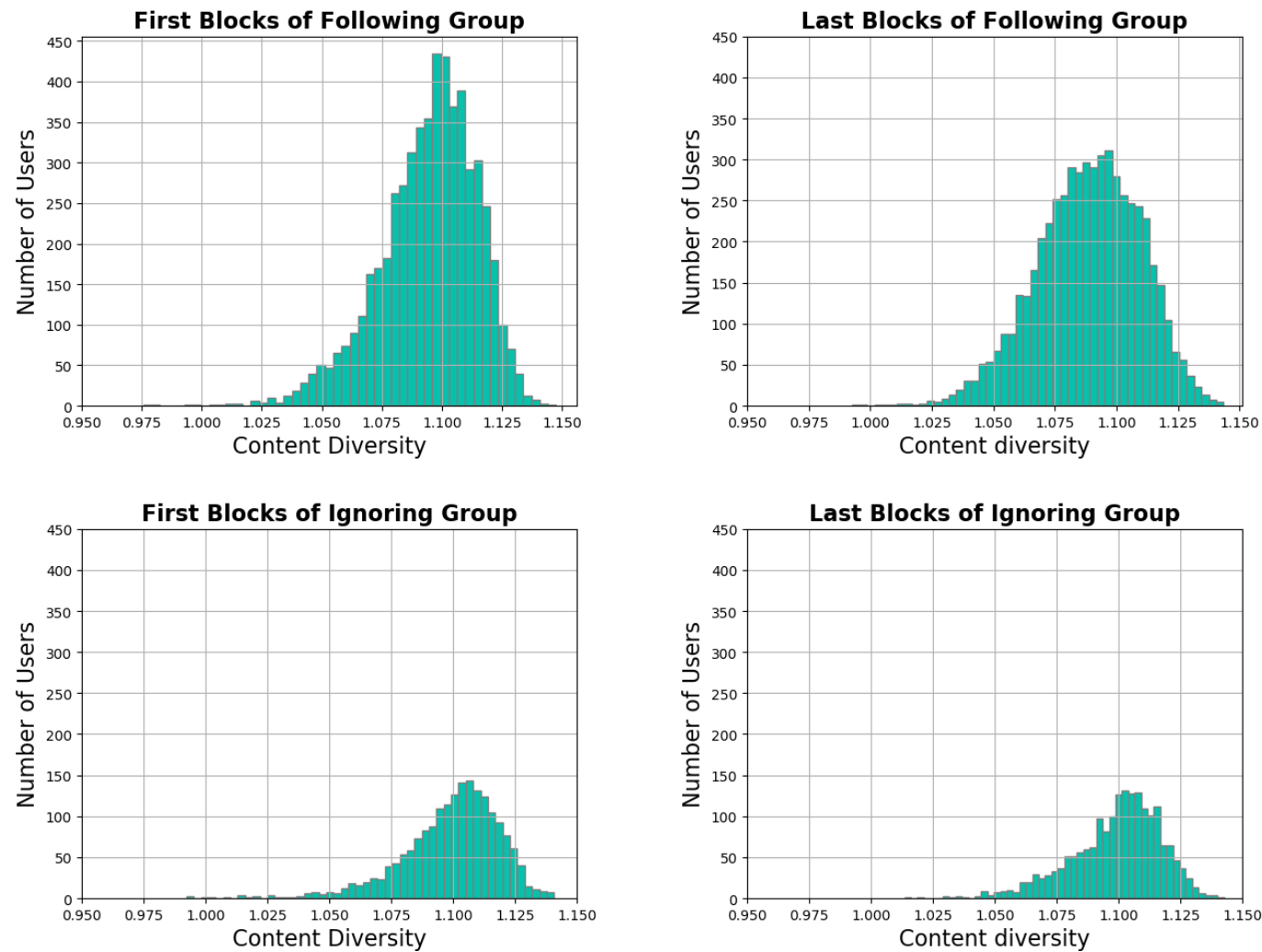


Fig. 5 The distribution of content diversity

# Conclusions

- The recommender system reinforces user click and purchase interests.
- The reinforcement trend is caused by RS narrowing down the scope of items exposed to users.
- Echo chamber exists in terms of user click behaviors, but this tendency is relatively mitigated on user purchase behaviors.

# Acknowledgement





Q & A

Thank you !