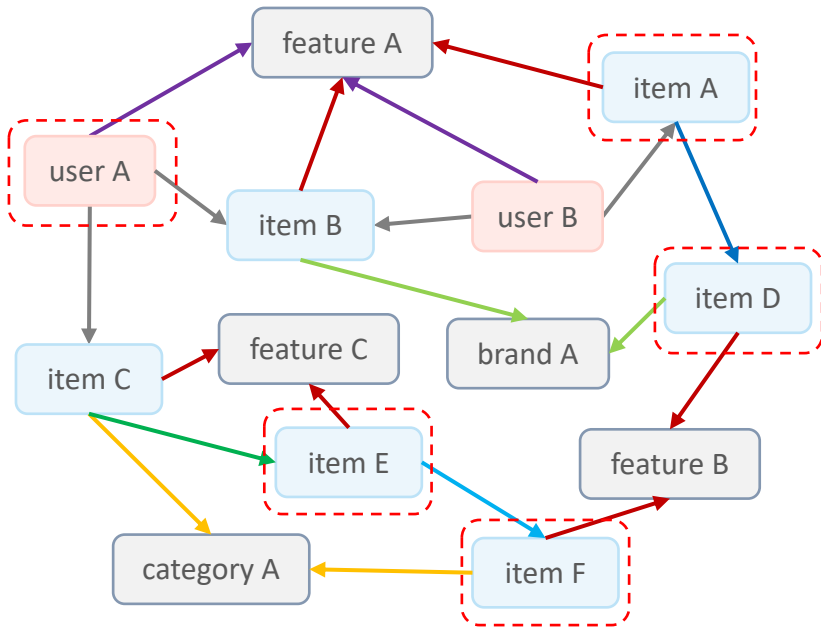


# Neural-Symbolic Reasoning over Knowledge Graph for Multi-stage Explainable Recommendation

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## Task: KG-based Explainable Recommendation



## Method: A Neural-Symbolic Reasoning Approach

### 1. Neural-Symbolic Representation Learning

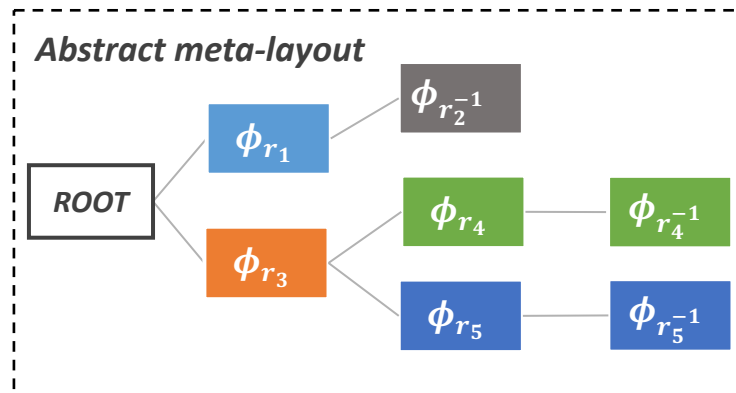
- $\ell_{path}(\Theta; \{L_u\}) = \sum_{L_u} \log P(L_u | u; \Theta)$
- $\ell_{rank}(\Theta; \{L_u\}) = \sum_{L_u} \sum_i -\sigma \left( s(i^-, r_{|L_u|}, u, h_{|L_u|}) - s(i^+, r_{|L_u|}, u, h_{|L_u|}) \right)$
- $\ell_{all}(\Theta) = \sum_u \ell_{path}(\Theta; \{L_u\}) + \lambda \ell_{rank}(\Theta; \{L_u\})$

### 2. Neural-Symbolic Explainable Recommendation (Generate explanations in two stages)

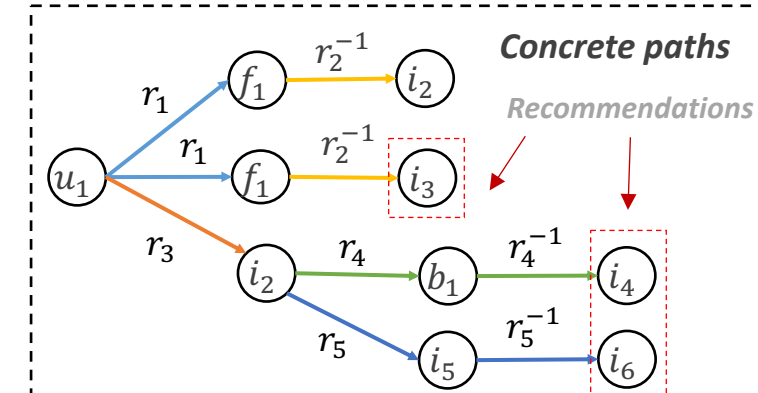
## Challenge:

- Unknown target: items (target node) are NOT known before path finding.
- Large node degree: this leads to large search space.

### Output: Coarse-grained Explanation



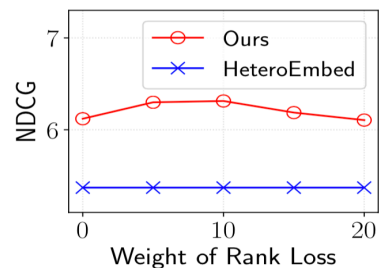
### Output: Fine-grained explanation



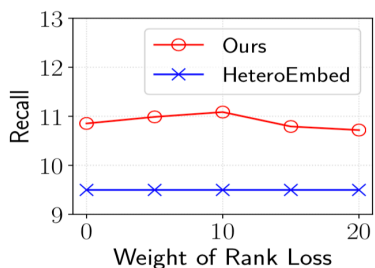
# Main Results

Dataset	CDs & Vinyl				Clothing				Cell Phones				Beauty			
Measures (%)	NDCG	Recall	HR	Prec.	NDCG	Recall	HR	Prec.	NDCG	Recall	HR	Prec.	NDCG	Recall	HR	Prec.
DeepCoNN	4.218	6.001	13.857	1.681	1.310	2.332	3.286	0.229	3.636	6.353	9.913	0.999	3.359	5.429	9.807	1.200
CKE	4.620	6.483	14.541	1.779	1.502	2.509	4.275	0.388	3.995	7.005	10.809	1.070	3.717	5.938	11.043	1.371
HeteroEmbed	5.563	<u>7.949</u>	<u>17.556</u>	<u>2.192</u>	<u>3.091</u>	<u>5.466</u>	<u>7.972</u>	<u>0.763</u>	<u>5.370</u>	<u>9.498</u>	<u>13.455</u>	<u>1.325</u>	<u>6.399</u>	<u>10.411</u>	<u>17.498</u>	<u>1.986</u>
PGPR	<u>5.590</u>	7.569	16.886	2.157	2.858	4.834	7.020	0.728	5.042	8.416	11.904	1.274	5.449	8.324	14.401	1.707
NSER (Ours)	<b>6.868</b>	<b>9.376</b>	<b>19.692</b>	<b>2.562</b>	<b>3.689</b>	<b>6.340</b>	<b>9.275</b>	<b>0.975</b>	<b>6.313</b>	<b>11.086</b>	<b>15.531</b>	<b>1.692</b>	<b>7.061</b>	<b>10.948</b>	<b>18.099</b>	<b>2.270</b>

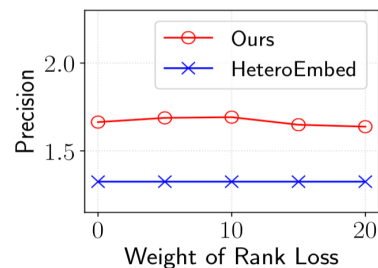
## Influence of Ranking Loss



(a) NDCG



(b) Recall



(c) Precision

## Effectiveness of Layout

Dataset	Cell Phones				Beauty			
Method	NDCG	Recall	HR	Prec.	NDCG	Recall	HR	Prec.
uniform	4.545	7.229	10.192	1.087	6.293	9.256	15.564	1.918
prior	6.255	10.842	15.097	1.659	6.880	10.393	17.258	2.224
heuristic	6.313	11.086	15.531	1.692	7.061	10.948	18.099	2.270

## Case Study:

