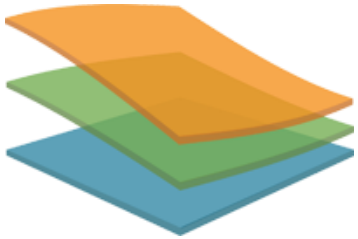

Learning Layers

Scaling up Technologies for Informal Learning in SME Clusters

Modeling Activation Processes in Human Memory to Improve Tag Recommendations

Doctoral Symposium, WWW 2015

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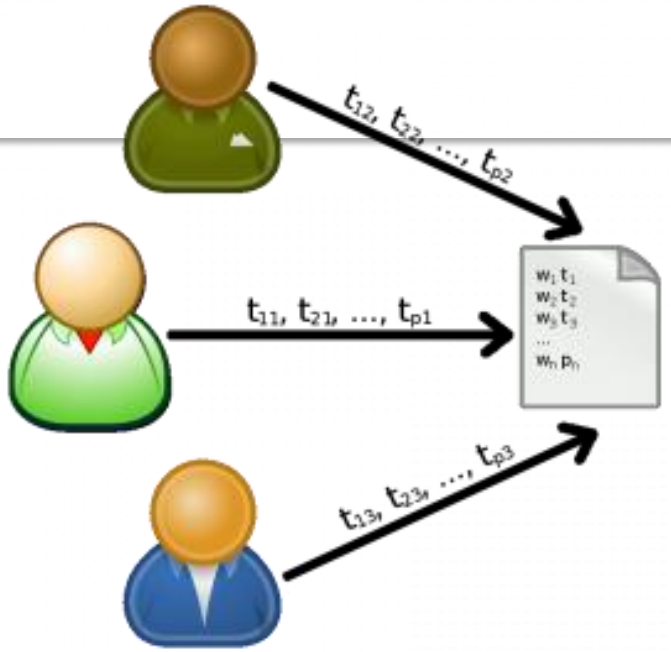
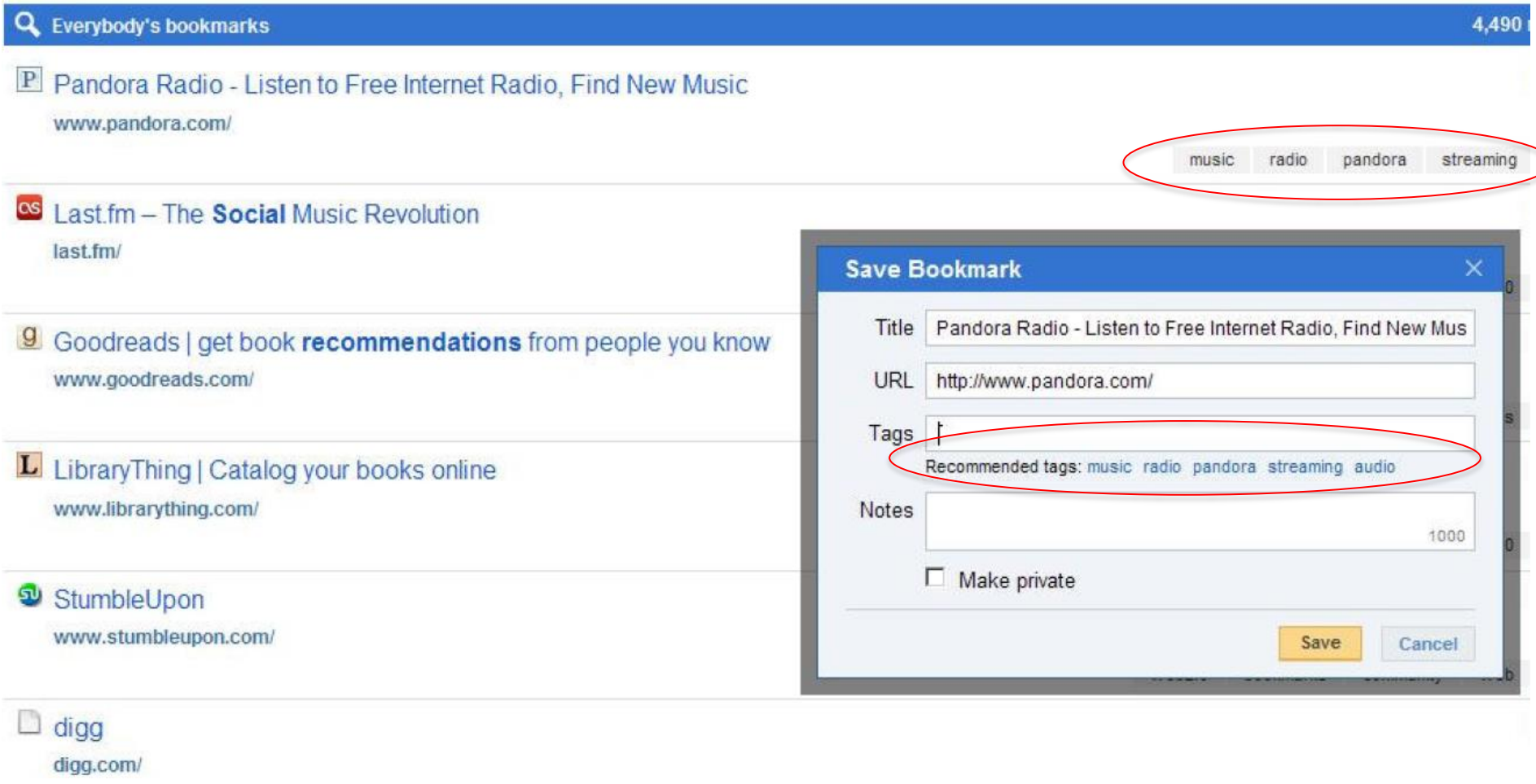
Social Tagging



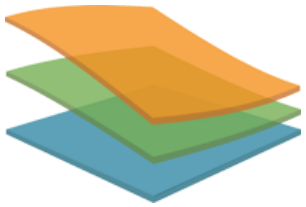
- Social tagging is the process of collaboratively annotating content
- Essential instrument of Web 2.0 to structure and search Web content

- **Issues**
  - No rules for tags → can be freely chosen
  - Hard for people to come up with a set of descriptive/relevant tags by their own
  - People are lazy in applying tags
  - Synonyms, homonyms, spelling errors, singular/plurar, etc.

Solution: Tag Recommenders



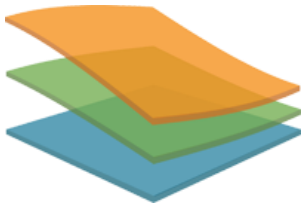
[Guy & Carmel, 2011]



Benefits of Tag Recommendations

- Help the individual to find relevant tags → better find the bookmarked resources
- Help the collective to consolidate a shared tag vocabulary [Lipczak, 2012] → create a shared understanding in a group

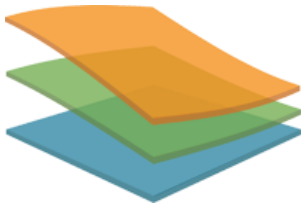
- Personalized tag recommeders can increase the indexing quality of resources [Dellschaft & Staab, 2002]
  - It is easier to understand the content of an indexed resource based on the tags



Issues / Research Gap

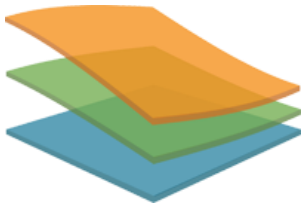
- Lot of research available about how people access words in their memory
  - i.e., **activation processes in human memory**
- Current tag recommender approaches ignore these insights from cognitive science
  - or apply them in a very rudimentary or incomplete way

- Some of the approaches are highly computational expensive → hard to integrate in a live recommender system
- Often evaluated only in simulated folksonomies (i.e., *p*-cores) → hard to determine their usefulness in real-world settings



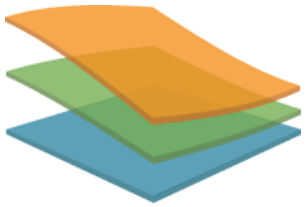
Problem Statement

There is a lack of knowledge about (1) how **activation processes in human memory** can be modelled for the task of **tag recommendations** and (2) if this could lead to **improvements** in terms of **recommender accuracy and computational costs** in **real-world folksonomies**



Research Questions

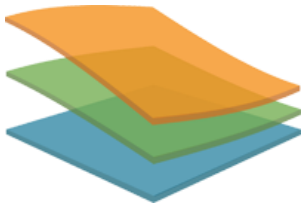
- *RQ1*: Which activation processes in human memory are appropriate to account for a tag's probability of being reused in a social tagging system?
- *RQ2*: Can the activation equation of the cognitive model ACT-R, that accounts for the activation processes in human memory, be exploited to effectively predict a user's tag reuse?
- *RQ3*: To what extent can a tag recommender algorithm, that extends the activation equation of the cognitive model ACT-R with tag imitation processes, compete with current state-of-the-art approaches in terms of recommender accuracy and computational costs?



RQ1

Which activation processes in human memory are appropriate to account for a tag's probability of being reused in a social tagging system?

- Parts of this RQ have been submitted to the Journal of Web Science



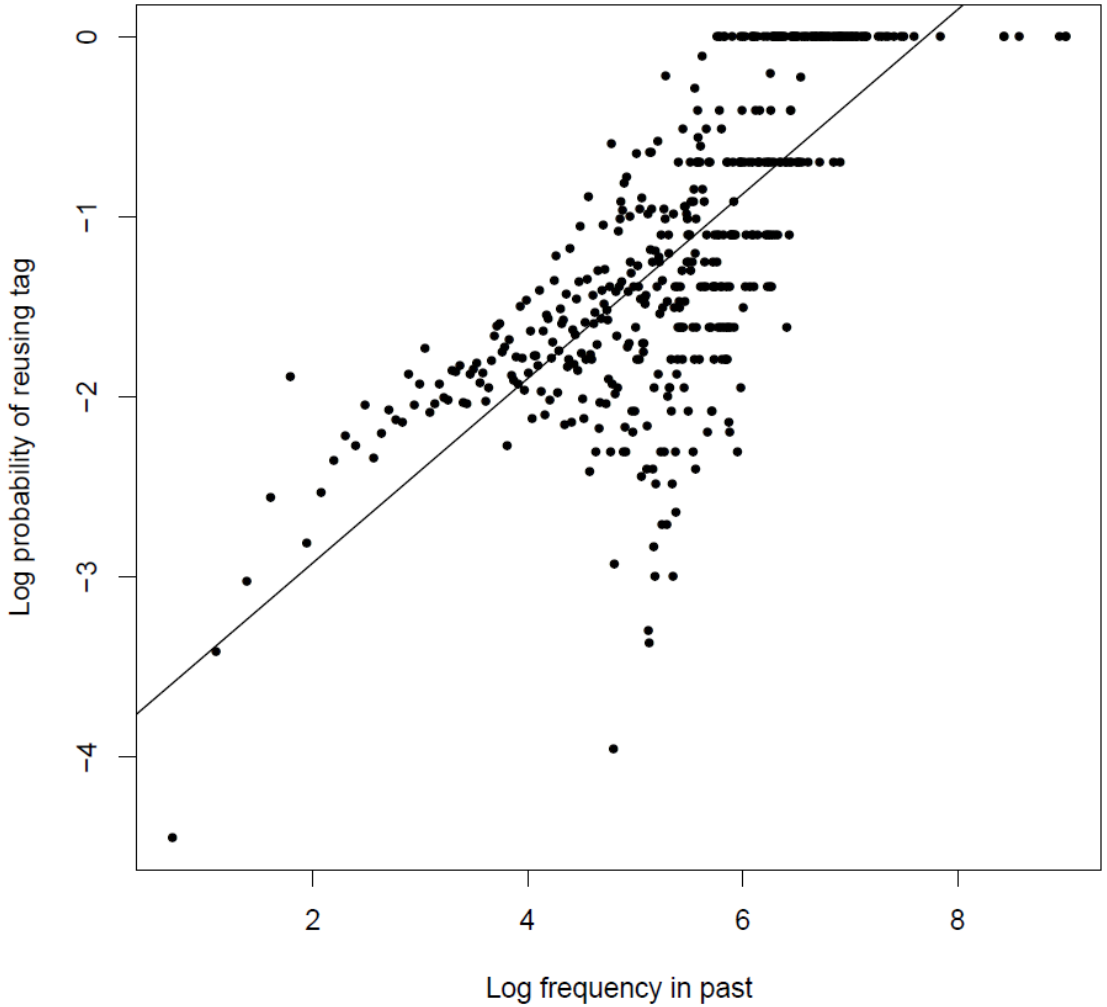
Activation Processes in Human Memory

- Account for the probability that a memory unit (e.g., word/tag) will be used (activated)

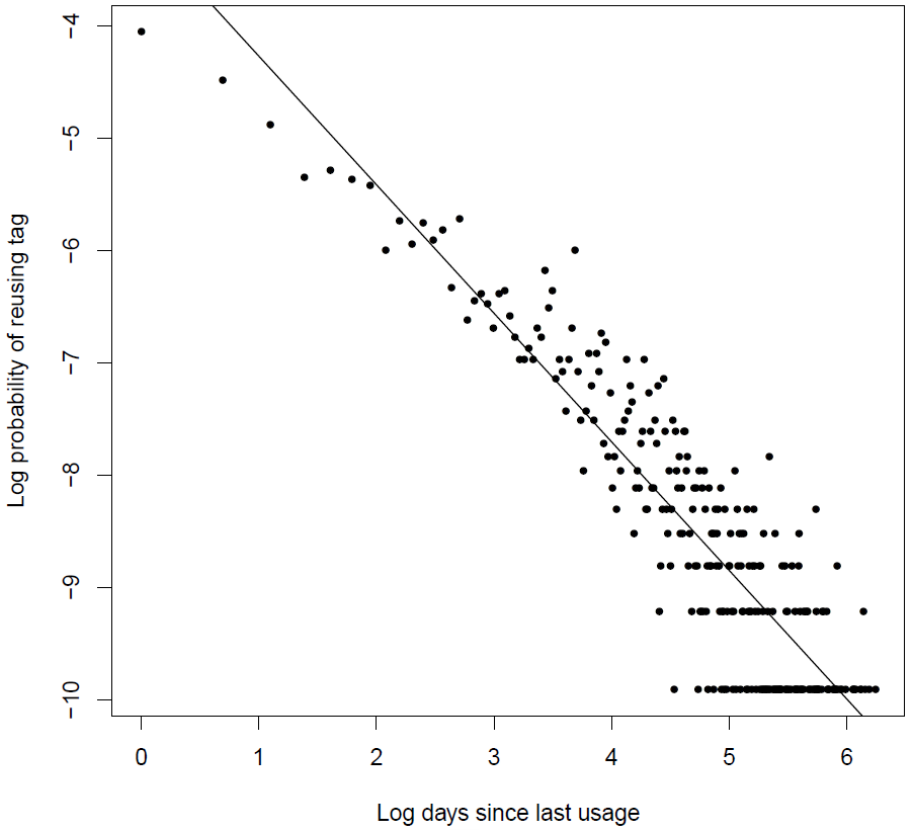
- Empirical research on human memory (Anderson & Schooler, 1991) showed that the activation of a human memory unit depends on its general usefulness in the past:
  - **usage-frequency (1)** (how often it was used) and
  - **recency (2)** (time since last usage → power-law of forgetting)
- And its usefulness in the **current context (3)** [Anderson et al., 2004]

- **Question:** How do these insights relate to social tagging systems (e.g., Flickr) ?

(1) Tag-Frequency: Flickr

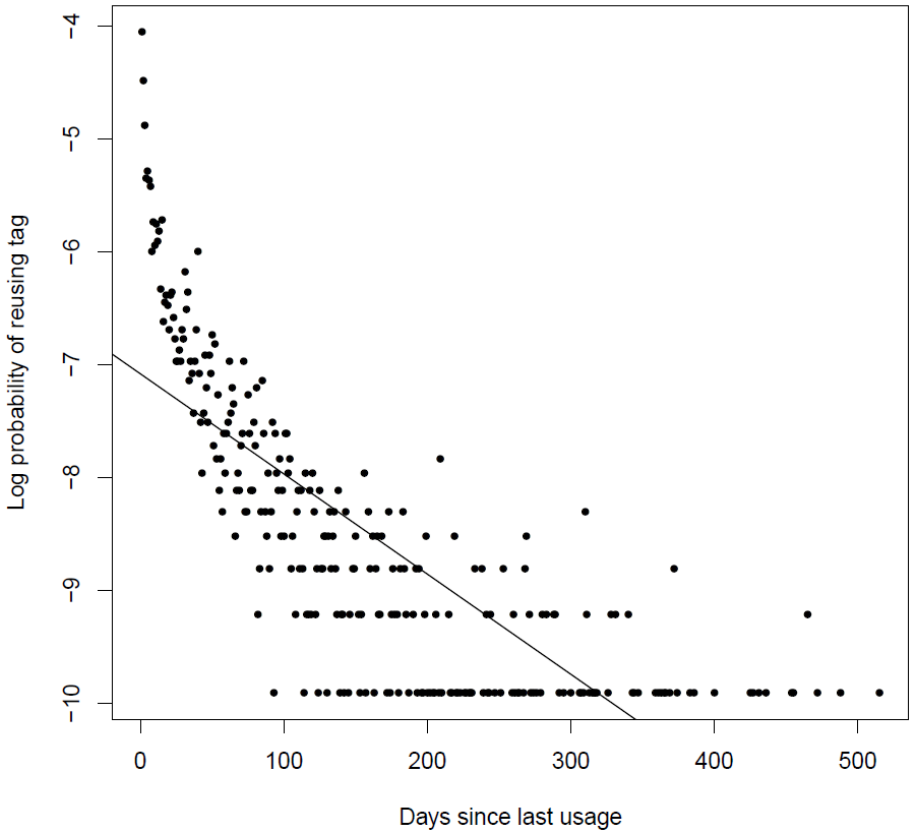


(2) Tag-Recency: Flickr



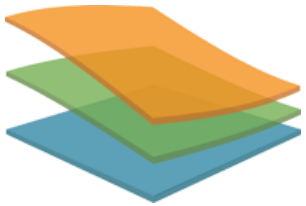
Power distribution

R^2 = 84%



Exponential distribution

R^2 = 61% (e.g., Zhang et al., 2014)



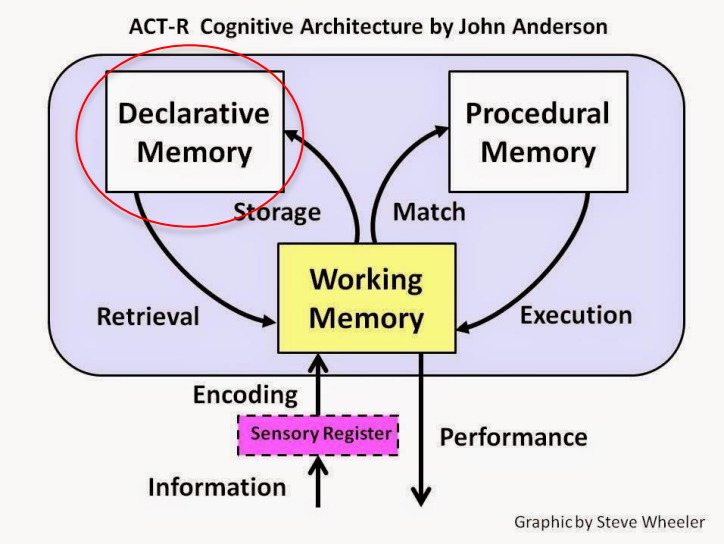
(3) Current Context

- **Open issue**
- Could be tackled in a similar way
- **Current context** is the target resource to be tagged (defined by the already given tags by other users → context cues)
- *Assumption*
  - Higher co-occurence with current context cues → higher reuse probability

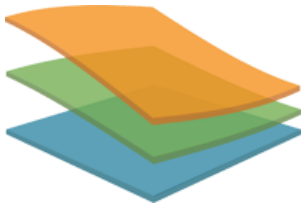
- **Conclusion**
  - Tag-frequency, recency and the current context seem to be important factors to predict the reuse of tags → cognitive model could formalize this

The Cognitive Model ACT-R

- Developed mainly by John Robert Anderson
- Defines the basic cognitive operations that enable human memory



- Declarative Memory Module
  - Is about access to memory units
  - **Activation processes that control this access via activation equation**



RQ2

Can the activation equation of the cognitive model ACT-R, that accounts for the activation processes in human memory, be exploited to effectively predict a user's tag reuse?

- **Kowald, D.**, Seitlinger, P., Trattner, C., & Ley, T. (2014). Long time no see: The probability of reusing tags as a function of frequency and recency. In *Proceedings of the companion publication of the 23rd international conference on World wide web companion* (pp. 463-468). International World Wide Web Conferences Steering Committee.

- **Kowald, D.**, Kopeinik, S., Seitlinger, P., Ley, T., Albert, D., & Trattner, C. (2015). Refining Frequency-Based Tag Reuse Predictions by Means of Time and Semantic Context. In *Mining, Modeling, and Recommending'Things' in Social Media* (pp. 55-74). Springer International Publishing.

Implementation

- **Activation equation**

$$A_i = B_i + \sum_j (W_j \cdot S_{j,i})$$

- Activation of memory unit *i* (tag) =

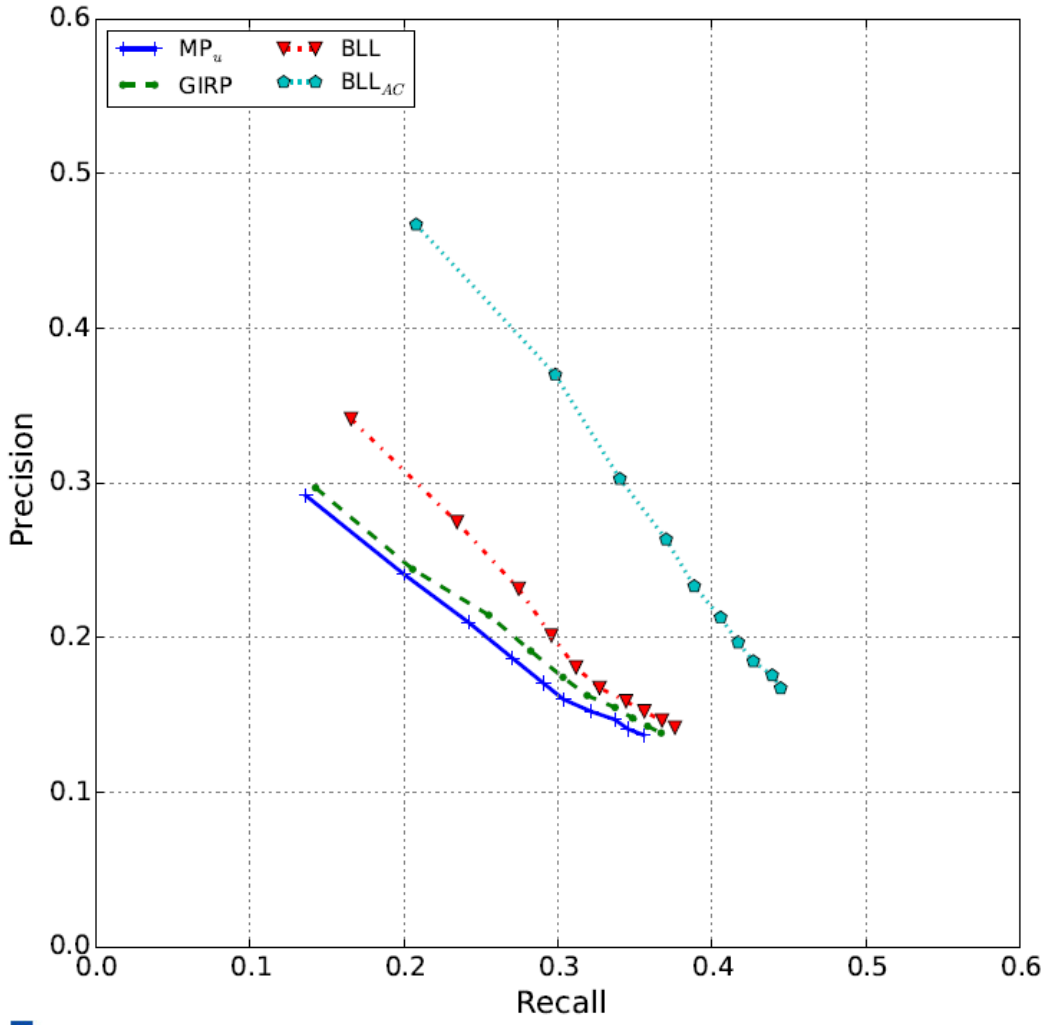
base-level activation of *i* (**general** usefulness) +
associative activation of *i* (relevance to ***current context cues***)

- **Base-level learning (BLL) equation** (Anderson & Schooler, 1991)

$$B_i = ln(\sum_{j=1}^{n} t_j^{-d})$$

- Integrates ***frequency*** and ***recency*** of the usage of *i* with a power function

Evaluation Results: BibSonomy

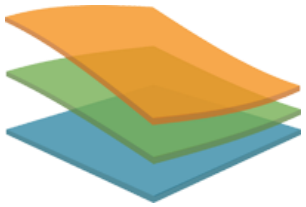


Conclusion

- GIRP > MP_u
- BLL > GIRP
- BLL_{AC} > BLL

(same for other datasets)

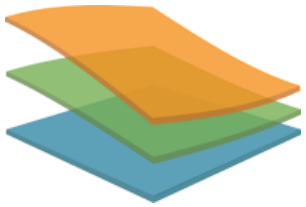
→ Also other processes are important to realize a „full“ tag recommender



Micro- and Macro-Level Processes

- Social tagging is an interplay between micro- (individual) and macro-level (collective) processes [Fu, 2008]
- A tag-recommender needs to implement both types of processes

- Micro-level: $\mathbf{BLL_{AC}}$ (activation equation)
- Macro-level: **Tag-imitation** (e.g., Wagner et al., 2014)



RQ3

To what extent can a tag recommender algorithm, that extends the activation equation of the cognitive model ACT-R with tag imitation processes, compete with current state-of-the-art approaches in terms of recommender accuracy and computational costs?

- Work in progress

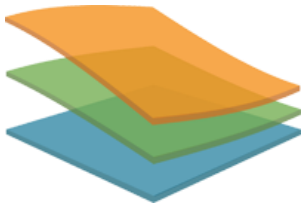
Implementation: Tag Imitation

- Usually a social tagging systems shows a tag-cloud for a resource
- Contains the tags that have already been assigned to the target resource
- People tend to reuse these tags (e.g., Wagner et al., 2014)

→ Most popular tags by resource (**MP_r**)

- Hybrid approach:

$$\widetilde{T}_k(u,r) = \arg\max_{t \in T}^{k} (\beta \underbrace{\|A(t,u,r)\|}_{BLL_{AC}} + (1-\beta)\|\|Y_{t,r}\|\|) \quad \underbrace{\qquad\qquad}_{BLL_{AC}+MP_r}$$



RQ3: Evaluation Plan

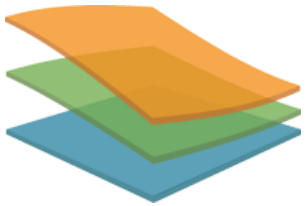
- Datasets
  - BibSonomy, CiteULike, Delicious, Flickr, MovieLens, LastFM
- Computational costs
  - Runtime and memory
- Other RS metrics
  - Not only accuracy and ranking
  - Diversity and novelty
- Rich set of state-of-the-art algorithms
  - CF, FolkRank, PITF …

- **Work in progress**

Further Contribution: TagRec

- **TagRec framework (https://github.com/learning-layers/TagRec/)**
  - **Kowald, D.**, Lacic, E., & Trattner, C. (2014). TagRec: Towards a standardized tag recommender benchmarking framework. In *Proceedings of the 25th ACM conference on Hypertext and social media*. ACM (best poster award)

- Contains everything that is needed to develop evaluate new tag recommender algorithms
  - Object-oriented data structures
  - Implementation of state-of-the-art algorithms
  - Evaluation protocols (i.e., train-/test-set splitting)
  - Evaluation metrics
- Extended for other types of recommendations (resource and user)
- Used as recommender engine in the Learning Layers EU project



Next Steps

- Open points from RQ1
  - Show empirically the importance of the current context
  - „Better“ way to prove the power-law of tag recency [Clauset et al., 2007]
- Evaluation for RQ3
- Use content data of the resources as context cues
- Better modeling of tag imitation
  - MP_r is not enough (unpersonalized) → each user imitates other tags
- Evaluate „real“ user acceptance
  - Online evaluation in a live recommender system
  - Learning Layers field studies

- **Vision for future work**
  - Use these insights from cognitive science for other types of recommendations/personalization services (e.g., resource recommender)

Thank you for your attention!

Questions?

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