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Portugal
21-23 October

BACK TO THE DIFFERENCES: Rethinking Information Search (and Recommendation) on the Web

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Agenda

- Introduction
- Web Search and recommendation
- Similarity patterns
- Problems
- Revisit the concept of information
- Other categories of web search & Searching as Learning
- Research agenda

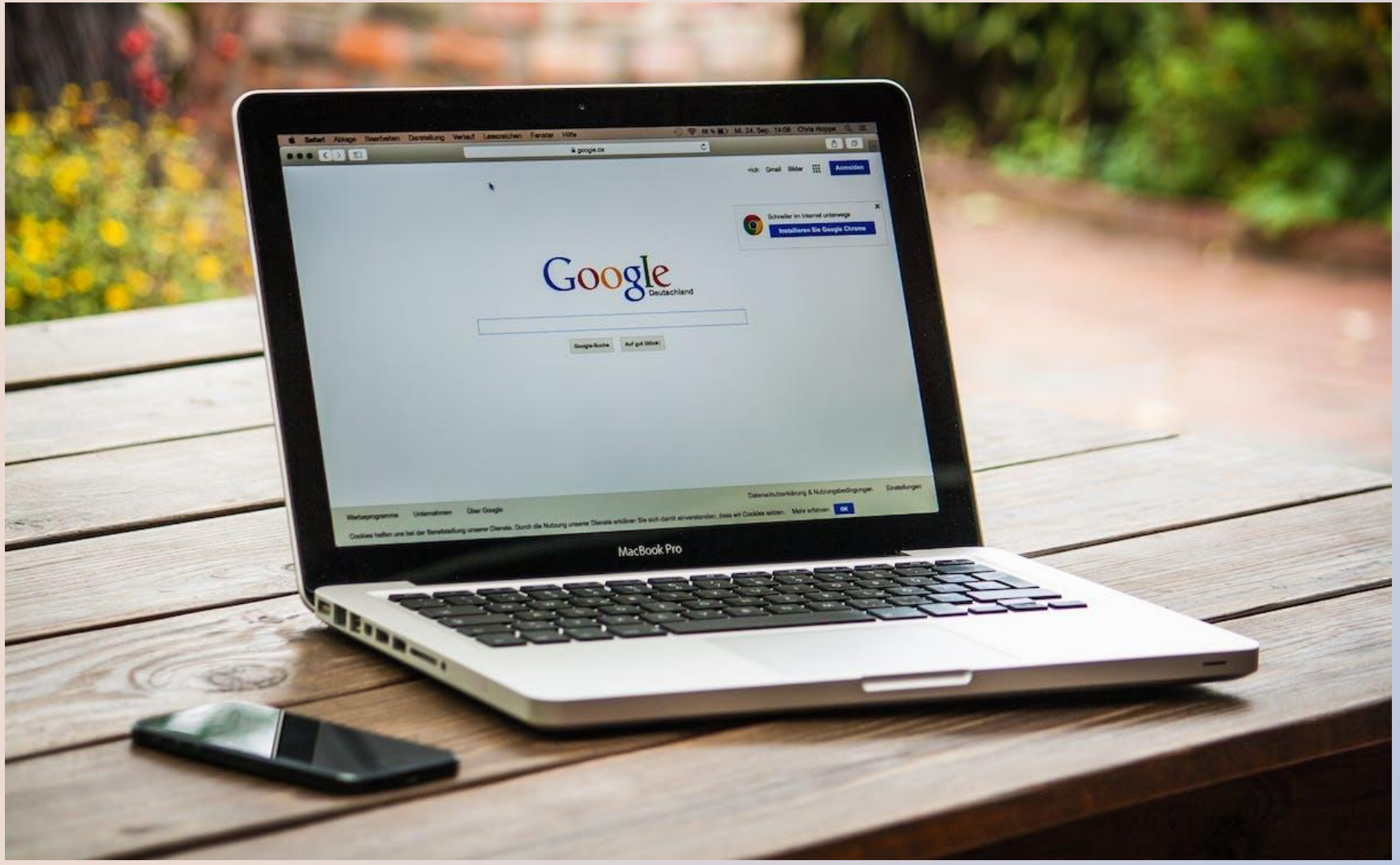
The Amount of Web Data

- Ubiquity of information
- Dynamic ecosystem with billions of websites
- 2.5 quintillion bytes of data created per day

The paradox of choice

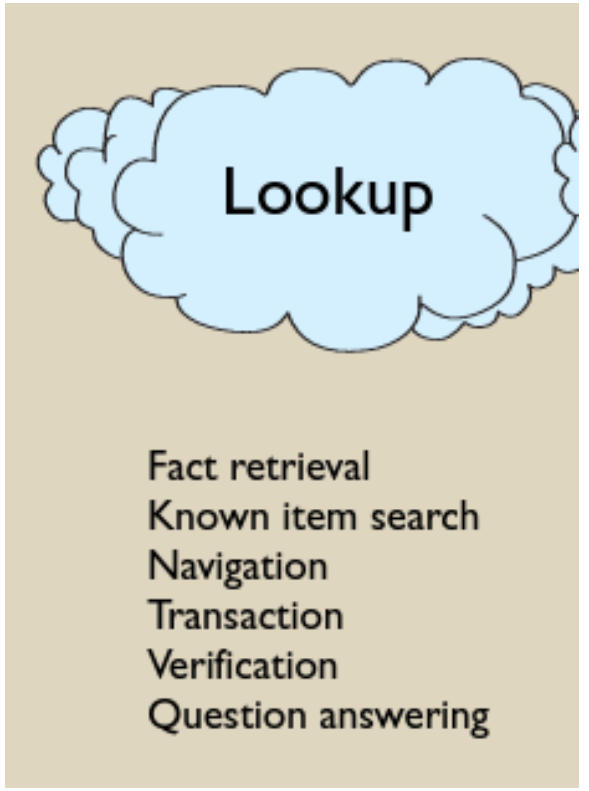
- Information as data
- Information as uncertainty reduction
- Information as meaningful content
- Information as knowledge
- Information as a signal
- Information as decision support

Information search on the web



Types/categories of information search

- Informational search
- Navigational search
- Transactional search



[Marchionini, 2006]

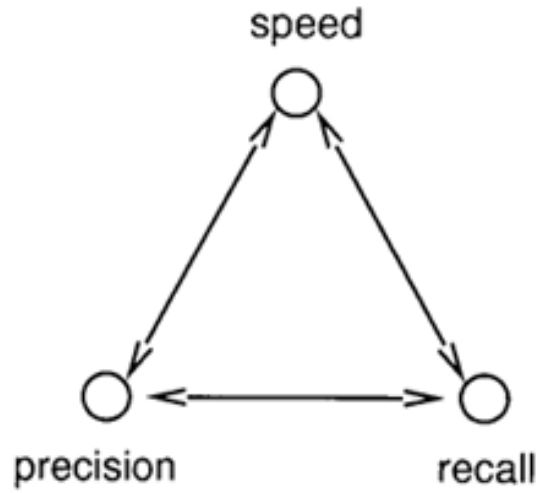


Figure 1. Three way trade-off in search engine performance: (1) speed of retrieval, (2) precision, and (3) recall.

Kobayashi, M., & Takeda, K. (2000). Information retrieval on the web. *ACM computing surveys (CSUR)*, *32*(2), 144-173.

Similarity strategies and patterns in IR

- Relevance ranking
- Keyword matching
- Vector Space Model
- Term Frequency-Inverse Document Frequency (TF-IDF)
- Latent Semantic Analysis (LSA)
- Word Embeddings
- Topic Modeling
- Machine Learning and Deep Learning
- User Behavior Analysis
- Relevance Feedback

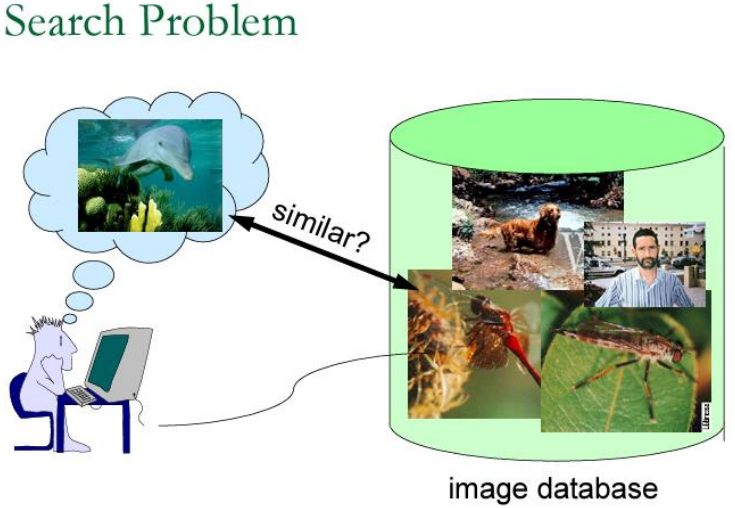


Image from ACM SAC Tutorial, March 2007: Similarity Search: the metric space approach Zezula, P., Amato, G., Dohnal, V., & Batko, M. (2006). *Similarity search: the metric space approach* (Vol. 32). Springer Science & Business Media.

Johnson, J., Douze, M., & Jégou, H. (2019). Billion-scale similarity search with gpus. *IEEE Transactions on Big Data*, *7*(3), 535-547.

Chen, W., Chen, J., Zou, F., Li, Y. F., Lu, P., & Zhao, W. (2019, June). RobustiQ: A robust ANN search method for billion-scale similarity search on GPUs. In *Proceedings of the 2019 on international conference on multimedia retrieval* (pp. 132-140).

Yu, W., McCann, J., Zhang, C., & Ferhatosmanoglu, H. (2022). Scaling high-quality pairwise link-based similarity retrieval on billion-edge graphs. *ACM Transactions on Information Systems (TOIS)*, *40*(4), 1-45.

Lakshman, V., Teo, C. H., Chu, X., Nigam, P., Patni, A., Maknikar, P., & Vishwanathan, S. V. N. (2021). Embracing Structure in Data for Billion-Scale Semantic Product Search. *arXiv preprint arXiv:2110.06125*.

Echihabi, K., Zoumpatianos, K., & Palpanas, T. (2021, April). High-dimensional similarity search for scalable data science. In *2021 IEEE 37th International Conference on Data Engineering (ICDE)* (pp. 2369-2372). IEEE.

Yang, K., Wang, H., Du, M., Wang, Z., Tan, Z., Zhang, J., & Xiao, Y. (2023). An efficient indexing technique for billion-scale nearest neighbor search. *Multimedia Tools and Applications*, 1-17.

Different models of information search

- Information search is a complex cognitive activity, which concerns various scientific fields in cognitive science. Consequently, many models of information search have been developed and related to individual differences and attributes of the system device used.

Dinet, J., Chevalier, A., & Tricot, A. (2012). Information search activity: An overview. *European review of applied psychology*, *62*(2), 49-62.

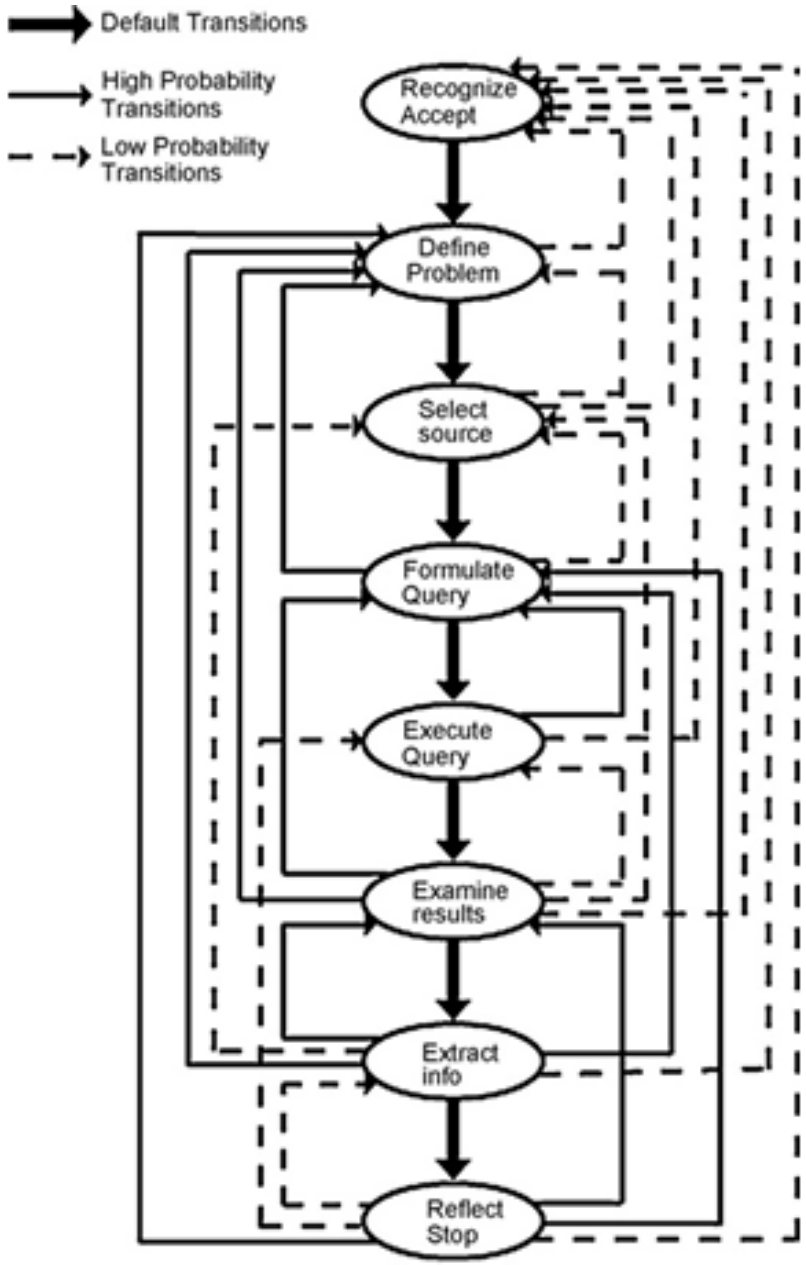


Fig. 1. The eight search steps of the search process according to Marchionini (1995).

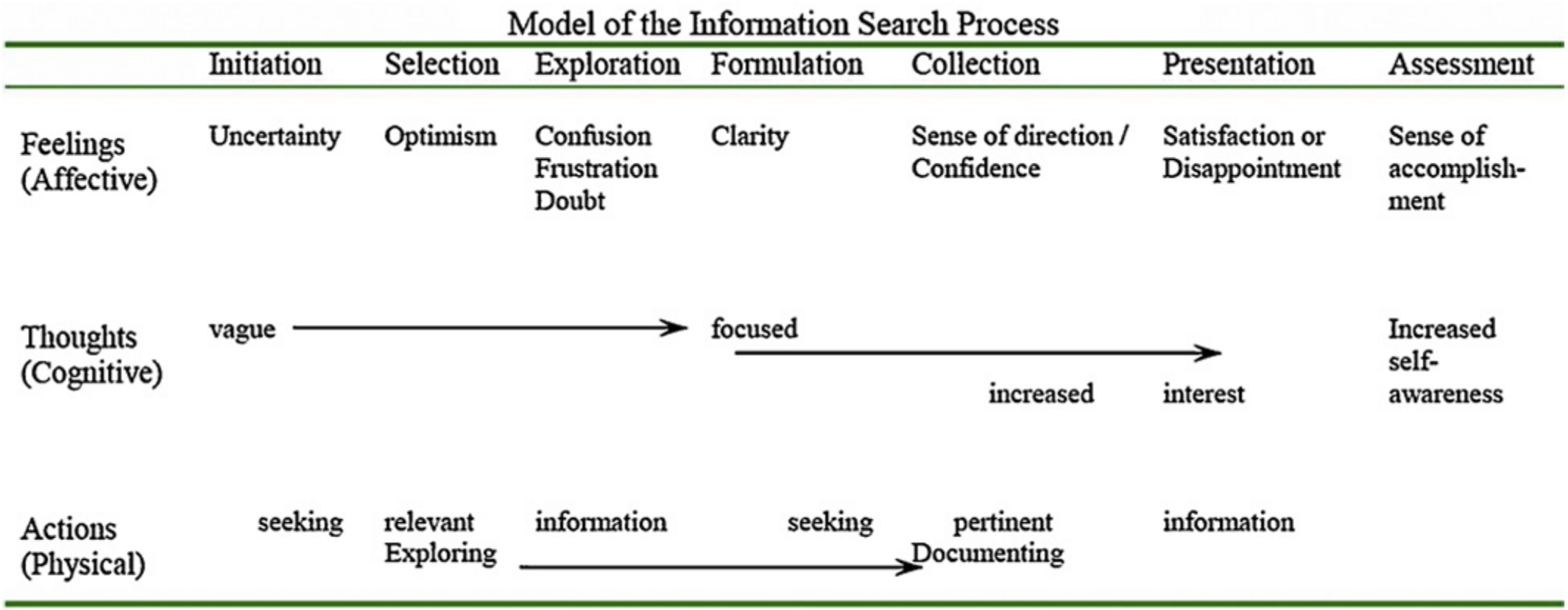


Fig. 2. The six stages model of Information Problem-Solving (IPS) according to Kuhlthau (2004).

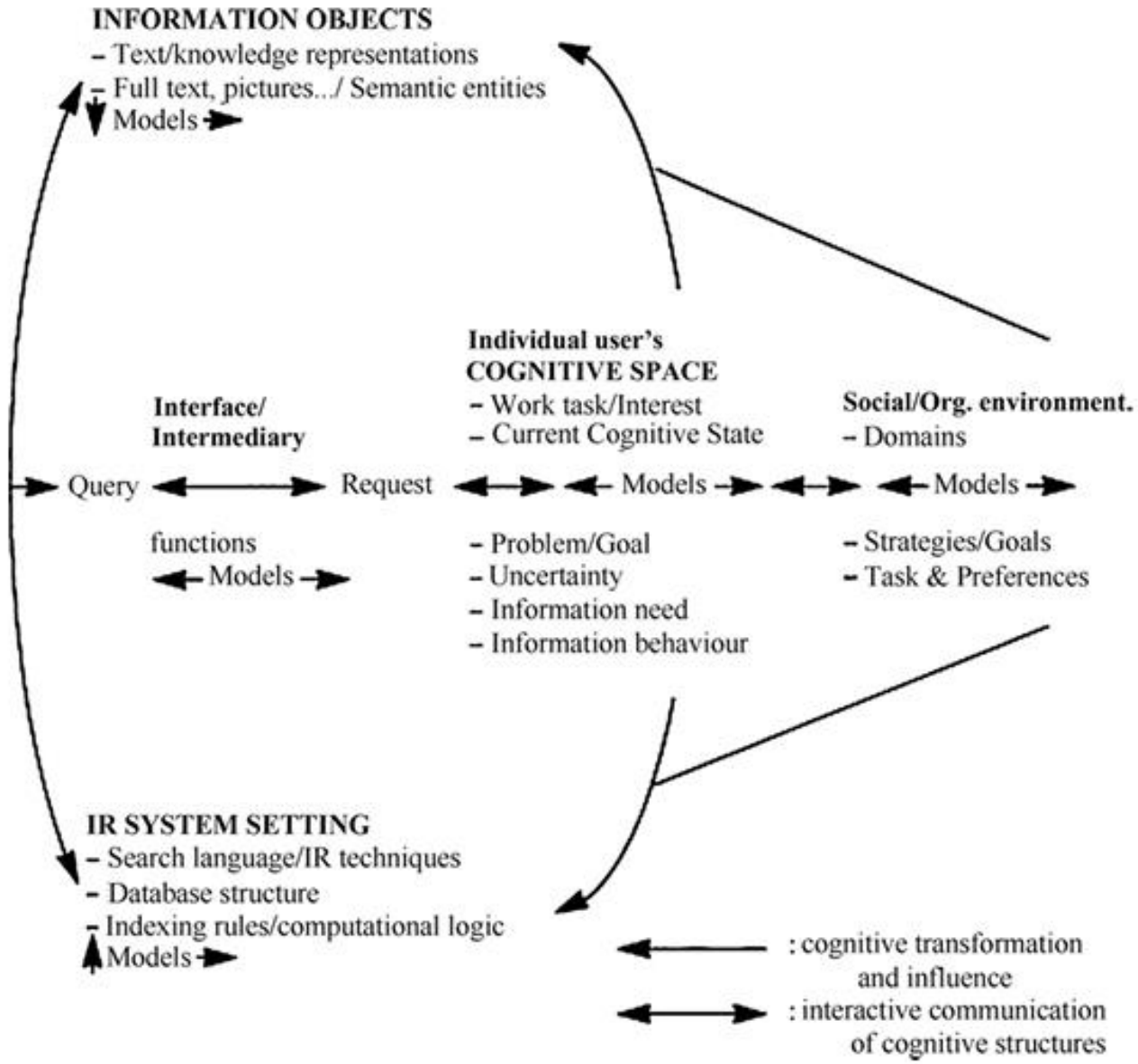


Fig. 3. Ingwersen's model of the information search process (Ingwersen, 1996).

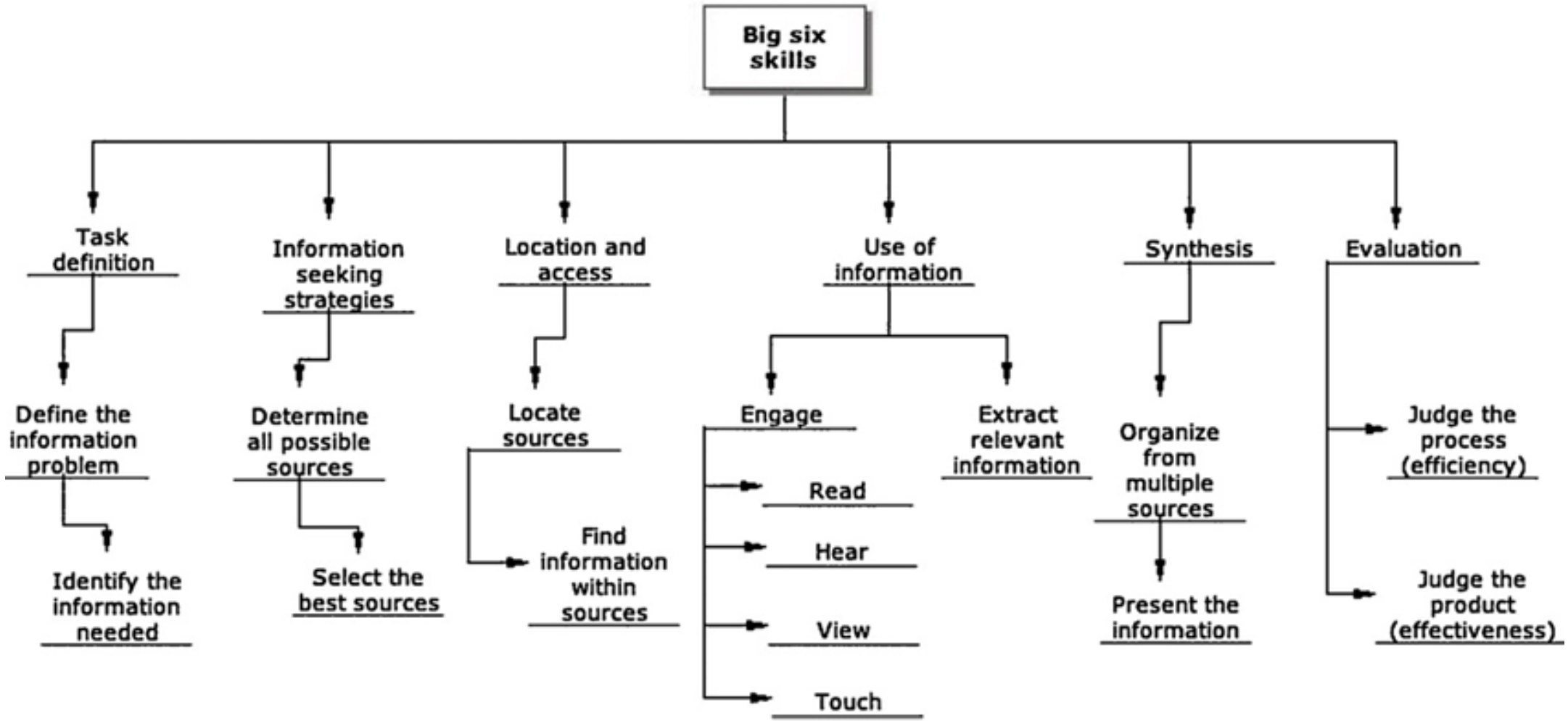
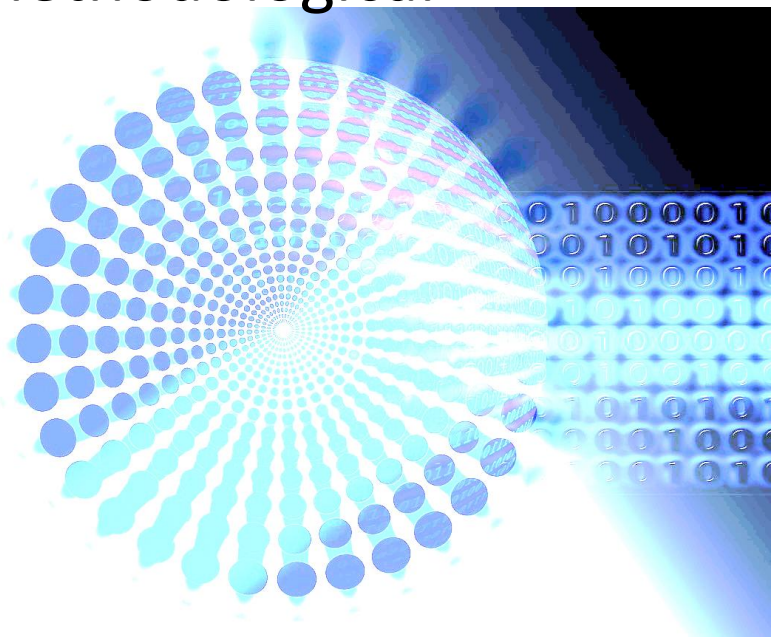


Fig. 6. The Big Six Skills and their relationships with information search activities according to Brand-Gruwel et al. (2005, 2009).

Multiple dimensions of Information Search Behaviour

- Human information behaviour and strategy cannot be fully described, or understood, without considering the cognitive, affective and social dimensions.
- Research in human information search behaviour should consider these multiple dimensions from a theoretical and methodological point of views.



Dinet, J., Chevalier, A., & Tricot, A. (2012). Information search activity: An overview. *European review of applied psychology*, *62*(2), 49-62.


ONLINE
MARKETING
S.E.O
Content
Lists
Links
Titles
Blogs
VDO
Sales

Web search and personalization

- Search history
- Location
- Browsing behavior
- Social signals

The Filter Bubble Effect

- Personalized content
- Content tailored to you
- Content selection and ranking

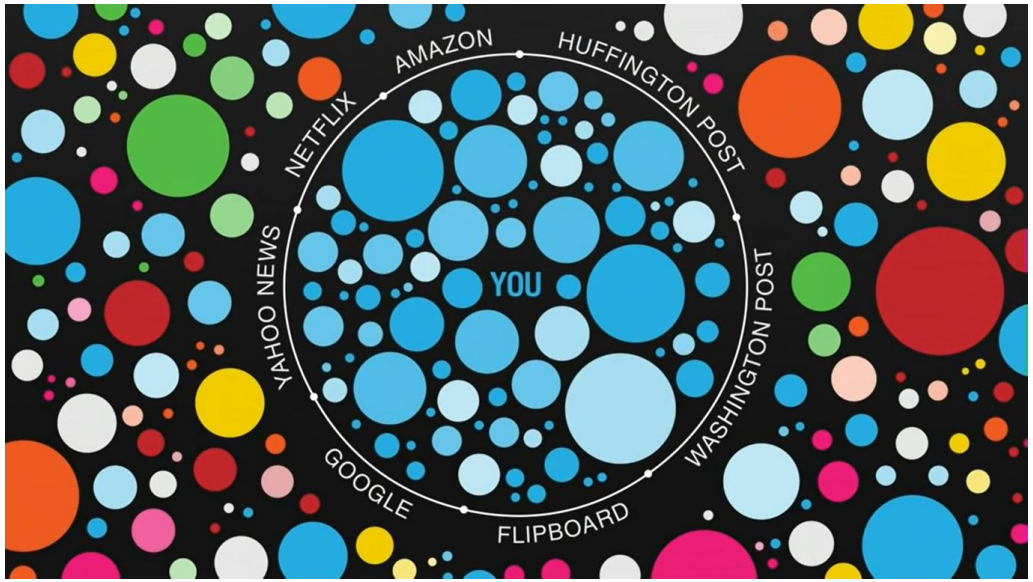


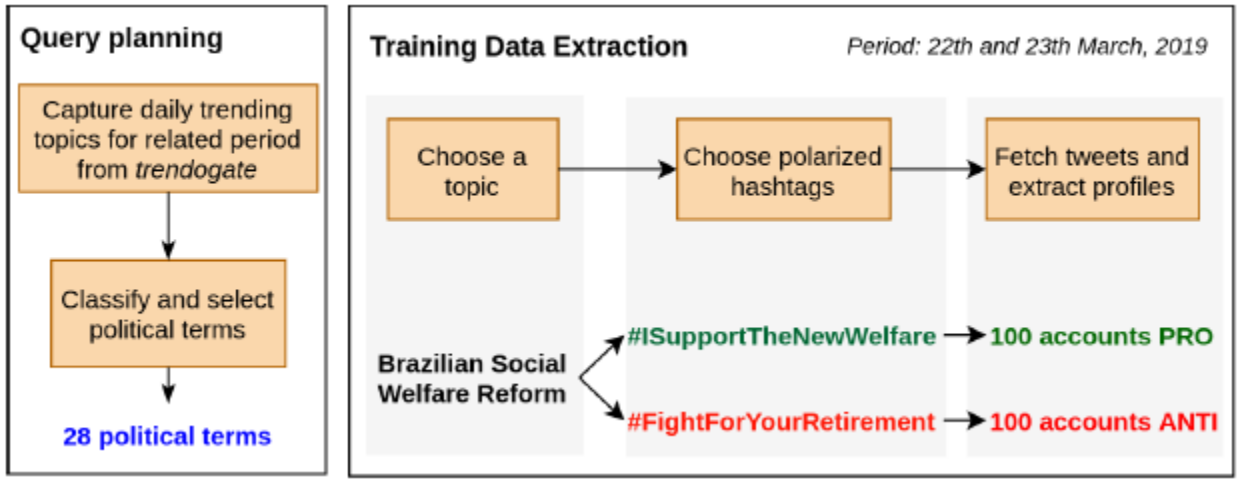
Image from YouTube –
Beware online “filter bubbles” | Eli Pariser
https://www.youtube.com/watch?v=B8ofWFx525s

The Echo Chamber Phenomenon

Confirmation bias in information search

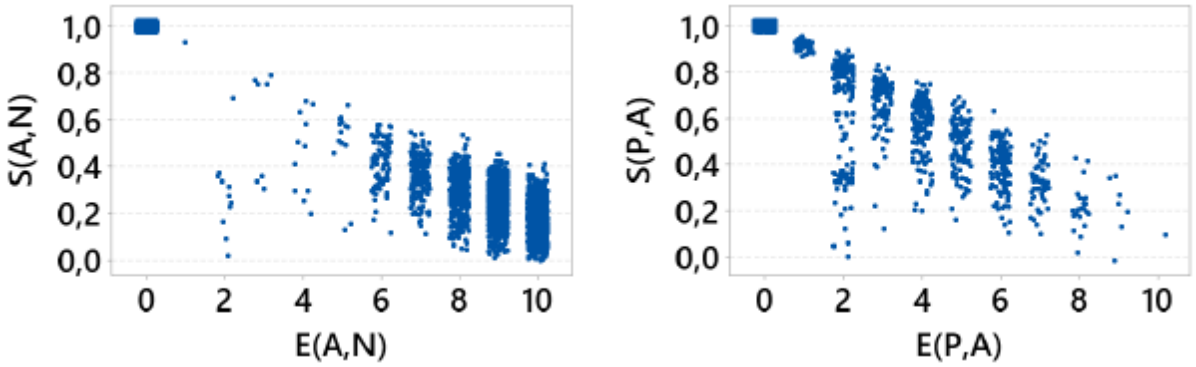
- We did indeed find that people were biased in favor of their position on a given issue when it comes to searching for information. This was true for all four selected topics, so our results constitute strong evidence of people adopting a confirmation strategy when looking for new information.
- We also found evidence for the biased interpretation of information, but only for the more polarizing topics.

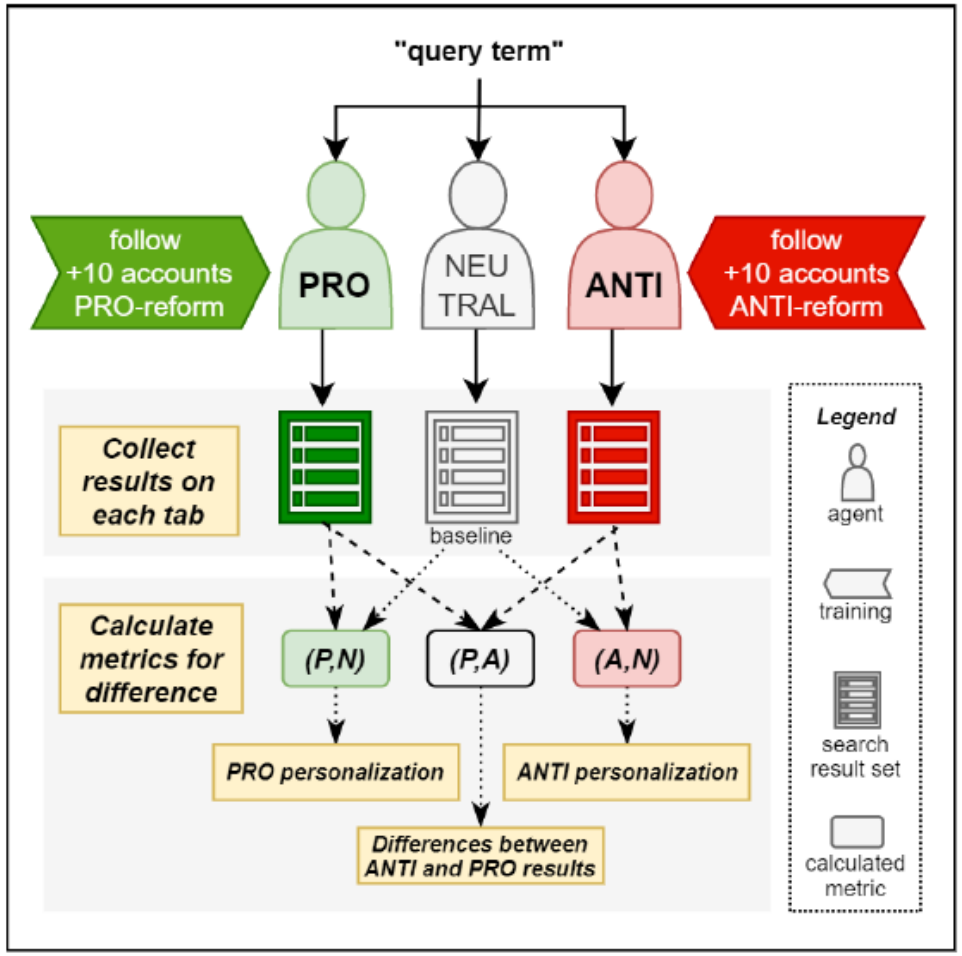
Vedejová, D., & Čavojová, V. (2022). Confirmation bias in information search, interpretation, and memory recall: Evidence from reasoning about four controversial topics. *Thinking & Reasoning*, *28*(1), 1-28.



$$s(u,v) = 1 - arccos\left(\frac{uv}{\|u\|\,\|v\|}\right) \quad (1)$$

$$S(A,B) = \frac{\sum_{j=1}^{n} s(A_i,B_i)}{n} \quad (2)$$





C. DOS SANTOS, JONATAS ; W. M. SIQUEIRA, SEAN ; PEREIRA NUNES, BERNARDO ; P. BALESTRASSI, PEDRO ; R. S. PEREIRA, FABRÍCIO . Is There Personalization in Twitter Search? A Study on polarized opinions about the Brazilian Welfare Reform. In: WebSci '20: 12th ACM Conference on Web Science, 2020. p. 267-276. http://dx.doi.org/10.1145/3394231.3397917

Personalisation of social media searches

- The key contributions presented in this paper are outlined as follows:
- (i) an open, extensible, and reproducible framework for controlling the noises and investigating the factors that affect personalisation in search results on various social media platforms.
- (ii) a comprehensive set of experiments that demonstrates the impact of the hypothesised factors on the personalised search results.
- (iii) a summary of guidelines to assist users in avoiding being trapped in filter bubbles and an appeal for social media platforms and policymakers to take responsibility for cultivating a healthier online information ecosystem.

YANG, C. ; XU, X. ; NUNES, B. P. ; SIQUEIRA, S. W. M. . Bubbles Bursting: Investigating and Measuring the Personalisation of Social Media Searches. TELEMATICS AND INFORMATICS, v. 82, p. 101999, 2023. http://dx.doi.org/10.1016/j.tele.2023.101999

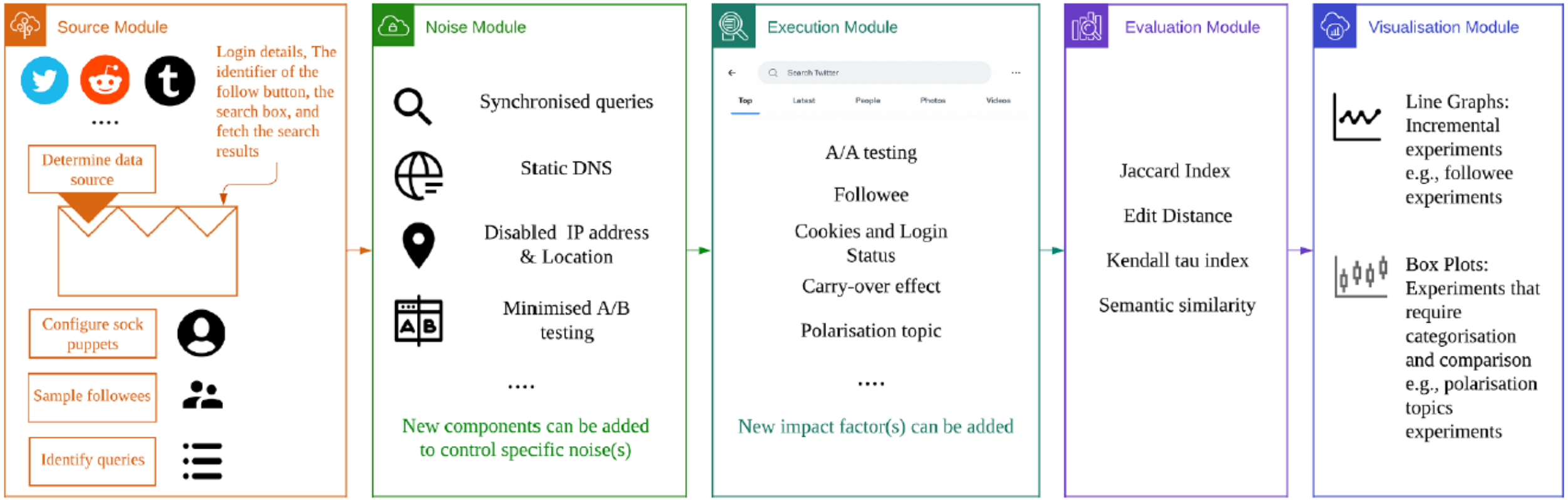


Fig. 1. The SNEEV Framework.

YANG, C. ; XU, X. ; NUNES, B. P. ; SIQUEIRA, S. W. M. . Bubbles Bursting: Investigating and Measuring the Personalisation of Social Media Searches. TELEMATICS AND INFORMATICS, v. 82, p. 101999, 2023. http://dx.doi.org/10.1016/j.tele.2023.101999

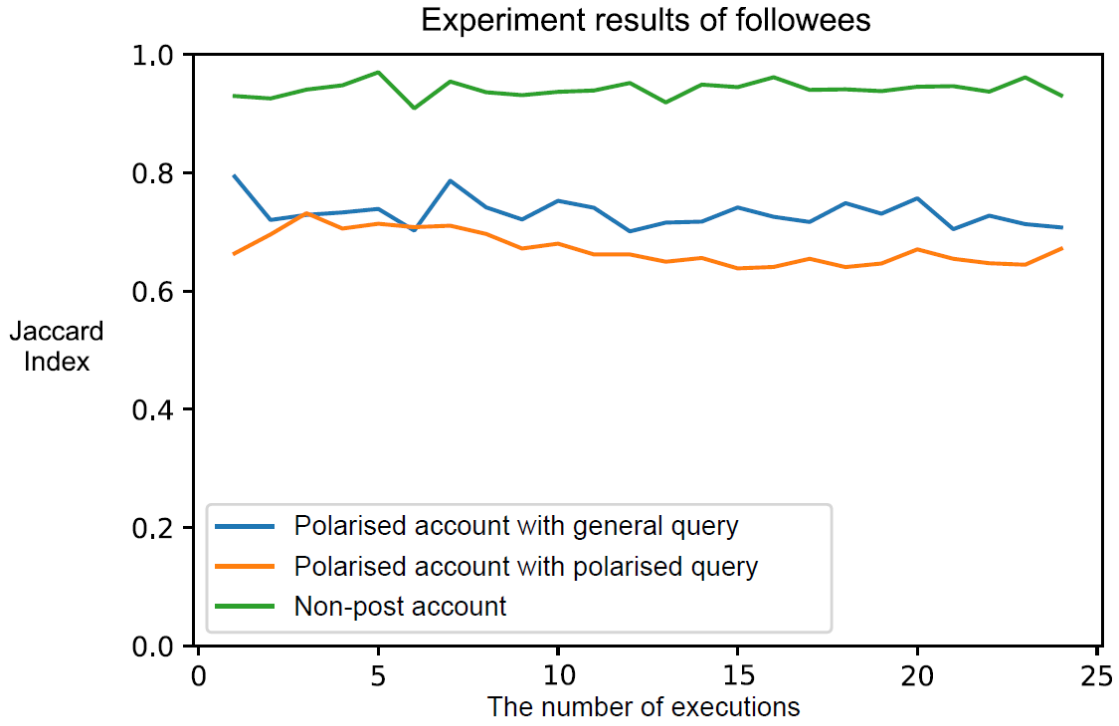
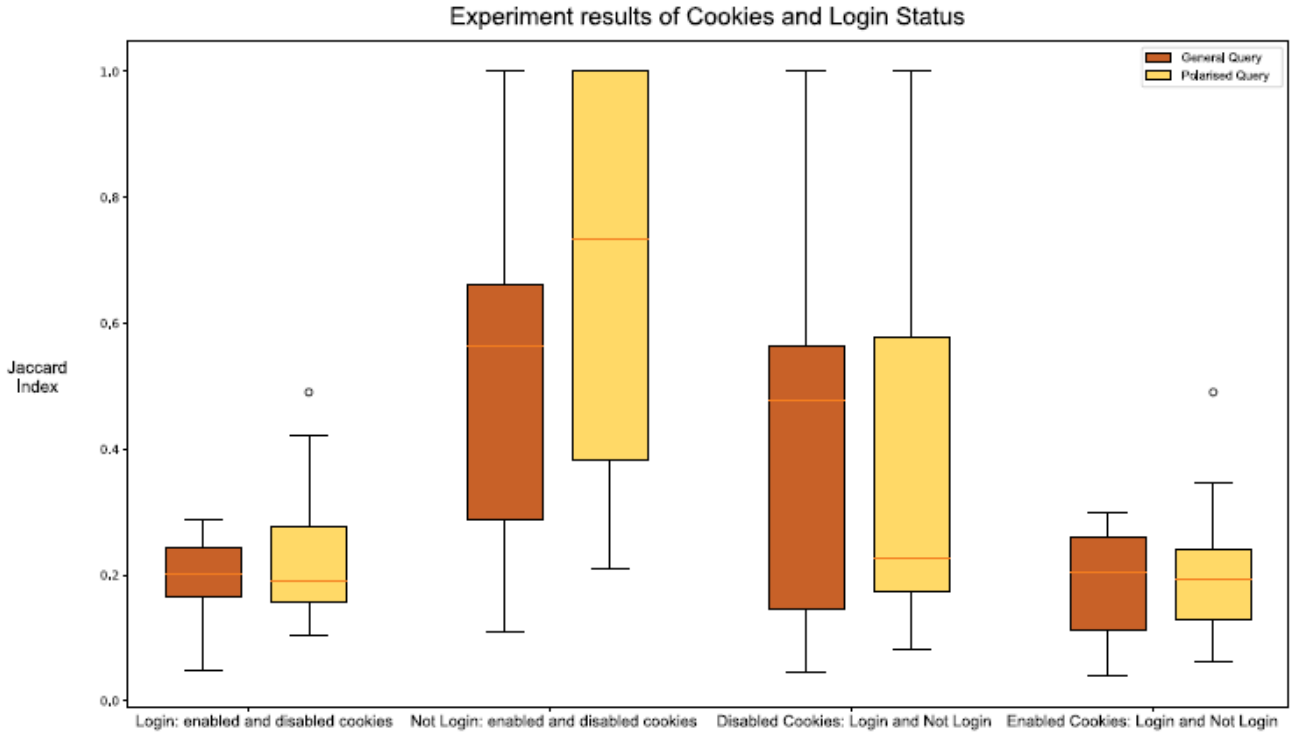


Fig. 7. Results for the Followees Experiments ($m = 25$ and $e = 10$).



YANG, C. ; XU, X. ; NUNES, B. P. ; SIQUEIRA, S. W. M. . Bubbles Bursting: Investigating and Measuring the Personalisation of Social Media Searches. TELEMATICS AND INFORMATICS, v. 82, p. 101999, 2023. http://dx.doi.org/10.1016/j.tele.2023.101999

The Filter Bubble Myth

- Initial findings indicate that, although search results were found to be contextualized to specific geographic locales, algorithmic personalization in search engines may be less extensive than was suggested by previous filter-bubble research. This leads to the question: If search is largely homogeneous, where is information polarization coming from?

Spina, D., Sanderson, M., Angus, D., Demartini, G., Mckay, D., Saling, L. L., & White, R. W. (2023). Human-AI Cooperation to Tackle Misinformation and Polarization. *Communications of the ACM*, *66*(7), 40-45.

Table 1. Classification of the 42 Online Platforms We Study

Category	Platforms
Dating	Bumble
Generic Forum	Quora, Reddit, Disqus, BG Mamma, Discord, Something Awful, Substack, Clubhouse
Specific forum-Gaming	Twitch, OverClocker UK
Specific forum-Finance	Invstr, Money Saving Expert, Finimize, Public, StockTwits, Bogleheads, Gastby, Motley Fool
Specific forum-Health	Mumsnet, Student Doctor Network, Patient, Doctissimo, Flo Health, Strava
Specific forum-Other	Fiveable, Airbnb, Blind, The Student Room, Shutterstock
Online Marketplace	Amazon, Depop, NTWRK, Rarible
Social Media	Facebook, YouTube, Twitter, Girl Tribe, TikTok
Mixed	Google, Spotify, Apple

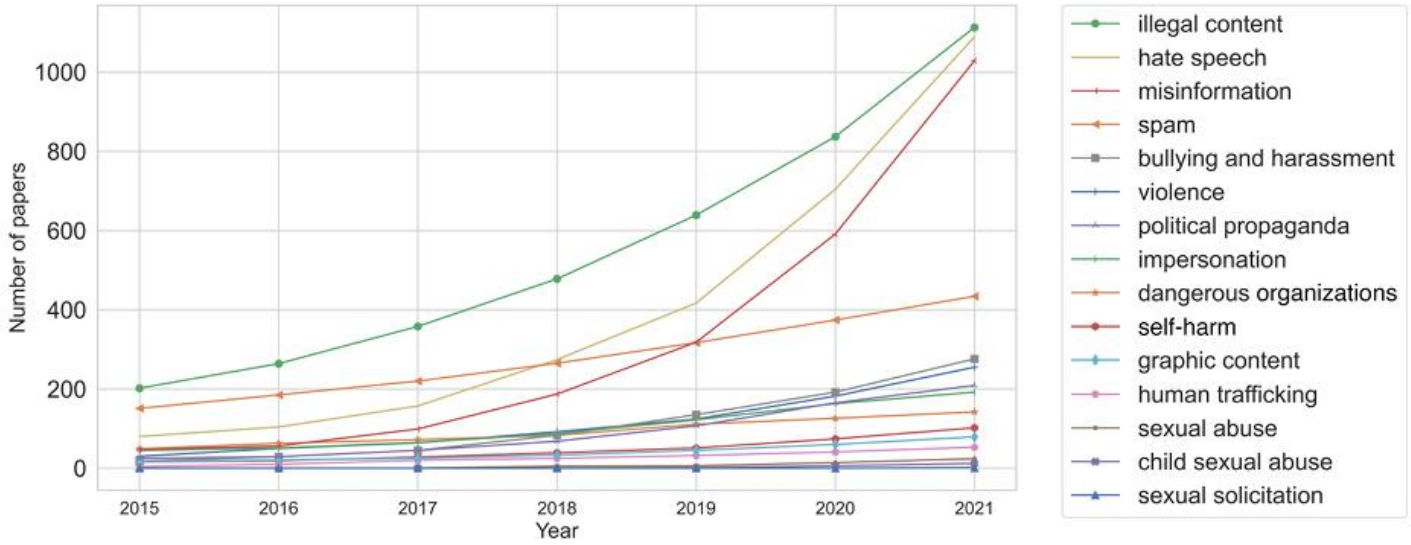


Fig. 3. Number of papers found in arXiv for the different topics over time.

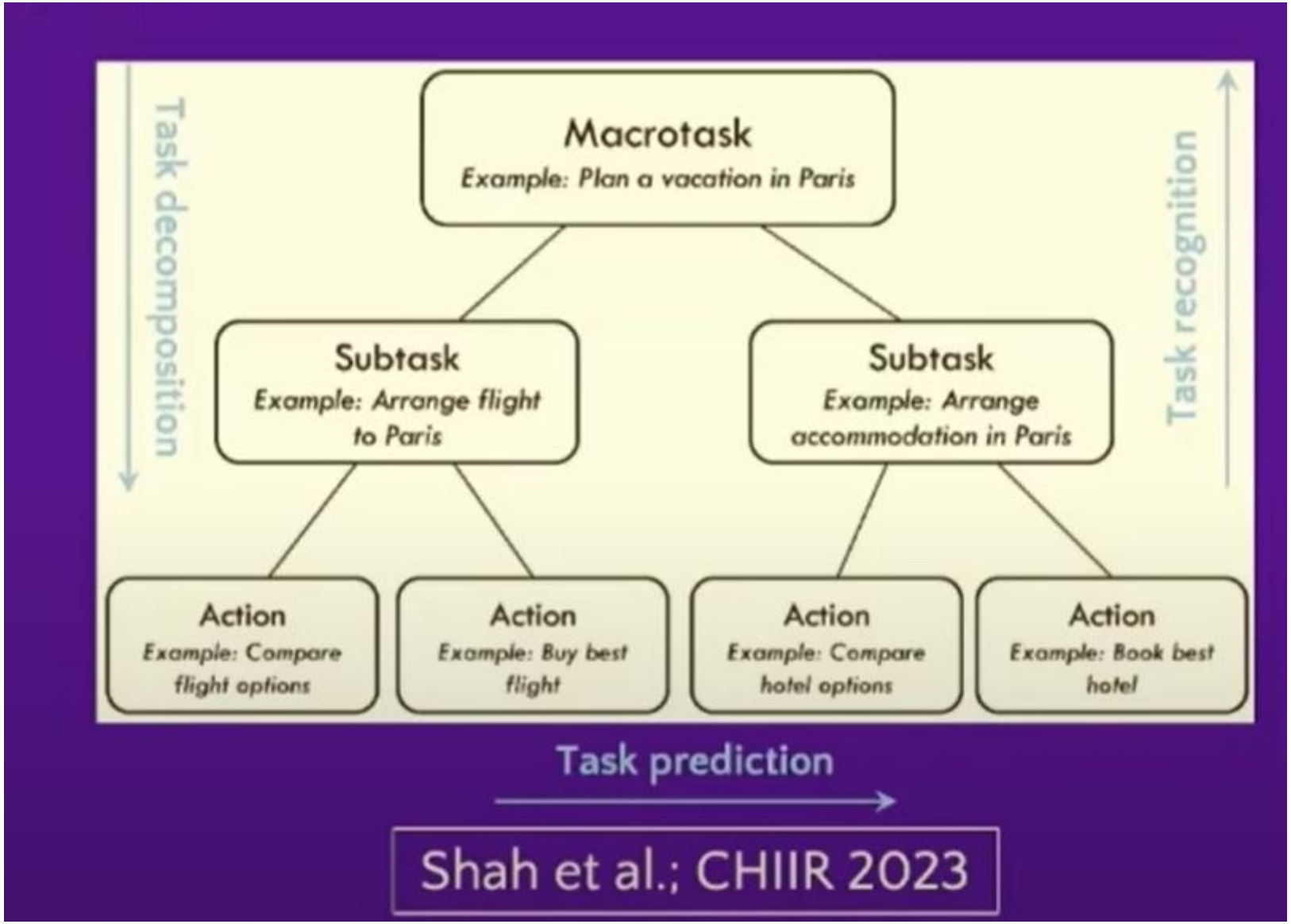
Table 2. Summary of the T&Cs of Big Tech

Policy Clause	Facebook‡	Twitter	Google	Apple	Amazon
Violence	✔	✔	✔	👁 Intimidating, Threatening	👁 Threatening
Dangerous organizations/people	✔	✔	Maps, Gmail, Meet*	? Illegal act	? Under illegal
Glorifying crime	✔	✔	Maps, Gmail, Meet*	? Illegal act	? Under illegal
Illegal goods	✔	✔	Maps, Google Chat and Hangout, Drive, Meet*	? Illegal act	? Under illegal
Self-harm	✔	✔	✔	✖	✖
		✔	✔	?	✖
		✔	✖	?	?
		? Sensitive media policy	Earth, Drive, Meet*	? Illegal act	? Under illegal
		✔	✔	? Illegal act	? Under illegal
		✔	✔	✔	👁 Threatening
		✔	✖	✖	? Obscene
		✔ Hateful conduct	✔	✔	👁 Threatening
		✔	Maps*	✖	?
		✔	Earth, Meet, Drive, Chat and Hangout*	✔	? Under obscene
		✖	Maps*	✖	✖
		✔	✔	✖	✔
		✔	Maps, Earth, Chat and Hangout, Gmail, Meet*	✔	✔
news		✔	Maps, Drive*	✔	✖
		COVID-19 specific	Drive*	✖	✖

n: ✔, explicitly mentioned in the policy; ✖, not mentioned in the policy; 👁, implicitly roadly mentioned in the policy under a more generic clause; *, mentioned in additional same policy applies to Instagram.

Arora, A., Nakov, P., Hardalov, M., Sarwar, S. M., Nayak, V., Dinkov, Y., ... & Augenstein, I. (2023). Detecting harmful content on online platforms: what platforms need vs. where research efforts go. *ACM Computing Surveys*, *56*(3), 1-17.

Beyond the Lookup Search



Shah et al., CHIIR 2023

	Non process oriented	Traditional IR study	L&I service user study	Typical user study with multiple channels
Non task oriented	Process oriented	Interaction with texts within a search session (between sessions)	Library use study	Citation study
	Non process oriented		Use of channels and document types for a *job*	
Task oriented	Process orientd	Interaction with texts within & between search sessions	Use of channels and document types for a *task* ---------- Use of documents to understand a problem	

* = as objects of study

Fig. 1. Types of information seeking and information retrieval studies.

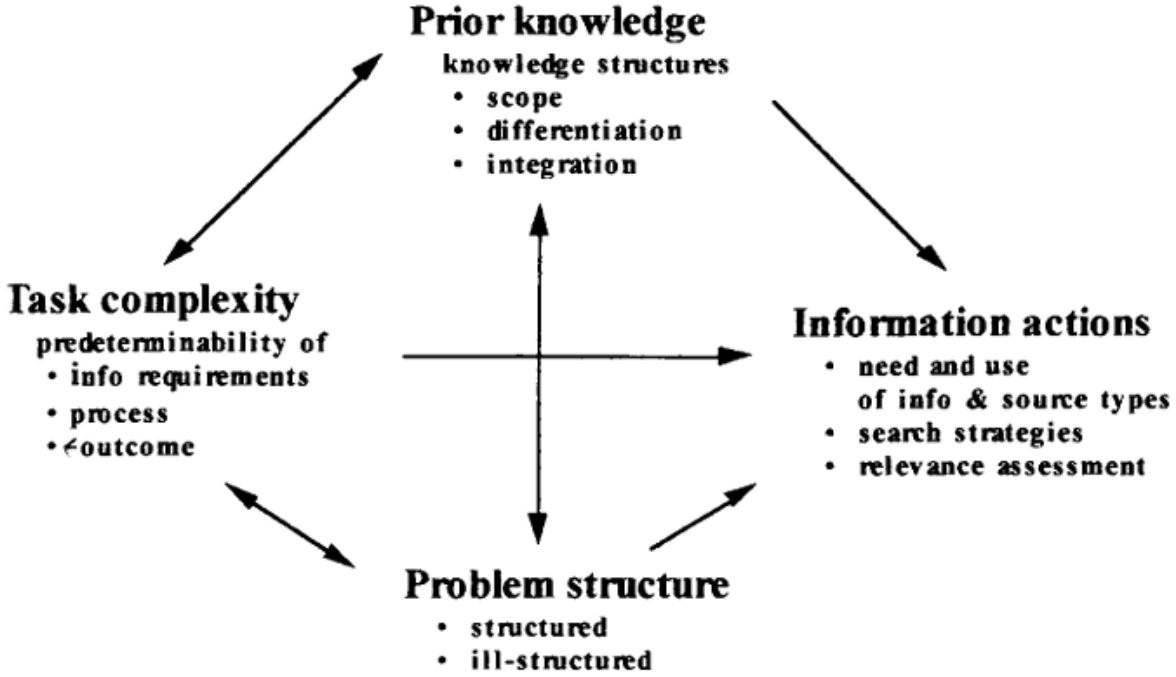


Fig. 3. Elements of a model on task complexity and information actions.

Structure of the problem

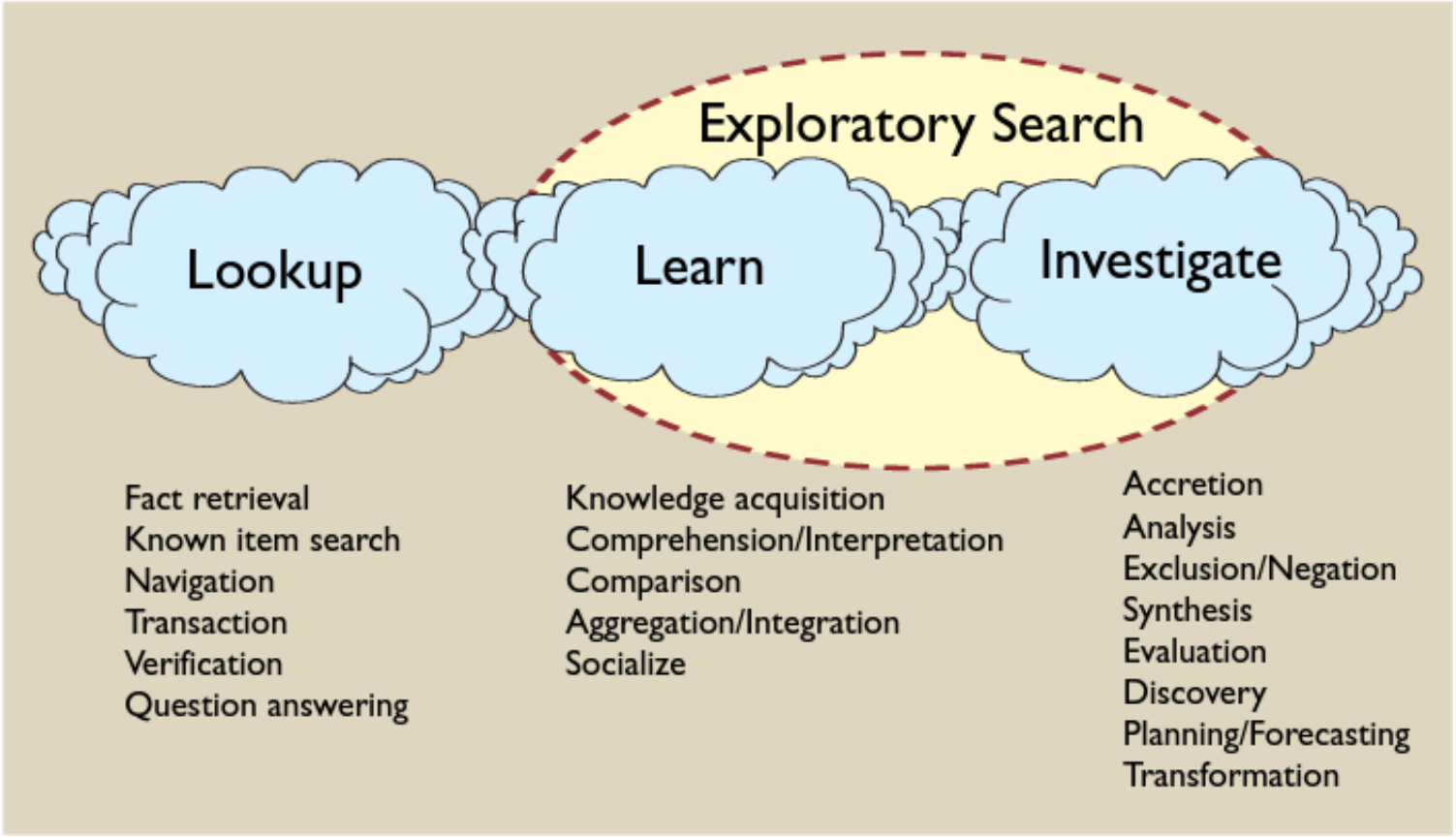
	Ill-structured	Structured
Search strategy	• *Browsing* • Scanning1 • Browsing2 • Learning1 • Recognition1 • Surveying-Chaining2 • Journal run3	• *Querying* • Selecting1 • Specification1 • Ending2

1) Belkin & all 1993; 2) Ellis & Haugan 1997; 3) Bates 1989

Fig. 4. Problem structure and search strategies.

Vakkari, P. (1999). Task complexity, problem structure and information actions: Integrating studies on information seeking and retrieval. *Information processing & management*, *35*(6), 819-837.

Types/categories of information search



[Marchionini, 2006]

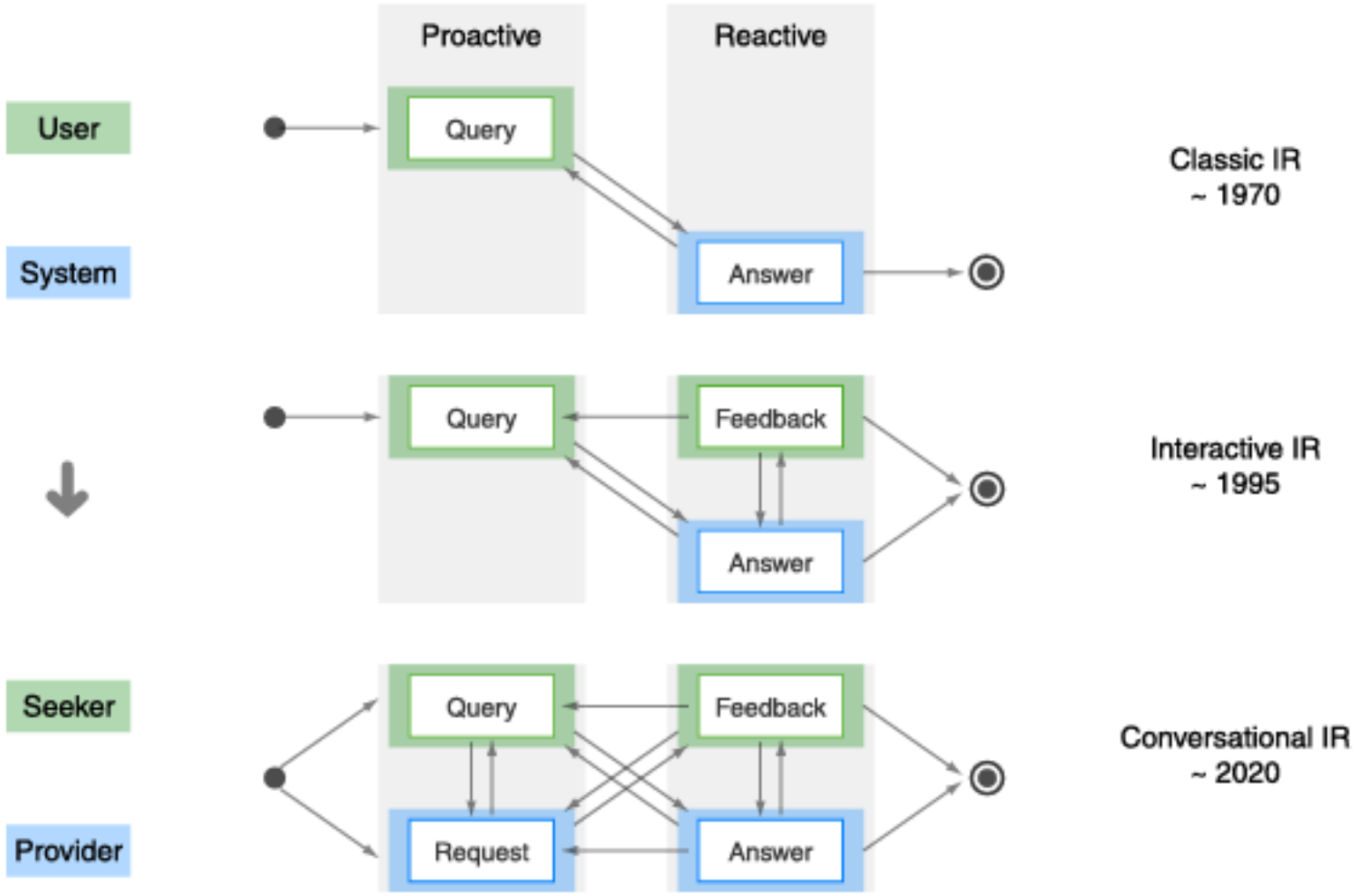
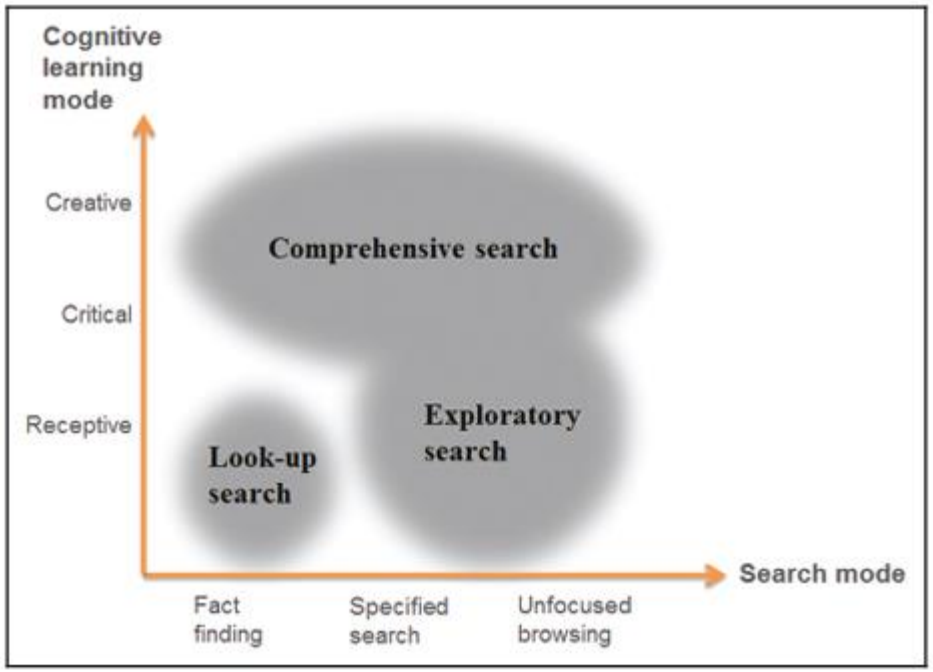


Fig. 1. Paradigm shifts in information retrieval illustrated through the QRFA-model [67] (bottom image). Where classic information retrieval focuses on answering a query (top), interactive information retrieval brings user feedback into the focus (middle), while conversational information retrieval allows a dynamic back-and-forth of actions between *equal partners* (say, seeker and provider [53]). The years are estimates, based on the volume of relevant scientific papers as per Semantic Scholar (https://www.semanticscholar.org/).

Kiesel, J., Meyer, L., Potthast, M., & Stein, B. (2021). Meta-information in conversational search. *ACM Transactions on Information Systems (TOIS)*, *39*(4), 1-44.



Rieh, Soo Young, Kevyn Collins-Thompson, Preben Hansen, and Hye-Jung Lee. "Towards searching as a learning process: A review of current perspectives and future directions." *Journal of Information Science* 42, no. 1 (2016): 19-34.

Cognitive learning mode	Bloom's cognitive learning taxonomy	Learning behaviour	Search behaviour
Receptive	remembering, understanding	recalling, presenting, identifying, matching, labelling, comprehending, demonstrating	known-item searching, specifying, modifying, obtaining, selecting, acquiring, judging relevance
Critical	applying, analysing, evaluating	separating, sorting, critiquing, distinguishing, contrasting, defending, attributing, probing, aggregating, integrating, synthesizing	evaluating usefulness, assessing credibility, comparing, extracting, differentiating
Creative	creating	hypothesizing, designing, discovering, planning, producing, generating, forecasting, inventing, composing, revising, building	prioritizing, sense-making

Column 1 from Lee et al. [49] and column 2 from Bloom and Krathwohl [50].

Systems thinking and Information

Searching as Learning

Table 1. Classification of the selected studies according to the variables involved in SAL processes.

Dimension	Variables	Papers
User Dimension	PK	(Lu and Hsiao, 2017), (Taibi et al., 2017), (Syed and Collins-Thompson, 2018), (Syed and Collins-Thompson, 2016), (Jansen et al., 2009), (Yu et al., 2018), (Al-Tawil et al., 2019), (Rieh et al., 2012), (Sendurur et al., 2019) (Tibau et al., 2018), (Azpiazu et al., 2017), (Karanam and van Oostendorp, 2016), (Wilson et al., 2016), (Crescenzi, 2016), (Mao et al., 2016), (Bhattacharya and Gwizdka, 2019), (Ibieta et al., 2019), (Biletskiy et al., 2009), (Pereira et al., 2019)
	DI	(Taibi et al., 2017), (Azpiazu et al., 2017), (Ibieta et al., 2019), (Yilmaz et al., 2019), (Biletskiy et al., 2009), (Lu and Hsiao, 2017), (Moraes et al., 2018)
Interaction Dimension	ESA	(Tibau et al., 2018), (Lu and Hsiao, 2017), (Moraes et al., 2018), (Ghosh et al., 2018), (Bhattacharya and Gwizdka, 2019), (Yu et al., 2018), (Ibieta et al., 2019), (Vakkari et al., 2019), (Biletskiy et al., 2009)
	AV	(Bhattacharya and Gwizdka, 2019), (Yu et al., 2018), (Rieh et al., 2012), (Karanam and van Oostendorp, 2016), (Ibieta et al., 2019), (Vakkari et al., 2019), (Wilson and Wilson, 2013), (Maxwell et al., 2019)
	SEF	(Azpiazu et al., 2017), (Syed and Collins-Thompson, 2016), (Weingart and Eickhoff, 2016), (Ibieta et al., 2019)
Knowledge Domain Dimension	KDR	(Taibi et al., 2017), (Al-Tawil et al., 2019), (Biletskiy et al., 2009), (Syed and Collins-Thompson, 2018), (Ibieta et al., 2019), (Ghosh et al., 2018), (Karanam and van Oostendorp, 2016), (Vakkari et al., 2019), (Tibau et al., 2019a), (Tolmachova et al., 2019)
	RCL	(Ghosh et al., 2018), (Syed and Collins-Thompson, 2018), (Syed and Collins-Thompson, 2016), (Smith and Rieh, 2019), (Yu et al., 2018), (Al-Tawil et al., 2019), (Pereira et al., 2019)
	RF	(Syed and Collins-Thompson, 2018), (Biletskiy et al., 2009), (Moraes et al., 2018), (Taibi et al., 2017), (Ghosh et al., 2018), (Weingart and Eickhoff, 2016), (Vakkari et al., 2019), (Wilson and Wilson, 2013), (Shi et al., 2019), (Fails et al., 2019)

Machado, M.D.O.C., Gimenez, P.J.A. and Siqueira, S.W.M., 2020, November. Raising the dimensions and variables for searching as a learning process: a systematic mapping of the literature. In *Anais do XXXI Simpósio Brasileiro de Informática na Educação* (pp. 1393-1402). SBC. http://dx.doi.org/10.5753/cbie.sbie.2020.1393

- PK: User Prior Knowledge
- DI: Demographic Information
- ESA: Exploratory Search Activities
- AV: Activities Variables
- SEF: Search Engine Feedback
- KDR: Knowledge Domain Representation
- RCL: Resource Cognitive Level
- RF: Resource Features

Features related to complexity

Method: Knowledge Graph – DBpedia
Textual Corpus – Wikipedia article

Feature-based categorization

Graph-based features

- Number of elements
- Novelty
- Diversity/variety
- Uncertainty
- Ambiguity
- ...

Information variety

Step I: We created a Wikipedia Category Graph

Step II: We extracted concepts from Wikipedia articles (https://en.wikipedia.org/wiki/Apartheid)

Step III – For each concept in a Wikipedia article, we obtained the shortest paths between the article categories and the top categories of the graph

Step IV: A document representation of the categorization of concepts is generated

Calculation of the coefficient of variation

Uncertainty

Step I: Extraction of concepts – Wikipedia article

Step II: Extraction of concepts categories

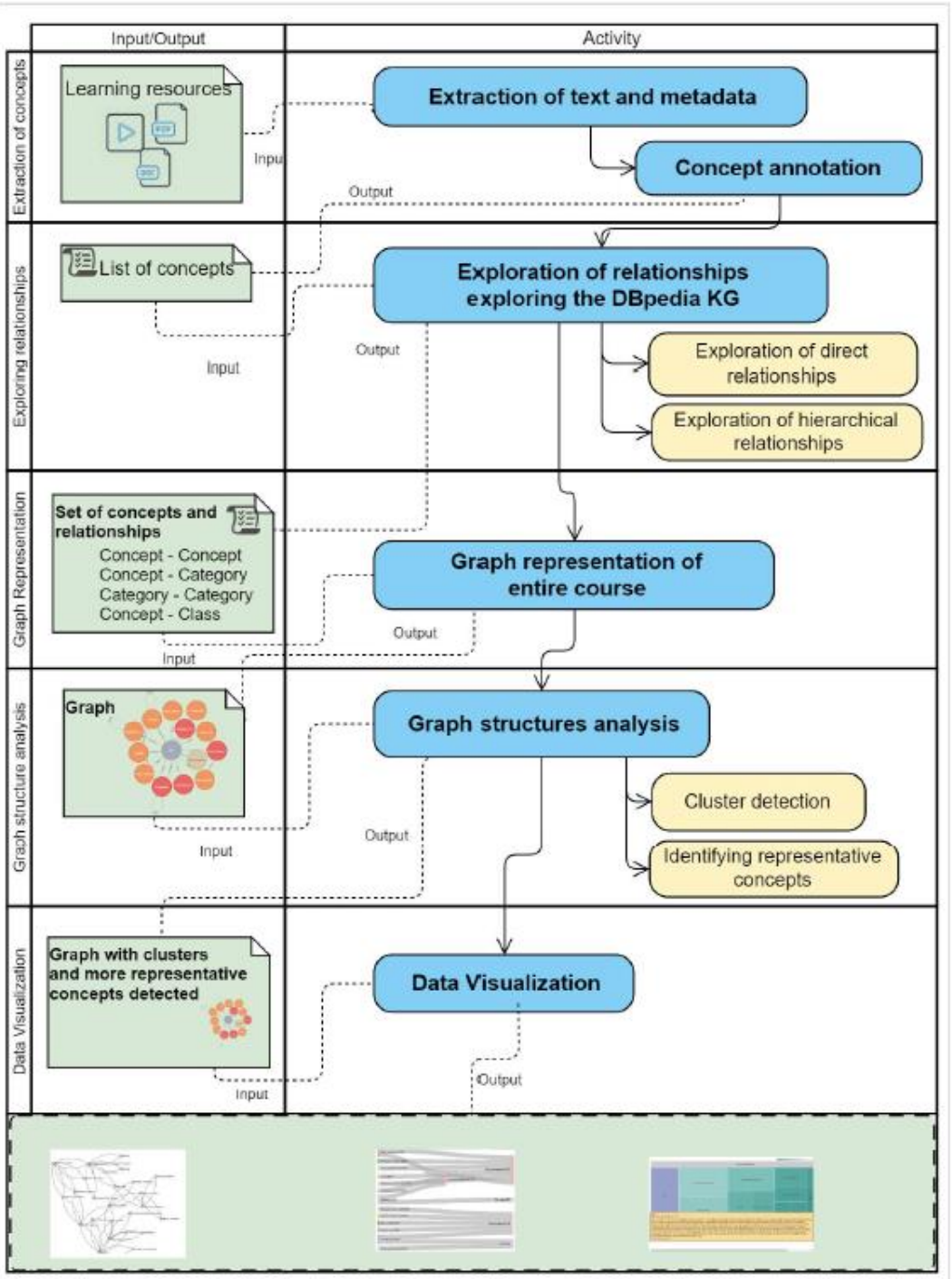
Step III: Grouping of concepts by category

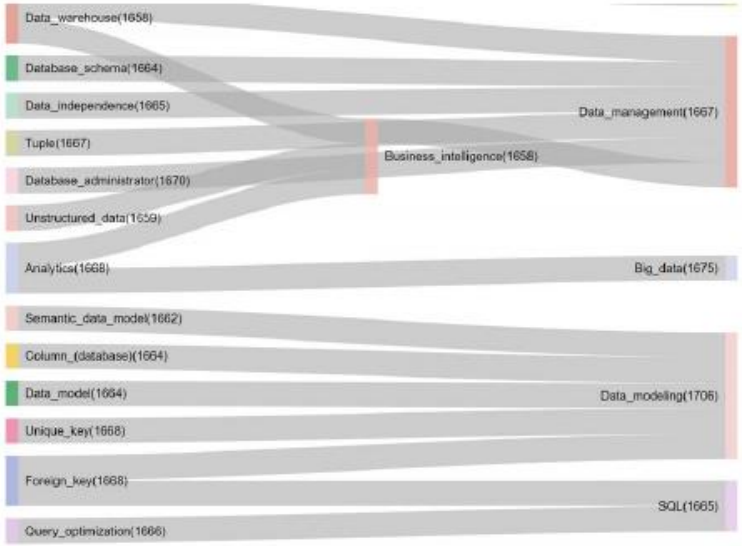
Step IV: Calculation of Shannon Index

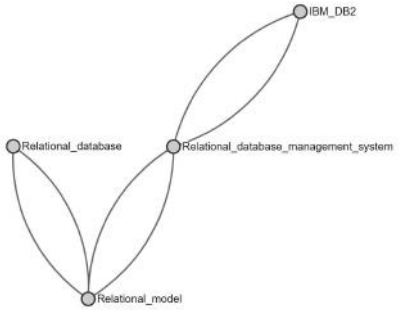
Graph-based Features

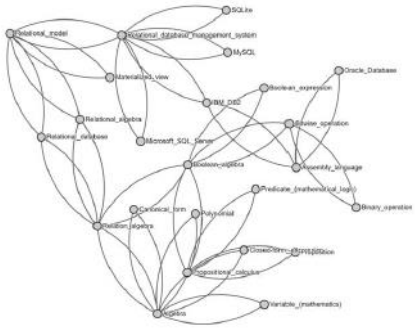
- LinkPage
- Direct Links
- OneIntermediateLink
- Triples Incoming
- Triples outgoing
- Path Length One
- Path Length Two
- The number of vocabularies in A (or B)
- The number of triples in A (or B)
- The number of domains in A (or B)

Pereira, C.K., Medeiros, J.F., Siqueira, S.W. and Nunes, B.P., 2019, July. How complex is the complexity of a concept in exploratory search. In *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT).* pp. 17-21. http://dx.doi.org/10.1109/ICALT.2019.00008









PEREIRA, CRYSTIAM KELLE ; NUNES, BERNARDO PEREIRA ; SIQUEIRA, SEAN W. M. ; MANRIQUE, RUBEN ; MEDEIROS, JERRY FERNES . `A Little Knowledge is a Dangerous Thing?: A method to automatically detect knowledge compartmentalization and oversimplification. In: 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), 2020. p. 140-144. http://dx.doi.org/10.1109/ICALT49669.2020.00048

ESKiP Taxonomy of Query States

	Query State	Definition
★	Initial State (IS)	Qi contains a set of terms representing the start of a search.
★	Return State (RS)	Qi contains at least one term and represents the start of a search or a previous search query; Qi+n contains exactly the same term of Qi.
	Generalization (GE)	Qi and Qi+1 contain at least one term in common; Qi+1 contains fewer terms than Qi.
	Specialization (SC)	
	Repeat (RP)	
	Word Substitution (WS)	
	New (NW)	
★	Related (RE)	

Query State	Overall Frequency Learn Web dataset	Overall Frequ Yahoo! datase
Initial State (IS)	24.61%	32.09%
Return State (RS)	1.24%	0.23%
Generalization (GE)	2.63%	3.46%
Specialization (SC)	6.19%	12.31%
Repeat (RP)	43.03%	3.00%
Word Substitution (WS)	2.63%	20.09%
New (NW)	12.85%	20.93%
Related (RE)	6.81%	7.90%

Domain	Description	Strategies
Behavioral Domain	Concerned with basic skills required for manipulating and searching the Web.	– **Control:** skills required for manipulating Web searching applications – **Disorientation:** learner's self-awareness about their searching orientation
Procedural Domain	Concerned with content-general searching approaches and overcoming problems that occur during the searching process	– **Trial and error:** skills in trying different searching approaches – **Problem-solving:** skills and commitment to overcome problems or frustrations resulting from searching
Metacognitive Domain	Concerned with monitoring the searching process, identifying key information, as well as interpreting and evaluating the information retrieved	– **Purposeful thinking:** skills required to self-monitoring the searching process – **Selection of the main ideas:** skills to identify key information concepts from the retrieved batch – **Evaluation:** skills to judge and organize the retrieved information

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Highlights

••It is important to understand the searching process of finding and deciding information's usefulness.

••**Think-aloud protocol** and observation were used to identify learning indicators in Web searching.

••**Learning indicators can aid at the understanding of how users gain knowledge online**.

••Knowledge is gained online when information is added by users that determine the retrieved information's usefulness.

••**Information added may be used as a learning attribute in Web searching**.

Table 4
Online information searching strategies' indicators.

Behavioral (Behav)
Control
C1: Using the most familiar or known search engine in the first place.
C2: Searching by typing the name of the search engine on the browser.
C3: Entering the name of the website on the search engine.
C4: Entering the name of the website on the address bar.
C5: Using the "home" button to return to the beginning of the search.
C6: Using the "next" and "previous" buttons of the browser.
C7: Using Boolean logic operators for narrowing/widening the search parameters.
C8: Doing a customized search with the help of the images, videos, maps, and other similar features of the search engine.
C9: Utilizing the advanced search options of images, videos, maps, and other similar features of the search engine.
C10: Utilizing the advanced search options of the search engine.
Disorientation
D1: Giving up in the case of failure to find an answer.
D2: Using search terms that are not given in the search task.
D3: Not having any idea about what to do when doing an Internet search.
D4: Feeling bad in the case of failure to retrieve the desired information.
Procedural (Proced)
Trial and Error
TE1: Modifying the keywords.
TE2: Using different search engines.
TE3: Opening different websites.
Problem-Solving
PS1: Doing one's best to resolve any problem that occurs during a search.
PS2: Trying to find out the possible reasons for any problem that occurs during a search.
Metacognitive (Metacog)
Purposeful Thinking
PT1: Narrowing down the searching field (subject).
PT2: Accessing additional websites from a main website.
PT3: Simultaneous information searching from different sources.
PT4: Doing in-site search.
Select Main Ideas
SMI1: Directly opening a website that is known to be relevant to a given search task.
SMI2: Typing specific terms about the search task.

Other Works

Facets of Fairness in Search and Recommendation

- Dimensions
  - Relevance
  - Diversity
  - Novelty
- Fairness Metrics
  - Non-personalized recommendation settings
    - Accuracy-based fairness metrics
    - Error based fairness metrics
    - Causal approach for mitigating discrimination
  - Crowd-sourced non-personalized recommendation settings
  - Personalized recommendation settings
  - Advertisement settings
  - Marketplace settings

Verma, S., Gao, R., & Shah, C. (2020). Facets of fairness in search and recommendation. In *Bias and Social Aspects in Search and Recommendation: First International Workshop, BIAS 2020, Lisbon, Portugal, April 14, Proceedings 1* (pp. 1-11). Springer International Publishing.

Information by Systems Thinkers

difference that makes a difference

a measure of [the] degree of organization

The piece of chalk can never enter into communication or mental process because of this infinitude

our understanding of the world is partial, that we take only from the world that information which we need at the time

reality, or at least all the ways human beings can approach it, is constructed through human perceptions, sense-making and interaction

there is no independent reality

there are, in fact, many different versions of reality

to bring to bear radically different views of the world derived from alternative paradigms

we always mean to refer to the *perceived* situation or circumstances *as appreciated through a reference system* of underpinning boundary judgments

The purpose now is to find changes which are both arguably *desirable* (given those models) but also culturally *feasible* for these people in this particular situation with its particular history, culture and politics

Research Agenda

- Raising the different agents/actants and presenting its agency, the influences on one another…
  - Who is pro/against, the arguments, the reasons, the (cultural, economical, political, social) factors that influence such positions
- Structured diversity
- Curated sources (not only who, but the ethical principles, the truth)
- Transparency
- Explainability
- FAIRness
- Accountability

- And considering the new technologies, such as quantum computing, large language models, metaverse, neuro information systems and so on

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BACK TO THE DIFFERENCES: Rethinking Information Search (and Recommendation) on the Web

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