Perceived Limits in Information Retrieval

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Outline

① Meanings of Bias

② Fighting Cognitive Biases with IR

③ Related Research @ Webis

Meanings of Bias

“Bias” has Acquired a Derogatory Definition

> *A leaning of the mind; inclination; prepossession; propensity towards an object, not leaving the mind indifferent; as, education gives a bias to the mind.* [Webster’s Dictionary 1913: bias]

> *An inclination of temperament or outlook especially; a personal and sometimes unreasoned judgment; prejudice* [Merriam-Webster 2022: bias]

Synonyms [Merriam-Webster 2022] :

Bias, Nonobjectivity, Prejudice, One-Sidedness, Tendentiousness

Synonyms [e.g. Kahneman et al. 1982, Gigerenzer et al. 2000, Roberts 2022] :

Heuristic, Rule-of thumb, Cognitive Bias

Meanings of Bias

Bias: Two Camps of Interpretation

Based on the following (and other) authorities . . .

- H. Simon (1955). A behavioral model of rational choice.
- A. Tversky, D. Kahneman (1974). Judgment under uncertainty: Heuristics and biases.
- D. Kahneman, P. Slovic, A. Tversky (1982). Judgment under uncertainty: Heuristics and biases.
- G. Gigerenzer, P. Todd, ABC Research Group (2000). Simple heuristics that make us smart.
- G. Gigerenzer, R. Hertwig, T. Pachur (2011). Heuristics: The foundation of adaptive behavior.

. . . Cleotilde Gonzalez defines:

> ***Heuristics are the "shortcuts"*** *that humans use to reduce task complexity in judgment and choice, and* ***biases are the resulting gaps*** *between normative behavior and the heuristically determined behavior.*
>
> [Oxford Handbooks Online 2017]

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$\rightsquigarrow$ When talking about bias,

(a) distinguish between the procedure or algorithm and its effect or impact,

(b) think twice before implying a negative, neutral, or positive assessment.

Meanings of Bias

Bias: A Neutral Interpretation

Heuristic:[1]

A procedure, algorithm, calculus, which is not complete or not sound.

Systematic error, Bias:

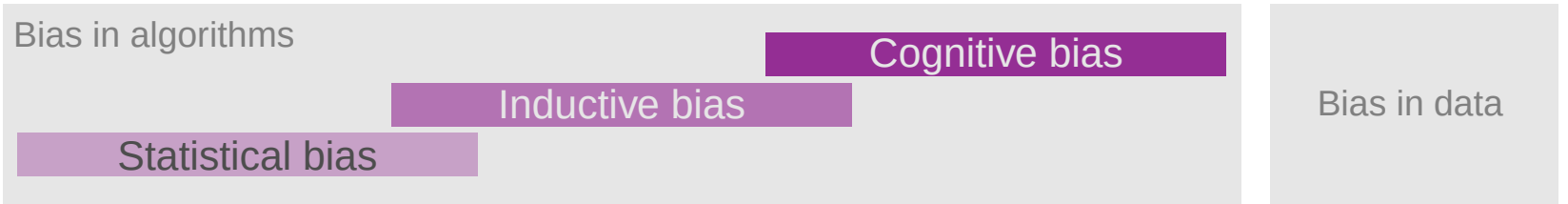
The incurred consequences for not being complete or sound.

[1] Various authors use the term “cognitive bias” for a heuristic that is applied by humans to judge.

https://www.towergateinsurance.co.uk/liability-insurance/hindsight-biases (2016)

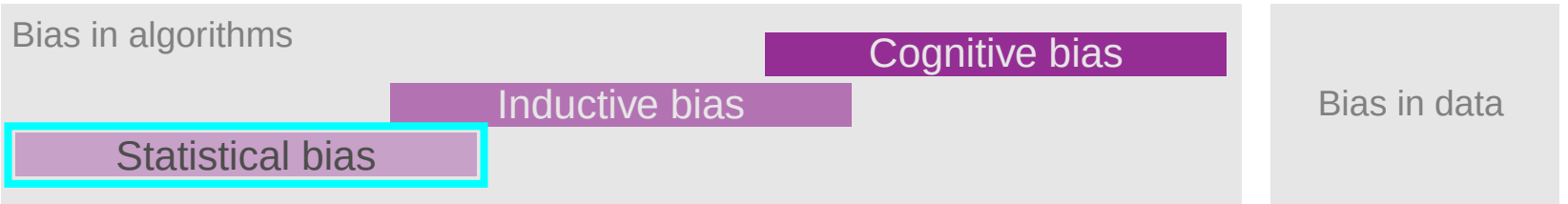
Meanings of Bias

Connections to Statistics



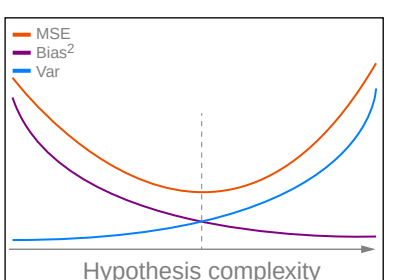
Meanings of Bias

Connections to Statistics



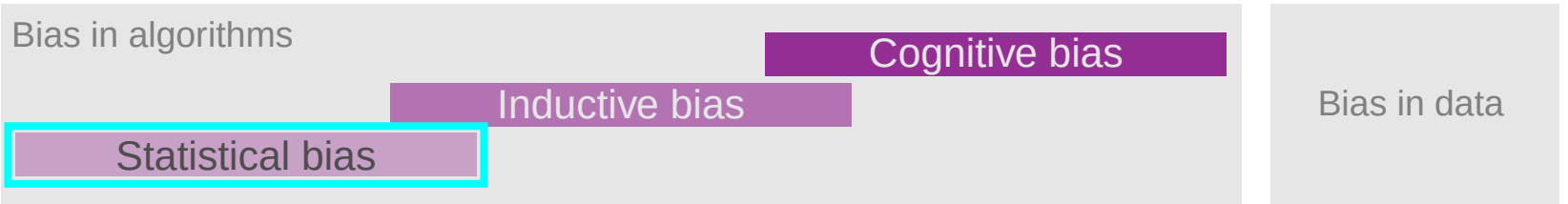
Trade unbiasedness for error reduction when learning from a sample.

E.g., bias-variance decomposition for squared error: $\text{MSE} = \text{Bias}(\hat{f})^2 + \text{Var}(\hat{f}) + \sigma^2$



Meanings of Bias

Connections to Statistics



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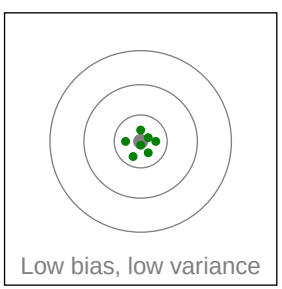
E.g., bias-variance decomposition for squared error: $\text{MSE} = \text{Bias}(\hat{f})^2 + \text{Var}(\hat{f}) + \sigma^2$

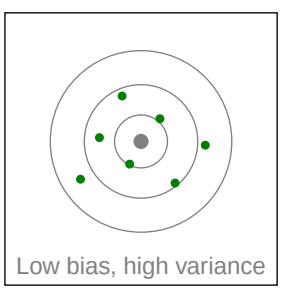
Compare to bias definition of C. Gonzales (2017):

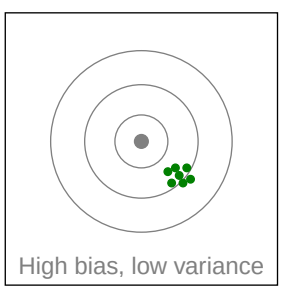
Reduce task complexity by analyzing small samples.

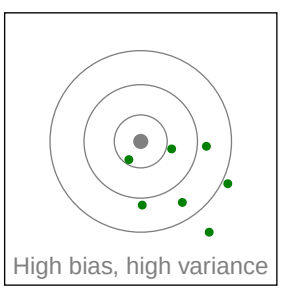
Applying heuristics entail bias but reduce risk of poorly representing unseen data.

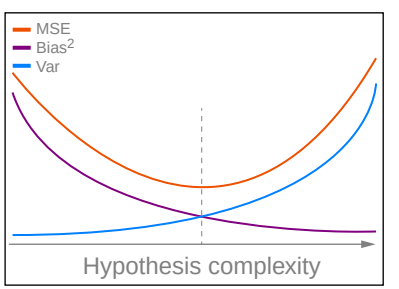
Gigerenzer et al. (2009). Homo heuristicus: Why biased minds make better inferences.





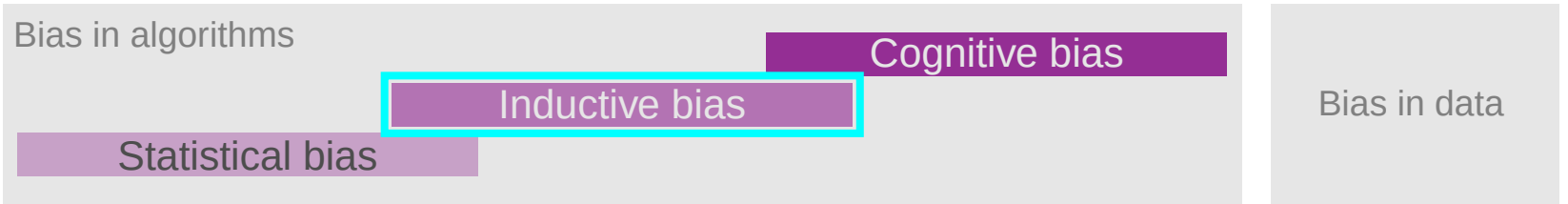






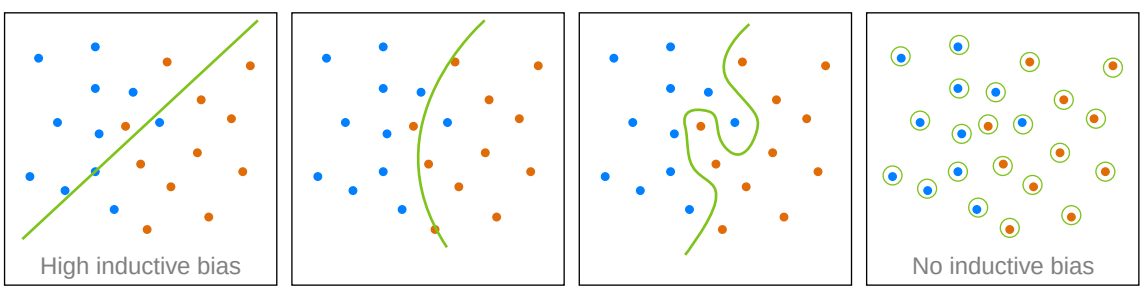
Meanings of Bias

Connections to Statistics (continued)



Set of assumptions used to perform induction (predict outputs for unseen inputs).

E.g., preference rules for hypotheses spaces, model parameters, data exploitation.



"Learning without bias is futile."

- T. Mitchell (1980)
- C. Schaffer (1997)
- Dembski et al. (2009)
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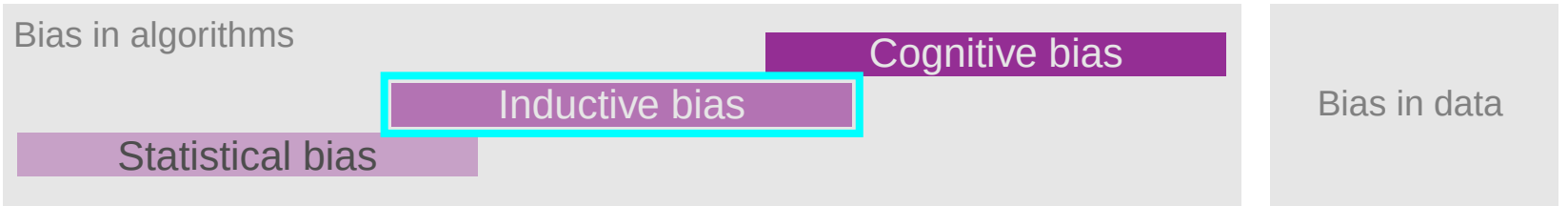
Meanings of Bias

Connections to Statistics (continued)

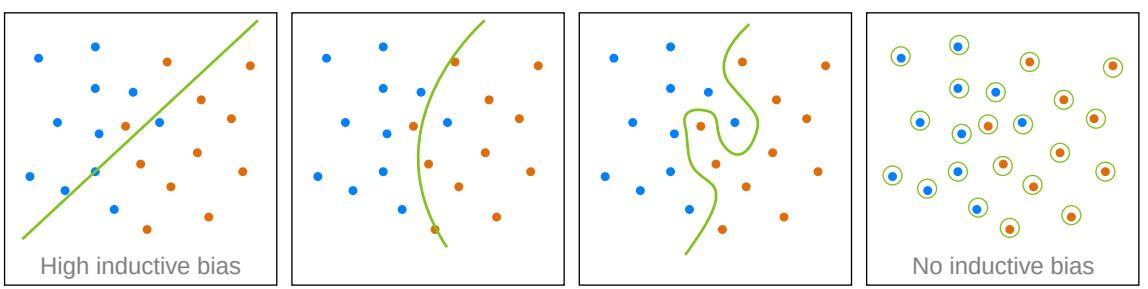


Set of assumptions used to perform induction (predict outputs for unseen inputs).

E.g., preference rules for hypotheses spaces, model parameters, data exploitation.

Examples of inductive biases:

- principle of parsimony, small is quick (search), nearest neighbors, maximum margin
- group equivariance, structured perception, drop out (deep learning)
- data augmentation, priors in Baysian models (learning setup)



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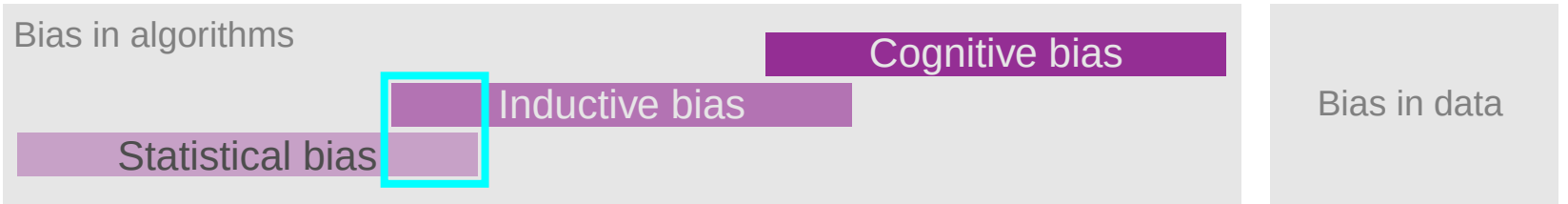
Meanings of Bias

Connections between the Meanings of Bias (a)



(a) Inductive and statistical bias can entail each other.

- Introducing statistical bias may be explained in terms of inductive bias.

↕

- Operationalization of inductive bias may entail statistical bias.

- Keyword: *regularization*

Example: LASSO (least absolute shrinkage and selection operator)

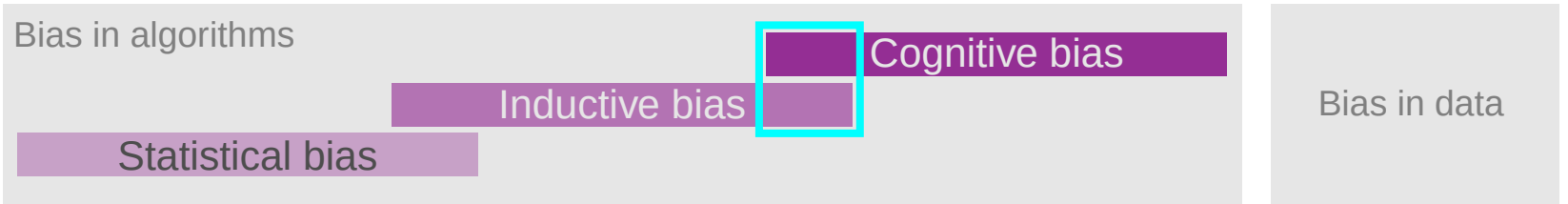
- Inductive bias: minimum features

↕

- Statistical bias: constrain absolute value of model parameters

Meanings of Bias

Connections between the Meanings of Bias (b)



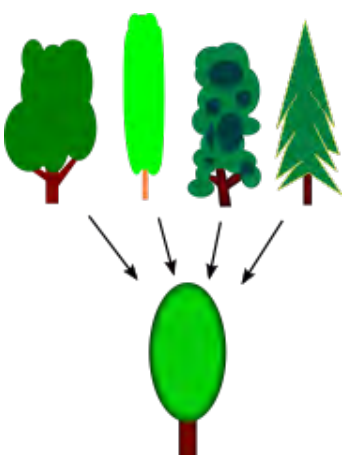
(b) Cognitive and inductive bias can entail each other.

- Ensuring inductive bias will become manifest as a cognitive bias.

↕

- Certain cognitive biases inspired inductive biases in machine learning.

- Keyword: *concept learning*



Example: CART (classification and regression tree)

- Cognitive bias: representativeness heuristic, stereotyping

↕

- Inductive bias: minimize description length

Meanings of Bias

Connections between the Meanings of Bias (continued)

(a) Inductive and statistical biases . . .

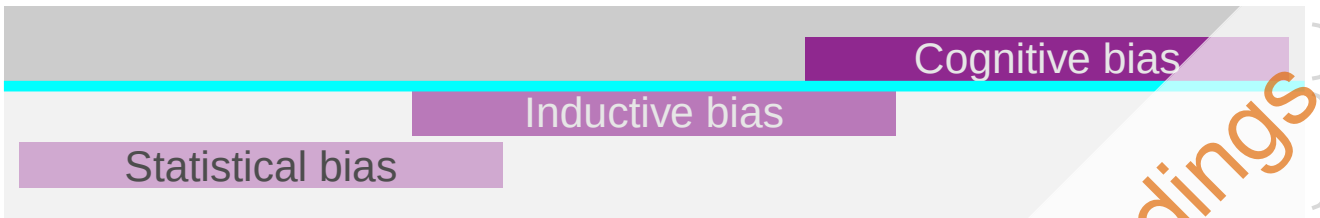
- are optimized against a (mathematical) loss function—but,
- trading bias against variance is an alchemical discipline.

(b) Cognitive biases depend on . . .

- cultural backgrounds,
- the zeitgeist,
- they are individually experienced, and, in particular,
- there is no unified value system for their mathematical quantification.

Meanings of Bias

Connections between the Meanings of Bias (continued)



Optimization hard to formalize.

Optimization easy to formalize, (albeit ...)

(a) Inductive and statistical biases . . .

- are optimized against a (mathematical) loss function—but,
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Source of misunderstandings

Meanings of Bias

Connections to Information Retrieval

Bias in algorithms

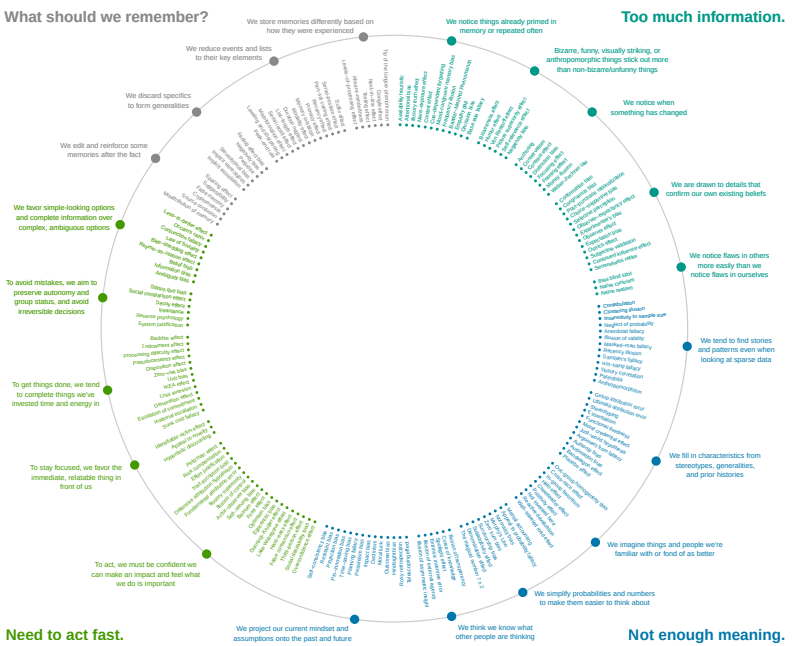
Cognitive bias

Inductive bias

Statistical bias

Bias in data

Extent to which IR is challenged.



Buster Benson (2016). Cognitive bias codex. (algorithmic design by John Manoogian III)

Meanings of Bias

Connections to Information Retrieval

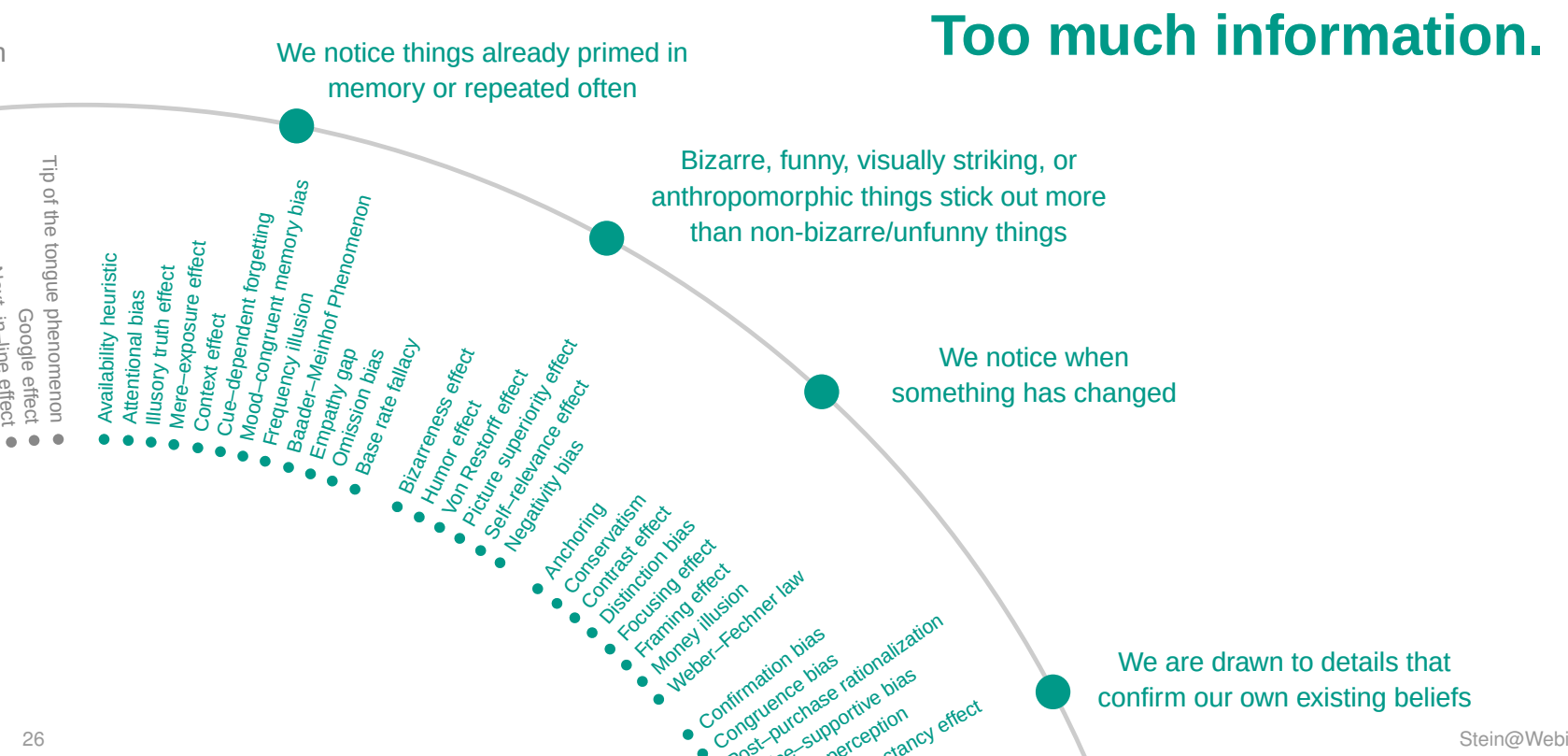
Bias in algorithms

Cognitive bias

Inductive bias

Statistical bias

Bias in data

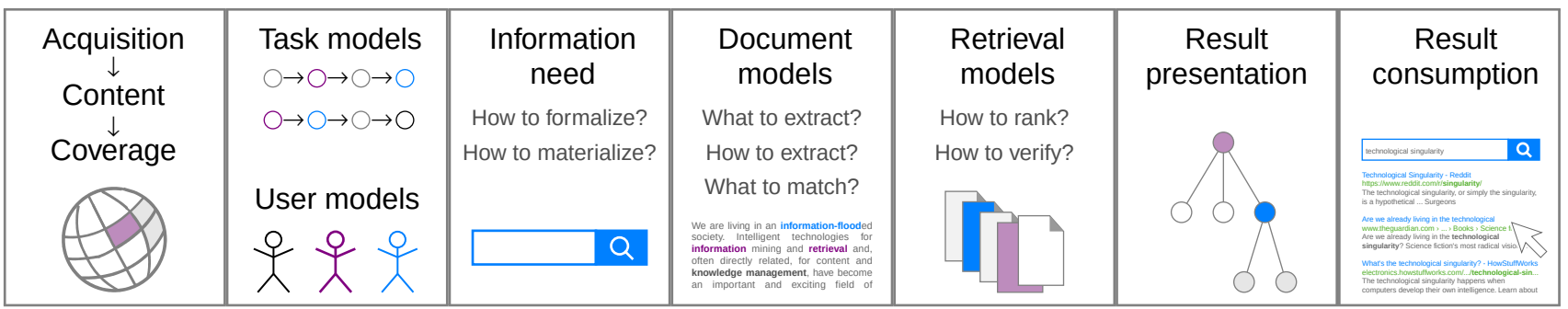


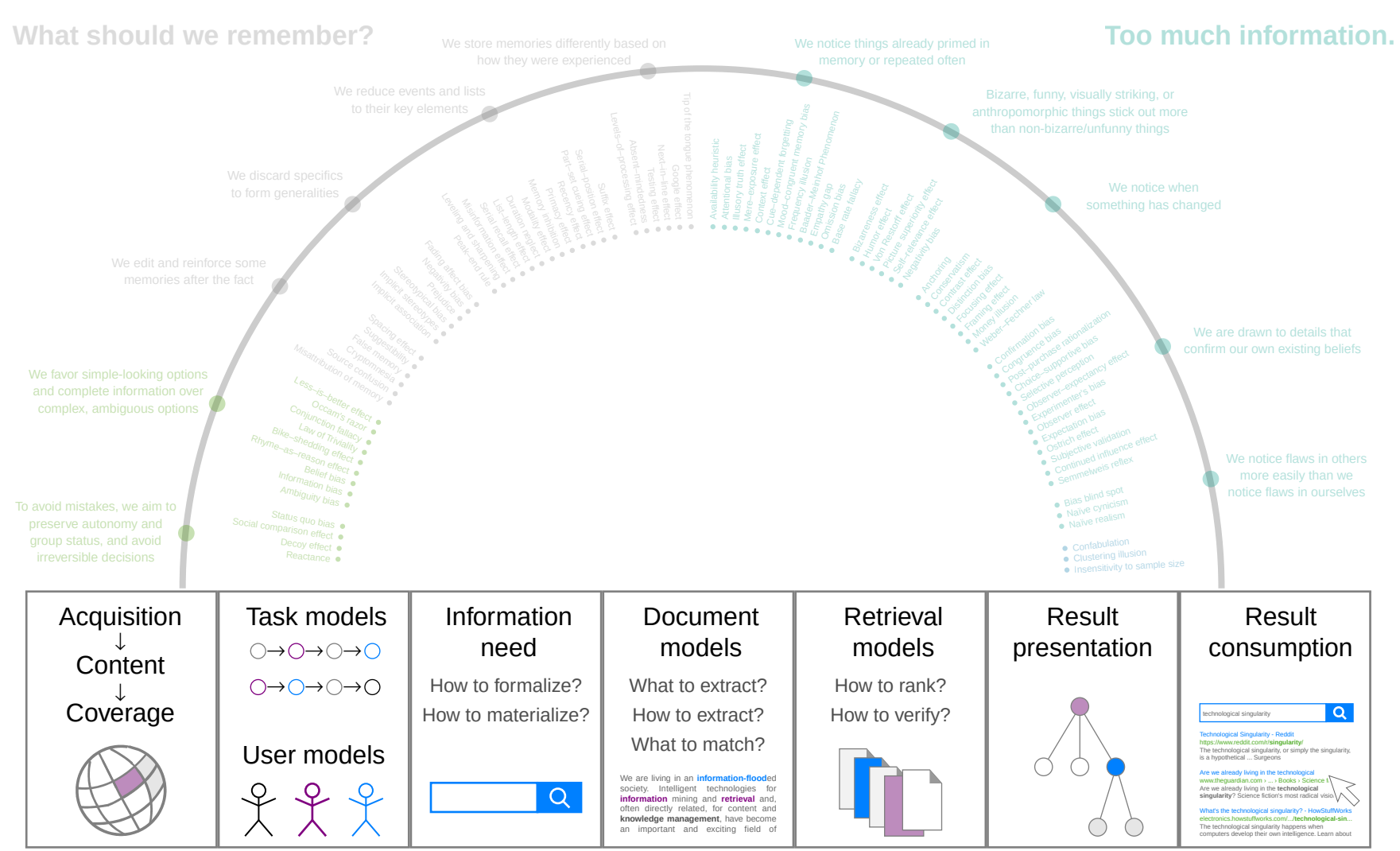
Fighting Cognitive Biases with IR

Fighting Cognitive Biases with IR

The Heart of IR is Evaluation

- Brenda Dervin, Michael Nilan (1986). Information needs and uses.
* Tefko Saracevic (1995). Evaluation of evaluation in information retrieval.
- Ellen Voorhees (2001). The philosophy of information retrieval evaluation.
- William Webber (2009). When did the Cranfield tests become the “Cranfield paradigm”?



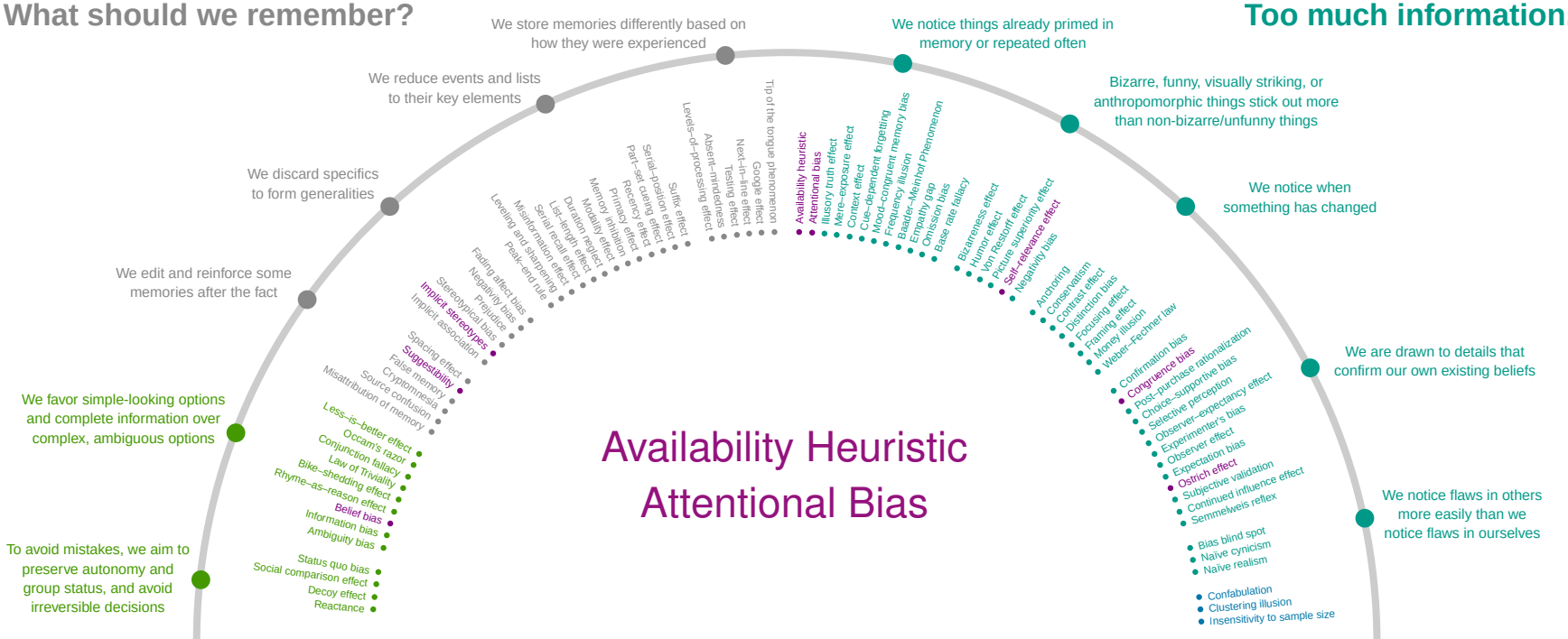


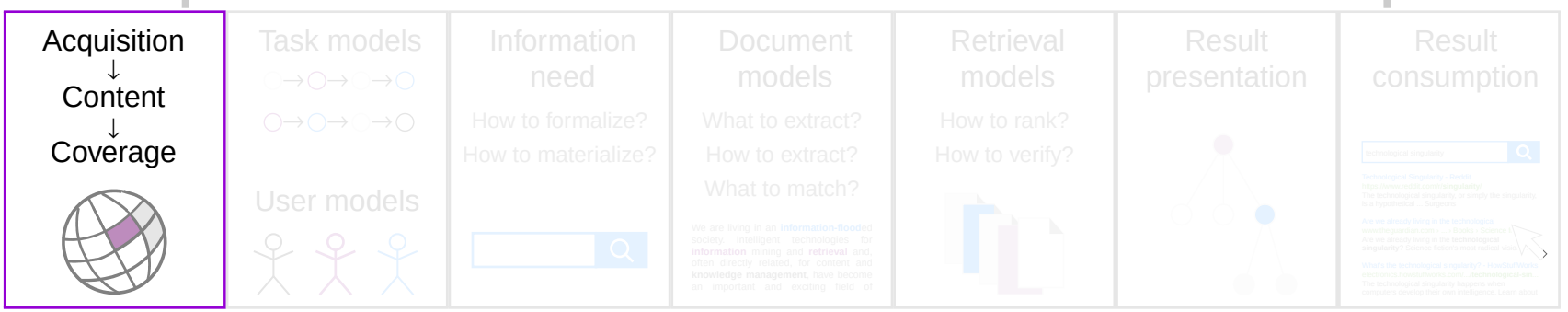
SOTA: Contextualization of IR deficits (not countermeasures) in the cognitive bias codex.

- Leif Azzopardi (2021). Cognitive biases in search: a review and reflection of cognitive biases in information retrieval.

What should we remember?

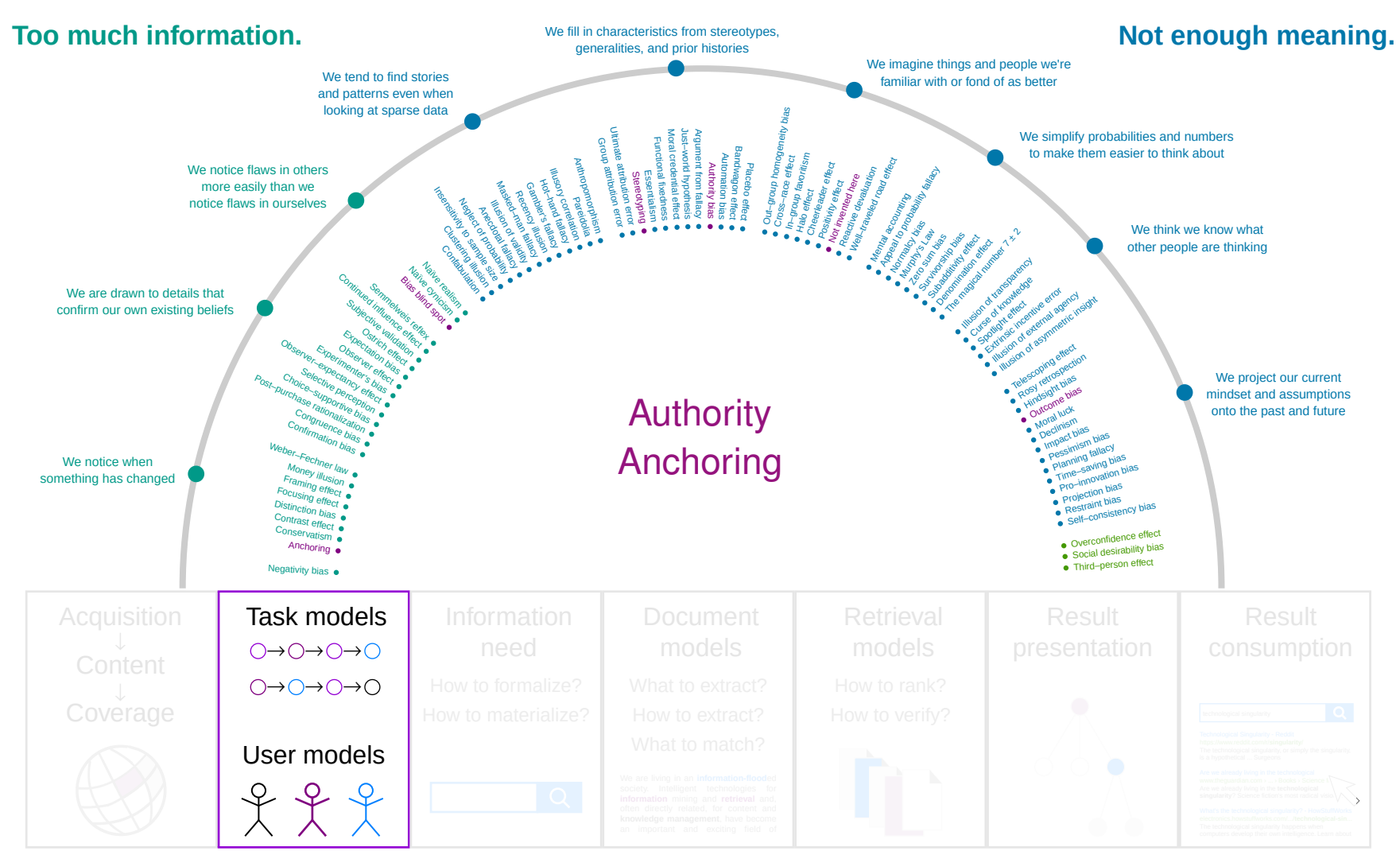
Too much information.





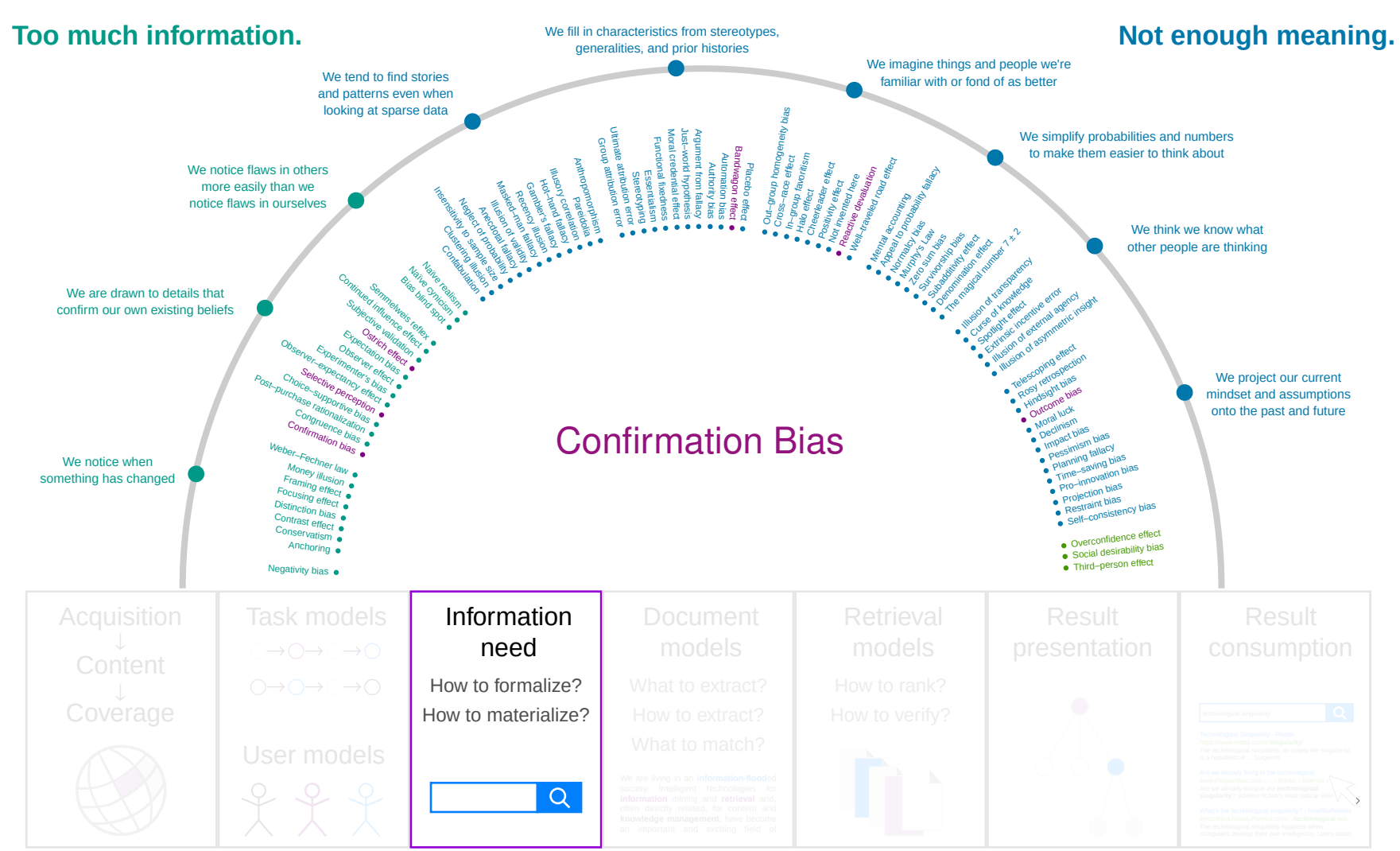
IR systems can assist in systematic and fair review.

- M. Grossman, G. Cormack, A. Roegiest (2016). TREC 2016 total recall track overview.
- A. Olteanu et al. (2021). FACTS-IR: Fairness, accountability, confidentiality, transparency, and safety in IR.



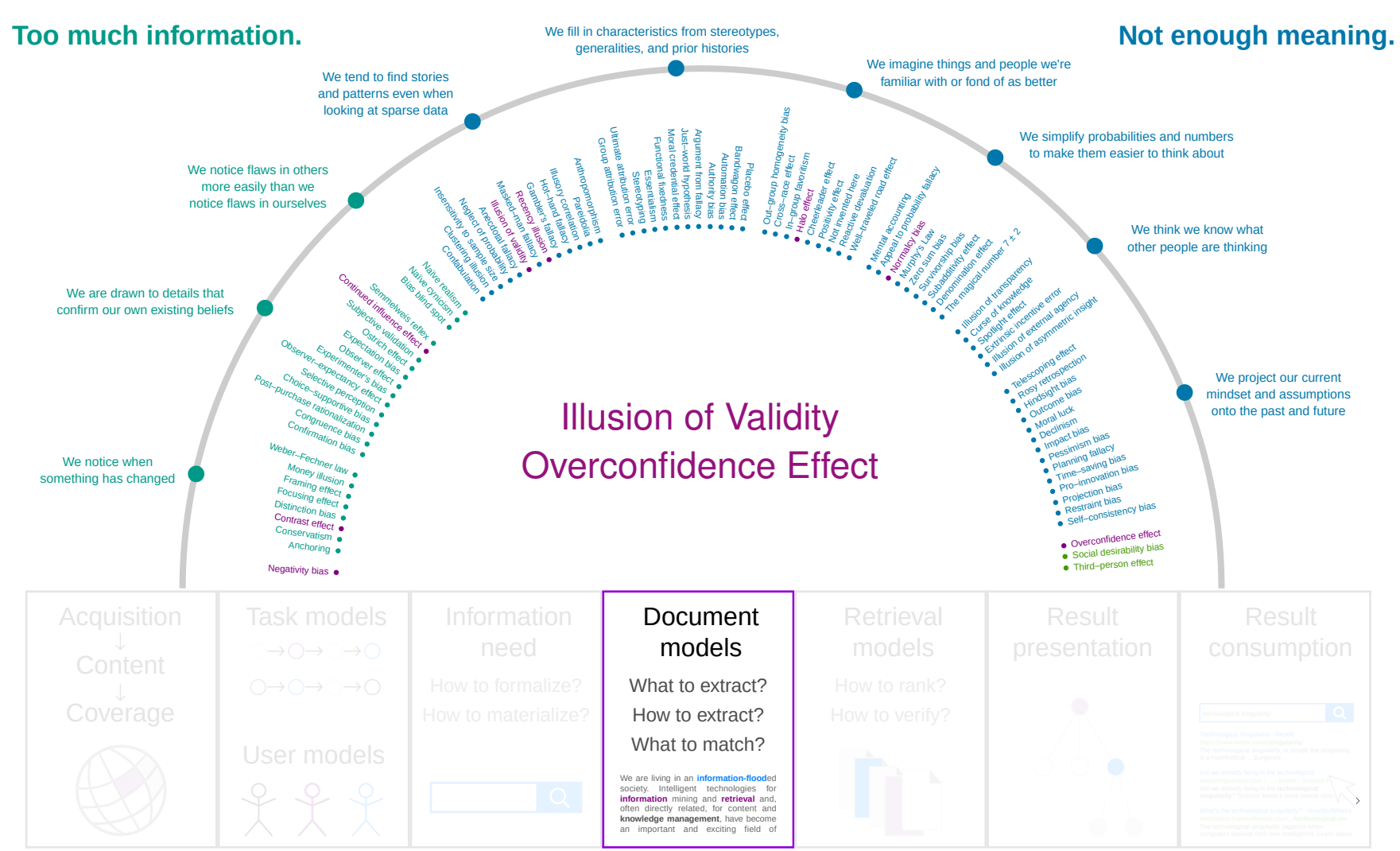
User models can incorporate biases.

- T. Joachims et al. (2005). Accurately interpreting clickthrough data as implicit feedback.
- N. Chen et al. (2022). Constructing better evaluation metrics by incorporating the anchoring effect into the user model



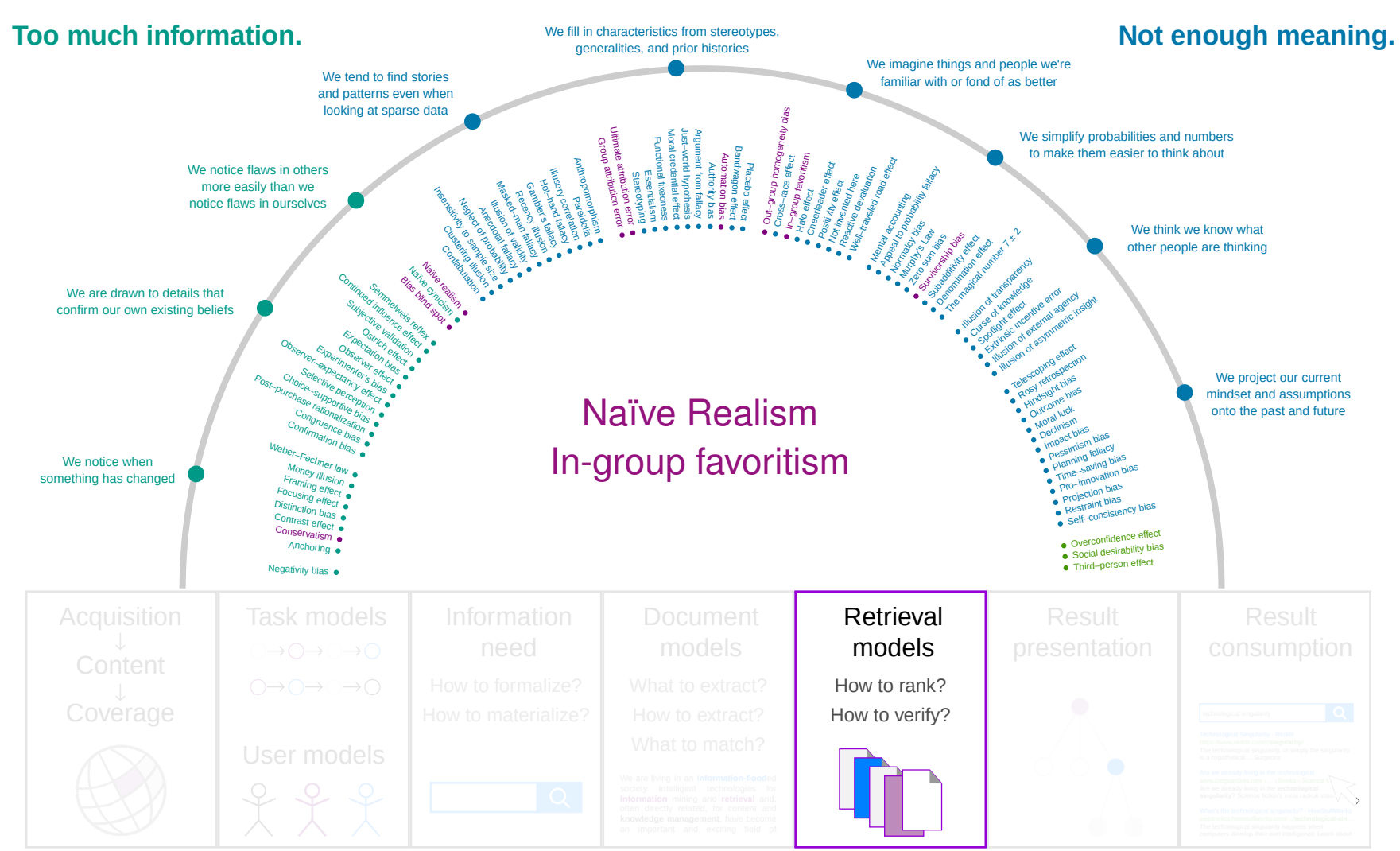
Query assistance (auto-completion, suggestion) can nudge searchers towards critical queries.

- Y. Yamamoto, T. Yamamoto (2018). Query priming for promoting critical thinking in web search.
- S. Pothirattanachaikul et al. (2020). Analyzing the effects of “People also ask” on search behaviors and beliefs.



IR systems can assist in checking claim veracity.

- P. Nakov et al. (2022). Overview of the CLEF'22 CheckThat! lab task on detecting previously fact-checked claims.
- Y. Qu et al. (2021). Human-in-the-loop systems for truthfulness: A study of human and machine confidence.

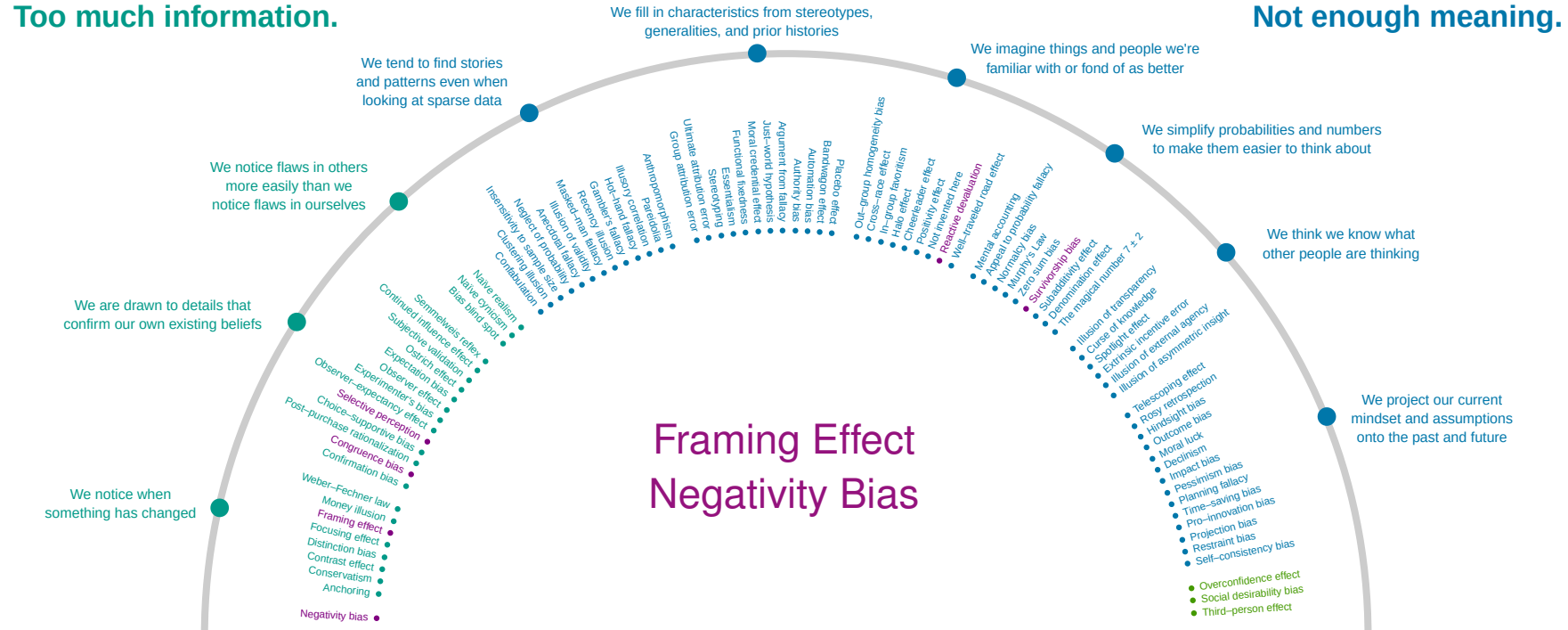


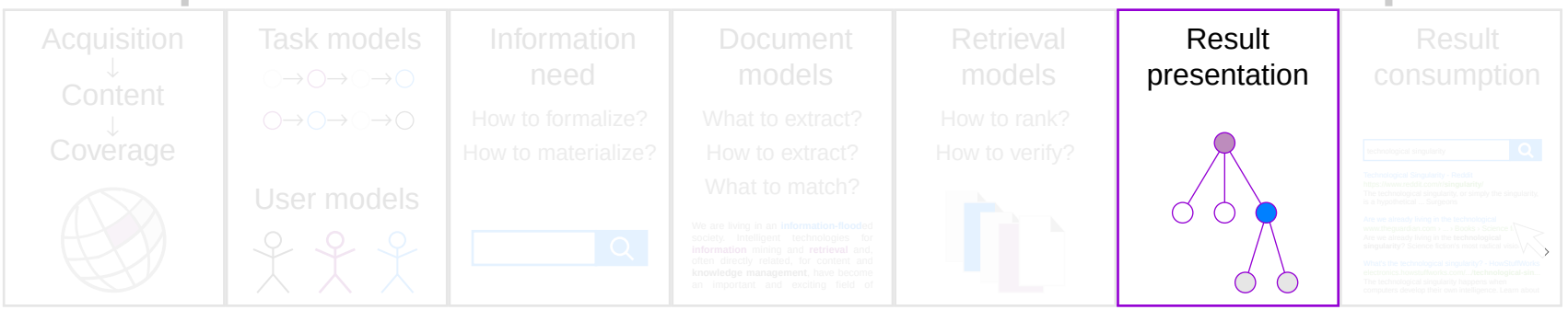
Result lists can be tweaked to reflect normative distributions.

- M. Ekstrand et al. (2022). Overview of the TREC'21 fair ranking track.
- P. Sapiezynski et al. (2019). Quantifying the impact of user attention on fair group representation in ranked lists.

Too much information.

Not enough meaning.



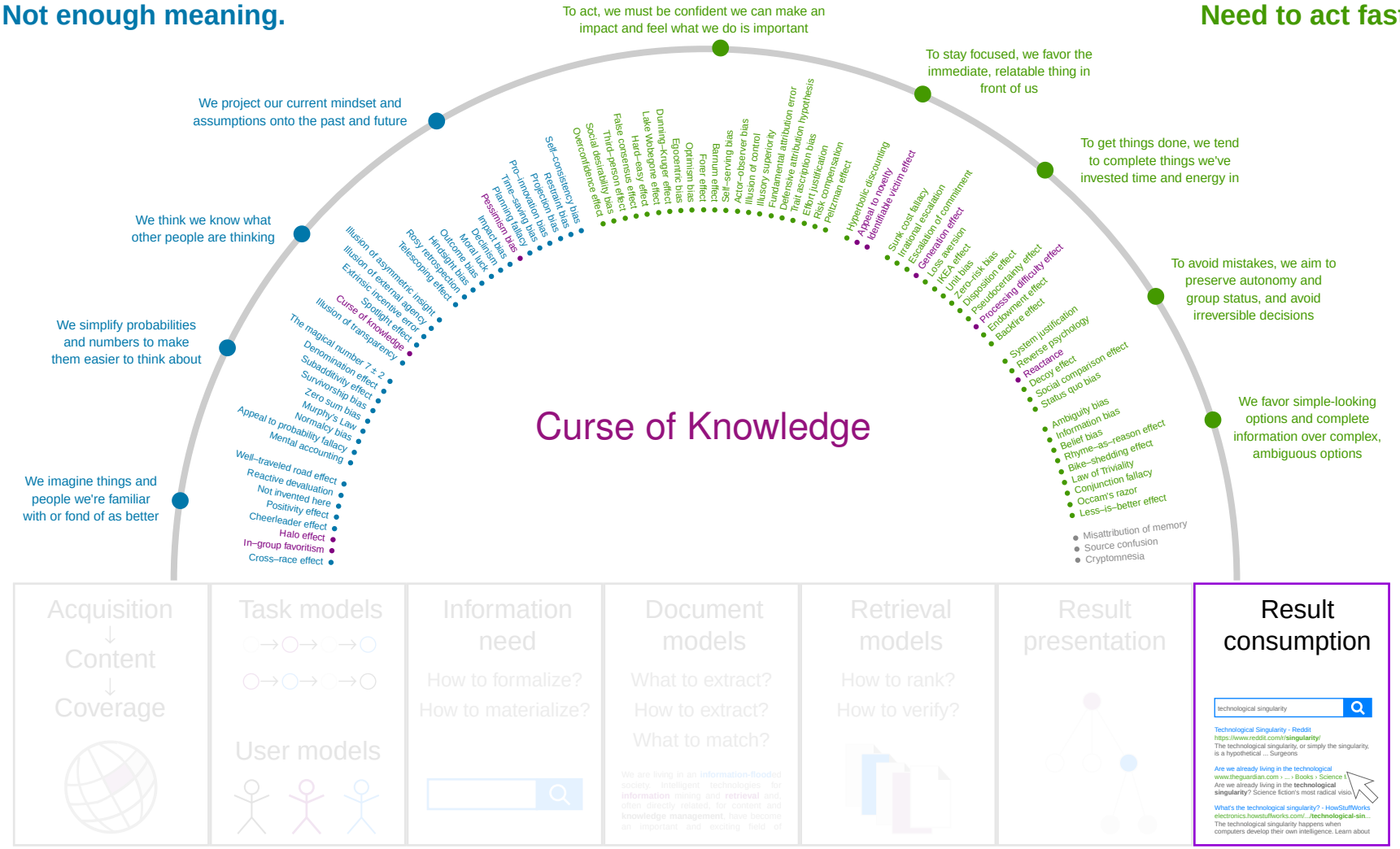


Result captions (title + snippet + URL in a SERP) can be changed to influence user behavior.

- C. Clarke et al. (2007). The influence of caption features on clickthrough patterns in web search.
- R. W. White (2013). Beliefs and biases in web search.

Not enough meaning.

Need to act fast.



Complex documents can be simplified to make them more accessible.

- L. Ermakova et al. (2022). Overview of the CLEF'22 SimpleText task on query biased simplification of scientific texts.
- M. Maddela et al. (2021). Controllable text simplification with explicit paraphrasing.

Related Research @ Webis

Google how long do cats live

Cat / Lifespan

15 years

Domesticated

Feedback

Cat

Animal

The domestic cat or the feral cat is a small, typically furry, carnivorous mammal. They are often called house cats when kept as indoor pets or simply cats when there is no need to distinguish them from other felids and felines. Wikipedia

Scientific name: Felis catus

Lifespan: 15 years (Domesticated)

Gestation period: 64 – 67 days

How Long Do Cats Live? | petMD
www.petmd.com/blogs/thedailyvet/.../**how_long_do_cats_live**-11496
Aug 8, 2011 - This question, typically rephrased as, "**How long** will my **cat** (or d horse, etc.) **live**," is something veterinarians hear on a daily basis.

Aging Cats: Changes, Health Problems, Food, and More
pets.webmd.com/**cats**/guide/aging-**cats**-qa
WebMD veterinarian experts answer common questions **cat** owners have ... Wh can you expect as your **cat** ages? ... Q: **How long do cats** usually **live**?

What Is the Life Span of the Common Cat? - Cats - About
cats.about.com › About Home › Cats
How long is the common **cat** supposed to **live**? Questions and answers from th Guide to **Cats**.

Ageing - How long do cats live | Adelaide Animal Hospital
adelaidevet.com.au/pet.../**how-long-do-cats-live**-ageing-and-your-feline
Life expectancy depends on many things, including one important factor - wheth cat is an indoor-only cat or an outdoor cat. Indoor cats generally live from **12-18** age. Many may live to be in their early 20s. The oldest reported cat lived to be a

Konrad Lischka

How does Google know when my cat will die?

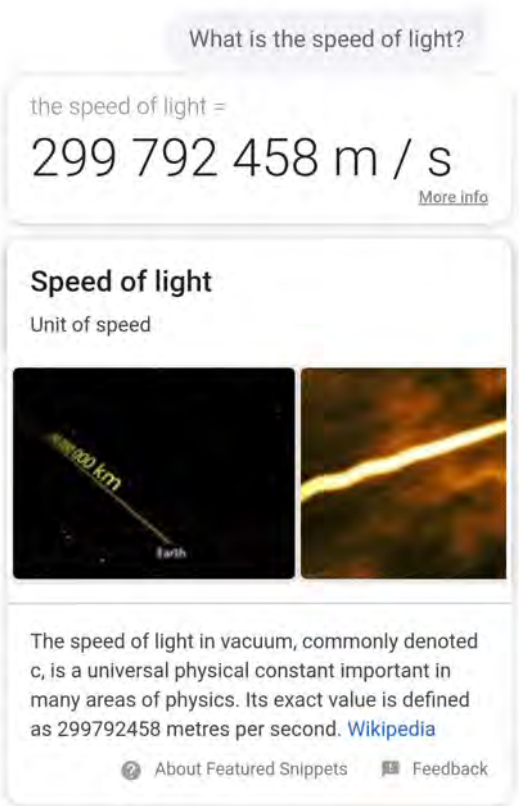
23. September 2015 by Konrad Lischka, in Blog @en

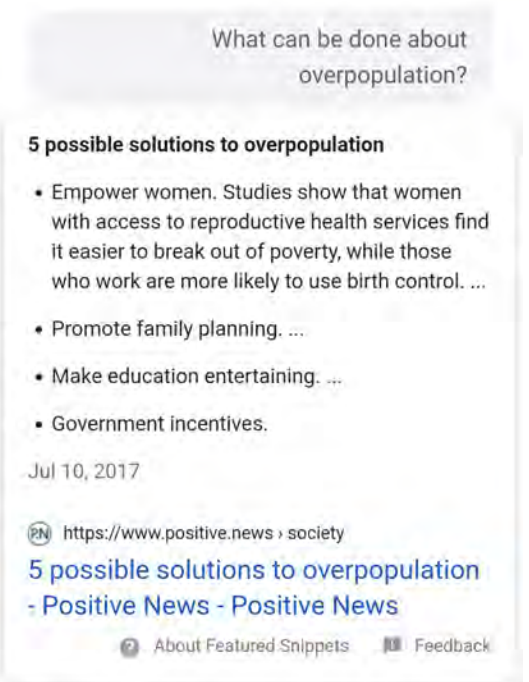
How long do cats live? Exactly 15 years says Google.com. Not "10 to 15", not "about 15 years", but "15 years". That sounds like a definitive answer. It's Google's answer to the search query "How long do cats live".

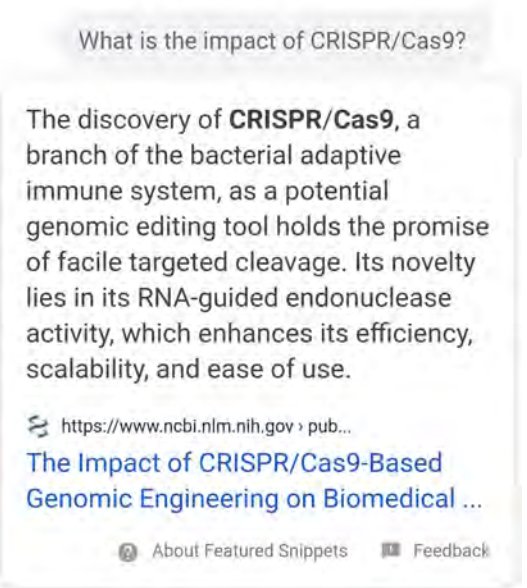
Related Research @ Webis

Dilemma of the Direct Answer

"A user's choice between convenience and diligence when using an information retrieval system."







- M. Potthast, M. Hagen, B. Stein (2020). The dilemma of the direct answer.

Related Research @ Webis

Dilemma of the Direct Answer (continued)

Direct answers amplify various cognitive biases, among others:

1. Authority bias.
   Puts forward the single result with the authority of the search engine.
2. Confirmation bias / overconfidence.
   Likely the most prominent answer, thus confirming people already believing in it.
3. Naive realism / survivorship bias.
   Suggests a “simple” one-answer truth.
4. Mere-exposure effect / illusory truth effect.
   Exposes users to just one answer (mere exposure increases the liking of ideas).
5. Outgroup homogeneity bias.
   Implies a well-accepted opinion.
6. Reactance.
   If the direct answer not the one that one beliefs in, it can cause reactance in users.

Related Research @ Webis

Dilemma of the Direct Answer (continued)

User

What is the user preference?

Task-based speed-accuracy tradeoff

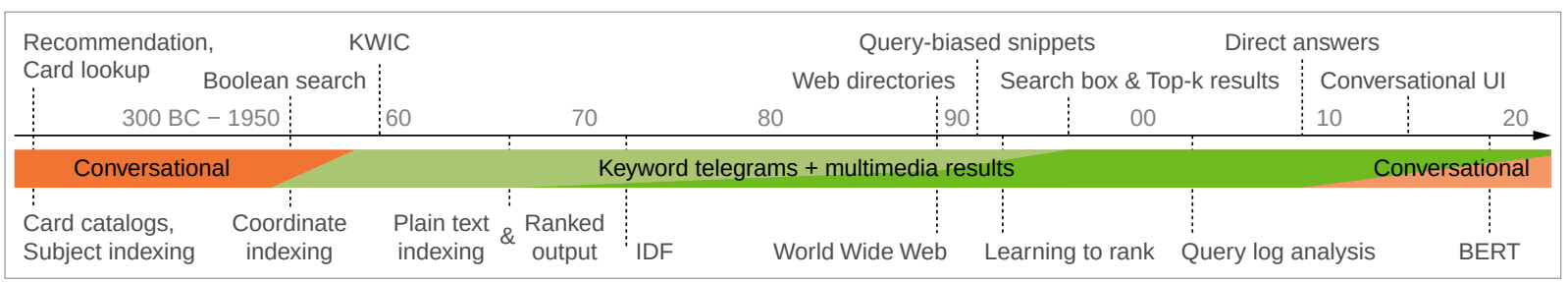
Accuracy

Speed

Of which kind is the user workload?

Physical

Cognitive



System

Who is doing the job of knowledge organization?

Human (hierarchical & ontological)

Machine (associative)

Which fraction is considered from the hypothesis space?

Peak retrievability

- M. Potthast, M. Hagen, B. Stein (2020). The dilemma of the direct answer.

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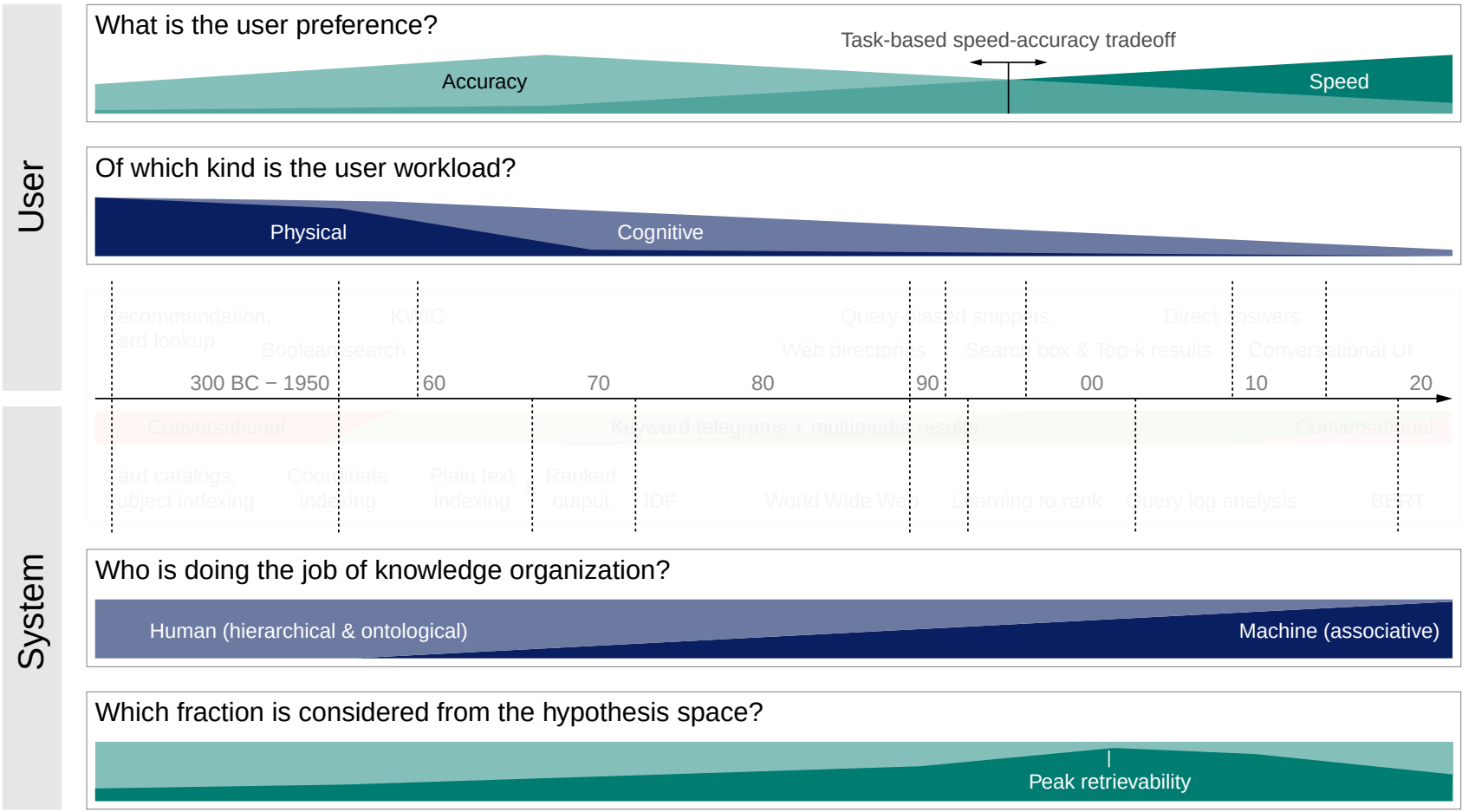
Dilemma of the Direct Answer (continued)



- M. Potthast, M. Hagen, B. Stein (2020). The dilemma of the direct answer.

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Dilemma of the Direct Answer (continued)

User

What is the user preference?

Of which kind is the user workload?

"What share of the retrieval workload should be carried out by the user to maximize the accuracy of the solution?"

System

Who is doing the job of knowledge organization?

Which fraction is considered from the hypothesis space?

- M. Potthast, M. Hagen, B. Stein (2020). The dilemma of the direct answer.

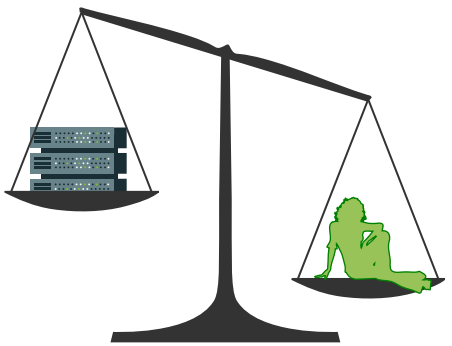
Related Research @ Webis

Information Retrieval and the Balance of Responsibilities

Direct Answer

Rationalization
Bias Analytics
Reframing
Information Labeling
SERP Axiomatization
Conversation Control
Medical Retrieval

More power to the machine?



Empower the user?

- support deliberation
- raise awareness
- demonstrate mechanisms
- provide meta information
- . . .

Related Research @ Webis

(1) Rationalize Answers → Information Seeker Deliberation

Direct Answer
Rationalization
Bias Analytics
Reframing
Information Labeling
SERP Axiomatization
Conversation Control
Medical Retrieval

- An argument search engine for the web.

  Released: 2017.
  Ca. 350,000 arguments over ca. 1,200 topics.
  Evidence types: discussions, news, people.

- Making arguments “digestible” with images.

  CLEF’22 Touché lab on image retrieval for arguments.
  Ca. 20,000 images over 50 topics

- What are the values behind arguments?

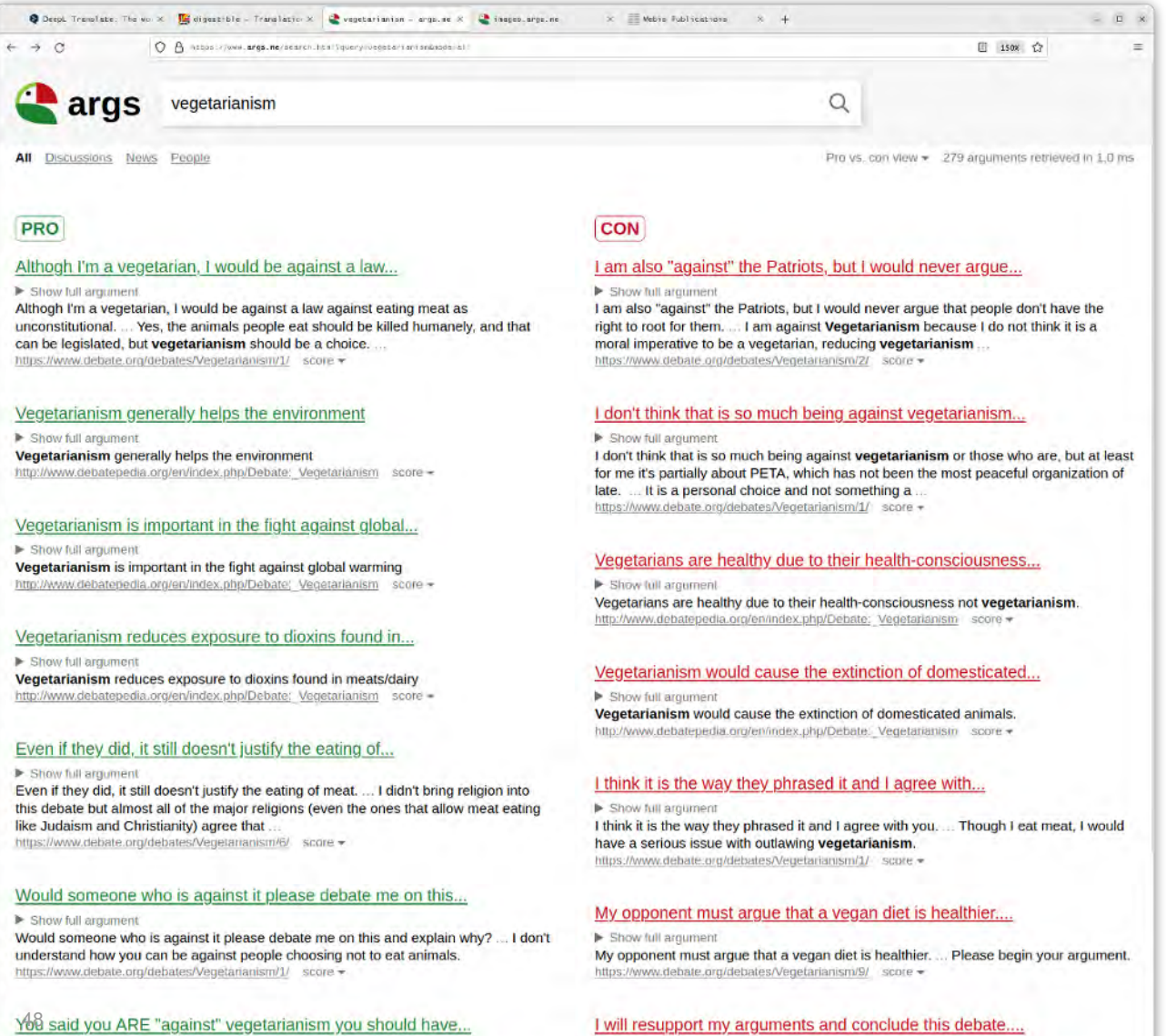
  Mapping arguments on 20 value categories.
  Basis: Schwartz et al. value continuum (2012).
  Classification performance: F_1 up to 0.8, mean: 0.3.

- H. Wachsmuth et al. (2017). Building an argument search engine for the web.
- J. Kiesel et al. (2021). Image retrieval for arguments using stance-aware query expansion.
- J. Kiesel et al. (2022). Identifying the human values behind arguments.

Related Research @ Webis

(1) Rationalize Answers → Values Behind Arguments

Direct Answer
Rationalization
Bias Analytics
Reframing
Information Labeling
SERP Axiomatization
Conversation Control
Medical Retrieval



- S. Schwartz et al. (2012). Refining the theory of basic individual values.

→ valueeval.webis.de. SemEval'23 ValueEval task on human value detection.

Related Research @ Webis

(1) Rationalize Answers → Values Behind Arguments

Direct Answer
Rationalization
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Reframing
Information Labeling
SERP Axiomatization
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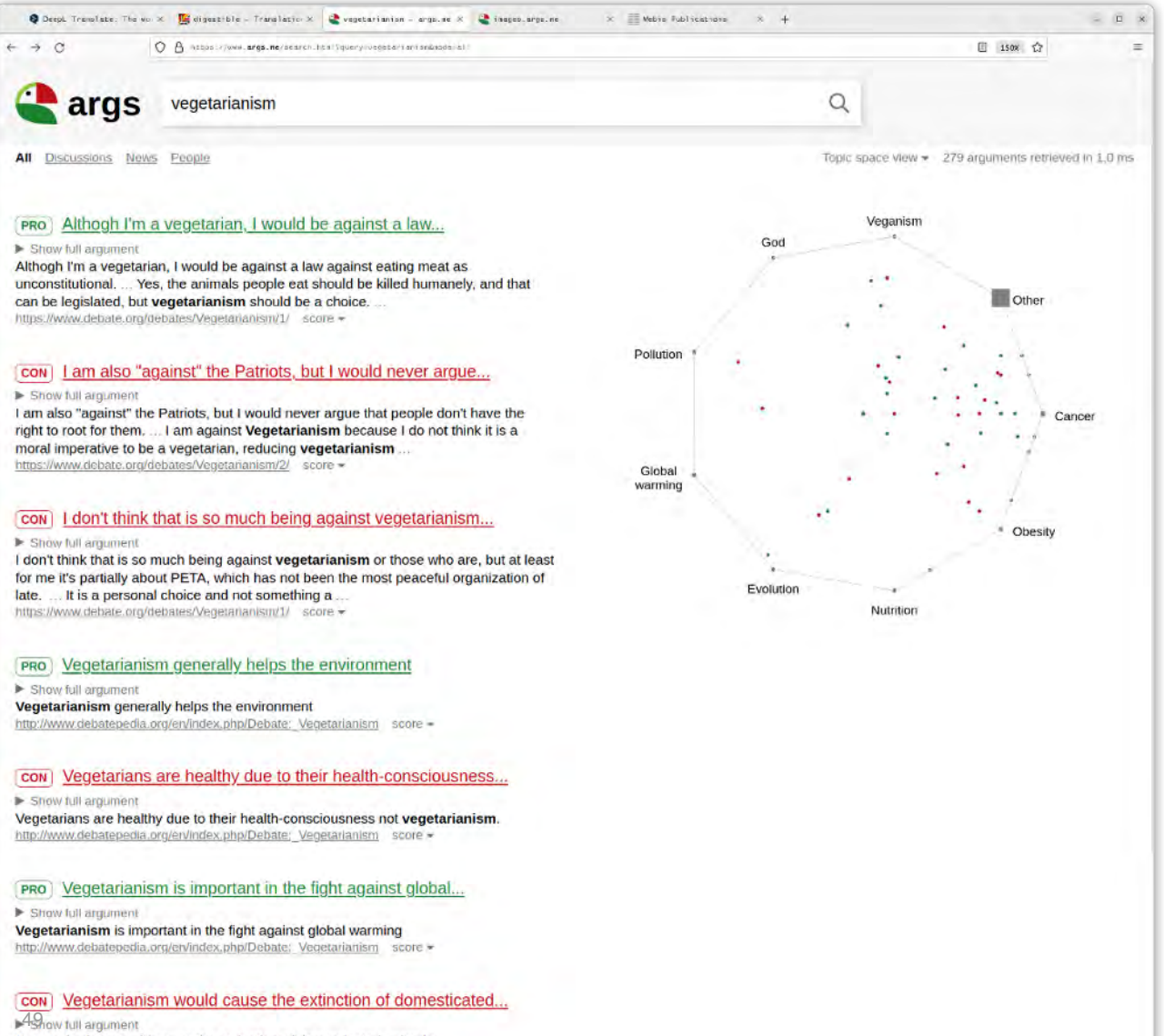
Medical Retrieval



- S. Schwartz et al. (2012). Refining the theory of basic individual values.

→ valueeval.webis.de. SemEval'23 ValueEval task on human value detection.

Related Research @ Webis

(1) Rationalize Answers → Values Behind Arguments

Direct Answer
Rationalization
Bias Analytics
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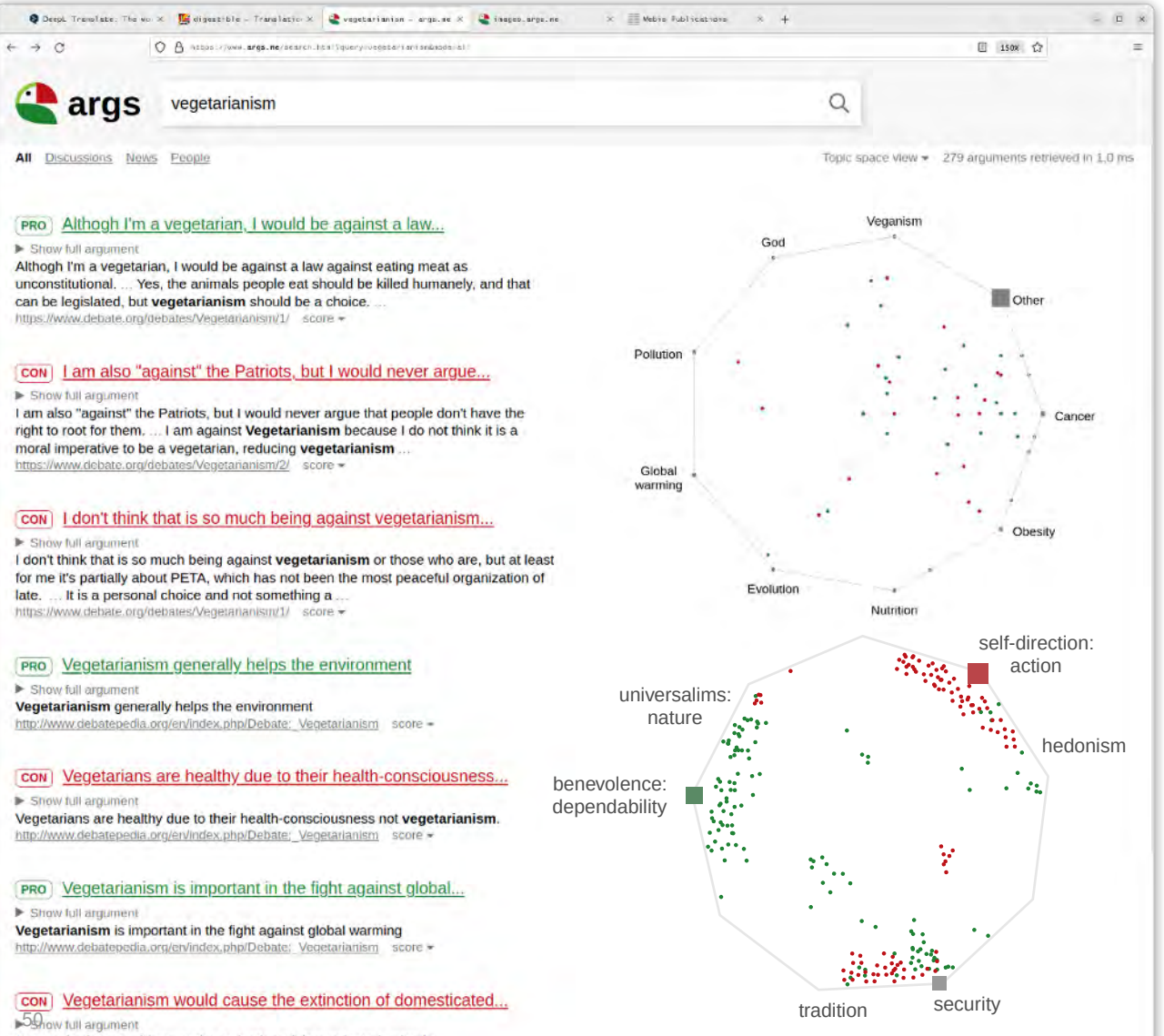
Medical Retrieval

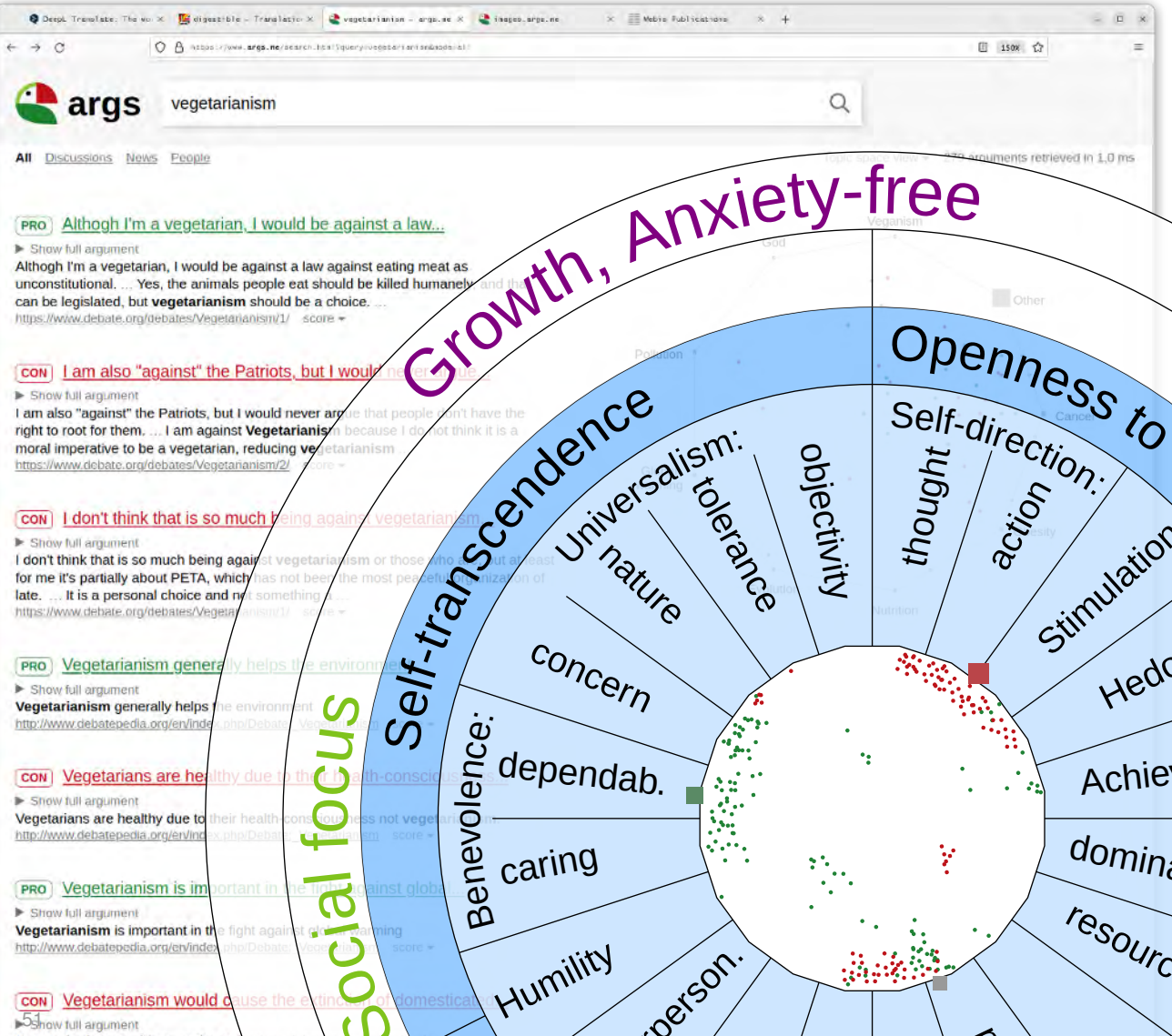


- S. Schwartz et al. (2012). Refining the theory of basic individual values.

→ valueeval.webis.de. SemEval'23 ValueEval task on human value detection.

Related Research @ Webis

(1) Rationalize Answers → Values Behind Arguments



- S. Schwartz et al. (2012). Refining the theory of basic individual values.

→ valueeval.webis.de. SemEval'23 ValueEval task on human value detection.

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(2) Annotate Bias → Raise Reader Awareness

Trump says “we'll do the emergency” if border talks fail

Trump says gun policy with 82 percent support has ‘not much political support (to put it mildly).’
Donald Trump is trying to defend his “school safety” plan, which doesn’t call for an age limit on assault weapon purchases (but does support arming teachers).
Predictably, his claims about those age limits are all about deflecting and obfuscating (or, to be less polite, are full of crap):

....on 18 to 21 age limits, watching court cases and rulings before acting.
States are making this decision.
Things are moving rapidly on this, but not much political support (to put it mildly).

Yes, on this one single issue in his entire life, Trump is “watching court cases and rulings before acting.”
I’m so sure.
And “states are making this decision”?

The thing about states making a decision about who can buy guns is that people—and guns—can cross state lines, and often do.
That’s why federal action is so important.
But this takes the cake: “not much political support (to put it mildly).”

If you only talk to Republican politicians elected with the help of the National Rifle Association, sure.
But an NPR poll that talked to more than just NRA Republicans found 82 percent support for raising the legal age to purchase guns to 21.
That’s a lot of support (to put it mildly).

- W. Chen et al. (2020). Analyzing political bias and unfairness in news articles at different levels of granularity.
- W. Chen et al. (2020). Detecting media bias in news articles using gaussian bias distributions.
- W. Chen et al. (2018). Learning to flip the bias of news headlines.

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(2) Annotate Bias → Raise Reader Awareness

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But on NBC poll that called for raising the legal age to purchase guns to 21,
not support (to put it mildly).

Data:
6,964 news articles on 111 topics from 41 publishers.

Selected results:
Political bias: $F_1 = 0.75$
Unfairness: $F_1 = 0.83$
Non-objectivity: $F_1 = 0.75$

Technology:
Recurrent neural networks.

Bias pattern:
Start with neutral tone, bias maximum within 3. or 4. quartile.

- W. Chen et al. (2020). Analyzing political bias and unfairness in news articles at different levels of granularity.
- W. Chen et al. (2020). Detecting media bias in news articles using gaussian bias distributions.
- W. Chen et al. (2018). Learning to flip the bias of news headlines.

Related Research @ Webis

(3) Reframe News → Demonstrate Framing Mechanisms

Economic Frame (original)

Key Congressional backers of the measure [. . .] wanted a flexible spending limit.
Implicit in the debate and the stalemate that left the bill to die when Congress adjourned was a recognition that the cost of immigration reform would be high, although no one knew how high. Without reform, though, the presence of what may be six million illegal aliens in this country exacts an economic and social toll.

Legality Frame (reframed)

Key Congressional backers of the measure [. . .] wanted a flexible spending limit.
"It's time for Congress to take action," says a spokesman for the bill's sponsors, who want a flexible spending limit. Without reform, though, the presence of what may be six million illegal aliens in this country exacts an economic and social toll.

Crime Frame (reframed)

Key Congressional backers of the measure [. . .] wanted a flexible spending limit.
"Illegal aliens' is a growing problem in the country," says a spokesman for the measure's sponsors. Without reform, though, the presence of what may be six million illegal aliens in this country exacts an economic and social toll.

- K. Budzynska et al. (2022). Framing in communication: From theories to computation.
- W. Chen et al. (2021). Controlled neural sentence-level reframing of news articles.
- Y. Ajjour, M. Alshomary, H. Wachsmuth, B. Stein (2019). Modeling frames in argumentation.

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(3) Reframe News → Demonstrate Framing Mechanisms

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Crime Frame (reframed)

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"Illegal aliens' is a growing problem in the country,"
sponsors. Without reform, though, the presence of wha
country exacts an economic and social toll.

Data:
35,700 frame annotated sentence triples.

Selected results:

Topic consistency:	1.71 crowd rating [0; 2]
Coherence:	1.64 crowd rating [0; 2]
Framing:	1.65 crowd rating [0; 2]

Technology:
Sentence-level fill-in-the-blank with transformer sequence-to-sequence models.

Training strategies: frame pretraining, named entity preservation, adversarial learning

- K. Budzynska et al. (2022). Framing in communication: From theories to computation.
- W. Chen et al. (2021). Controlled neural sentence-level reframing of news articles.
- Y. Ajjour, M. Alshomary, H. Wachsmuth, B. Stein (2019). Modeling frames in argumentation.

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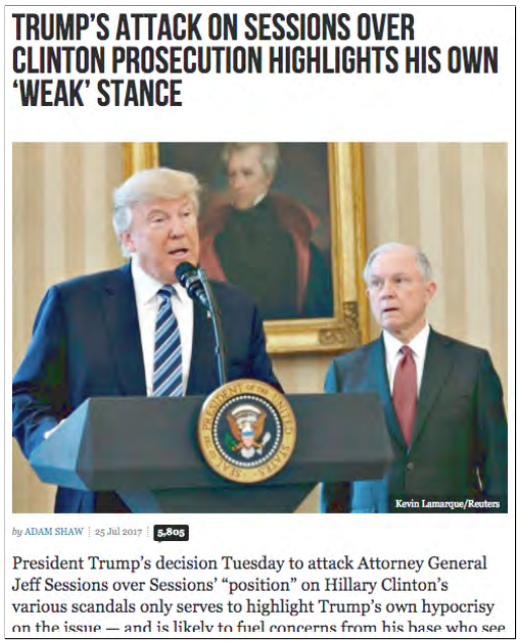
(4) An Information Nutrition Label → Provide Meta Information



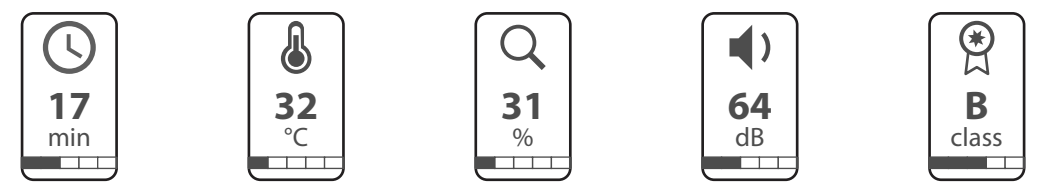
TRUMP'S ATTACK ON SESSIONS OVER CLINTON PROSECUTION HIGHLIGHTS HIS OWN 'WEAK' STANCE

Kevin Lamarque/Reuters

by ADAM SHAW | 25 Jul 2017 | 5,805

President Trump's decision Tuesday to attack Attorney General Jeff Sessions over Sessions' "position" on Hillary Clinton's various scandals only serves to highlight Trump's own hypocrisy on the issue — and is likely to fuel concerns from his base who see

INFORMATION NUTRITION LABEL		
Best before: Jan 1, 2018		
Per 1,000 words		**Recommended daily allowance**
Fact	30%	60%
Opinion	40%	20%
Controversy	9.0	–
Emotion	6.7	1.3
Topicality	8.7	5.0
Reading level	4.0	8.0
Technicality	2.0	–
Authority	4.3	9.0
Viralness	–	1.0
Additional substances: advertising, subscription, invective, images (2), tweets, video clips		
Traces: product placement		



- T. Gollub, M. Potthast, B. Stein (2018). Shaping the information nutrition label.
- N. Fuhr et al. (2017). An information nutritional label for online documents.

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(4) An Information Nutrition Label (continued)

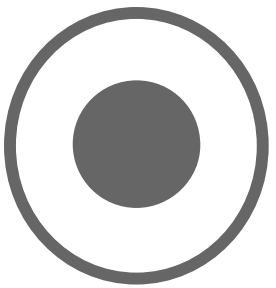
Direct Answer

Rationalization
Bias Analytics
Reframing
Information Labeling
SERP Axiomatization
Conversation Control
Medical Retrieval

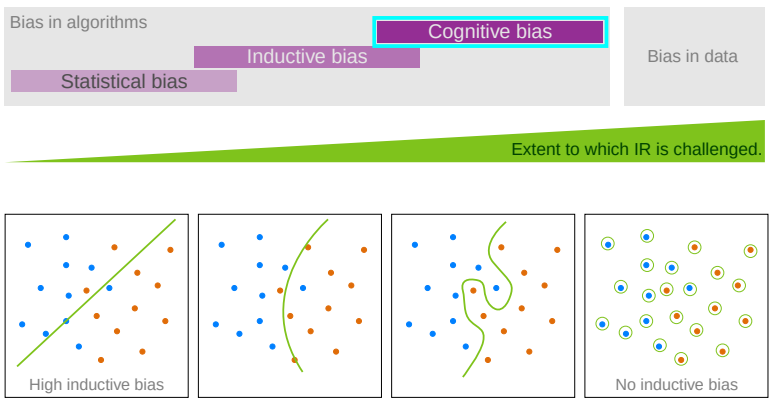
"It is not our intention to say what is true or what is false, right or wrong, and in particular not what is good or bad.*

That is, an Information Nutrition Label is not a substitute for a moral compass."

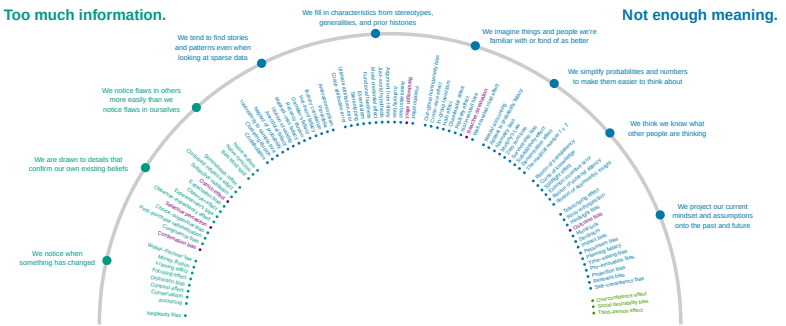
* Norbert Fuhr, Anastasia Giachanou, Gregory Grefenstette, Iryna Gurevych, Andreas Hanselowski, Kalervo Jarvelin, Rosie Jones, Yiqun Liu, Josiane Mothe, Wolfgang Nejdl, Isabella Peters, Benno Stein @ Schloss Dagstuhl (2017)



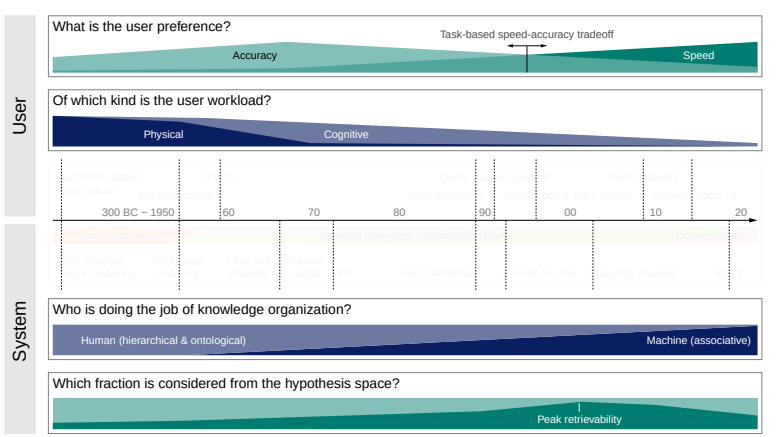
Summary



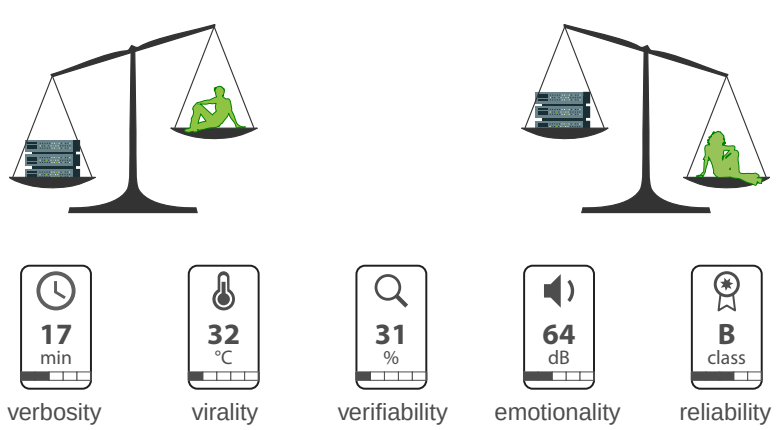
The meanings of bias, and their connections.



Fighting cognitive biases with IR.



Direct answers—the pride of IR?



More power to machines—or, empower the user?

J. Ajjour

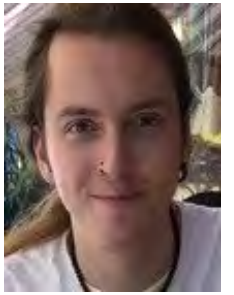
J. Bevendorff

A. Bondarenko

W. Chen

M. Fröbe

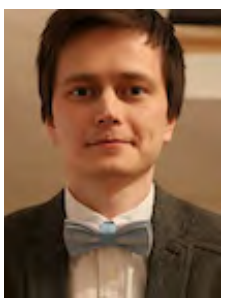
N. Glaser


M. Ghosen

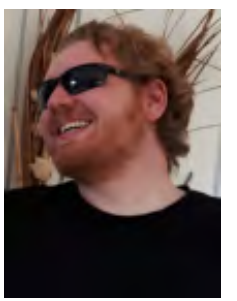
T. Gollub

J. Kiesel

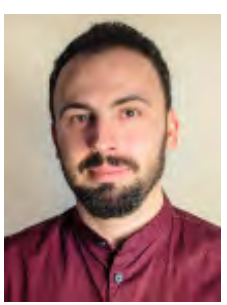
E. Körner


N. Kolyada

M. Völske


M. Wiegmann

M. Wolska


K. Al-Khatib

M. Hagen

M. Potthast

B. Stein

H. Wachsmuth

Thank You!

AVAILABILITY HEURISTIC
SECOND SHARK DEATH IN FIVE YEARS
"THEY MUST HAVE A DEATH WISH TO SWIM IN THAT WATER."

ANCHORING EFFECT
"BREATH-TAKING ISN'T IT? THE SELLER WANTED 5,000 BUT I GOT IT FOR JUST 4,500!"

CONFIRMATION BIAS
FLAT EARTH SOCIETY
PLANET EARTH IS DEFINITELY FLAT
COSMOS
SPHERE
Eratosthenes
THE EARTH
GREEK THINKERS
THE SOLAR SYSTEM
THE 3D GUIDE TO THE EARTH
THE EARTH IS ROUND
Galileo Galilei
ONE KOMO PLANET

"AHA! I KNEW IT!"

FRAMING EFFECT
THANKS TO OUR AGGRESSIVE STANCE ON CLIMATE CHANGE, THIS GOVERNMENT HAS REDUCED CARBON EMISSIONS BY ALMOST 5%!
WE ♥ YOU!
CARBON EMISSIONS REDUCED BY JUST 4.6% IN LAST 5 YEARS

"WELL I DON'T KNOW HOW YOUR LECTURES WENT, BUT I CAN'T SEEM TO GET THROUGH TO THESE PEOPLE!"