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 . . .


. . . 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]
Meanings of Bias
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[Oxford Handbooks Online 2017]

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.

¹Various authors use the term “cognitive bias” for a heuristic that is applied by humans to judge.
"Although we gave him all of that money and support, I always had my doubts that Jim could build his own helicopter."
Meanings of Bias
Connections to Statistics

- Bias in algorithms
  - Statistical bias
  - Inductive bias
  - Cognitive bias

- Bias in data
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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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.
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)
- G. Montañet et al. (2019)
Meanings of Bias
Connections to Statistics (continued)

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

“Learning without bias is futile.”
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- G. Montañet et al. (2019)
Meanings of Bias

(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
(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)

- Statistical bias
- Inductive bias
- Cognitive bias

Optimization

- easy to formalize,
- hard to formalize.

(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)

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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.

What should we remember?
- We store memories differently based on how they were experienced.
- We notice things already known in memory or repeated after.
- We notice when something has changed.

Too much information.
- We are drawn to details that we often have existing beliefs.
- We notice fears in others more easily than we notice fears in ourselves.
- We need to find solutions and patterns more when looking at sparse data.

Not enough meaning.
- We simplify probabilities and numbers to make them easier to think about.
- We imagine things and people with identities and prior behaviors.

Need to act fast.
- We discard specifics to be generalizable.
- We will and continue some memories after the facts.
- We notice when something has changed.

Bias blind spot
- We fill in characteristics from stereotypes, generalities, and prior histories.
- We notice flaws in others more easily than we notice flaws in ourselves.
- We notice flaws in others more easily than we notice beliefs in ourselves.

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Meanings of Bias
Connections to Information Retrieval

Bias in algorithms
Bias in data

Cognitive bias
Inductive bias
Statistical bias

We notice things already primed in memory or repeated often.

Bizarre, funny, visually striking, or anthropomorphistic things stick out more than non-bizarre/unfunny things.

We notice when something has changed.

We are drawn to details that confirm our own existing beliefs.
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.
- William Webber (2009). When did the Cranfield tests become the “Cranfield paradigm”?

We are living in an information-flooded society. Intelligent technologies for information mining and retrieval and, often directly related, for content and knowledge management, have become an important and exciting field of...

The technological singularity, or simply the singularity, is a hypothetical ... Surgeons Are we already living in the technological ... Science fiction’s most radical vision of...

Use and user level

Processing level

Input level

Engineering level
What should we remember?

We store memories differently based on how they were experienced.

We reduce events and lists to their key elements.

We notice things already primed in memory or repeated often.

We discard specifics to form generalities.

We edit and reinforce some memories after the fact.

We favor simple-looking options and complete information over complex, ambiguous options.

To avoid mistakes, we aim to preserve autonomy and group status, and avoid irreversible decisions.

We notice when something has changed.

We are drawn to details that confirm our own existing beliefs.

We notice flaws in others more easily than in ourselves.

The technological singularity happens when computers develop their own intelligence. Learn about it.

Too much information.

Acquisition ↓

Content ↓

Coverage

Task models

Information need

Document models

Retrieval models

Result presentation

Result consumption

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

IR systems can assist in systematic and fair review.

User models can incorporate biases.

- 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.

- 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.
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.
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.
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.
Related Research @ Webis
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 dog, etc.) live," is something veterinarians hear on a daily basis.

Aging Cats: Changes, Health Problems, Food, and More | petMD
www.petmd.com/cats/guide/aging-cats-qa
WebMD veterinarian experts answer common questions cat owners have: 1. How can you expect as your cat ages? 2. How long do cats usually live?

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

Ageing - How long do cats live | Adelaide Animal Hospital
Life expectancy depends on many things, including one important factor - whether a cat is an indoor-only cat or an outdoor cat. Indoor cats generally live from 12-18 years. Many may live to be in their early 20s. The oldest reported cat lived to be a
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.
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 believes in, it can cause reactance in users.
Related Research @ Webis

Dilemma of the Direct Answer (continued)

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

https://publications.webis.de
Related Research @ Webis
Dilemma of the Direct Answer (continued)

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

https://publications.webis.de
“What share of the retrieval workload should be carried out by the user to maximize the accuracy of the solution?”

- M. Potthast, M. Hagen, B. Stein (2020). The dilemma of the direct answer.
Related Research @ Webis
Information Retrieval and the Balance of Responsibilities

More power to the machine?

Empower the user?

- support deliberation
- raise awareness
- demonstrate mechanisms
- provide meta information
- ...
(1) Rationalize Answers → Information Seeker Deliberation

- An argument search engine for the web. 🌍
  - 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.
  - Classification performance: $F_1$ up to 0.8, mean: 0.3.

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- J. Kiesel et al. (2022). Identifying the human values behind arguments.
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.

**PRO**

Although I'm a vegetarian, I would be against a law...

Vegetarianism generally helps the environment

Vegetarianism is important in the fight against global...

Vegetarianism reduces exposure to dioxins found in...

Even if they did, it still doesn't justify the eating of...

Would someone who is against it please debate me on this...

You said you are "against" vegetarianism you should have...

**CON**

I am also "against" the Patriots, but I would never argue...

I don't think that is so much being against vegetarianism...

I think it is the way they phrased it and I agree with...

My opponent must argue that a vegan diet is healthier...

I will respectfully maintain and conclude this debate...
(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.
Related Research @ Webis

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https://publications.webis.de
Related Research @ Webis

(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).

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

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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.
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.
Related Research @ Webis

(3) Reframe News → Demonstrate Framing Mechanisms

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**Economic Frame** (original)

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**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

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- K. Budzynska et al. (2022). Framing in communication: From theories to computation.
(4) An Information Nutrition Label → Provide Meta Information

### INFORMATION NUTRITION LABEL

<table>
<thead>
<tr>
<th>Per 1,000 words</th>
<th>Recommended daily allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact</td>
<td>30%</td>
</tr>
<tr>
<td>Opinion</td>
<td>40%</td>
</tr>
<tr>
<td>Controversy</td>
<td>9.0</td>
</tr>
<tr>
<td>Emotion</td>
<td>6.7</td>
</tr>
<tr>
<td>Topicality</td>
<td>8.7</td>
</tr>
<tr>
<td>Reading level</td>
<td>4.0</td>
</tr>
<tr>
<td>Technicality</td>
<td>2.0</td>
</tr>
<tr>
<td>Authority</td>
<td>4.3</td>
</tr>
<tr>
<td>Viralness</td>
<td>–</td>
</tr>
</tbody>
</table>

Additional substances: advertising, subscription, invective, images (2), tweets, video clips

Traces: product placement

- N. Fuhr et al. (2017). An information nutritional label for online documents.
“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?
Thank You!
AVAILABILITY HEURISTIC

"THEY MUST HAVE A DEATH WISH TO SWIM IN THAT WATER."
“BREATHTAKING ISN’T IT? THE SELLER WANTED 5,000 BUT I GOT IT FOR JUST 4,500!”
CONFIRMATION BIAS

"AHA! I KNEW IT!"
THANKS TO OUR AGGRESSIVE STANCE ON CLIMATE CHANGE, THIS GOVERNMENT HAS REDUCED CARBON EMISSIONS BY ALMOST 5%!

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!"