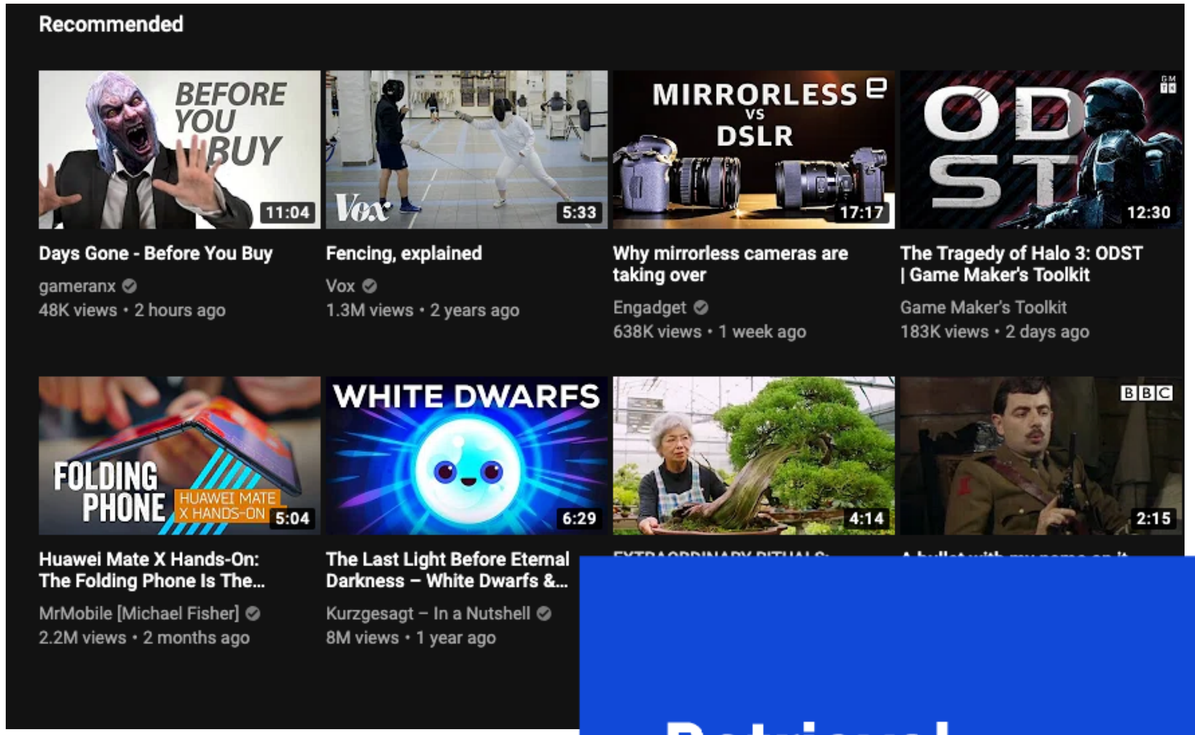
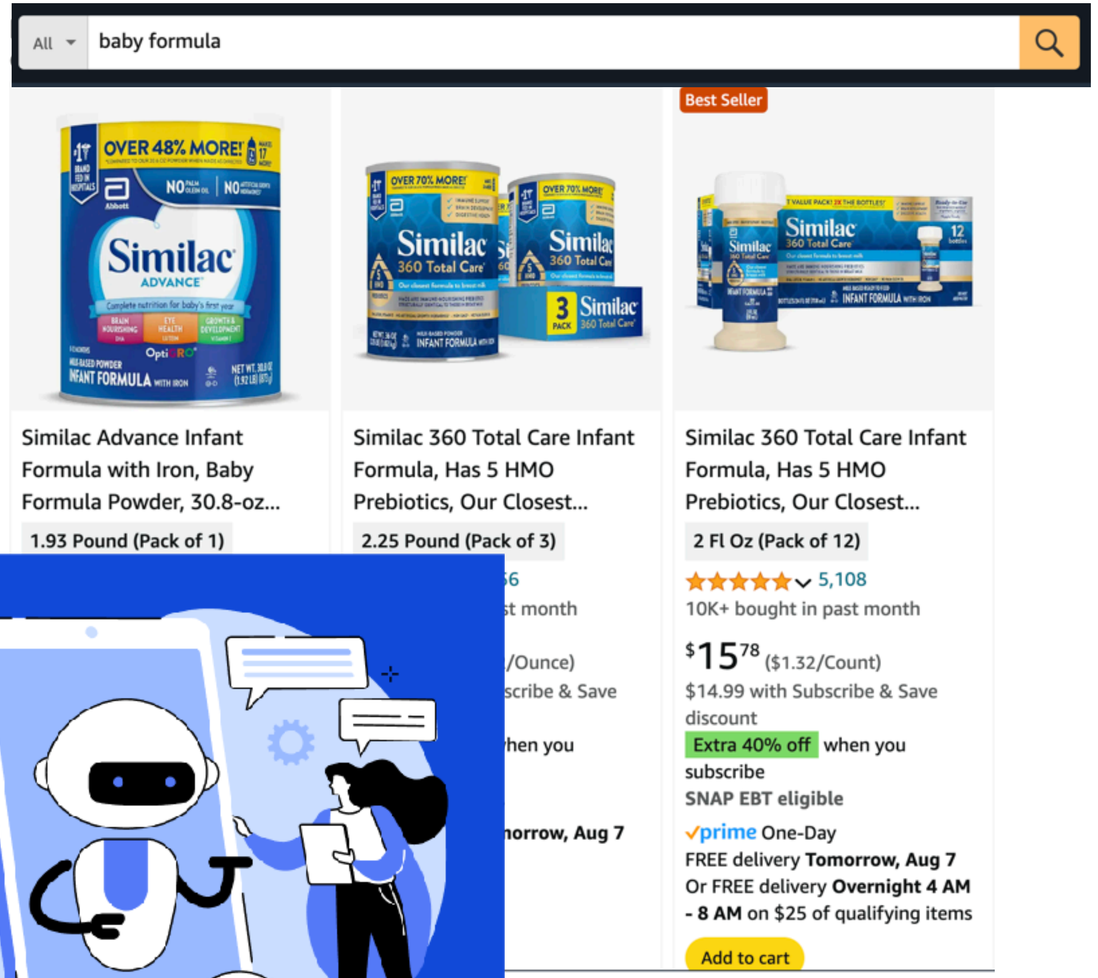
Orbit: A Framework for Designing and Evaluating Multi-objective Rankers

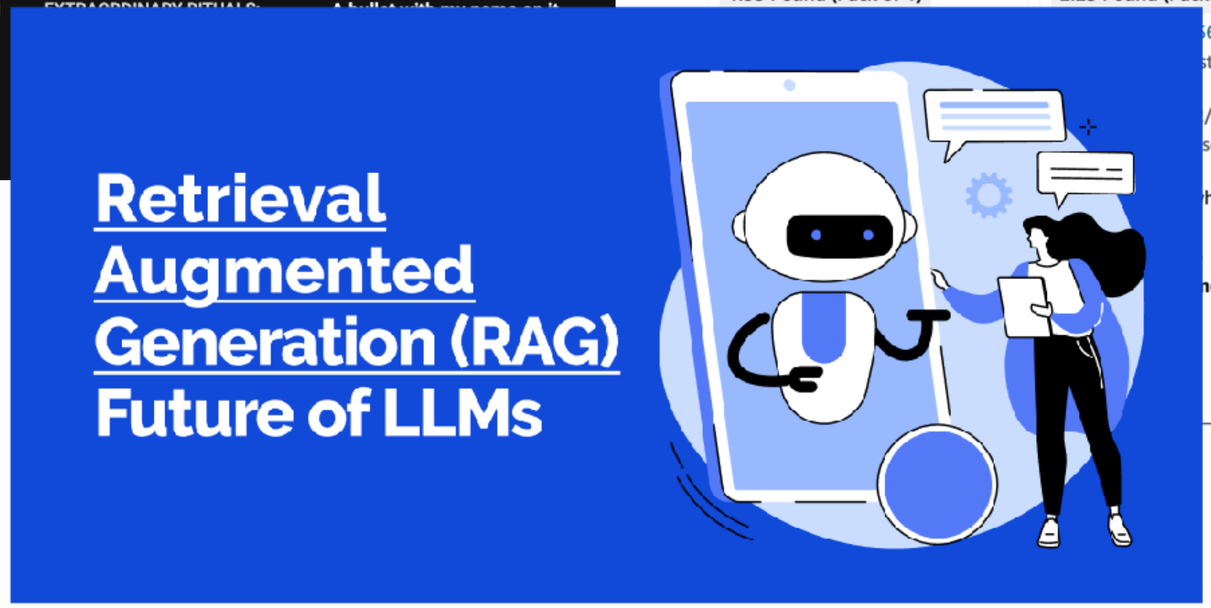
Chenyang Yang, Tesi Xiao, Michael Shavlovsky, Christian Kästner, Sherry Tongshuang Wu

amazon Carnegie Mellon University

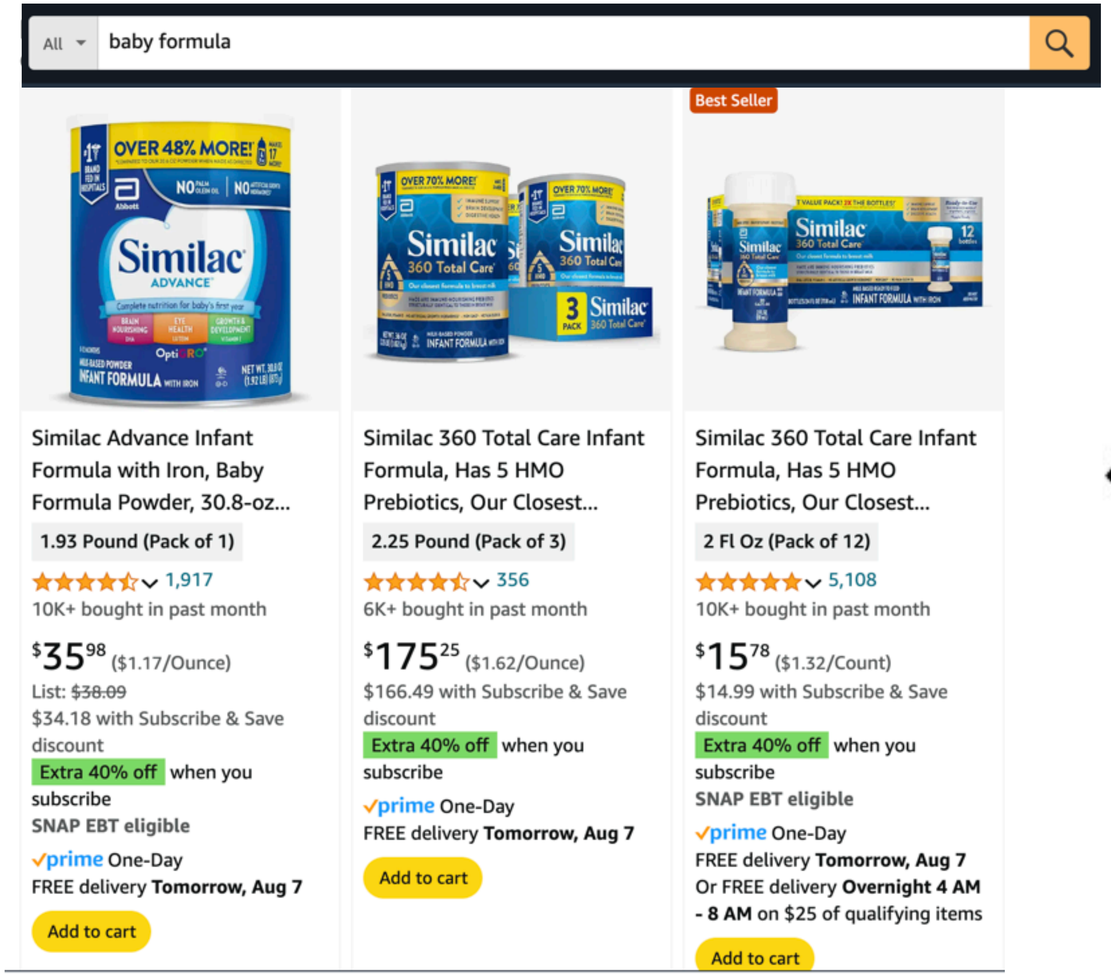
Ranking models are prevalent in AI applications







Ranking models need to consider multiple objectives

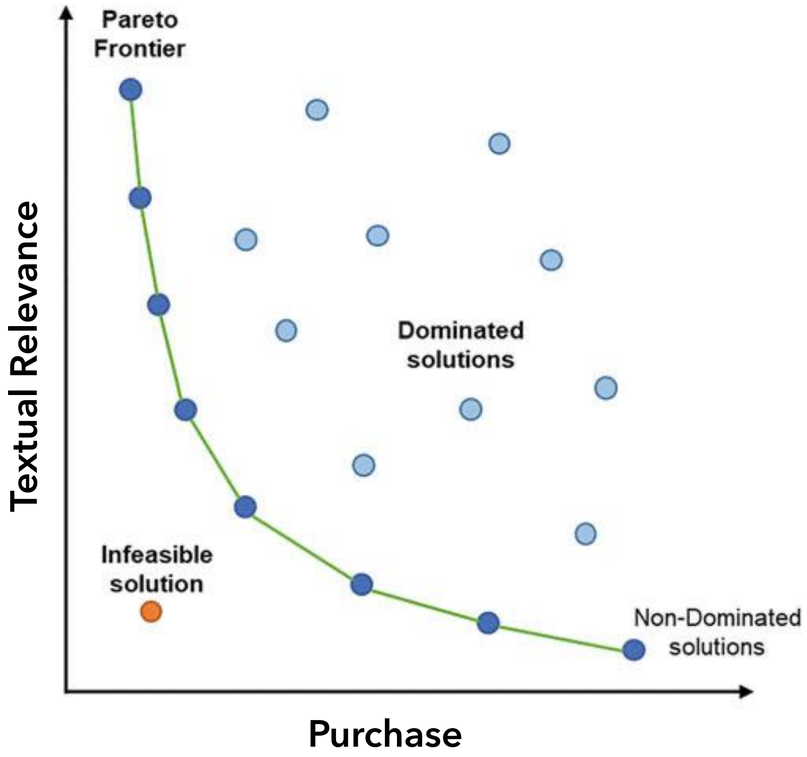


- Click
- Purchase
- **Relevance**
- **Popularity**
- ...

How do we train a model optimized for all these objectives 🤔?

The Reality of Multi-objective Optimization

For multi-objective optimization, there is **no single "best" solution**.
Every solution needs to consider **trade-offs**.
With changing environment, there are **constantly new dimensions** (and trade-offs) to consider.



Multi-objective ranking is a **wicked problem**!

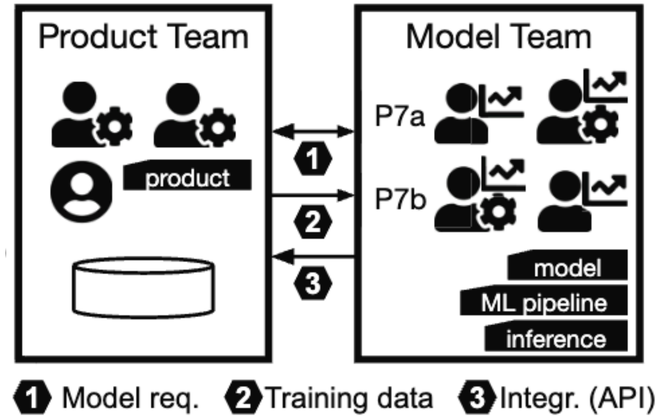
"a wicked problem is a problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize."

https://en.wikipedia.org/wiki/Wicked_problem

Observation #1: Collaboration Challenges

Multi-objective ranking is a wicked problem: **Need to iterate and make trade-offs**.
Product team and **model team** need to **collaborate** to iterate on product rankers, but they speak different languages!

Strong domain knowledge, concrete observations, understand customer experience and needs.
Think about ***examples, observations, user expectations***.



Strong experimentation skills, understand data, model, objectives, and metrics
Think about ***(multi-)objectives, metrics, guardrails***.

Struggle to provide actionable feedback & incorporate feedback!

Nahar, Nadia, et al. "Collaboration challenges in building ml-enabled systems: Communication, documentation, engineering, and process." Proceedings of the 44th international conference on software engineering. 2022.

Observation #1: Collaboration Challenges

With changing environment, there are **constantly new dimensions** (and trade-offs) to consider.
Model team and product team need to collaborate to iterate on product rankers, but they speak different languages!

How to provide a shared language for practitioners to **communicate** 💬 and **collaborate** 🤝?

1 Model req. 2 Training data 3 Integr. (API)

Struggle to provide actionable feedback & incorporate feedback!

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Observation #2: Design & Evaluation Challenges

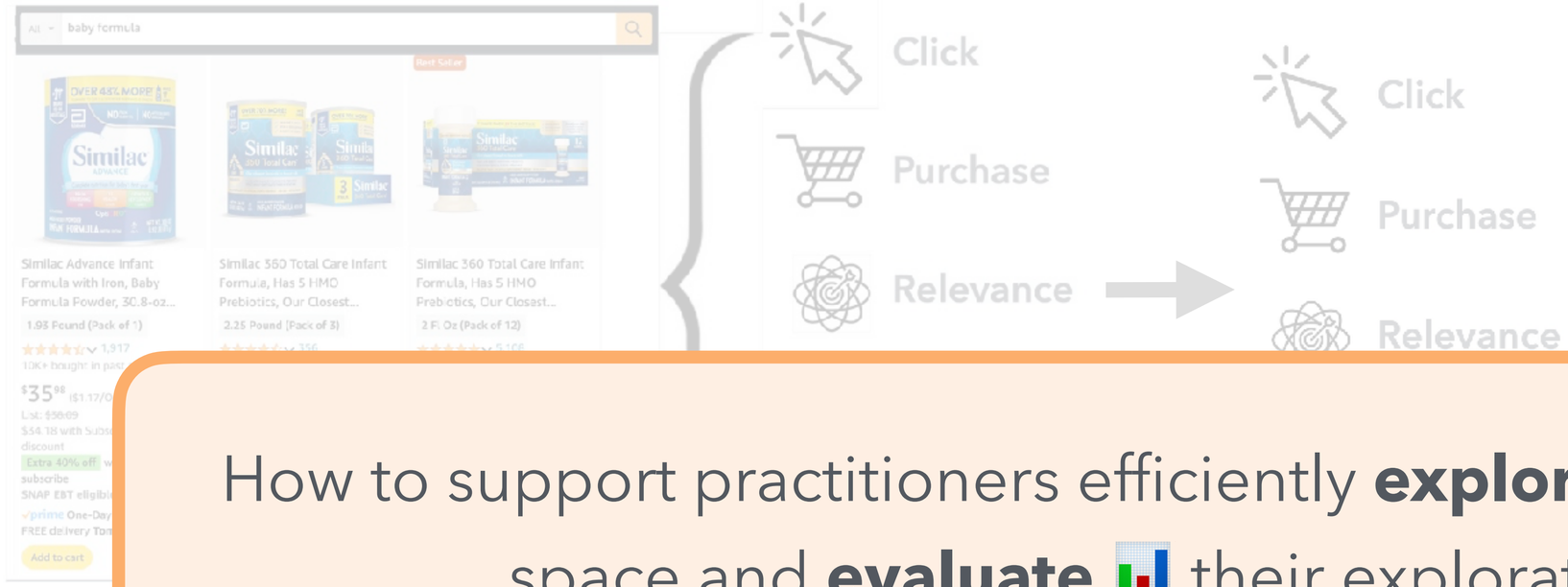
Huge design space to iterate over

Many different potential objectives, and different ways to combine them into the model.

Lots of evaluation information to track

- Aggregated metrics for overall trend
- Individual examples for concrete customer experience
- Data slices for more detailed analysis & refined insights

Observation #2: Design & Evaluation Challenges



How to support practitioners efficiently **explore** 🔍 the design space and **evaluate** 📊 their explorations?

Hug
iterate over

ways to combine them into the model.

Lots of evaluation information to track

- Aggregated metrics for overall trend
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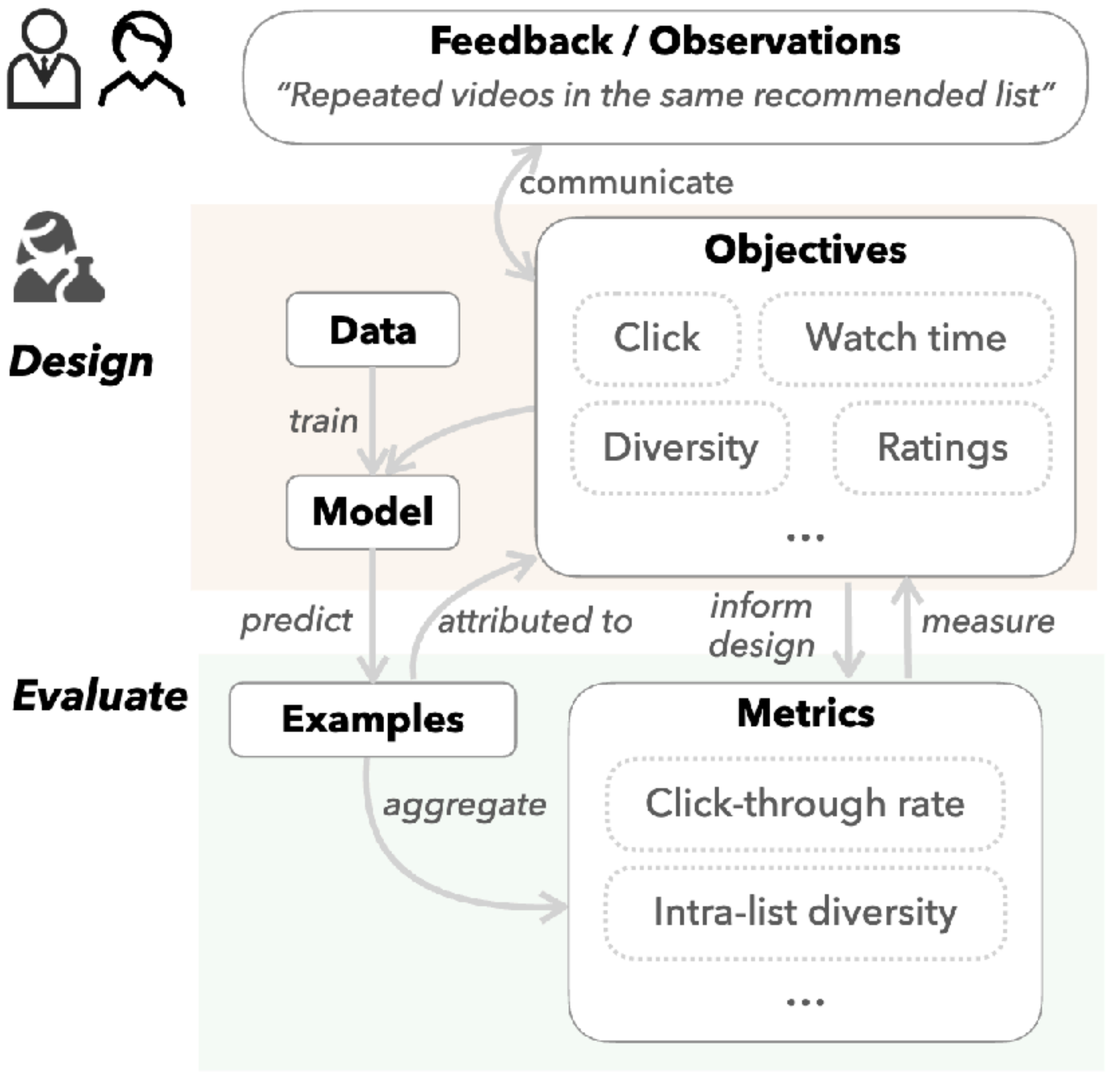
Orbit 💫: A Framework for Designing and Evaluating Multi-objective Rankers

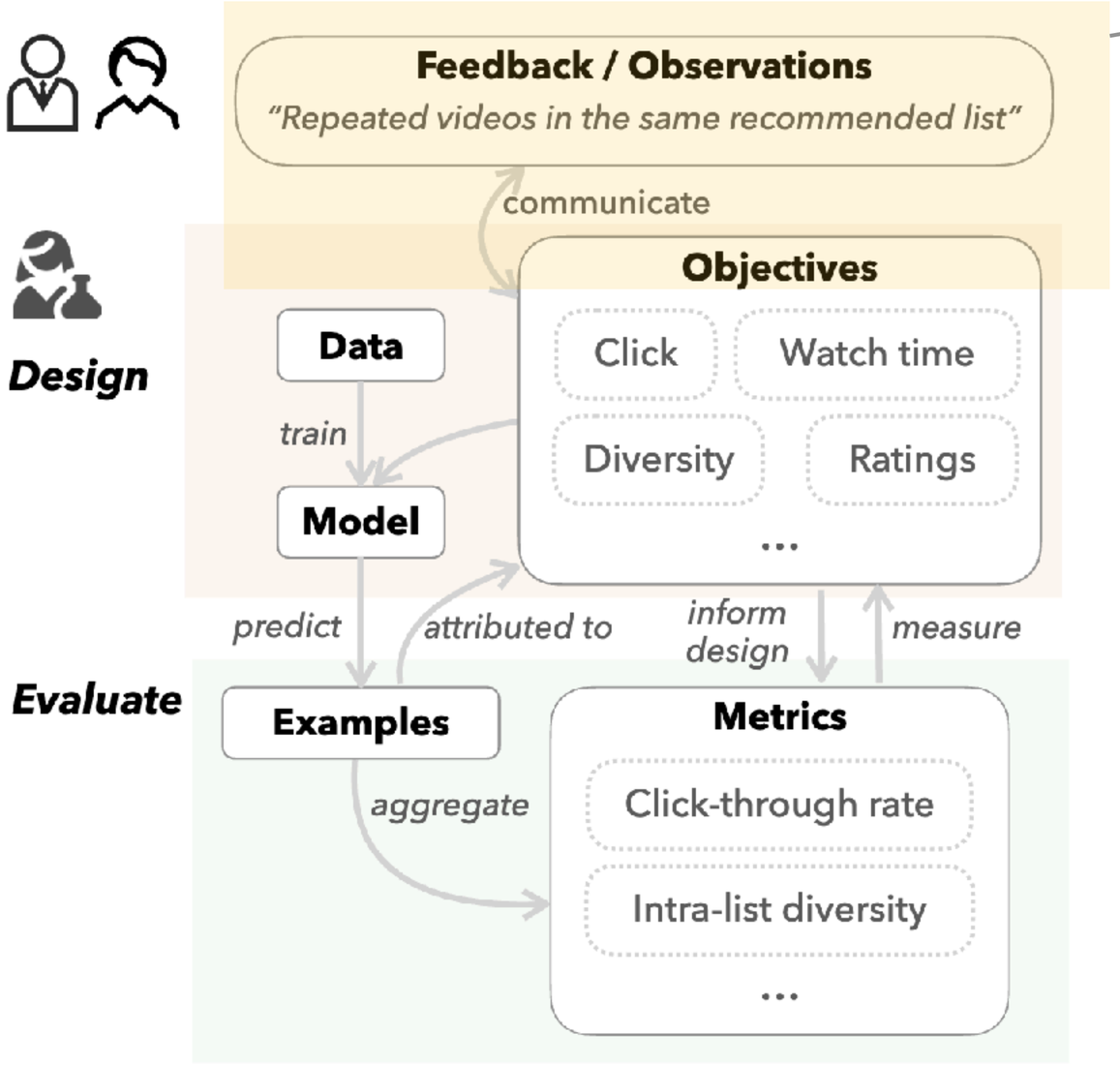
Key idea: Objectives-centric Design & Evaluation



Objectives should be surfaced as the main object for stakeholders to **navigate** through the design space, **communicate** their findings, and **negotiate** over trade-offs.

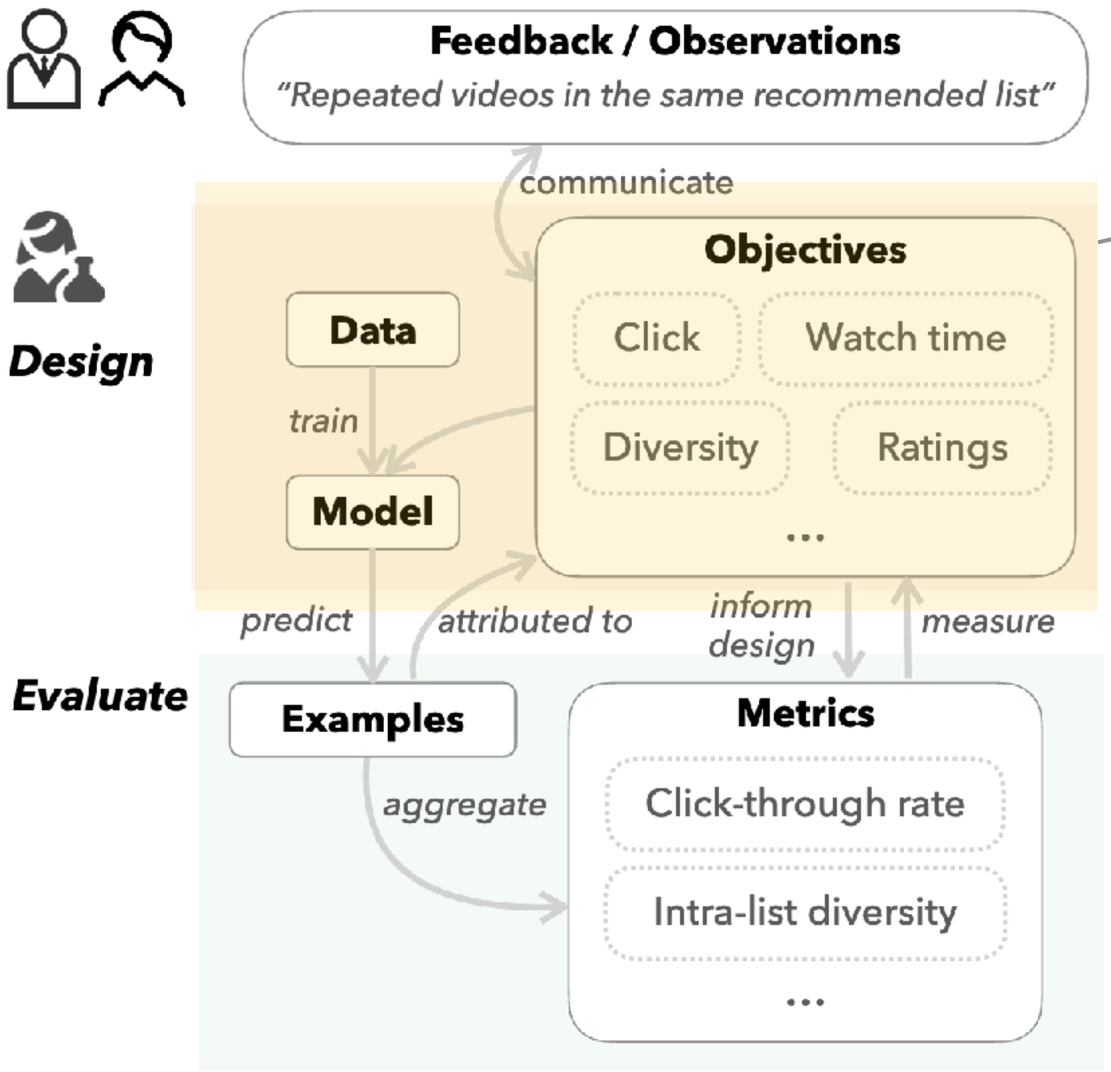
This helps provides **a shared language** and **appropriate guidance** for practitioners.

Key idea: Objectives-centric Design & Evaluation



Objectives encode product requirements.

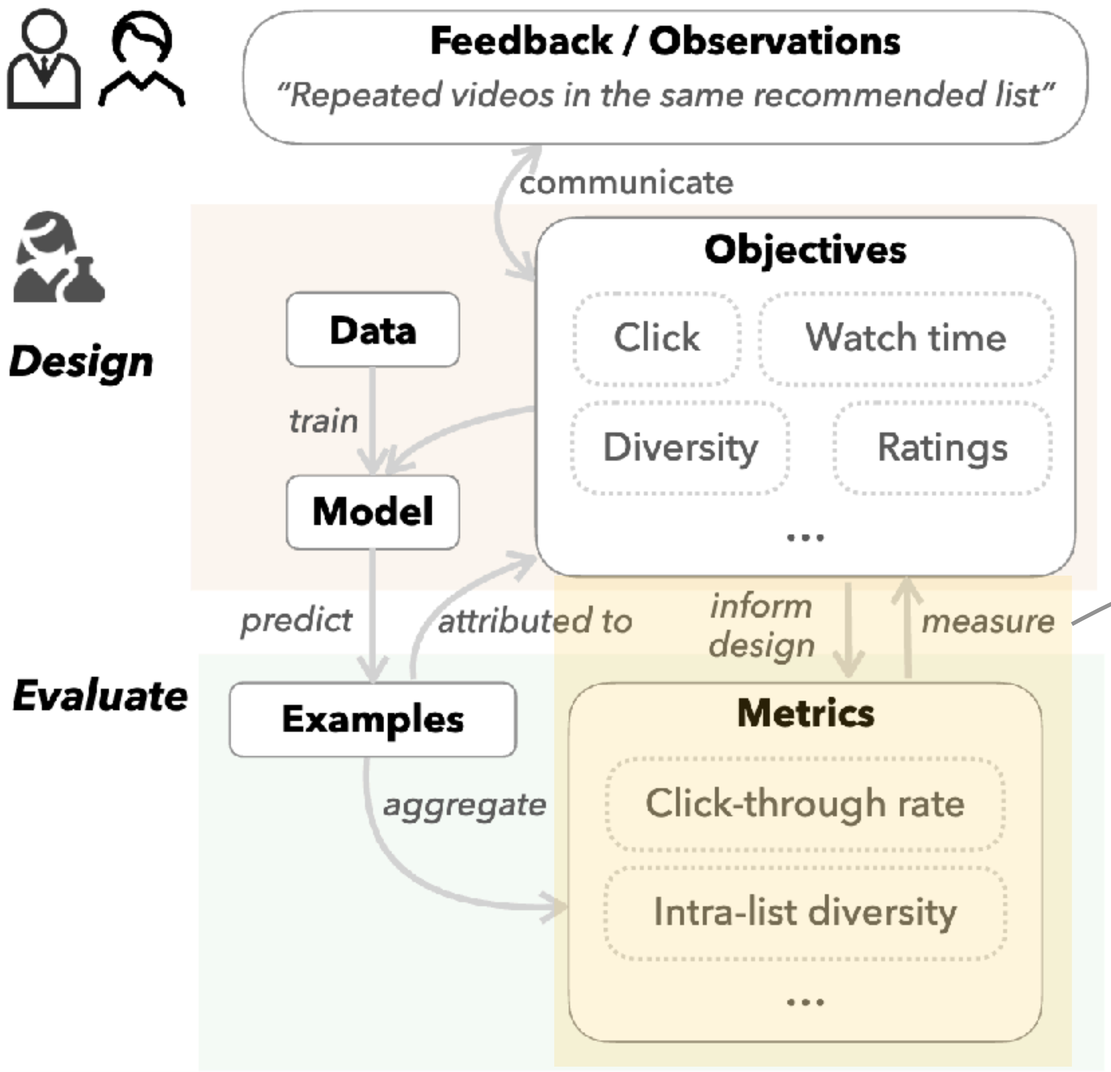
Key idea: Objectives-centric Design & Evaluation



Objectives encode product requirements.

Objectives define model training.

Key idea: Objectives-centric Design & Evaluation

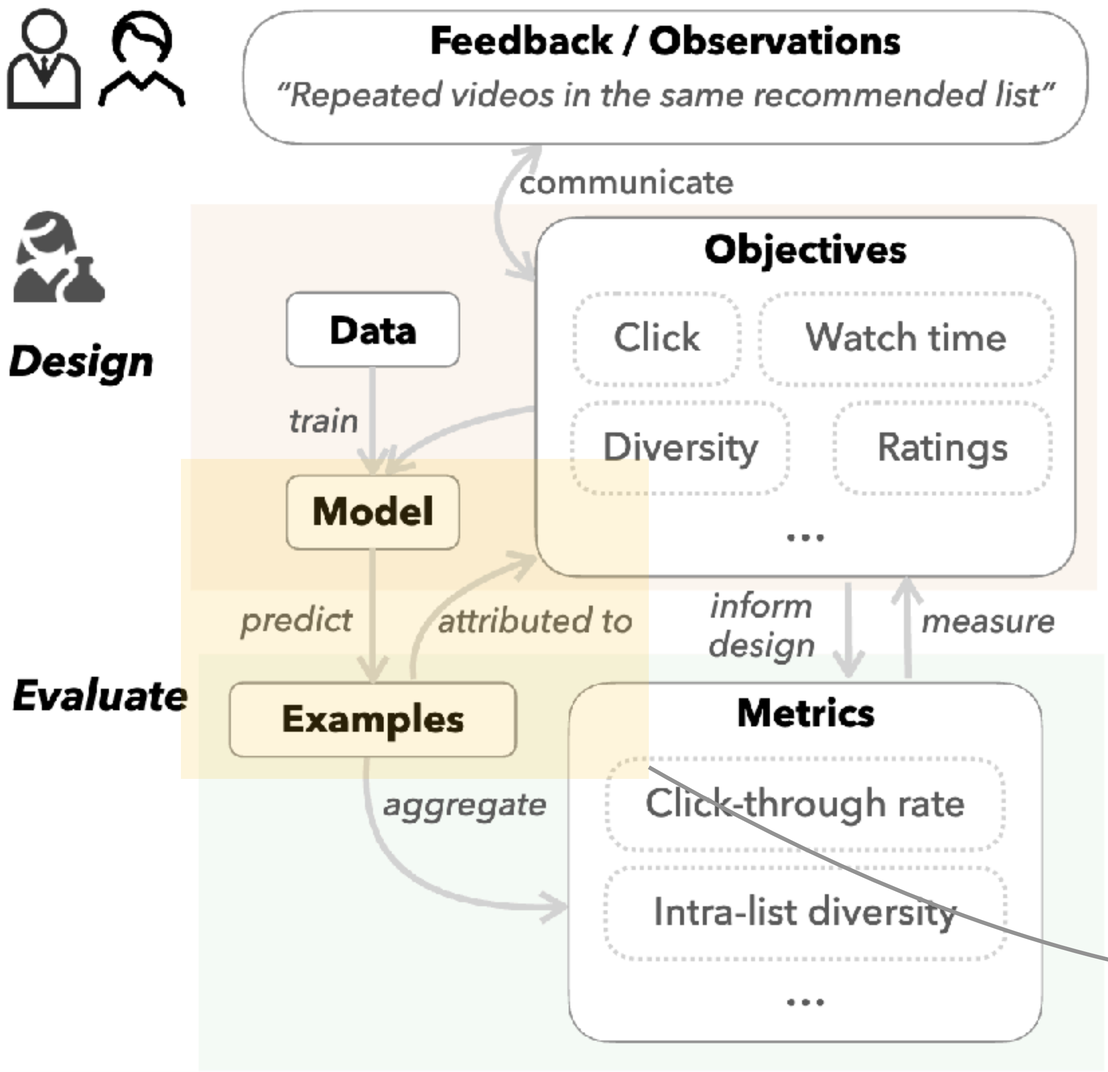


Objectives encode product requirements.

Objectives define model training.

Objectives inform metrics design & tracking.

Key idea: Objectives-centric Design & Evaluation



Objectives encode product requirements.

Objectives define model training.

Objectives inform metrics design & tracking.

Objectives explain concrete observations.

Objectives can be used as boundary objects

Better communication 💬 and collaboration 🤝

"a boundary object is information, such as specimens, field notes, and maps, used in different ways by different communities for collaborative work through scales"

Objectives encode product requirements.

Objectives define model training.

Objectives inform metrics design & tracking.

Objectives explain concrete observations.

- Leigh Star, Susan (2010-09-01). "This is Not a Boundary Object: Reflections on the Origin of a Concept". Science, Technology, & Human Values. 35 (5).
- PAIR Symposium 2020, Ed Chi: A twist on loss functions as boundary objects

Objectives can help navigate design space and forage evaluation information

More efficient exploration 🔍 and more thorough evaluation 📊

- What designs have I explored?
- What should I explore next?
- What metric(s) should I monitor?
- Why is this model design problematic?

Objectives encode product requirements.

Objectives define model training.

Objectives inform metrics design & tracking.

Objectives explain concrete observations.

Orbit 💫
System Walkthrough

Models

T1 × T2 ×

Model A: T1 | Model B: T2

Metric: ndcg_click_prob

Slices

All instances	1.0000 (15,559)	0.9794 (15,559)
30 quart coolers	1.0000 (15)	0.9912 (15)
numerical	1.0000 (3,194)	0.9766 (3,194)

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exact_density +30.70%	0.4953 (15,559)	0.6474 (15,559)

Metadata

keywords

NOT | Search | Aa ab .* | SET

match '2t baby girl toys'

keywords (match '2t baby girl toys') clear all

click | purchase | highly_rated_click | relevant_click

T1

Combined objectives: click * 1

T2

Combined objectives: click * 3 +

relevant_click * 1 +

highly_rated_click * 1

Type a new model name here. '⌘ + ↵' to submit.

2t baby girl toys

RANKING:

1. Disney Toddler Boys' Toy Story Short Sleeve T-Shirt — → ↑2
2. Simple Joys by Carter's Girls' 2-Piece Assorted Rashguard Sets — → ↑2
3. Simple Joys by Carter's Toddler Girls' Pull-On Fleece Pants, Pack of 2 — → ↑2
4. Simple Joys by Carter's Girls' 2-Piece Assorted Rashguard Sets

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RANKING:

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Query Groups Per Page 1 | 1 - 1 of 1

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T1 × T2 ×

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1. Objectives Overview

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Combined objectives: click * 3 +

relevant_click * 1 +

highly_rated_click * 1

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1. Objectives Overview

Drag the objective to apply it.

click_probability

click * 1

T2

Combined objectives: click * 3 +

relevant_click * 1 +

highly_rated_click * 1

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2t baby girl toys

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T1

Combined objectives: click * 1

T2

Combined objectives: click * 3 +

relevant_click * 1 +

highly_rated_click * 1

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Query Groups Per Page 1 — 1 - 1 of 1

2. Qualitative Evaluation

Models

T1 × T2 ×

Model A: T1 | Model B: T2

Metric: ndcg_click_prob

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Metadata

keywords

NOT | Search | Aa ab .* | SET

match '2t baby girl toys'

keywords (match '2t baby girl toys') clear all

click | purchase | highly_rated_click | relevant_click

T1

Combined objectives: click * 1

2t baby girl toys

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T2

Combined objectives: click * 3 | relevant_click * 1 | highly_rated_click * 1

Type a new model name here. '⌘ + ↵' to submit.

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Metadata

keywords

NOT | Search | Aa .ab .* | SET

match '2t baby girl toys'

3. Quantitative Evaluation

keywords (match '2t baby girl toys') clear all

click | purchase | highly_rated_click | relevant_click

T1

Combined objectives: click * 1

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Combined objectives: click * 3 + | relevant_click * 1 + | highly_rated_click * 1

Type a new model name here. '⌘ + ↵' to submit.

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4. Fine-grained Analysis

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T1 × T2 ×

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Metric: ndcg_click_prob

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Metadata

keywords

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match '2t baby girl toys'

keywords (match '2t baby girl toys') clear all

click | purchase | highly_rated_click | relevant_click

T1

Combined objectives: click * 1

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Combined objectives: click * 3

relevant_click * 1

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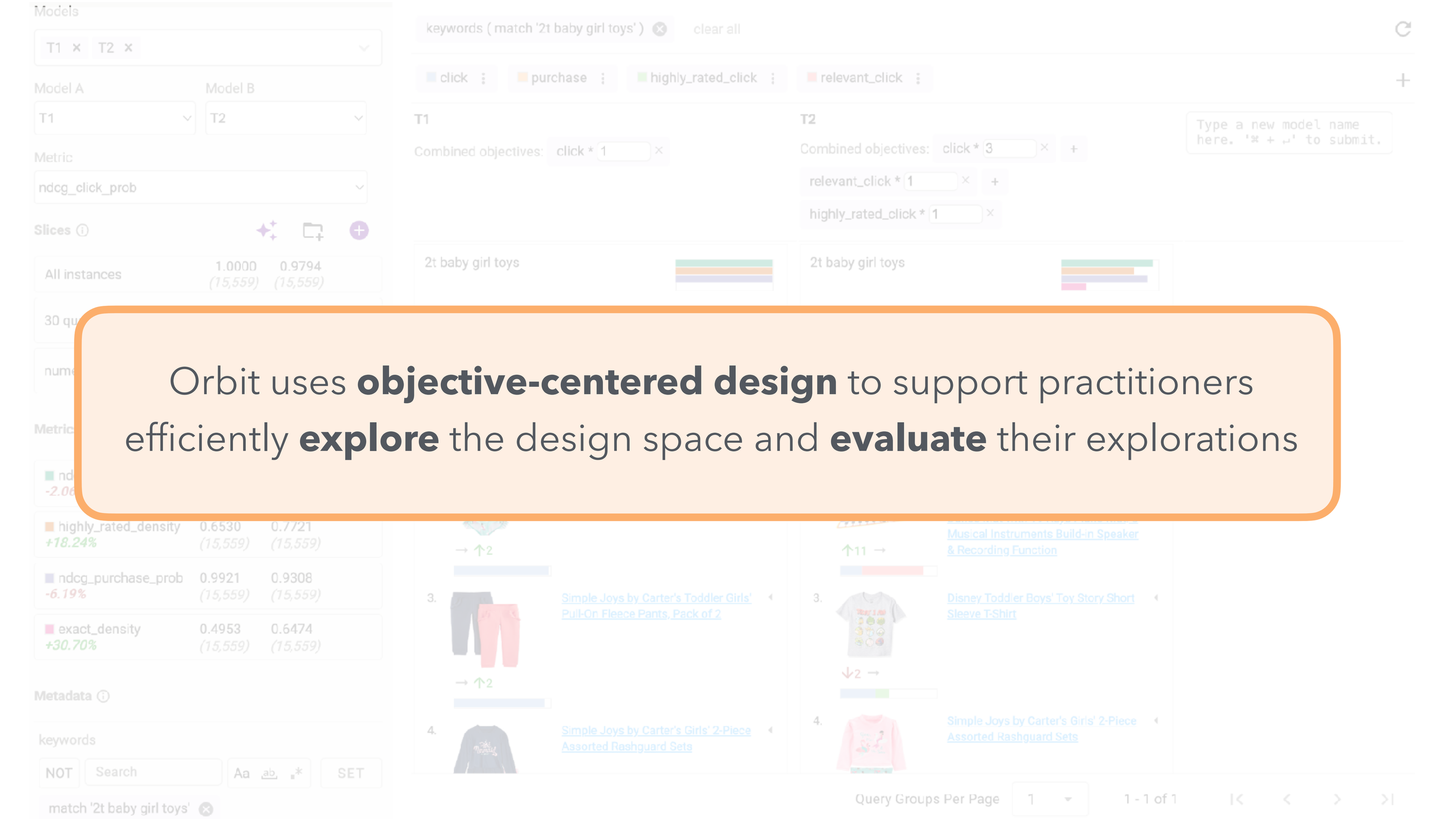
RANKING:

1. ToyVelt Toy Piano for Toddler Girls – Cute Piano for Kids with Built-in Microphone & Music Modes - Best Birthday Gifts for 3 4 5 Year Old Girls – Educational Keyboard Musical Instrument Toys — ↑8 →
2. Toys for 1-6 Year Old Girls Boys Toddlers Infant Kids, Gifts for 1-3 Year Old Boys Girls Piano Music Dance Mat with 19 Keys Piano Mat, 8 Musical Instruments Build-in Speaker & Recording Function — ↑11 →
3. Disney Toddler Boys' Toy Story Short Sleeve T-Shirt — ↓2 →
4. Simple Joys by Carter's Girls' 2-Piece Assorted Rashguard Sets

Query Groups Per Page 1 | 1 - 1 of 1


Orbit uses **objective-centered design** to support practitioners efficiently **explore** the design space and **evaluate** their explorations

Evaluation

We conducted a within-subject controlled experiment (N=12) with industry practitioner to see whether Orbit helps users…

- Explore the design space more efficiently
- Make more informed decisions
- Consider and communicate tradeoffs

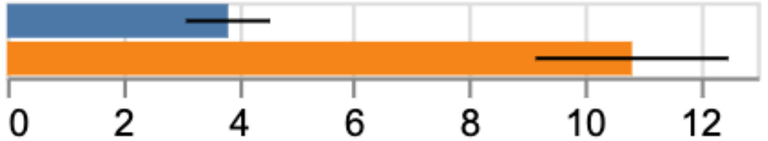
Orbit helps explore the design space more efficiently

vs. Exploring objective design in computational notebooks, Orbit…

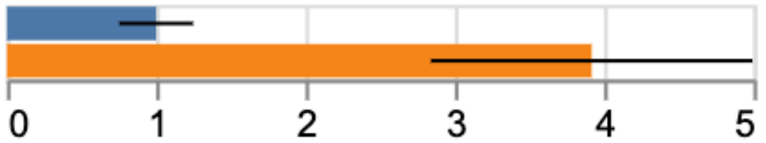
Objective-centric interface design

Explore more designs (+183%)

Bigger changes in exploration (+292%)



number of exploration



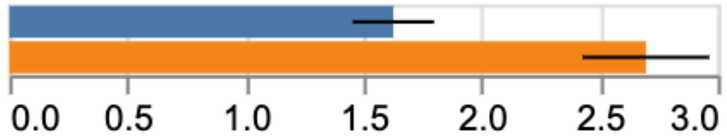
number of large changes

Orbit helps users make more informed decisions

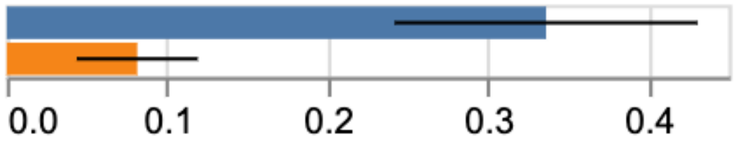
vs. Evaluating objective design in computational notebooks, Orbit…

Gathered quan & qual eval results

More distinct evaluations (+66%)
More balanced evaluations (76% closer to uniform)



number of eval per exploration



KL-divergence from uniform dist.

Orbit encourages users to communicate tradeoffs

vs. Objective design in computational notebooks, Orbit…

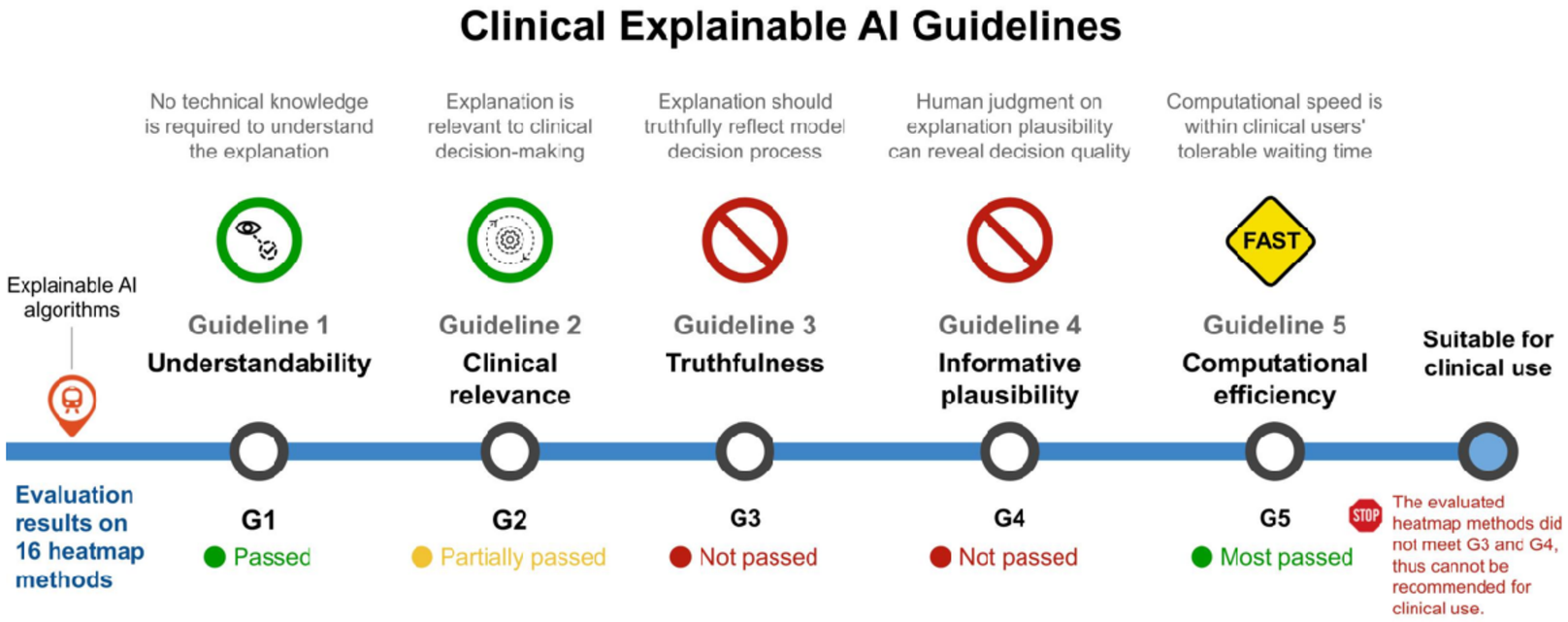
Explicated objective design space

More thorough thinking over trade-offs (+8.6%)

*"There exists **trade-off between objectives** such as popularity and exact… the weights/objectives suits for keywords with quantities may not perform good on the overall instances" (P5)*

Future Directions: Beyond Multi-objective Ranking

Many ML problems are also multi-objectives – how do we help practitioners think about trade-offs and navigate thorough the design space?



LLM Criteria

Simplicity

Does the example use only simple language by avoiding complex words/sentences, and presents situations or actions that a young child would be able to relate to?

Faithfulness

The summary is devoid of factual errors, where a factual error is a statement that contradicts the source document, or is not directly stated, heavily implied, or logically entailed by the source document.

Takeaways

The Reality of Multi-objective Optimization

For multi-objective optimization, there is **no single "best" solution**.
Every solution needs to consider **trade-offs**.
With changing environment, there are **constantly new dimensions** (and trade-offs) to consider.

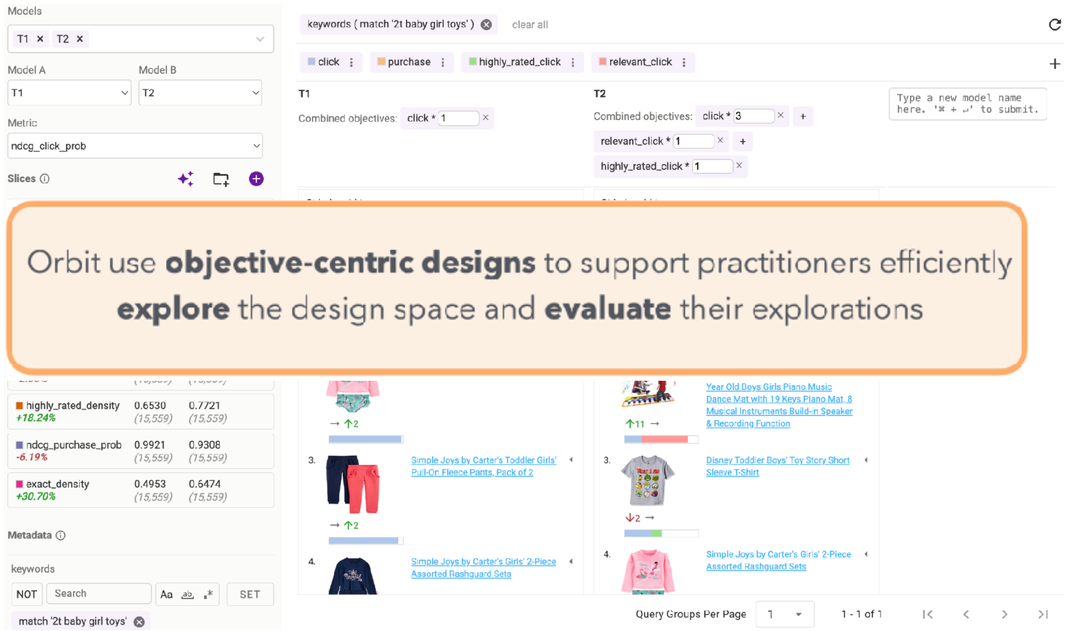
How to support model team and product team **communicate** 💬 and **collaborate** 🤝?

How to support practitioners efficiently **explore** 🔍 the design space and **evaluate** 📊 their explorations?

Our user study shows Orbit is effective to

- Explore the design space more efficiently
- Make more informed decisions
- Consider and communicate tradeoffs

Key idea: Objectives-centric Design & Evaluation



Orbit use **objective-centric designs** to support practitioners efficiently **explore** the design space and **evaluate** their explorations

Check out our paper!

amazon Carnegie Mellon University