

Media
Informatics
Group

The Impact of Expertise In the Loop for Exploring Machine Rationality

Changkun Ou, Sven Mayer, Andreas Martin Butz

Media Informatics Group

LMU Munich

ACM Intelligence User Interfaces 2023

Session 4

March 29, Sydney, Australia

Motivation

Human-in-the-Loop (HITL) Optimization Systems

A human-in-the-loop optimization system refers systems or processes that involves an **underlying optimization** process **towards** user **expectation** or preference.



Human-in-the-Loop (HITL) Optimization Systems

A human-in-the-loop optimization system refers systems or processes that involves an **underlying optimization** process **towards** user **expectation** or preference.

Examples

Text Summarization [Simpson et al. 2020]

Photo Color Enhancement [Koyama et al. 2016]

Melody composition [Zhou et al. 2021]

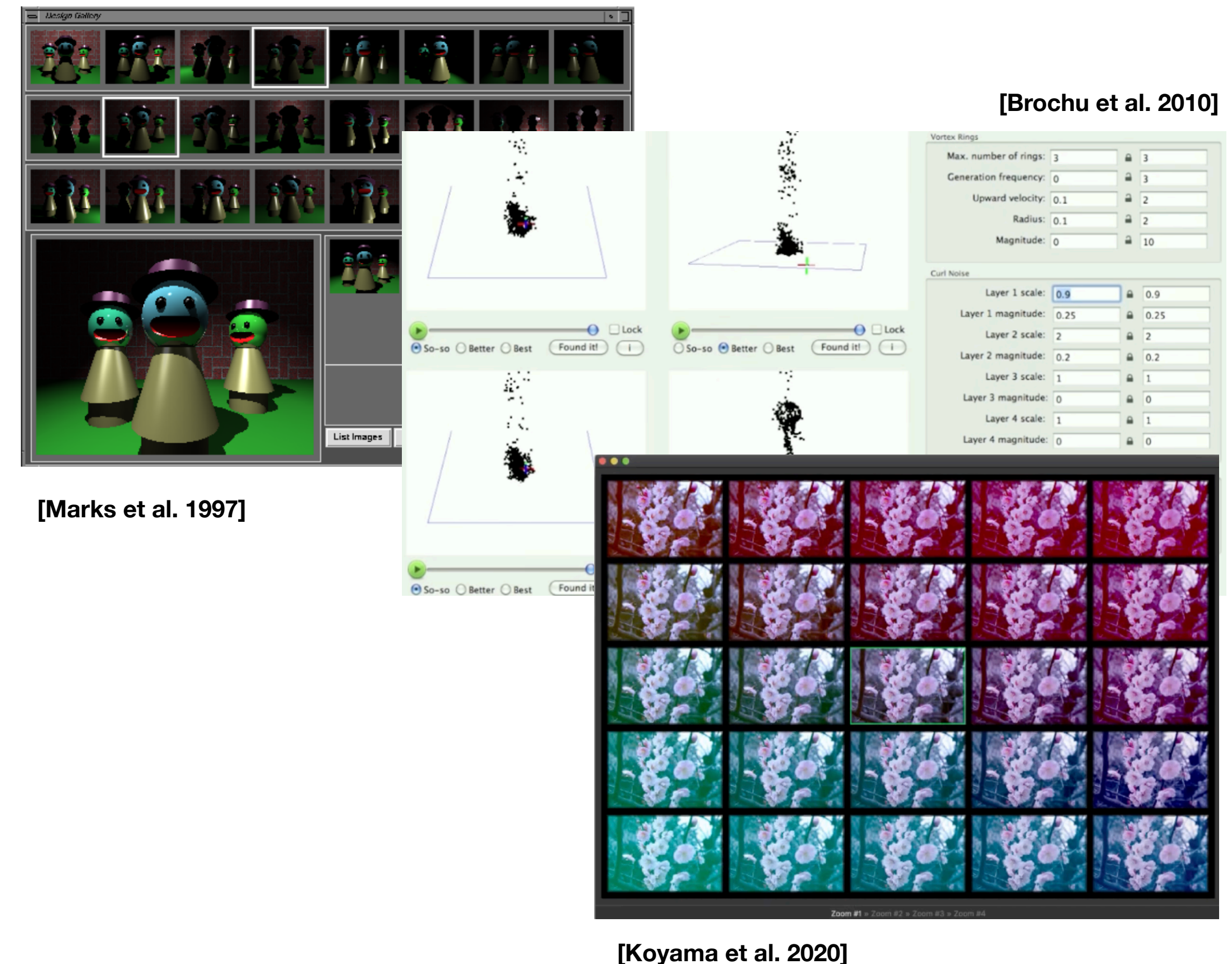
Meshing [Ou et al. 2022]

Material design [Brochu et al. 2007]

Animation [Brochu et al. 2010]

Illumination [Marks et al. 1997]

...



Research Questions and Hypothesis

Observations:

1. Problem context, unstable preference objectives can lead to non-satisfactory results
2. Prior HITL optimization systems are mostly evaluated on novice users and rarely report on the effect of user expertise
3. Prior HITL optimization systems are evaluated based on subjective responses

Research Questions and Hypothesis

Observations:

1. Problem context, unstable preference objectives can lead to non-satisfactory results
2. Prior HITL optimization systems are mostly evaluated on novice users and rarely report on the effect of user expertise
3. Prior HITL optimization systems are evaluated based on subjective responses

RQs:

What is the objective impact of involved expertise on the system outcomes?

What is the subjective impact of involved expertise on user satisfaction?

Research Questions and Hypothesis

Observations:

1. Problem context, unstable preference objectives can lead to non-satisfactory results
2. Prior HITL optimization systems are mostly evaluated on novice users and rarely report on the effect of user expertise
3. Prior HITL optimization systems are evaluated based on subjective responses

RQs:

What is the objective impact of involved expertise on the system outcomes?

What is the subjective impact of involved expertise on user satisfaction?

Hypothesis:

Using higher expertise leads to better results in HITL optimization

User Study

User Study and Workflow

Task:

Fill beginning survey, providing feedback to the AI results; inspect improved results; loop until satisfaction, and fill ending survey

User Study and Workflow

Task:

Fill beginning survey, providing feedback to the AI results; inspect improved results; loop until satisfaction, and fill ending survey

Selection Criteria:

- A task should partially involve rational, objective judgment, and subjective components.
- Each domain requires different levels of human expertise

User Study and Workflow

Task:

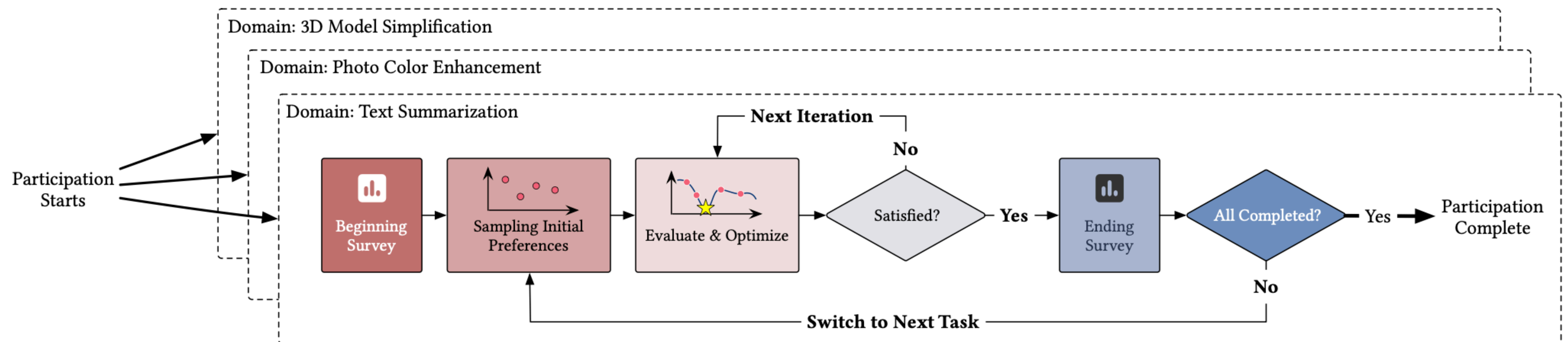
Fill beginning survey, providing feedback to the AI results; inspect improved results; loop until satisfaction, and fill ending survey

Selection Criteria:

- A task should partially involve rational, objective judgment, and subjective components.
- Each domain requires different levels of human expertise

Participants (N=60)

3 selected domains. 20 for each domain, 31 female, 29 male, no diverse; age M=26.92, range 19-52



Apparatus: Text Summarization

Pre-trained BART model, fine-tuned for CNN, nucleus sampling

4 adjustable hyper parameters

- Summarization ratio
- Length penalty
- top-p
- temperature

Provide feedback using the ranking interface about summarized text to archive these objectives:
Objective 1: Let AI summarize the article as much as possible
Objective 2: Preserve the meaning of the original article

Original News Article

Lionel Messi scored for the sixth game in a row as Barcelona defeated big-spending Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Messi (left) is congratulated by Ronaldinho after scoring again in Barcelona's 3-0 win over Atletico Madrid. Barcelona had thumped Atletico 6-0 on their own ground last season and the visitors were out for revenge -- but conceded twice in four minutes. After 15 minutes, Italian goalkeeper Christian Abbiati let a routine Messi cross slip out of his hands and Deco rolled home into the empty net. Four minutes later Messi played a great one-two with Ronaldinho and rifled a shot past Abbiati for his sixth goal of the season and Xavi added a third late on. "It was a deserved victory against a rival that we have had problems with in the past," explained Barca coach Frank Rijkaard. "We scored twice in quick succession and then we controlled the match using aggression and with the team attacking and defending as a unit." "Conceding two early goals inside four minutes is not easy to turn around especially against Barcelona," admitted Atletico coach Javier Aguirre. It was Barcelona's fourth straight league win but they still trail Real Madrid by two points after the champions beat

Total: 462 words

AI Summarized Article A

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth goal of the season for the Catalan giants. Real Madrid beat Recreativo Huleva 2-0 in a last minute to keep Real two points clear. Real's first-ever league win since 1991 as Real Madrid make their best start since 1991.

AI Summarized Article B

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth goal of the season for the Catalan giants. Real Madrid beat Recreativo Huleva 2-0 in their La Liga clash to stay two points clear of Real. Real's Gonzalo Higu

AI Summarized Article C

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth goal of the season for the Catalan giants. Real Madrid beat Recreativo Huleva 2-0 in their La Liga clash to stay two points clear of Real. Real's Gonzalo Higuain scores late winner to keep Real two points behind Real Madrid at the top.

AI Summarized Article D

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth goal of the season for the Catalan giants. Real Madrid beat Recreativo Huleva 2-0 in a last minute to keep Real two points clear. Real's Abel Resino becomes first Spanish league coach to be sacked this season.

Drag and drop the following boxes to rank AI optimized results.

☐ ☒ B ☐ ☐

Excellent

☒ C ☐ Good

☒ A ☐ Fair

☐ Poor

☐ Terrible

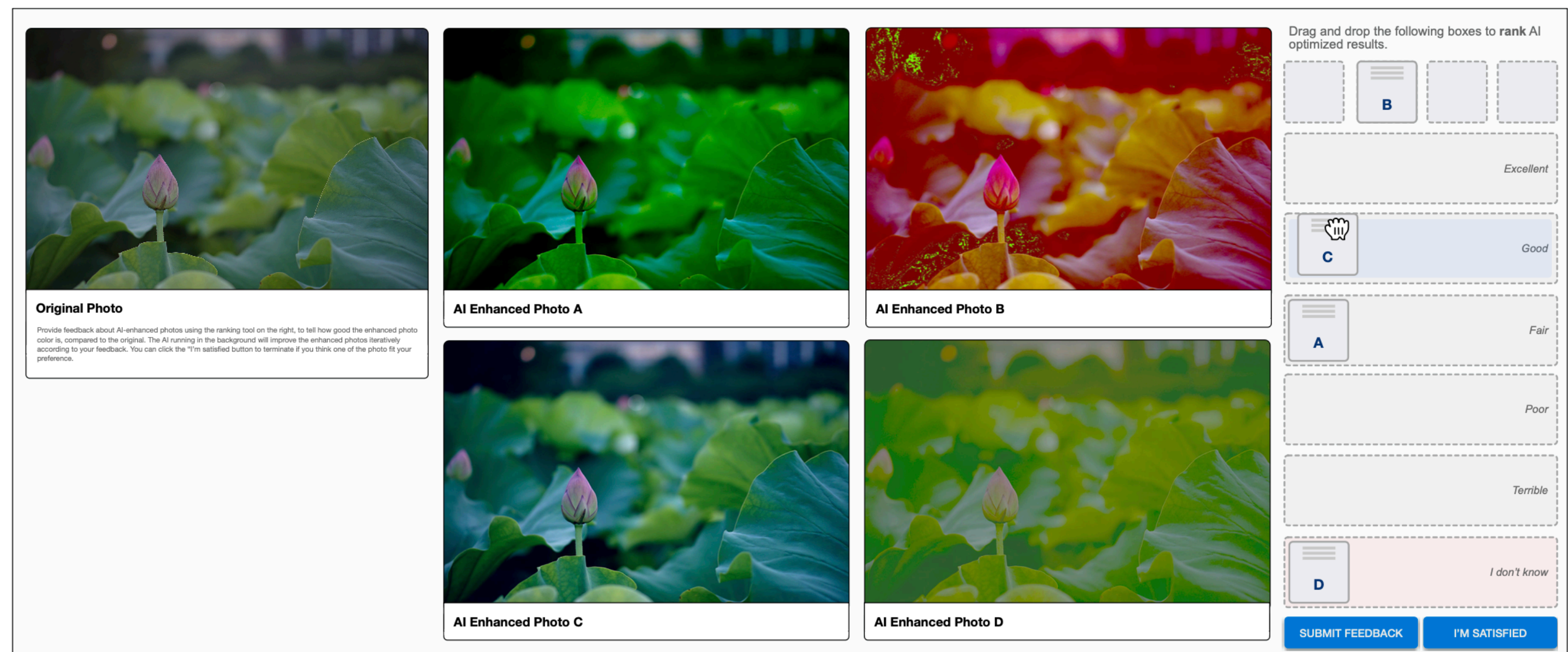
☒ D ☐ I don't know

Apparatus: Photo Color Enhancement

A parameterized photo color enhancer [Koyama et al. 2016, 2017, 2020]

4 adjustable hyper parameters

- Brightness
- Contrast
- Saturation
- Temperature

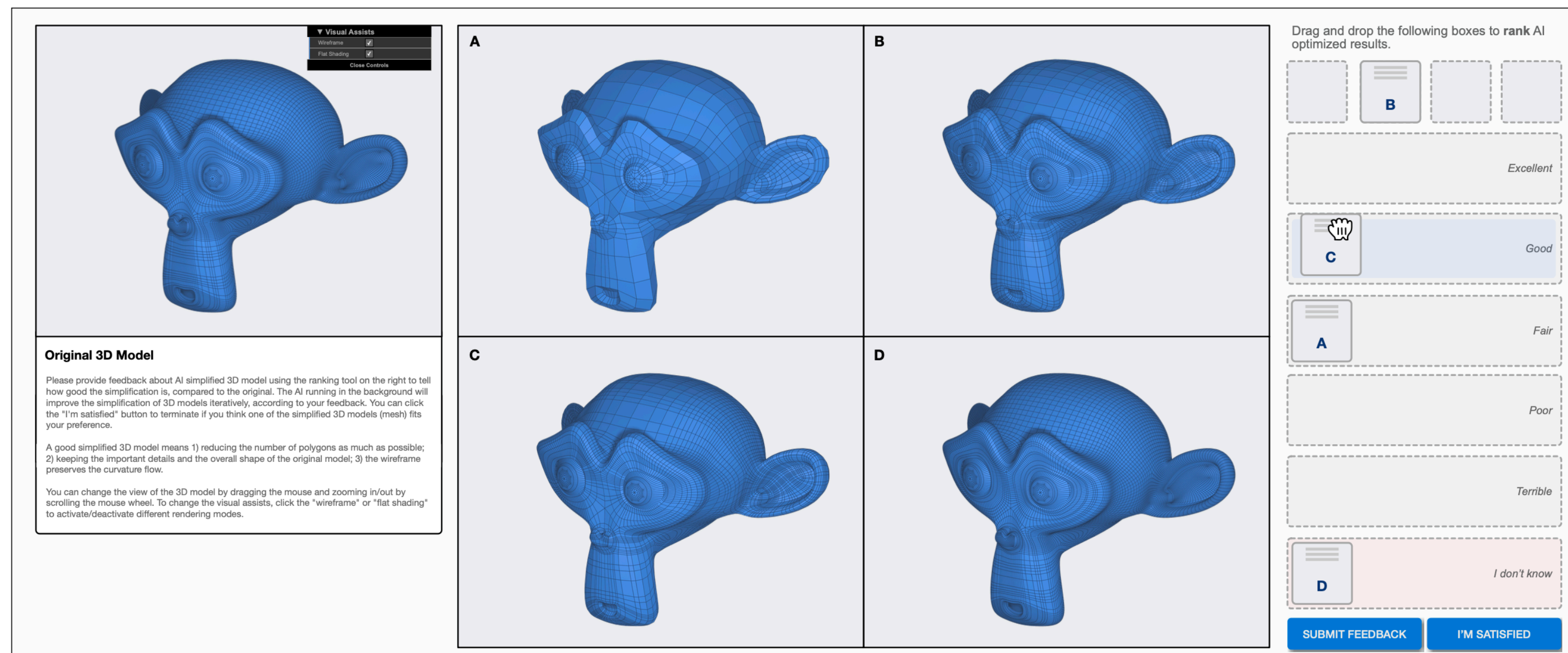


Apparatus: 3D Model Simplification

A parameterized 3D mesh simplifier [Ou et al. 2022]

5 adjustable hyper parameters

- Simplification ratio
- Border preservation
- Hard edge preservation
- Sharpness preservation
- Quadrilateral preservation



Apparatus: Bayesian Optimizer

Based on Expected Utility Bayesian Optimization [Lin et al. 2022]

Modified to fit objects ranking optimization

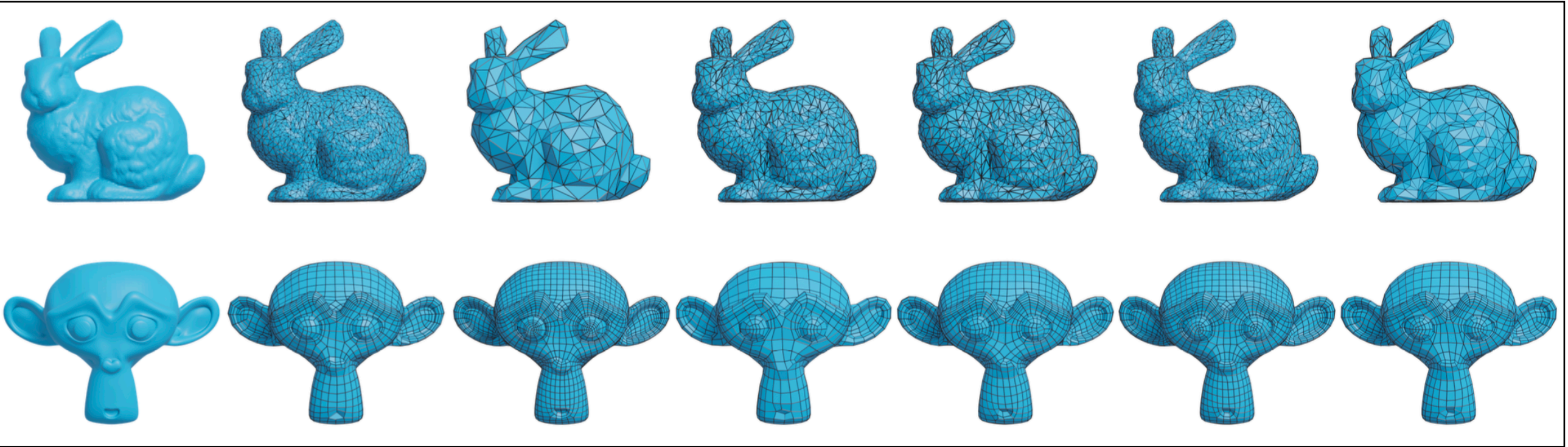
Barcelona beat Atletico Madrid 3-0 to remain in touch with Real Madrid in La Liga. Lionel Messi and Deco score for Barca in Barca's fourth straight league win against big-spending rivals. Real keep pace at top of table after second straight league victory at Recreativo H

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Real beat Recreativo Huleva 2-0 and Real Madrid beat Real 2-1 to stay two points clear of Real. Real's first-half goalscorer Gonzalo Higuain scores in the dying minutes to keep Real two points behind Real

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Real beat Recreativo Huleva 2-0 and Real Madrid beat Real 2-1 to stay two points clear of Real. Real's first-half goalscorer Gonzalo Higuain scores in the dying minutes to keep Real two points behind Real

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth successive goal of the season as Barcelona beat big-spending Atletico. Real Madrid beat Recreativo Huleva 2-0 in La Liga to keep Real two points clear

Barcelona beat Atletico Madrid 3-0 to stay in touch with Primera Liga leaders Real Madrid. Lionel Messi scores sixth successive goal of the season as Barcelona win 4th straight league game. Real Madrid beat Recreativo Huleva 2-0 and Gonzalo Higuain scored in the dying minutes. Real have made their best start since 1991 but coach Bernd Schuster's rotation policy questioned.



Example outcomes

Evaluation & Results

Evaluation Methodology

Machine performance

Objective outcome quality measures

BLEU, ROUGE; HSV, YUV; SSIM/PSNR, Jacobian Cell, Chamfer Distance

Optimizer measures

Posterior mean of the estimated ranking utility

User performance

Interaction behavior measures

decision time, iterations, incomplete/indifference preference, ranking interactions

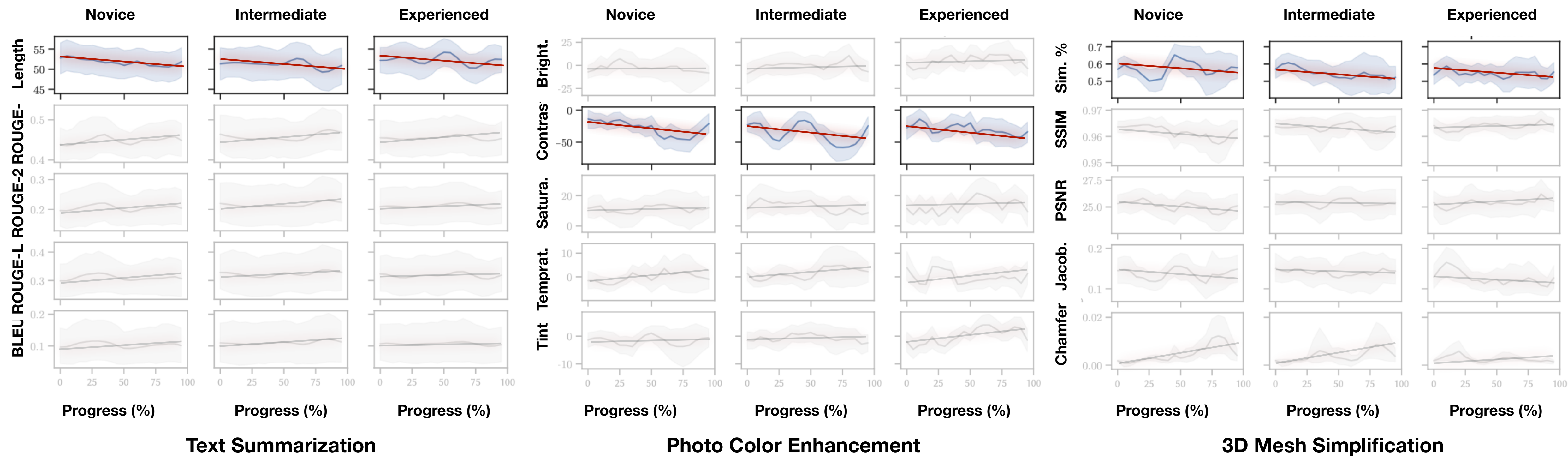
Expertise measures, hindsight questionnaire measures

years of expertise, subjective satisfaction

Quantile-based discretization* (relative expertise)

Machine Performance: Objective Outcome Quality

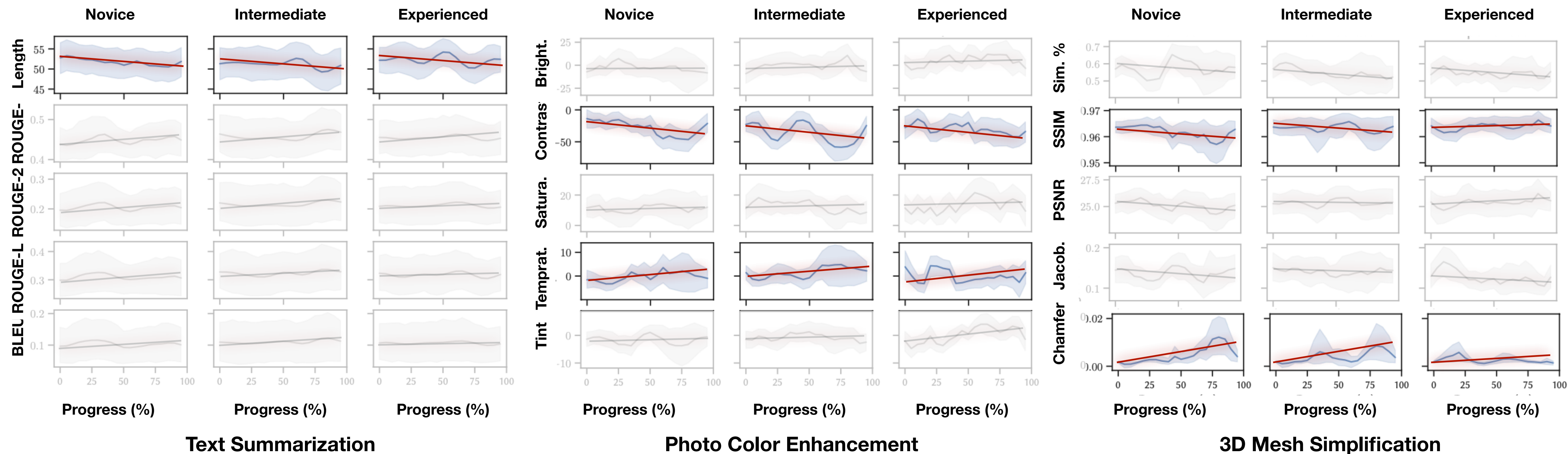
Novices and intermediates can reach expert level performance



Machine Performance: Objective Outcome Quality

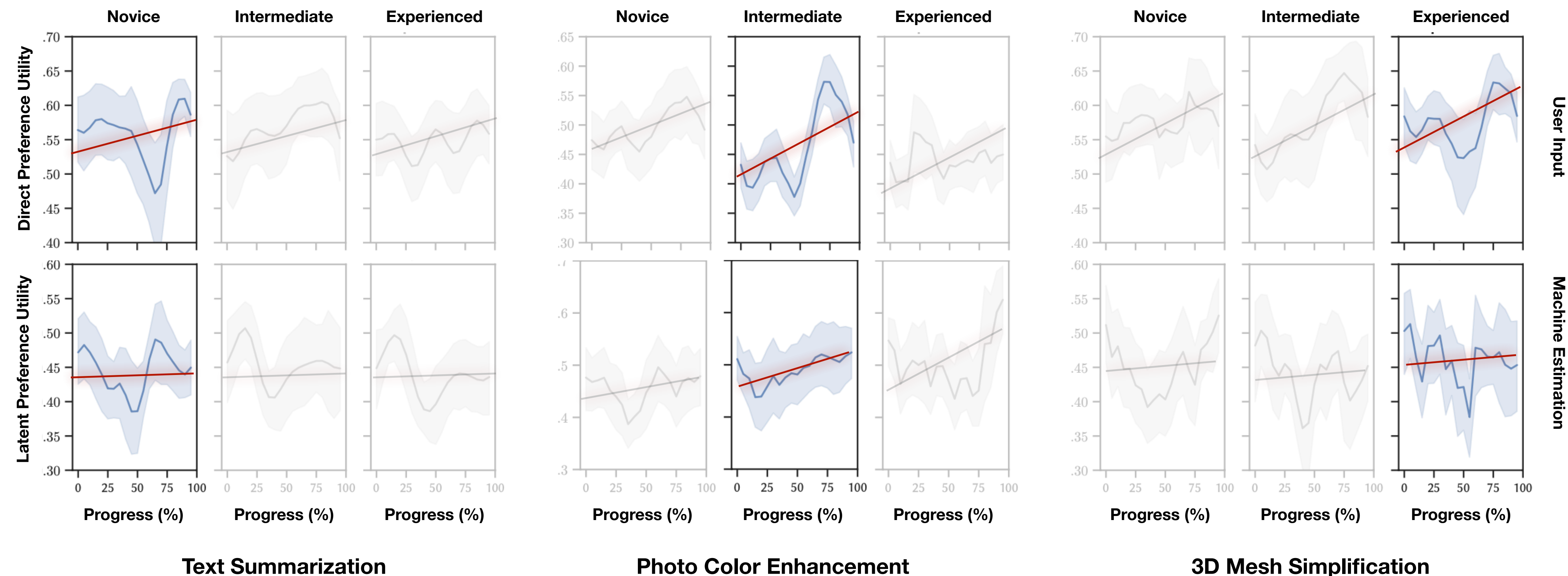
Novices and intermediates can reach expert level performance

The effect of iteration was statistically significant for at least one objective



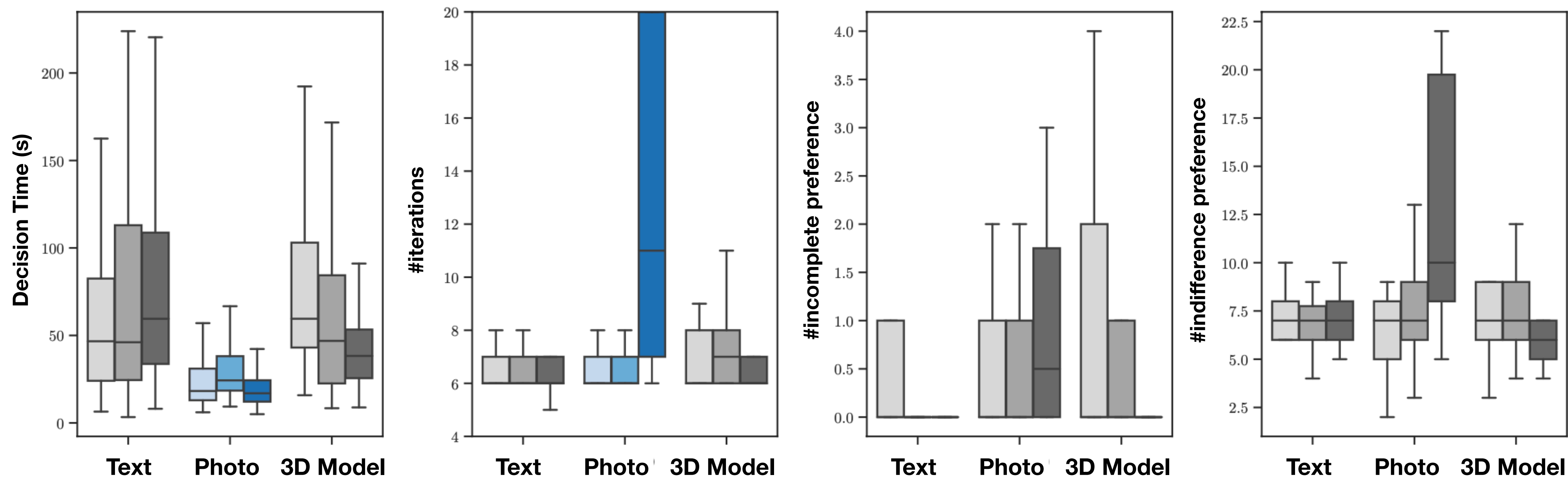
Machine Performance: Direct/Latent Utility

Direct preference utility matches latent preference utility



User Performance: Interaction Behavior

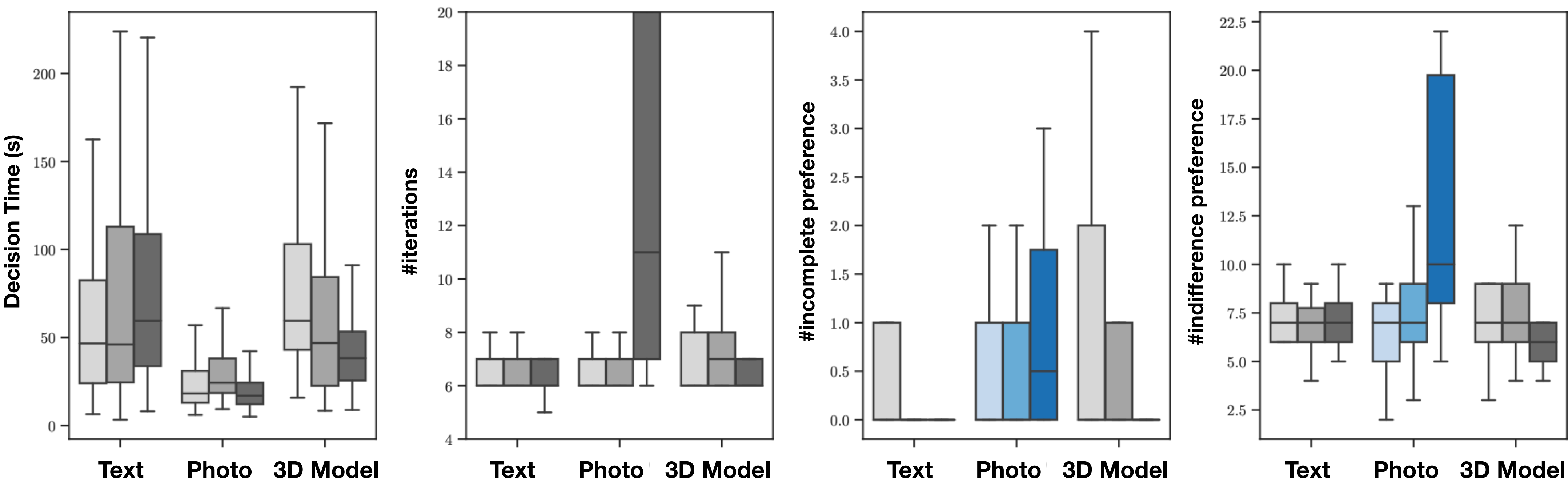
Experienced participants explore solutions more when feedback loop is more efficient



User Performance: Interaction Behavior

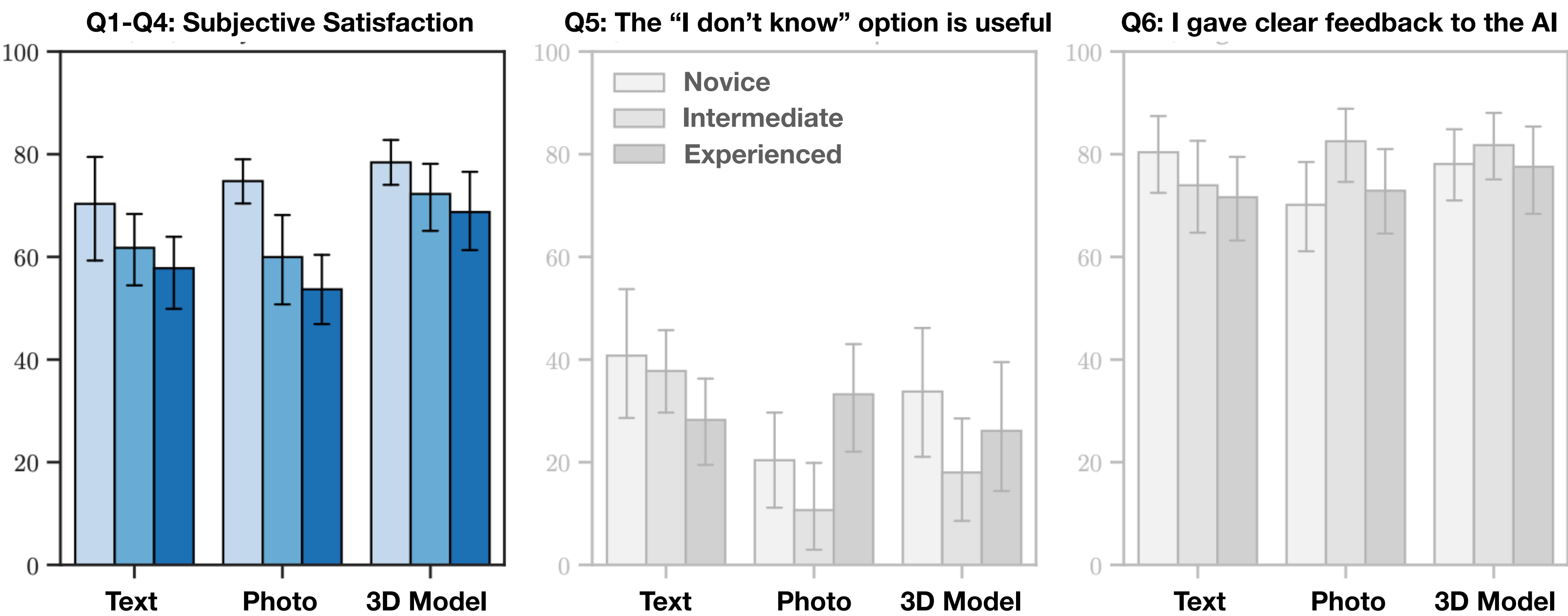
Experienced participants explore solutions more when feedback loop is more efficient

Experienced participants indicate clearer preference by showing more incomplete/indifference preference



User Performance: Subjective Satisfaction

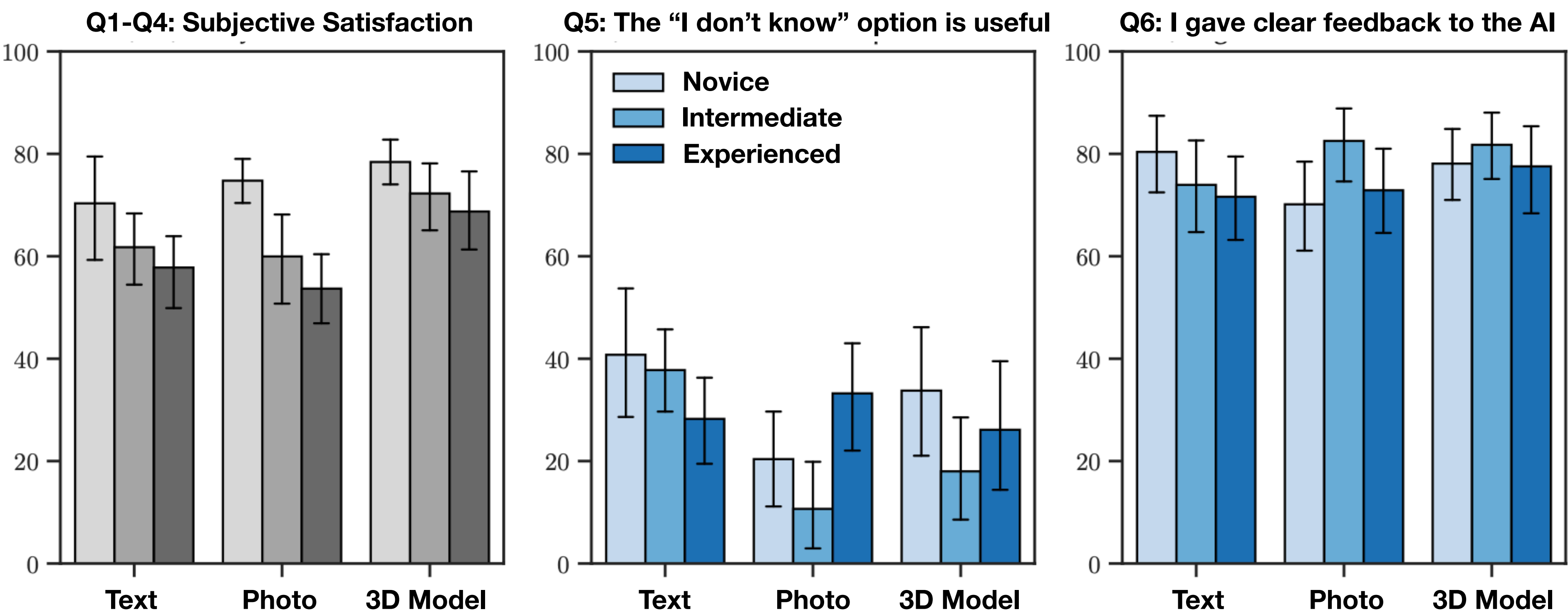
Instead, novices are significantly **more satisfied** than experienced ones



User Performance: Subjective Satisfaction

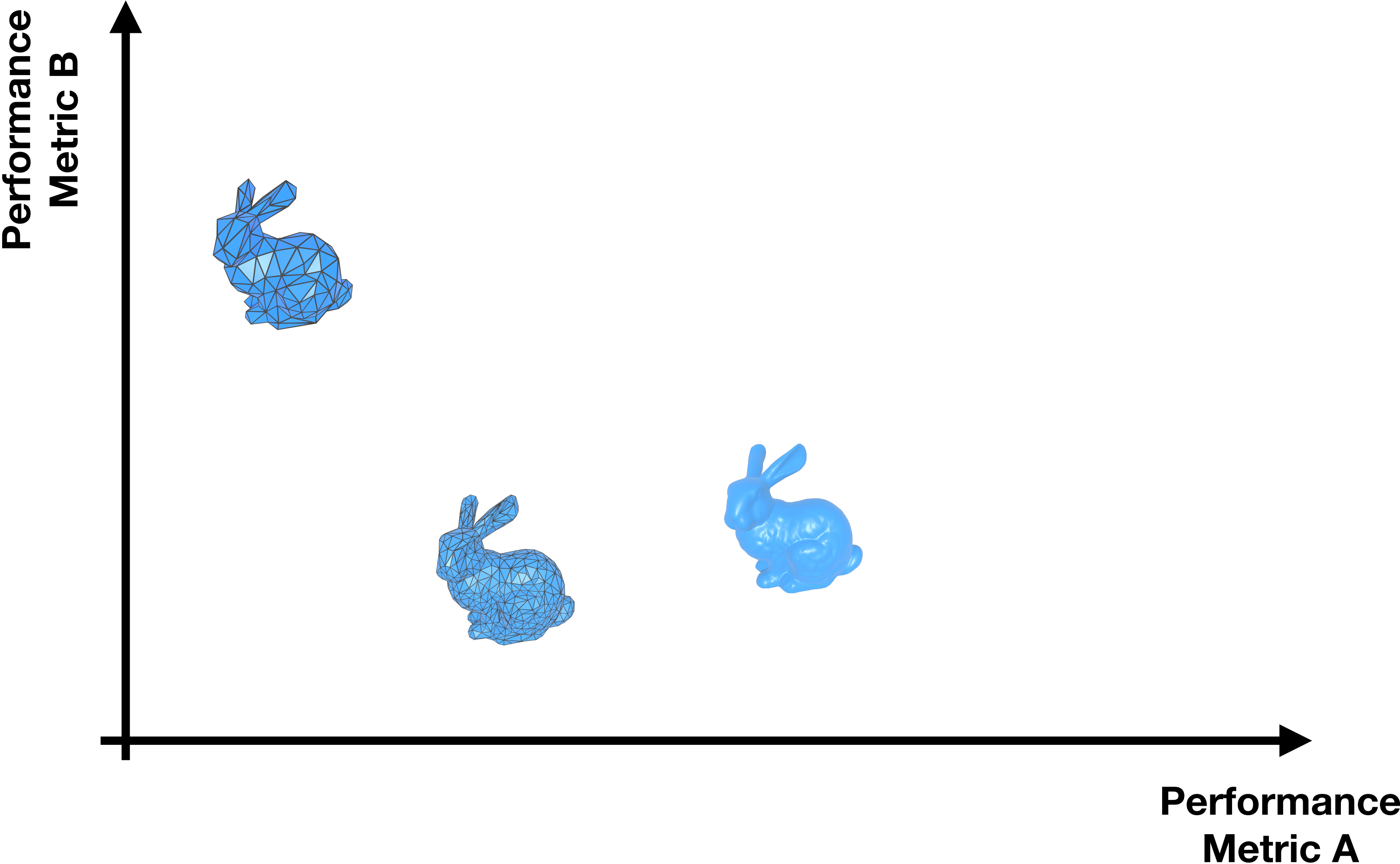
Instead, novices are significantly more satisfied than experienced ones

All participants consider they gave **clear feedback**

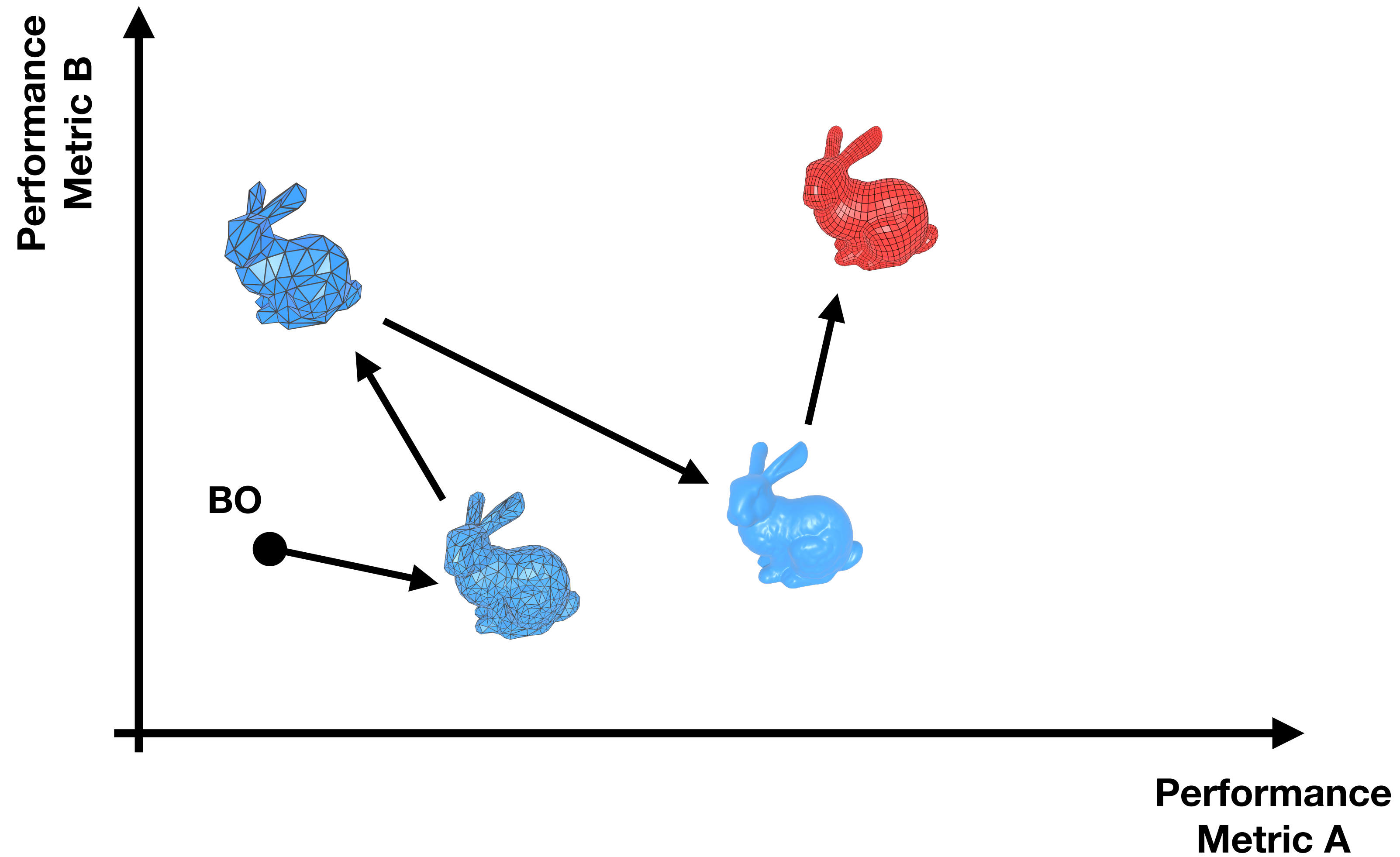


Implications

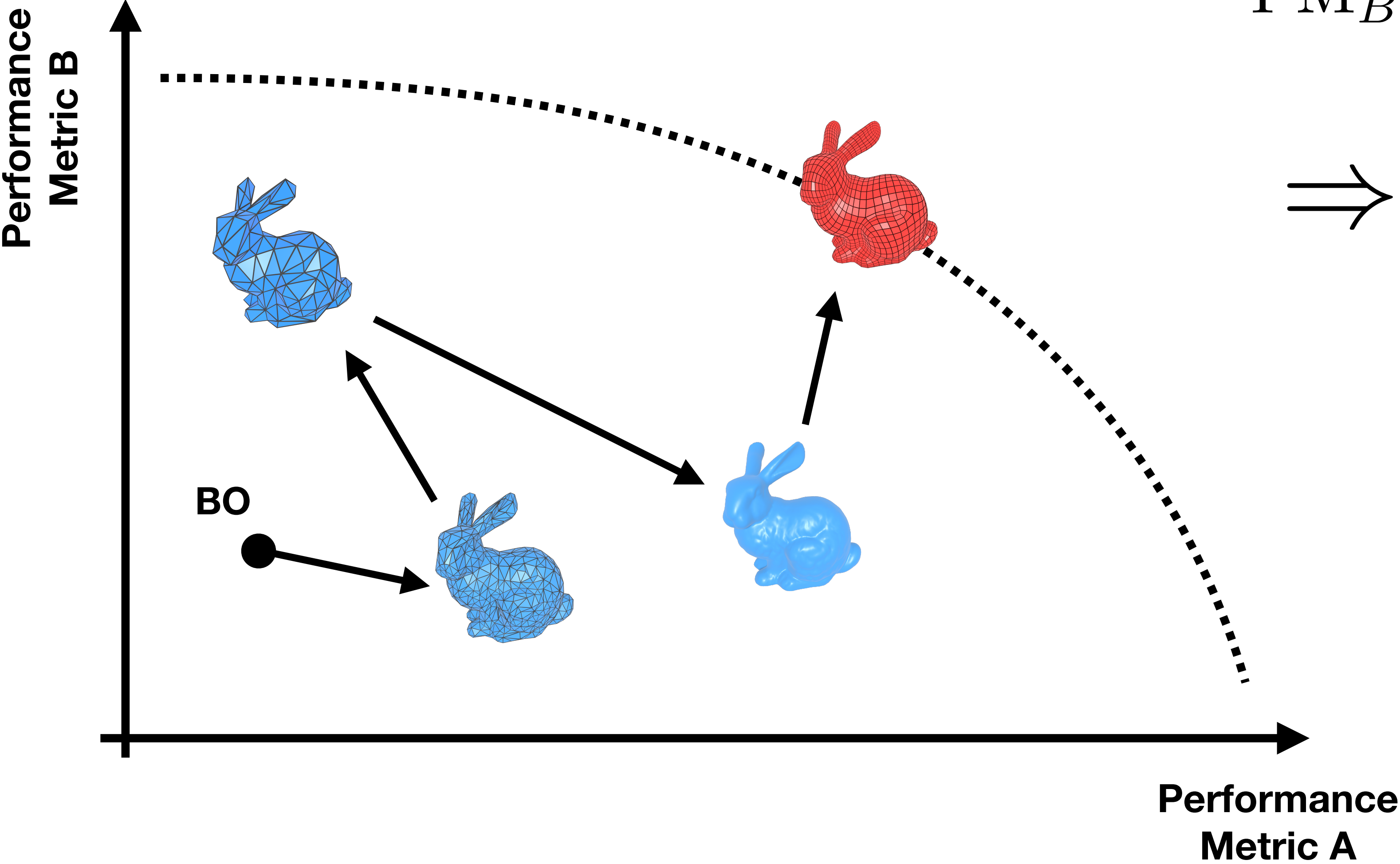
Pareto Optimality [Pareto, 1912]



Pareto Optimality [Pareto, 1912]



Pareto Optimality [Pareto, 1912]

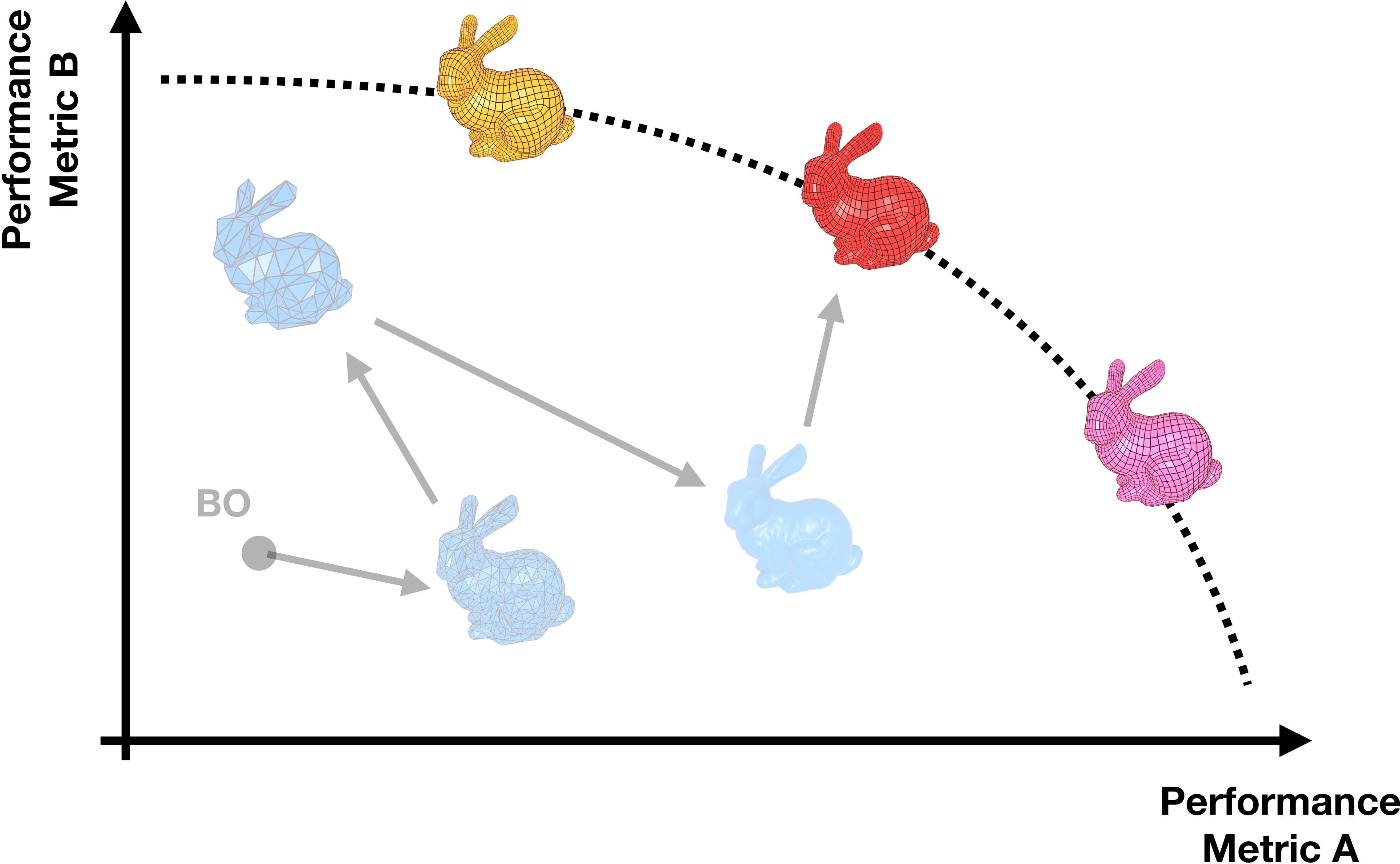


$$PM_A(\text{red rabbit}) \geq PM_A(\text{blue wireframe rabbit})$$

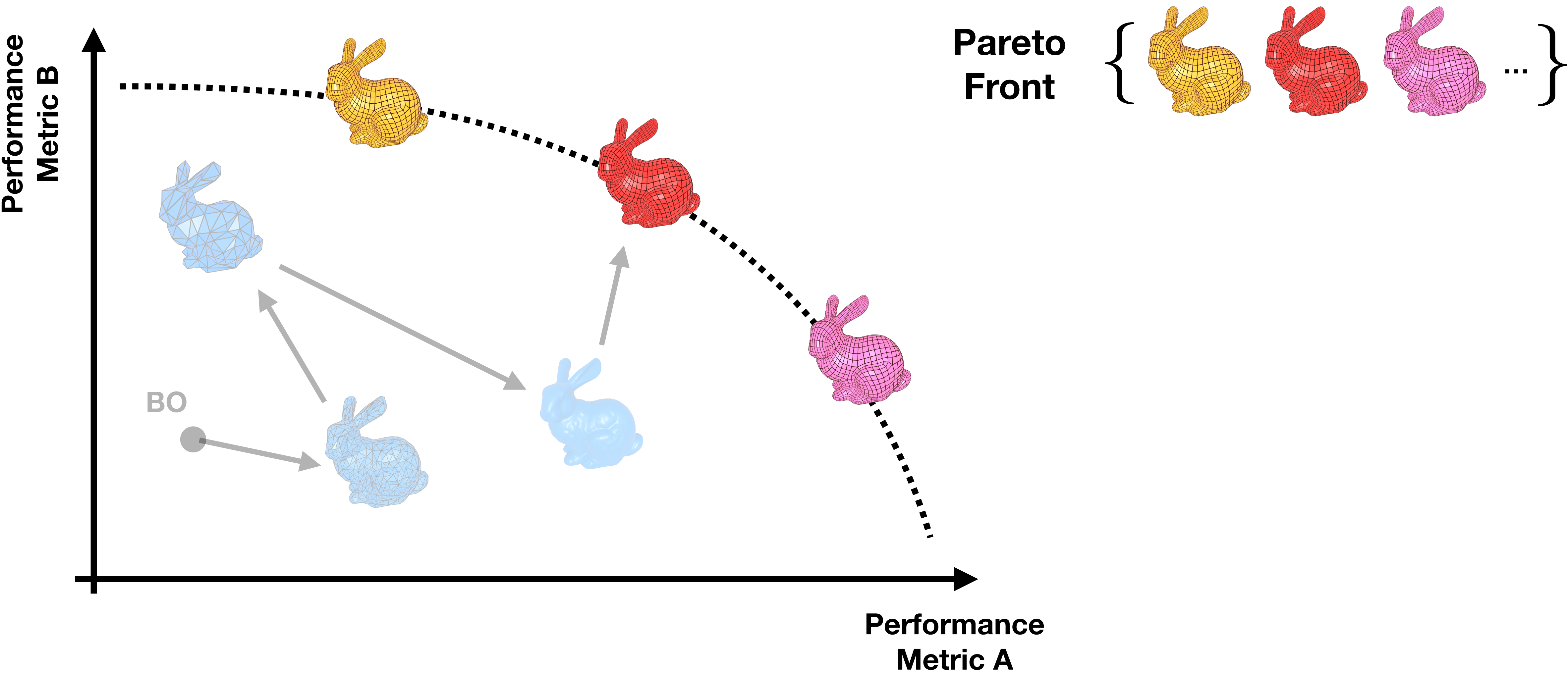
$$PM_B(\text{red rabbit}) \geq PM_B(\text{blue wireframe rabbit})$$

\Rightarrow red rabbit dominates blue wireframe rabbit

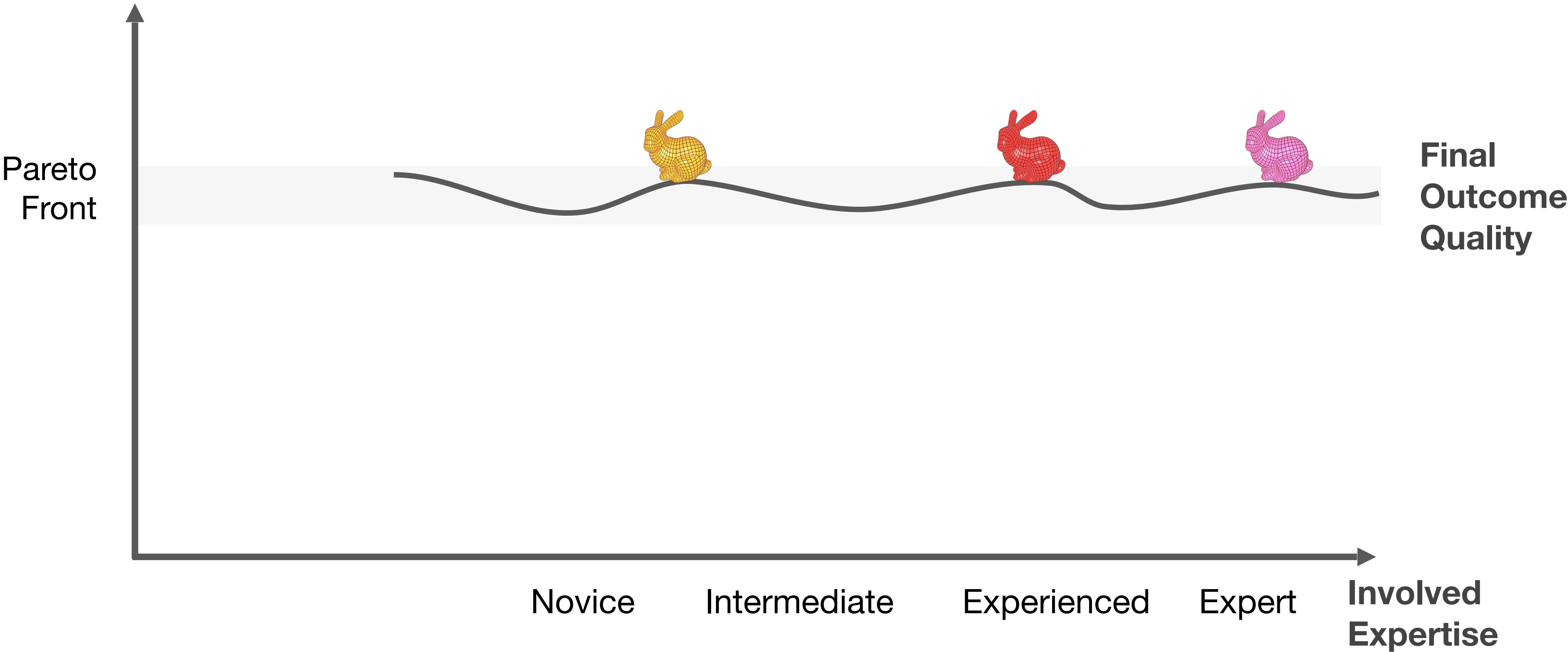
Pareto Optimality [Pareto, 1912]



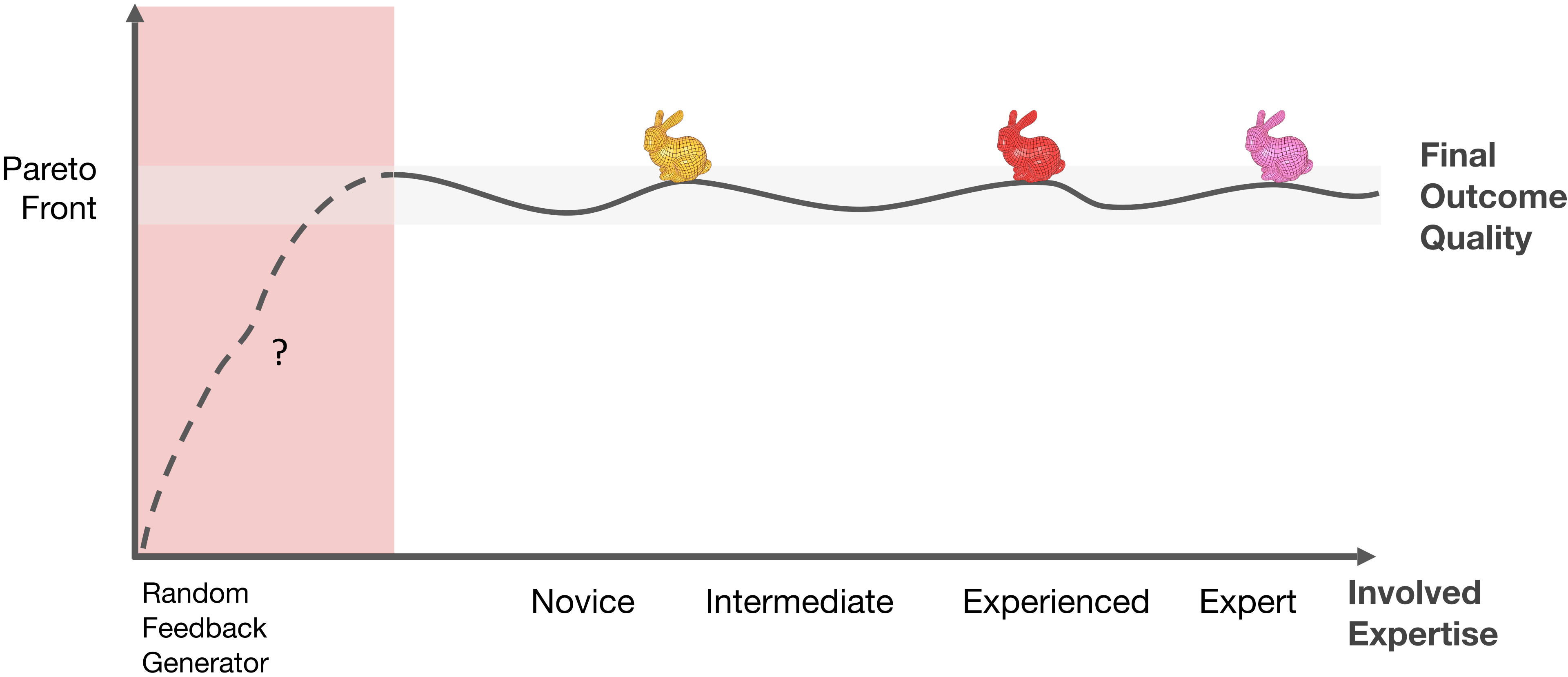
Pareto Optimality [Pareto, 1912]



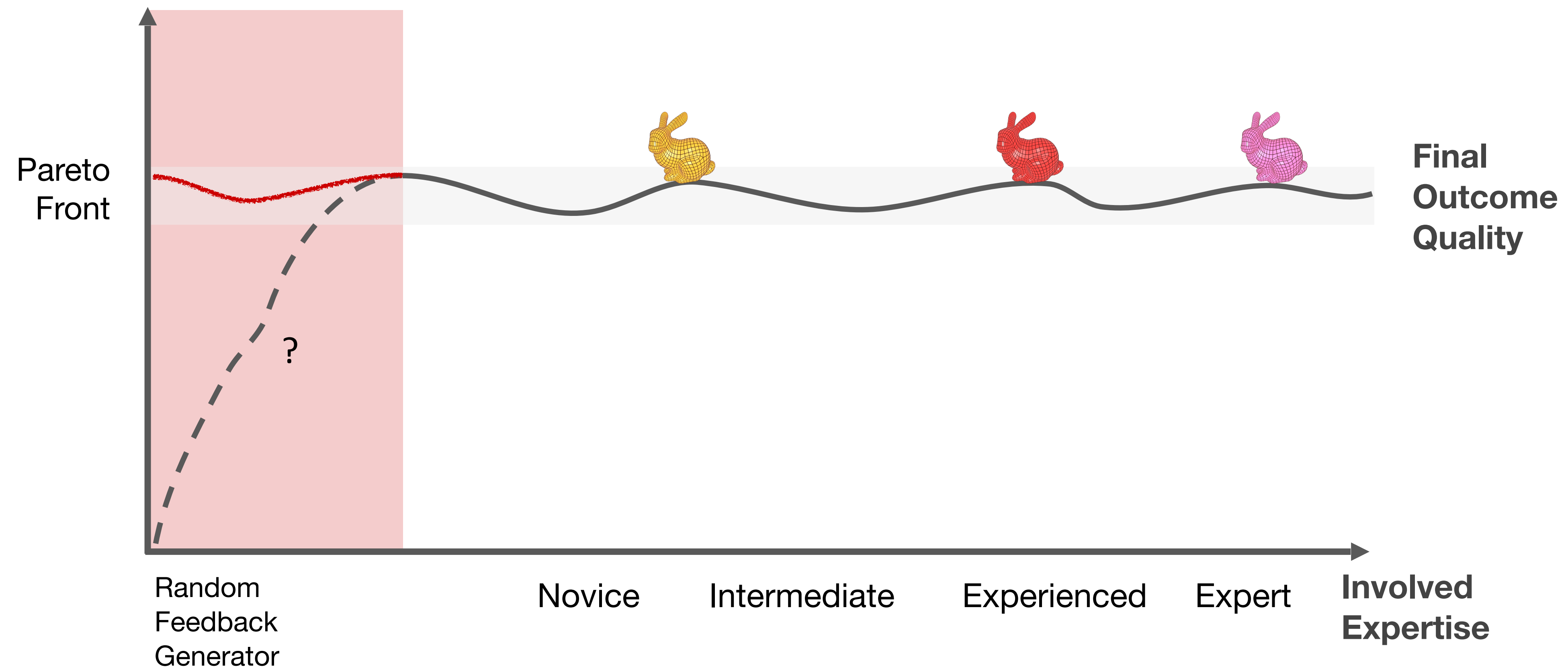
Implications on the Impact of Expertise in HITL



Implications on the Impact of Expertise in HITL



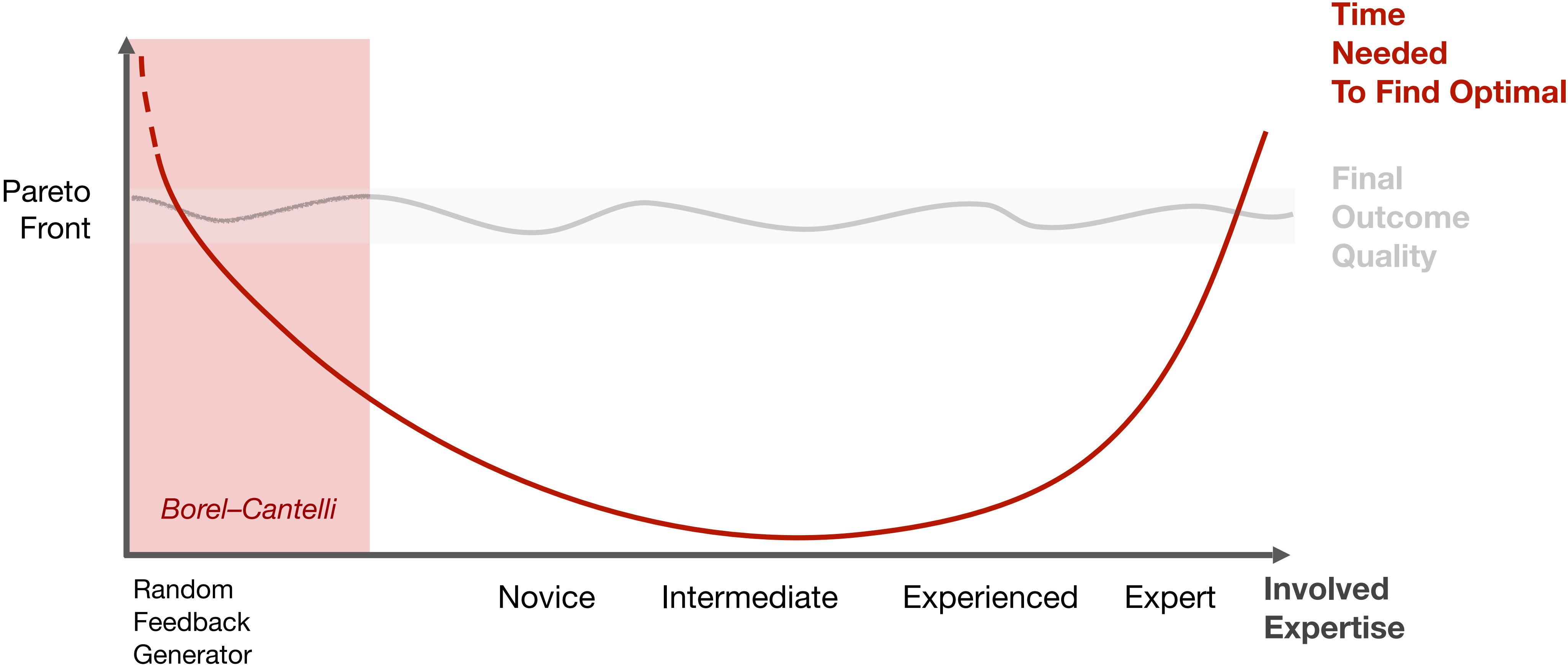
Implications on the Impact of Expertise in HITL



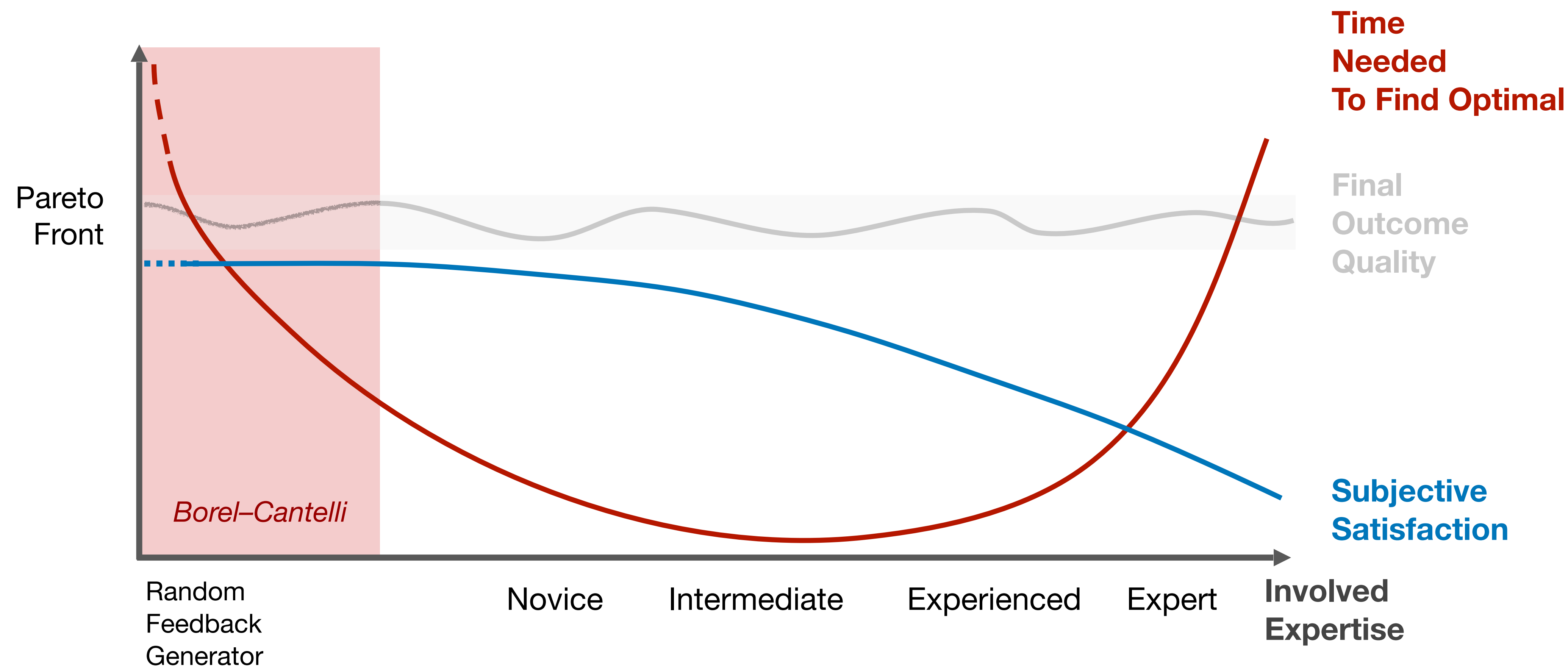
The Borel–Cantelli lemma [Borel 1909] [Cantelli 1917]

With infinite amount of events, the probability of observing any meaningful result is 1.0

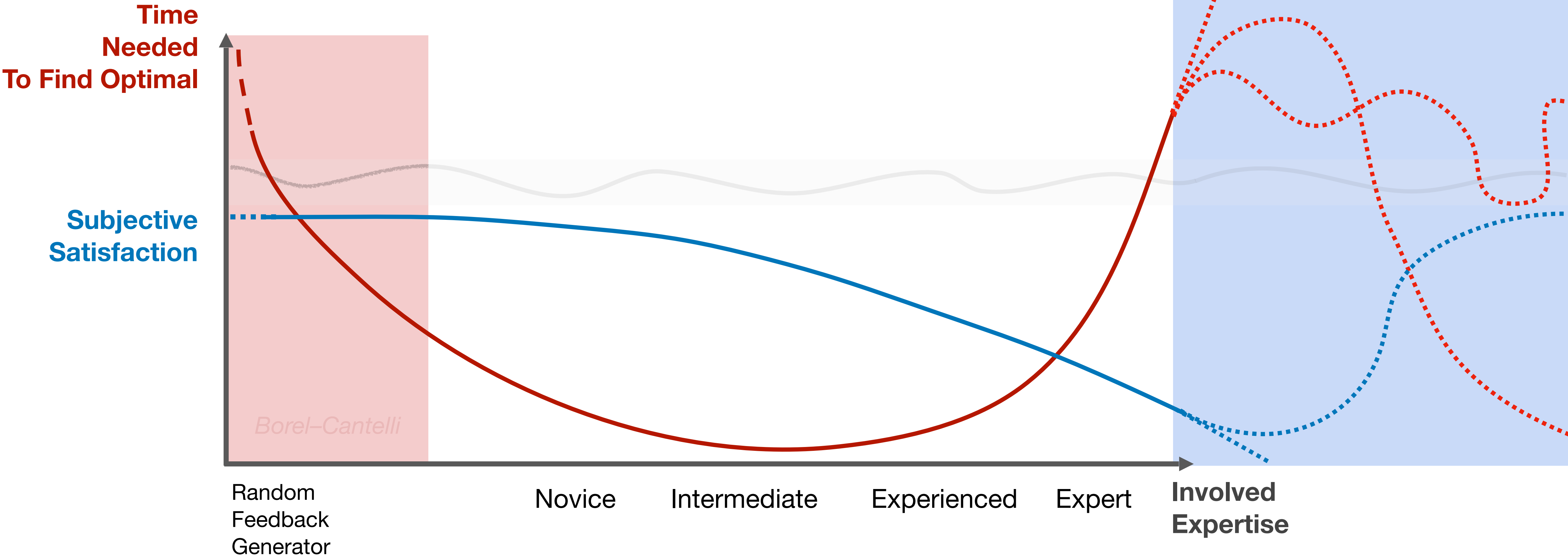
Implications on the Impact of Expertise in HITL



Implications on the Impact of Expertise in HITL



Implications on the Impact of Expertise in HITL



The Impact of Expertise In the Loop for Exploring Machine Rationality

Changkun Ou, Sven Mayer, Andreas Martin Butz

Media Informatics Group

LMU Munich

ACM Intelligence User Interfaces 2023

Session 4

March 29, Sydney, Australia