University of Bamberg

Working Paper

The Effect of Explainable AI-based Decision Support on Human Task Performance: A Meta-Analysis

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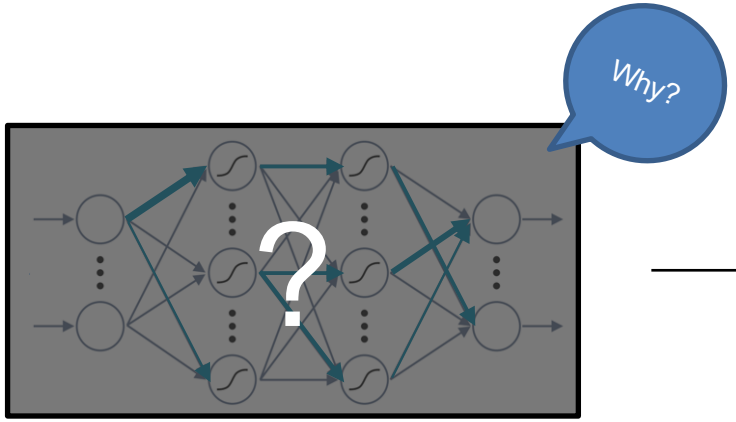
Explainable AI (XAI) for Decision Support!

(Complex) Machine Learning (ML)



XAI

XAI Research
(Human-centered view)

- Increases *trust and confidence* (Förster et al., 2020; Wanner et al., 2020)
- Increases *acceptance and satisfaction* (Shin, 2021)
- Allows *black box ML use in practice* (legal and compliance) (Holzinger et al., 2018; Wischmeyer, 2018)

Another important stream:
XAI to improve human decision-making

- Price estimations (Bauer et al., 2023)
- Diabetes detection (van der Waa et al., 2021)
- Industrial process design (Senoner et al., 2021)

Some studies report improved human task performance, while others report negligible effects

- XAI research is experiencing an increasing number of studies evaluating the **effect of XAI-assisted decision-making on human task performance** (Bansal et al., 2021; Buçinca et al., 2022; Hemmer et al., 2022; van der Waa et al., 2021; Zhang et al., 2020)

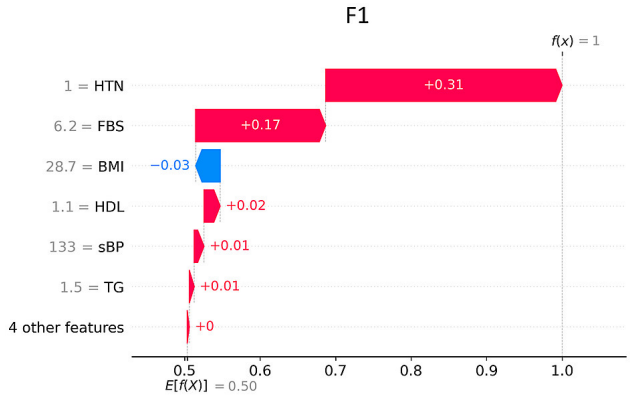
Popular forms of XAI explanation types

Method 1: Feature Attributions

Describe causal attributions (*why?)*

“X had occurred, because of Y”

ML prediction: Class 1

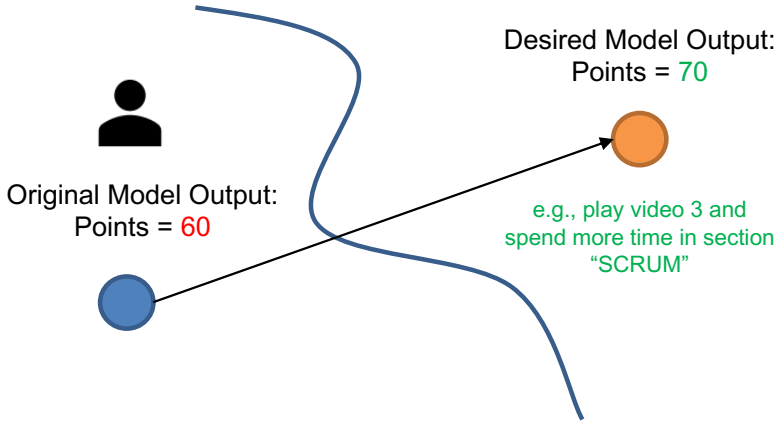


Method 2: Counterfactuals

Describe causal situations (*what if?)*

“If X had occurred, Y would have occurred”

ML prediction: 60 Pts.



(Mohseni et al., 2021; Herm, 2023)

Popular forms of XAI explanation types

Method 3: Example-based

Describe similar instances (*what-else?)*

“X had occurred, because Y is very similar to X”

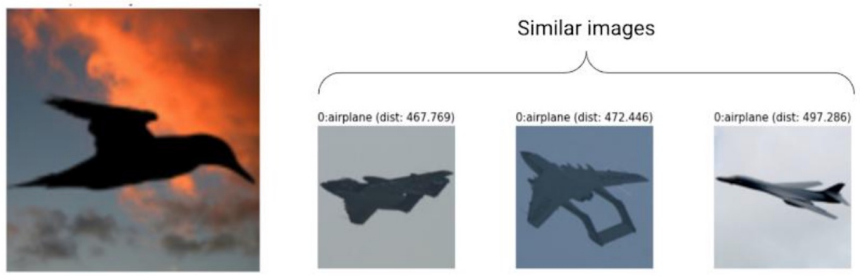


FIGURE 2. USE EXAMPLE-BASED EXPLANATIONS FOR MISCLASSIFICATION ANALYSIS

(Mohseni et al., 2021; Herm, 2023)

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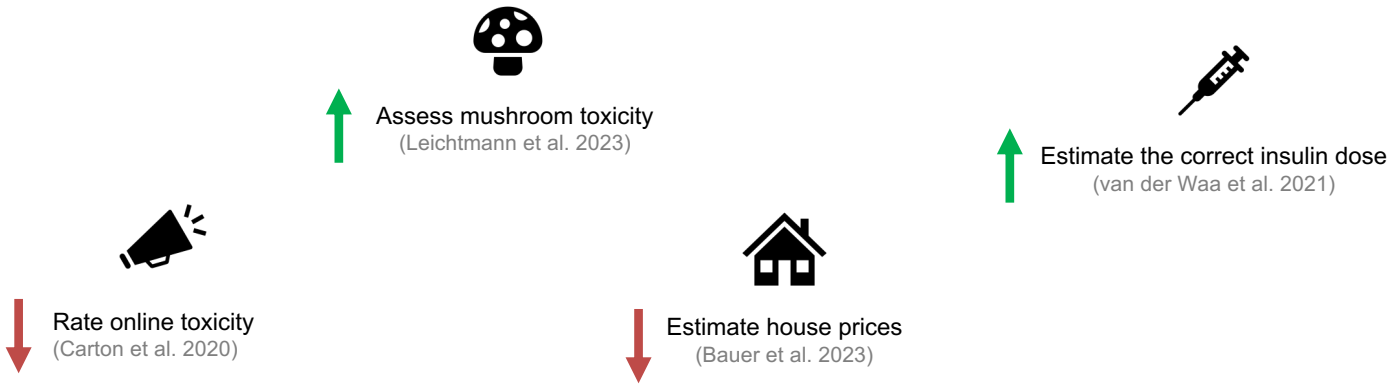


- In this work, I'd like to present an **initial synthesis of existing research on user studies examining the effect of XAI-assisted decision-making on human task performance**
  1. The **overall/main effect** of XAI on human **task performance** (already done with 9 articles; see Schemmer et al. 2022)
  2. The **conditions** under which **XAI is helpful** (or not): Subgroup analyses

Research Question

Overarching RQ

RQ 1a: To what extent does XAI-based decision support affect human performance in classification tasks, considering the current body of empirical studies?

Sub analysis 1

RQ 1b: To what extent does the risk of bias in studies affect the outcome of XAI-based decision support on human performance in classification tasks?

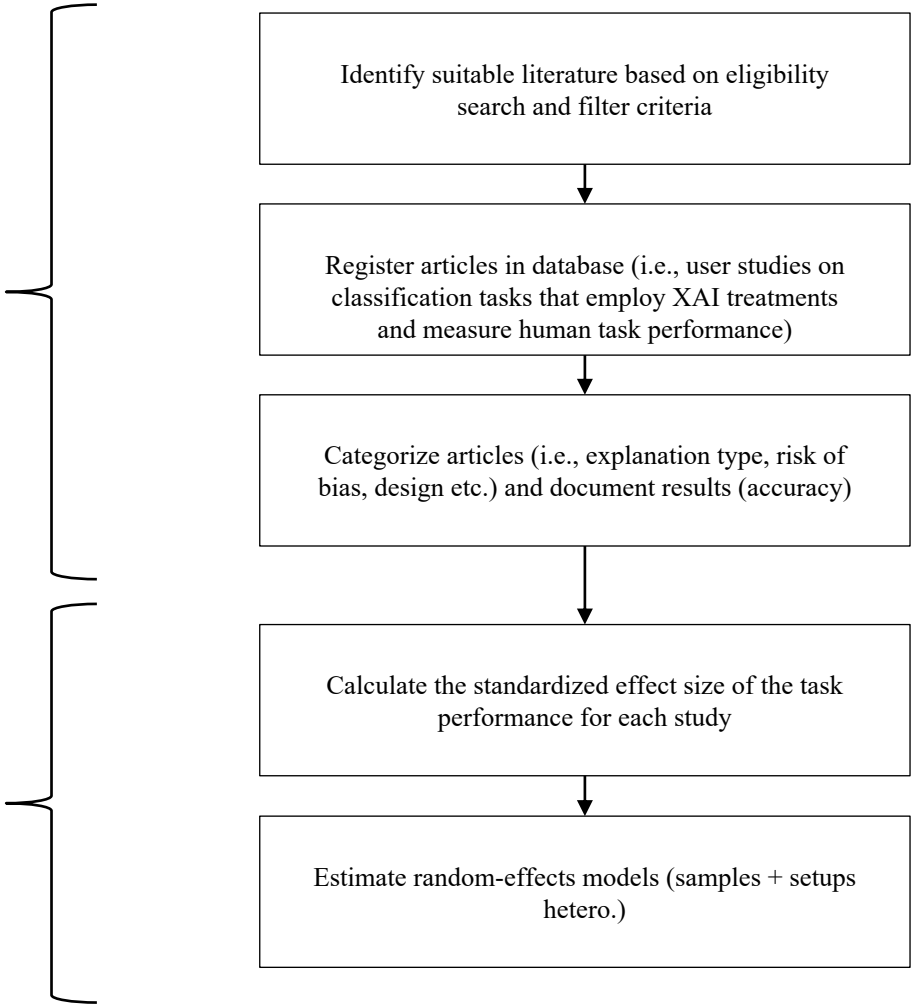
Sub analysis 2

RQ 2: To what extent do (i) feature attribution, (ii) counterfactual, or (iii) example-based explanations affect human performance in classification tasks, considering the current body of empirical studies?

Methodology Overview: Meta-Anlysis

Part 1 Data collection & categorization

Part 2 Statistical analysis



Methodology: Literature Search String

OR		OR		OR
"explainable artificial intelligence"	AND	"instance based"	AND	"task performance"
”xai"		"example based"		"decision performance"
"explainable AI"		"counterfactual"		"human accuracy"
"interpretable machine learning"		"hypothetical"		"human performance"
"interpretable ml"		"causal"		"user study"
"explainable machine learning"		"anchor"		"empirical study"
"explainable ml"		"contrastive"		"field experiment"
("machine learning" OR "artificial intelligence" OR "AI" AND (interpret* OR explain* OR "explanation"))		"feature attribution"		"online experiment"
		"feature importance"		"human experiment"
		"LIME"		"human evaluation"
		"SHAP"		"user evaluation"
				((behavior* OR behaviour*) AND "experiment"))

Methodology: Risk of Bias Assessment of Studies

- The “Risk of Bias 2” tool (RoB 2) is divided into **five risks of bias domains**, where each domain contains a **series of signaling questions** relevant to study bias (Sterne et al., 2019)
- The judgement for the risk posed by a domain is calculated from an algorithm. Judgements on the **risk of bias can be “Low”, “Some concerns”, and “High”**
- Each rating was **double-checked** by a non-affiliated colleague; deviations in the assessment were discussed and resolved

RoB 2 Domains (D1-D5)

D1: Bias arising from the randomization process

D2: Bias due to deviations from intended interventions

D3: Bias due to missing outcome data

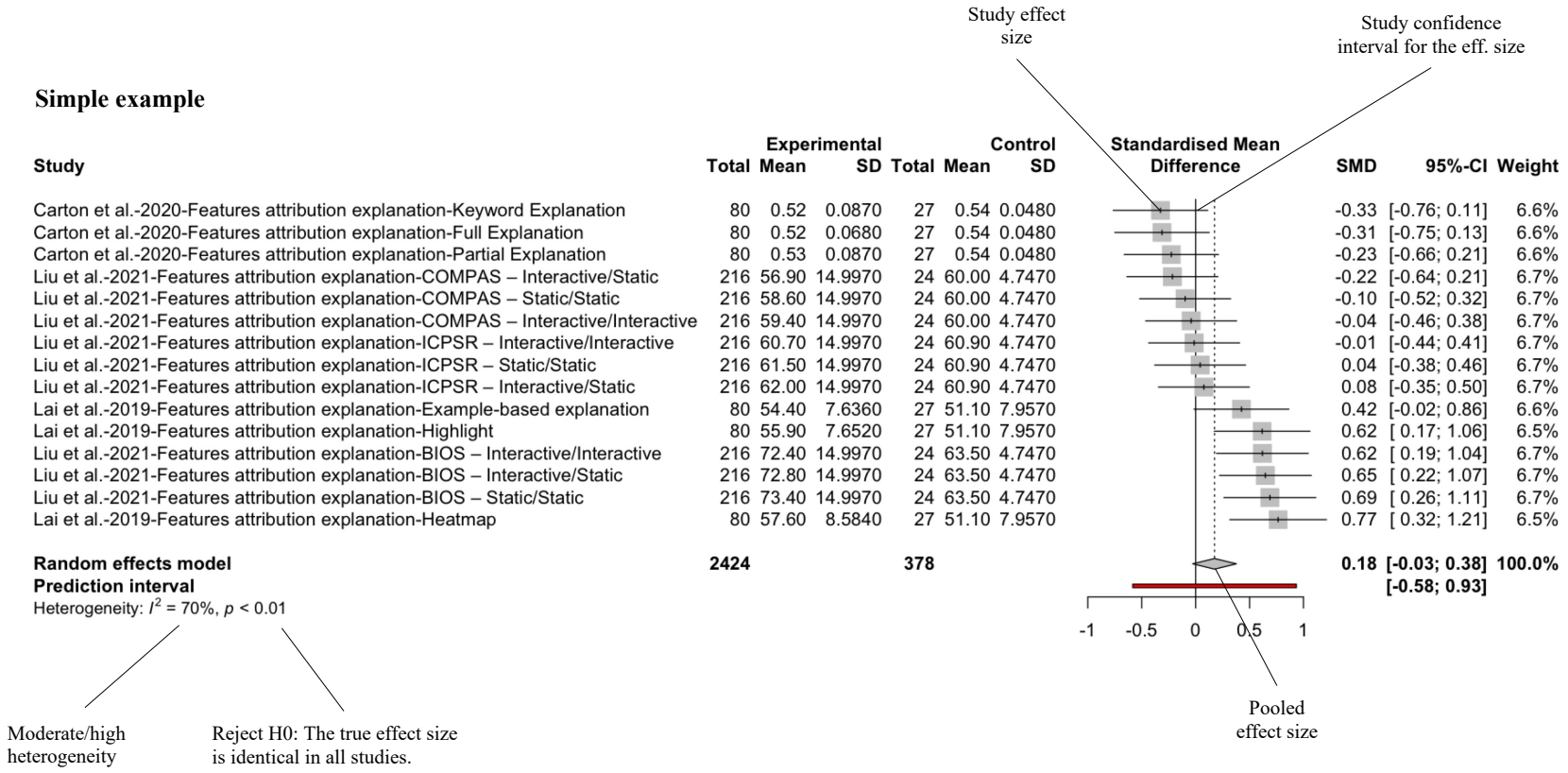
D4: Bias in measurement of the outcome

D5: Bias in selection of the reported result

(Templier & Paré, 2018)

Methodology: Statistical Analysis - Random Effect Models

- The experiments conducted do probably not share a common true effect size (i.e., a fixed effect) because the experimental setups, tasks, and respective samples considerably vary between studies
- Instead of fixed-effects regression models, we employ random-effects regression models to estimate the mean of effects (called “pooled effect”)
- Controlled for multiple control group inclusion (sample N control group / times included in the model)



Results RQ1a: Main Effect – No support vs. XAI

On request: Please send an e-mail to felix.haag@uni-bamberg.de

Results RQ1a: Main Effect – AI vs. XAI

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Results RQ1b: Subgroup Analyses – Risk of Bias

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Results RQ1b: Subgroup Analyses – Risk of Bias

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Results RQ2: Explanation Type Categorization

On request: Please send an e-mail to felix.haag@uni-bamberg.de

Results RQ2: Differences in Explanation Types

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Main Contributions & Next Steps

Main Contributions

- **Practical**: Assessment of the value of XAI for decision-making and human task performance (implications for the design of XAI-based DSS)
- **Theoretical:** Exploration of the conditions under which XAI is effective for decision support (in this paper: which type of explanation is effective)

Next Steps

- Further sub-analyses (e.g., task complexity, task domain, (X)AI literacy etc.)
- Publish the dataset; refine and submit the paper

Thank you very much.