# Applying the Technology Acceptance Model to Understand Attitudes towards Brain-Computer Interfaces and Brain Stimulation Devices

Sebastian Sattler[1,2], Guido Mehlkop[3], Kathrin Schumacher[4]

[1] UNIVERSITÄT BIELEFELD  [2] IRCM INSTITUT DE RECHERCHE CLINIQUES DE MONTRÉAL  [3] UNIVERSITÄT ERFURT  [4]

## Background

- While neurotechnological devices (NDs), such as *Brain Stimulation Devices* (BSDs) or *Brain Computer Interfaces* (BCIs), are becoming more routine in medical settings, they are also becoming more frequently implemented without medical necessity to enhance performance in work, sports, or leisure activities.[1]
- Applications for both treatment and enhancement purposes, have led scientists to voice concerns about potential ethical, legal, and social issues.[2] These issues, often obscured from the public view, include concerns about data security, autonomy, stigma, or potential side effects.
- As emphasized by the Emerging Issues Task Force of the International Neuroethics Society (INS)[3], it is therefore essential to understand the public acceptability of NDs.
- This study examines conditions of this acceptability of BSDs and BCIs by applying an adapted version of the Technology Acceptance Model (TAM).[4,5] To this end, we test if the willingness to use both NDs is affected by the use purpose. We also examine if perceived usefulness (i.e., perception of the ND being able to help perform a task better) and perceived ease of use (i.e., the degree to which a person believes that using the ND would be free of effort) mediate this relationship. Moreover, our adaptation expands the TAM by including perceived trust (i.e., expectation that the ND is consistent, reliable, functional, and provides the help needed) as a possible further mediator between use purpose and the intention both NDs.
- We also test data security of the ND and whether the ND is invasive (or not) as two candidate factors that moderate the mentioned mediating effects.

## Methods

- Using a Germany-wide general population sample, we conducted two vignette-based experiments concerning BSDs (Experiment 1, N=3,166) and BCIs (Experiment 2, N=3,263).
- Therein, we varied the purpose of using the ND (treatment vs. enhancement), whether it is invasive vs. not, and the level of data-security (low vs. high).
- Subsequently, perceptions concerning the trust in each ND, its ease of use, and its usefulness were assessed as mediators between the manipulated factors and the willingness to use each NDs.

Disclosures: None

## Results

### Descriptive statistics for experiment 1 on BSD (N=3,166) and experiment 2 on BCIs (N=3,263)
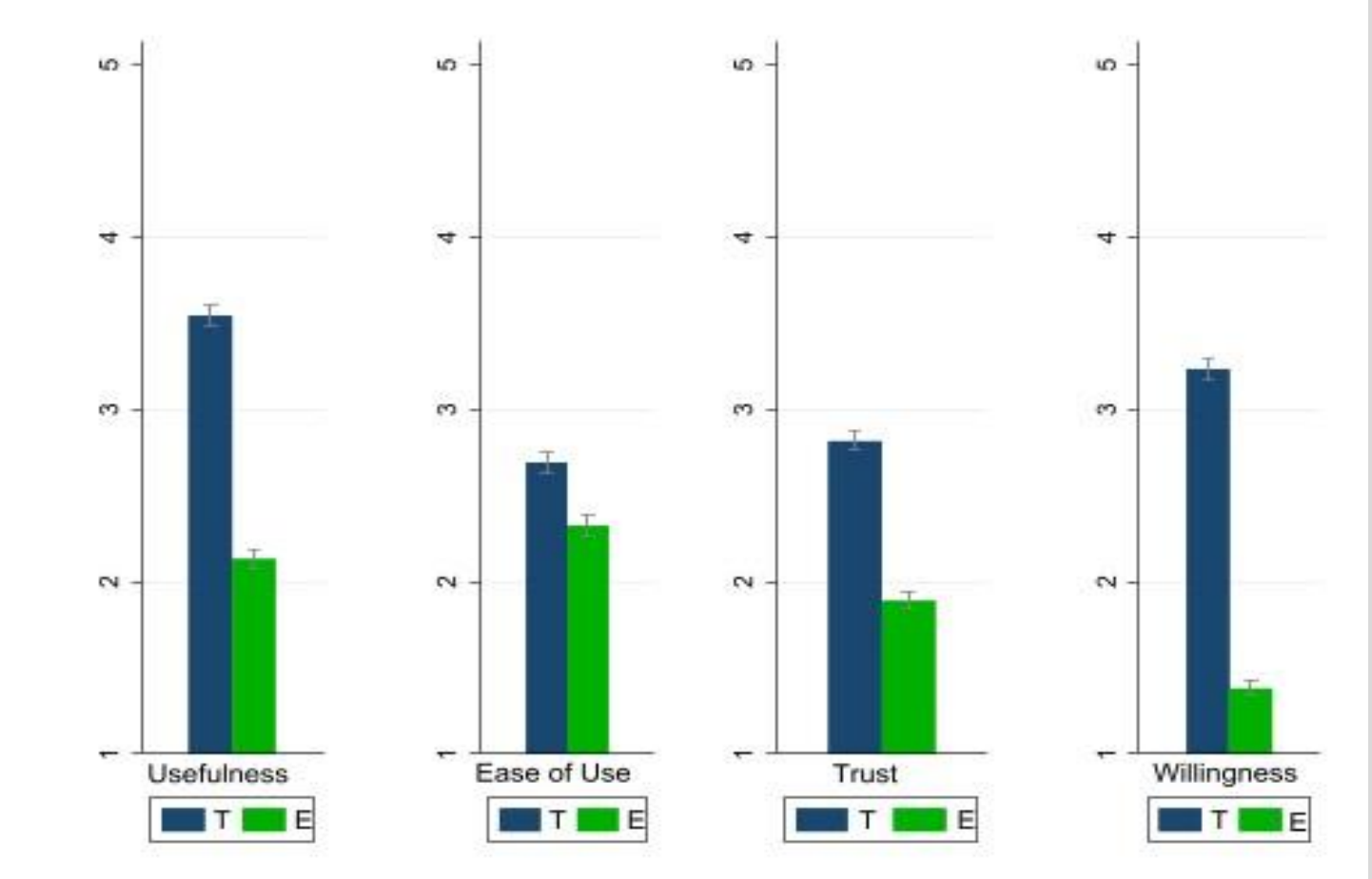


**Fig. 1:** Experiment 1 (BSD) – Mean values with confidence intervals concerning the usefulness, ease of use, trust, and use willingness depending on use purpose. *Notes:* T=Treatment; E=Enhancement; Value 1 indicates either low usefulness, ease of use, trust, or use willingness; Value 5 indicates either high usefulness, ease of use, trust, or use willingness.
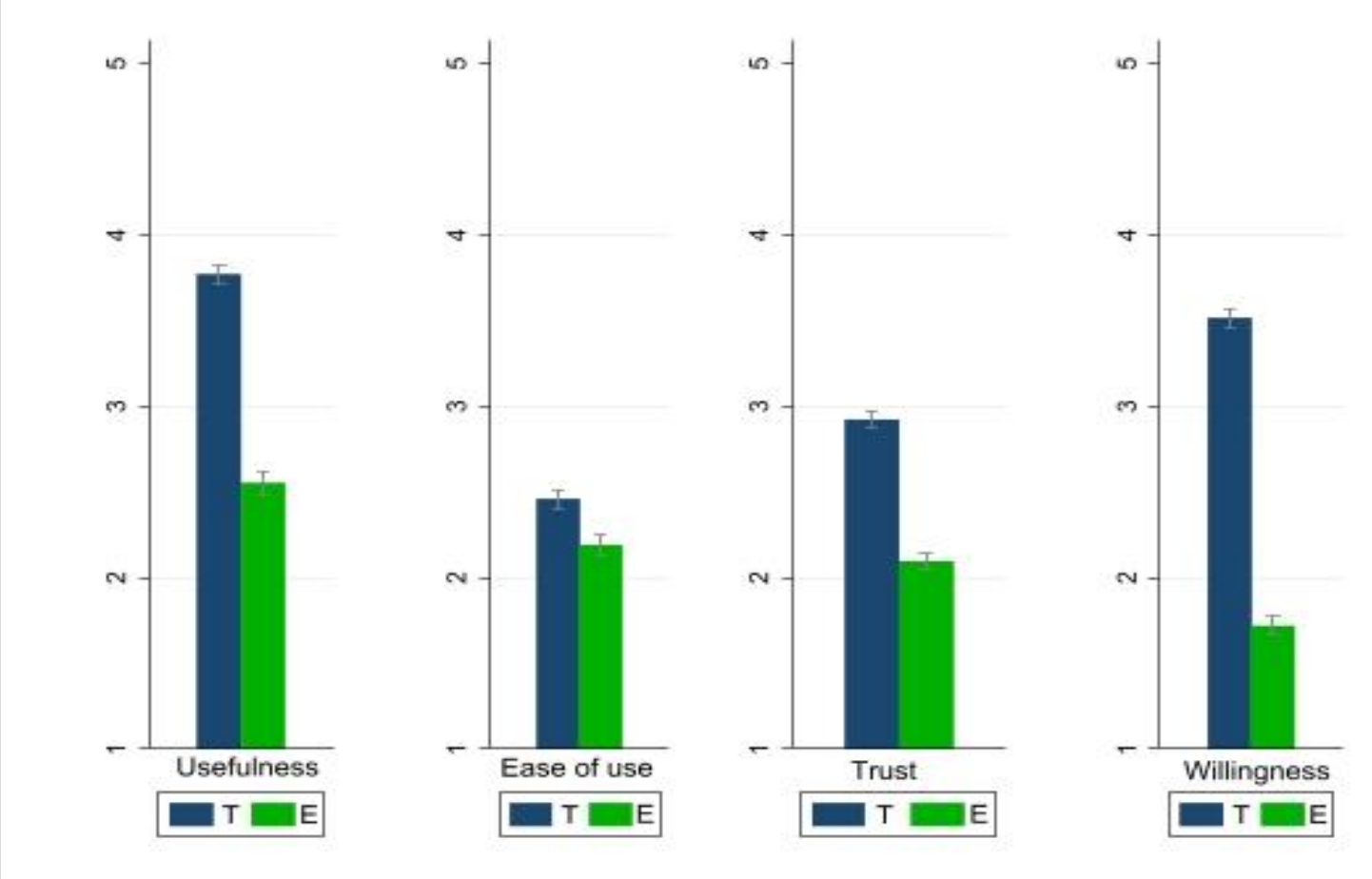


**Fig. 2:** Experiment 2 (BCI) – Mean values with confidence intervals concerning the usefulness, ease of use, trust and use willingness depending on use purpose. *Notes:* T=Treatment; E=Enhancement; Value 1 indicates either low usefulness, ease of use, trust or use willingness; Value 5 indicates either high usefulness, ease of use, trust or use willingness.

### Parallel multiple mediation models

- Results show that the effect of the purpose of using BSDs (Fig. 4, Panel A) and BCIs (Panel B) on the respective use willingness is mediated via:
  - perceived usefulness,
  - perceived ease of use, and
  - perceived trust.
- That is: enhancement purposes lead to lower levels of these three mediating variables, while higher levels of the mediators increase the respective use willingness.
- Moreover, the purpose of using an ND has no remaining direct effect when considering the mediating variables.
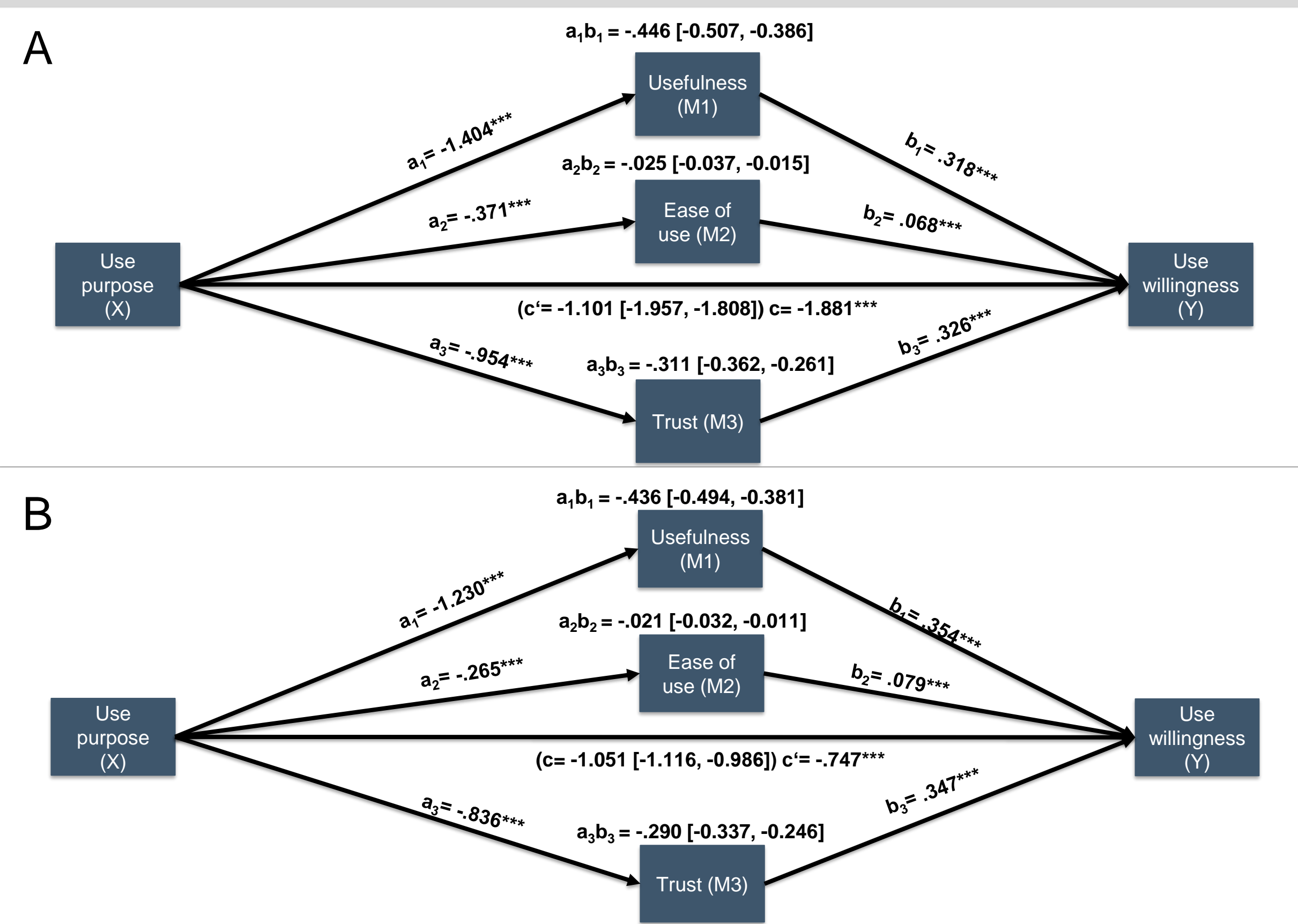


**Fig. 3**: Panel A (Experiment 1, BSD) and Panel B (Experiment 2, BCI) show the use purpose as predictor (X), perceived usefulness, perceived ease of use, and trust as mediators (M1-M3), as well as use willingness as outcome variable. *Notes:* *p<.05, **p<.01, ***p<.001; a_ib_i: specific indirect effect of X on Y through M_i; c: remaining direct effect of X on Y; c': total effect of X on Y. All analyses are controlled for invasiveness and data security. Analyses were performed using Model 4 of the SPSS macro PROCESS.[6]

### Multiple moderated mediation models

- When investing whether data security or invasiveness moderated the indirect effects of use purpose on use willingness via usefulness, ease of use or trust, we found no such conditioning effects.
- One exception is that data security moderated the indirect effect of use purpose on trust in Experiment 1 (Fig. 5). The negative effect of use purpose on trust is stronger if data security is low as compared to high.
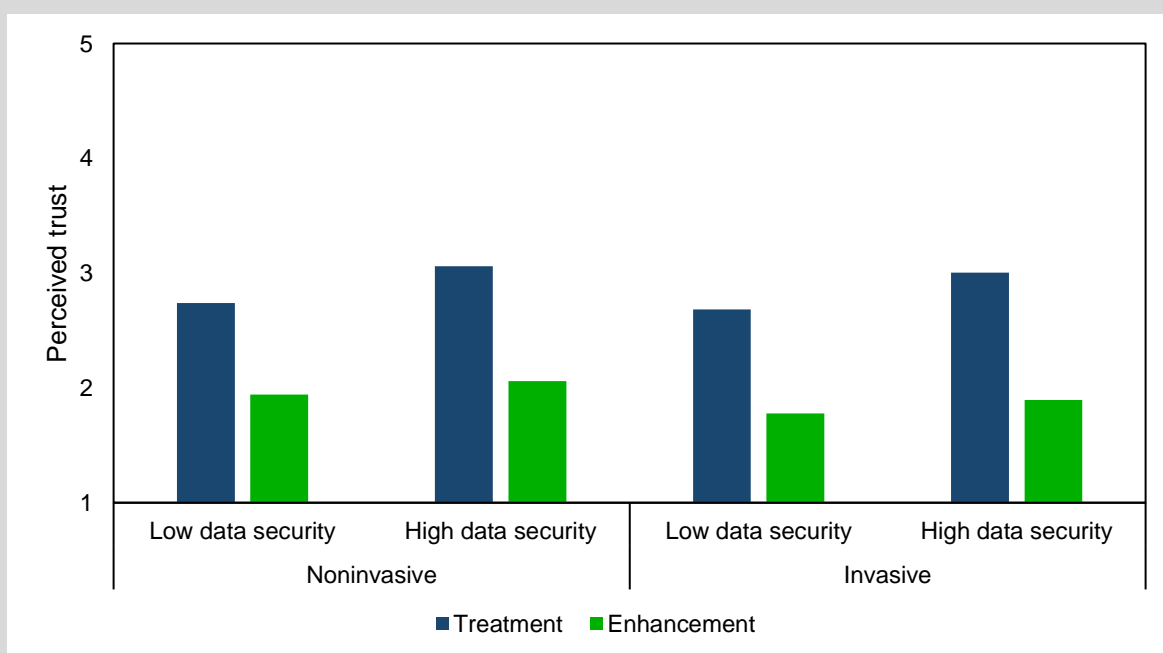


**Fig. 4:** Interaction plot of the effects of use purpose on trust depending on data security and invasiveness. *Notes:* Analyses performed with Model 9 of the SPSS macro PROCESS.[6] Value 1 indicates low and value 5 indicates high trust.

## Discussion

### Summary of the findings
- Our results suggest stronger enthusiasm to use both examined NDs for medical purposes, while the demand for enhancement purposes seems more limited (Fig. 1 & 2).
- Individuals perceived NDs for treatment purposes as more useful, easy to use, and more trustworthy than for enhancement purposes what increased their willingness to use them (Fig. 3). Thus, all three mediators help to explain the relation between use purpose and use willingness.
- Invasiveness and data security do not moderate the mediation effects. There is only one exception: the indirect effect from use purpose via trust on use willingness was moderated by data security (Fig. 4), suggesting that data security is important for trust.
- These results can inform technology developers about the public's needs and concerns and also enrich legal and ethical debates.

### Strengths
- Based on the TAM, our two experiments provide insight about the use willingness of two key NDs for treatment and enhancement purposes as well as three mechanisms why medical purposes are preferred over enhancement purposes, i.e., perceptions about trust, ease of use, and usefulness.
- Both experiments used a large representative sample, while the design allows for causal inference of the manipulated variables.

### Limitations
- It remains unclear, whether the voiced use willingness results in actual use and under which conditions it may not.

### Future research
- For a broader understanding of the acceptance of NDs, future research should extend the TAM and apply it to other NDs.
- Further research should also test under which conditions a use willingness turns into actual use and when not.

## References

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