

Prediction of Speech Outcomes with Cochlear Implants

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Marta Campi, Alexander Huber, Tobias Goehring



Deep
Hearing
Lab



University of
Zurich^{UZH}



European
Commission

USZ Universitäts
Spital Zürich

Disclosure

No financial interests or affiliations related to the information presented.

No conflicts of interest.

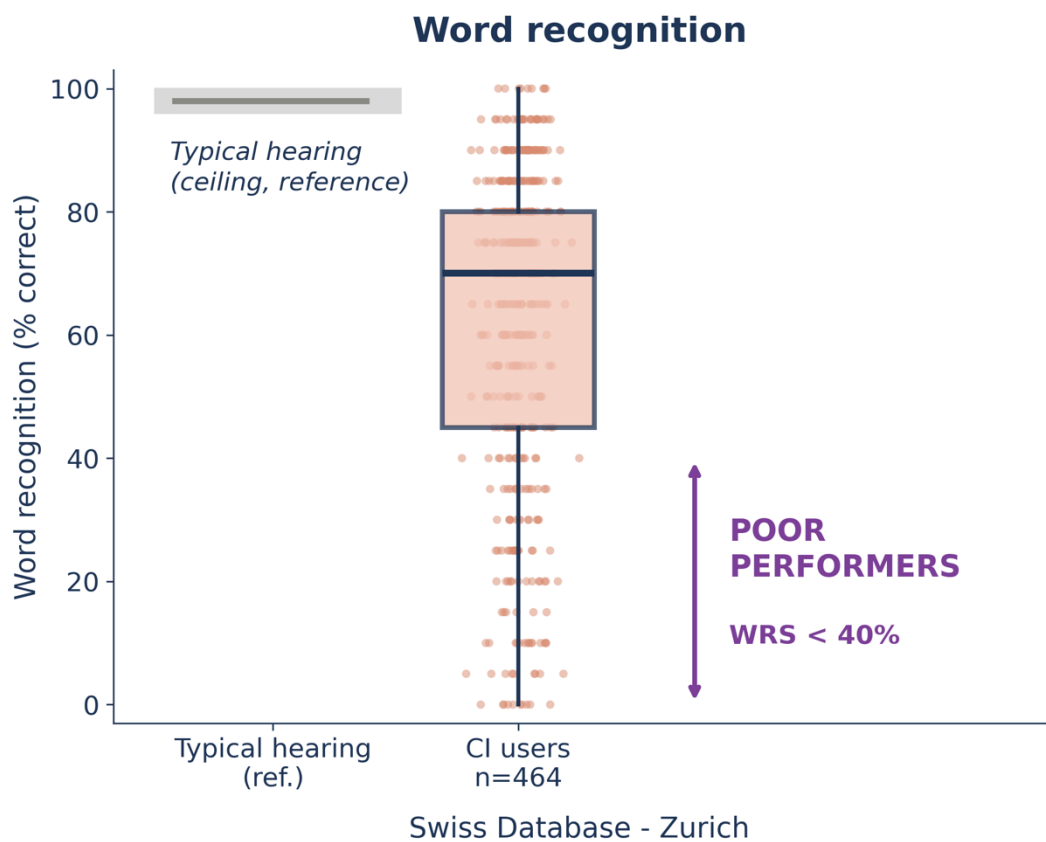
Outcome Prediction in Cochlear Implant (CI)

- *“How well will I hear with an implant?”*
- Important information for counselling, monitoring, and rehabilitation
- Limited prediction ability: variance explained $< 20\%$ ^[1,2,3]
- **So what can we predict?**

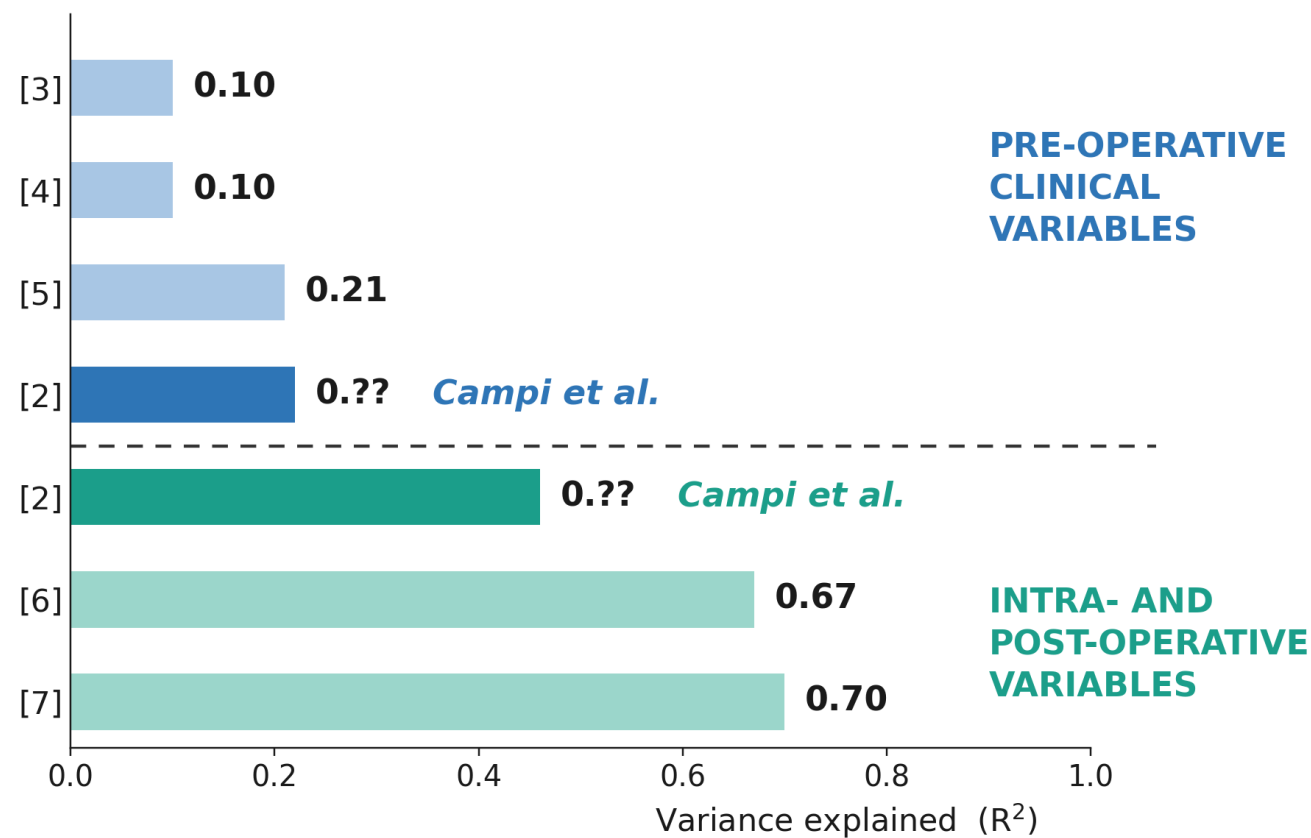


Word Recognition Score (WRS)

Post-operative monosyllabic WRS in quiet represents one outcome used in the literature^[1, 2]



Can we **explain** the variance of **word recognition**?



[1] Holden et al. 2013 · [2] Campi, Huber, Goehring 2026

[3] Blamey 2013 · [4] Shafieibavani 2021 · [5] Blamey 1996 · [6] Kludt 2025 · [7] Canfarotta 2021

Research Questions

RQ1 Prediction of speech scores

RQ2 Prediction of risk for poor performance

RQ3 Prediction of scores over time

Data & Methods

DATASET · CICH Database, Zurich

378 adults, bilateral HL (single-sided deafness excluded), median age 60 (18 to 92), 53% female

PRE-OPERATIVE VARIABLES

35 Acoustic variables

pure-tone audiometry (both ears) · aided free-field thresholds · four pre-operative speech tests

22 Non-acoustic variables

demographic · developmental & communicative · socioeconomic · aetiology & history

SCORE TO PREDICT

- **RQ1: WRS** (Post-operative Freiburger monosyllabic score)
- **RQ2: Poor Performance** (WRS < 40%)
- **RQ3: Long-term WRS** (measured at 12 to 24 months)

PREDICTION METHODS

Linear regression · Ridge · Random Forest · Gradient Boosting · XGBoost · LightGBM · TabPFN (fine-tuned)

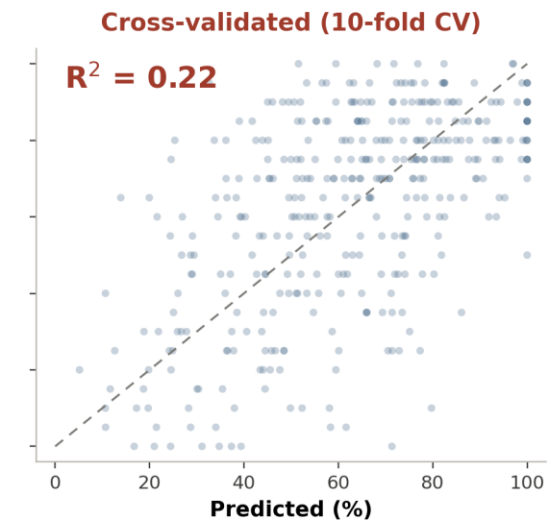
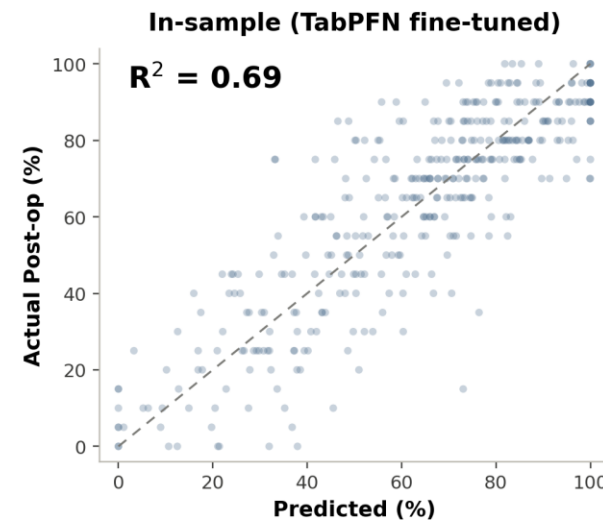
RQ1 Prediction of Speech Scores

Score: WRS

EXPLAINED VARIANCE: *Best Cross-Validated $R^2 = 0.22$*

How does R^2 looks like?

Algorithm	In-Sample R^2	Cross-validated R^2
Linear regression	0.21	-0.27
Ridge	0.20	-0.24
Random Forest	0.84	-0.03
Gradient Boosting	0.72	-0.04
XGBoost	0.94	-0.19
LightGBM	0.94	-0.09
TabPFN (fine-tuned)	0.69	0.22



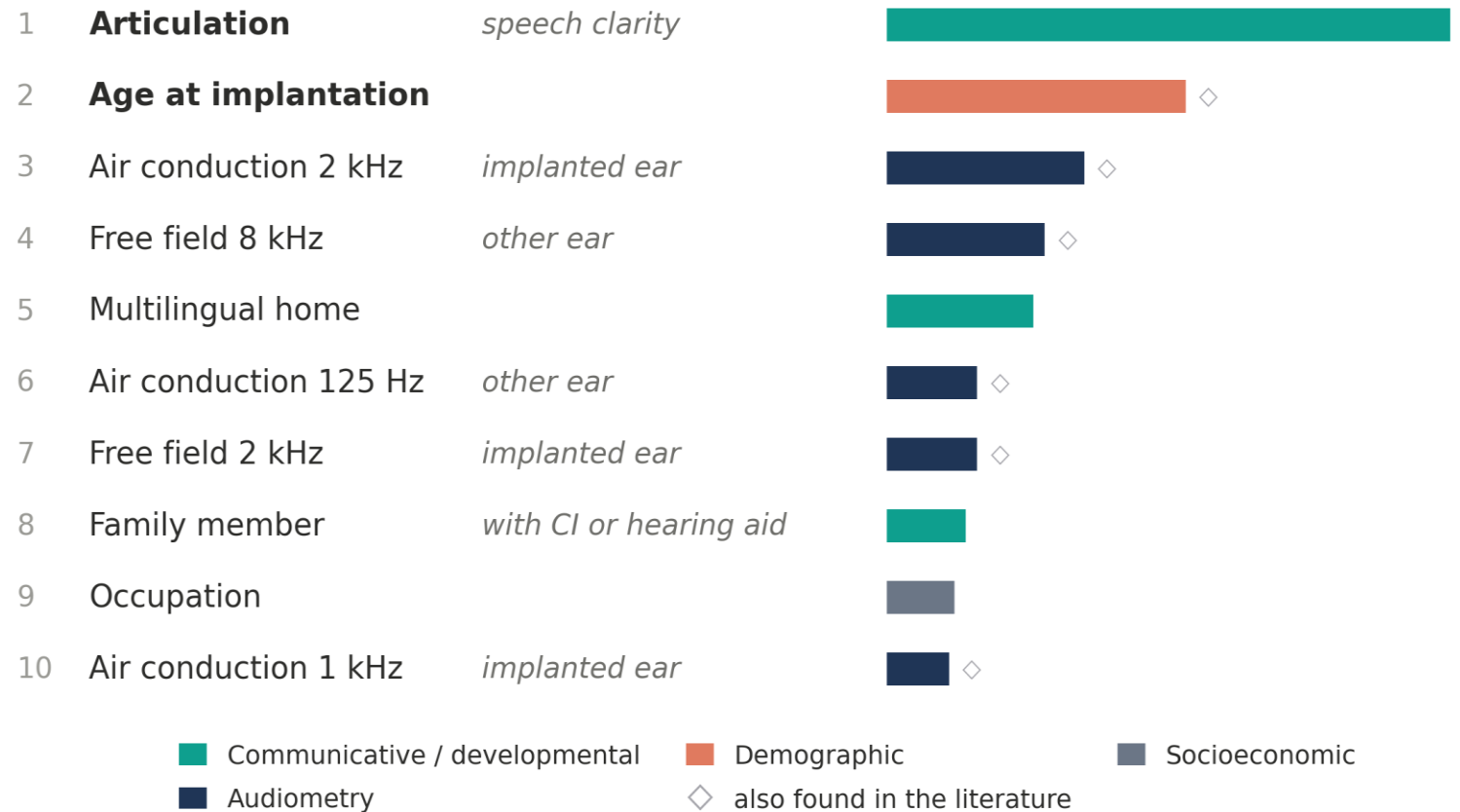
Pre-op variables predict post-op WRS at best with $R^2 = 0.22$ (TabPFN - fine-tuned)

RQ2 Prediction of Risk for Poor Performance

Score: WRS < 40%

- Reframed to classification task:
Who is at risk of a poor performance?
- **Discriminative power: 0.71**
(0.5 = chance, 1.0 = perfect)

WHAT DRIVES IT: variable importance



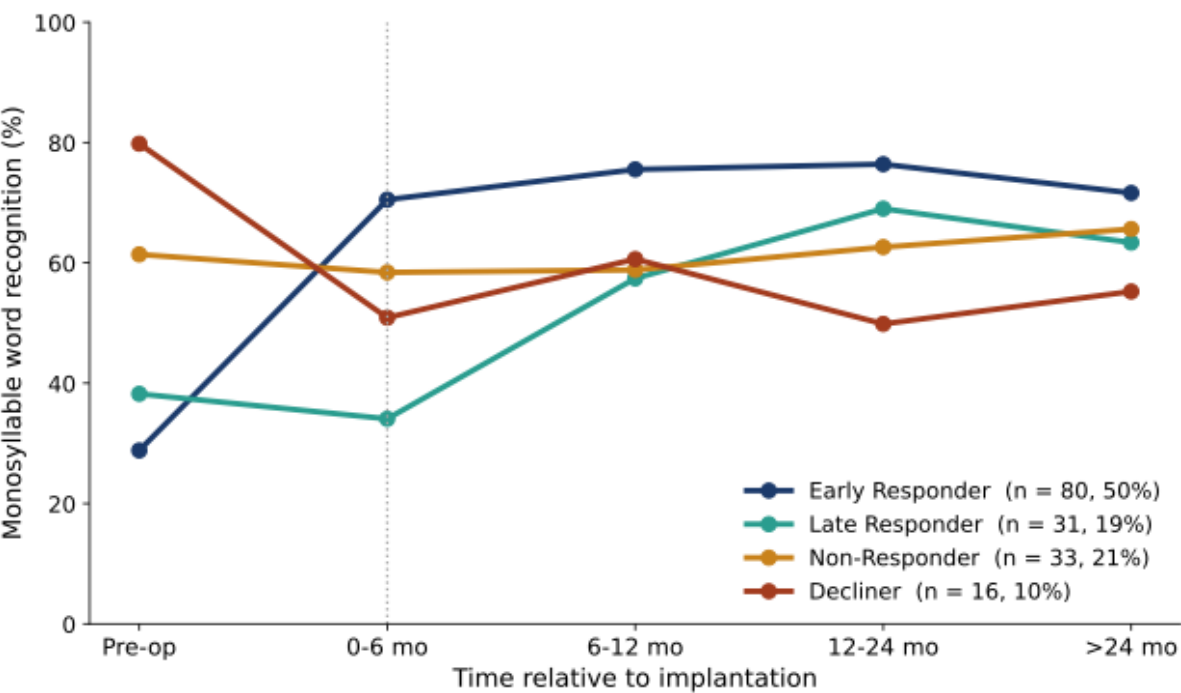
◇ = also a top predictor in prior work (Kim 2018, Demyanchuk 2025, Anthonisen 2026, Blamey 2013, Shew 2025)

RQ3 Prediction of Scores Over Time

Score: WRS 12/24 months

Predictors	Score R ²
pre-operative	0.03
+ six-month WRS	0.48

Four trajectories found by clustering the serial scores



Six months after CI surgery, WRS inclusion improves predictions of later performance and trajectory type

Summary & Conclusions

Prediction of speech outcomes

WRS is hard to predict with pre-operative variables (our data provides $R^2 = 0.22$).
The information those variables carried is **compressed after implantation**.

Prediction of risk for poor performance

Risk is partly predictable: **discriminative power 71%**. Driven by **articulation**.

Prediction over time

One six-month score beats every pre-operative variable ($R^2 = 0.48$).

We propose a two-stage framework

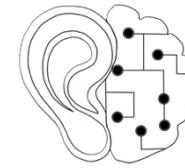
Before surgery: counsel on risk of poor performance.

After surgery: monitor the trajectory and intervene when a patient is not on track.



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Thank you!

marta.campi@uzh.ch

Dr Michael Büchler

Dr Rahel Bertschinger

Dr Marlies Gyes

Prof Alexander Huber

Prof Tobias Goehring

