HearClip: an Application of Bayesian Machine Learning to Personalization of Hearing Aids

Tjeerd Dijkstra, ReSound, RU Nijmegen & TU Eindhoven

Tom Heskes RU Nijmegen

Bert de Vries ReSound & TU Eindhoven

Adriana Birlutiu RU Nijmegen

Perry Groot RU Nijmegen

Iman Mossavat TU Eindhoven

Rolph Houben AMC Amsterdam

Wouter Drechsler AMC Amsterdam

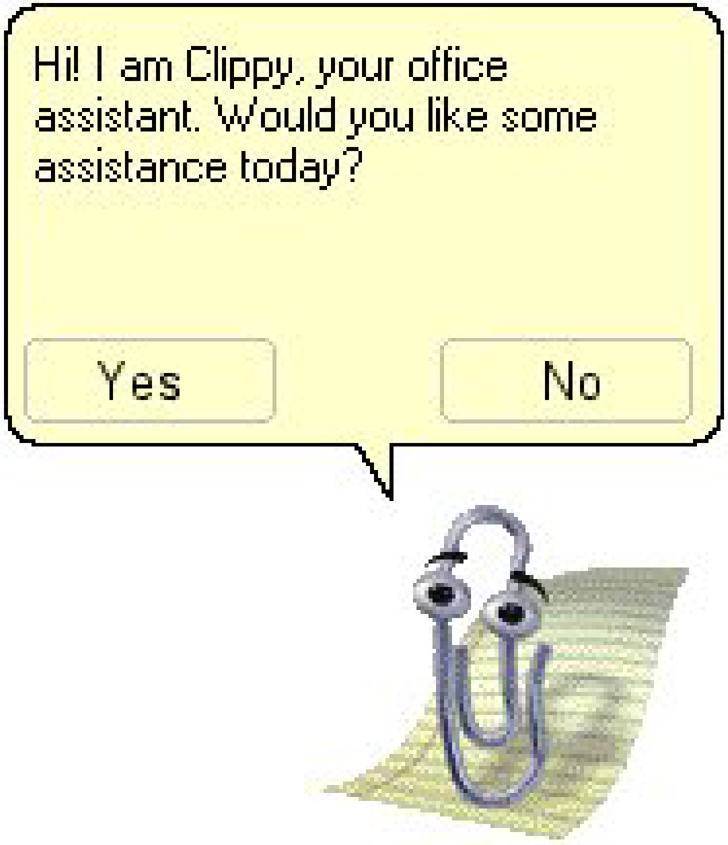
Why HearClip?

- The signal processing in digital hearing aids has many parameters. Examples: feedback cancellers, beamformers and noise suppression systems
- These parameters are fixed at default values and most of them cannot be changed by the dispenser.

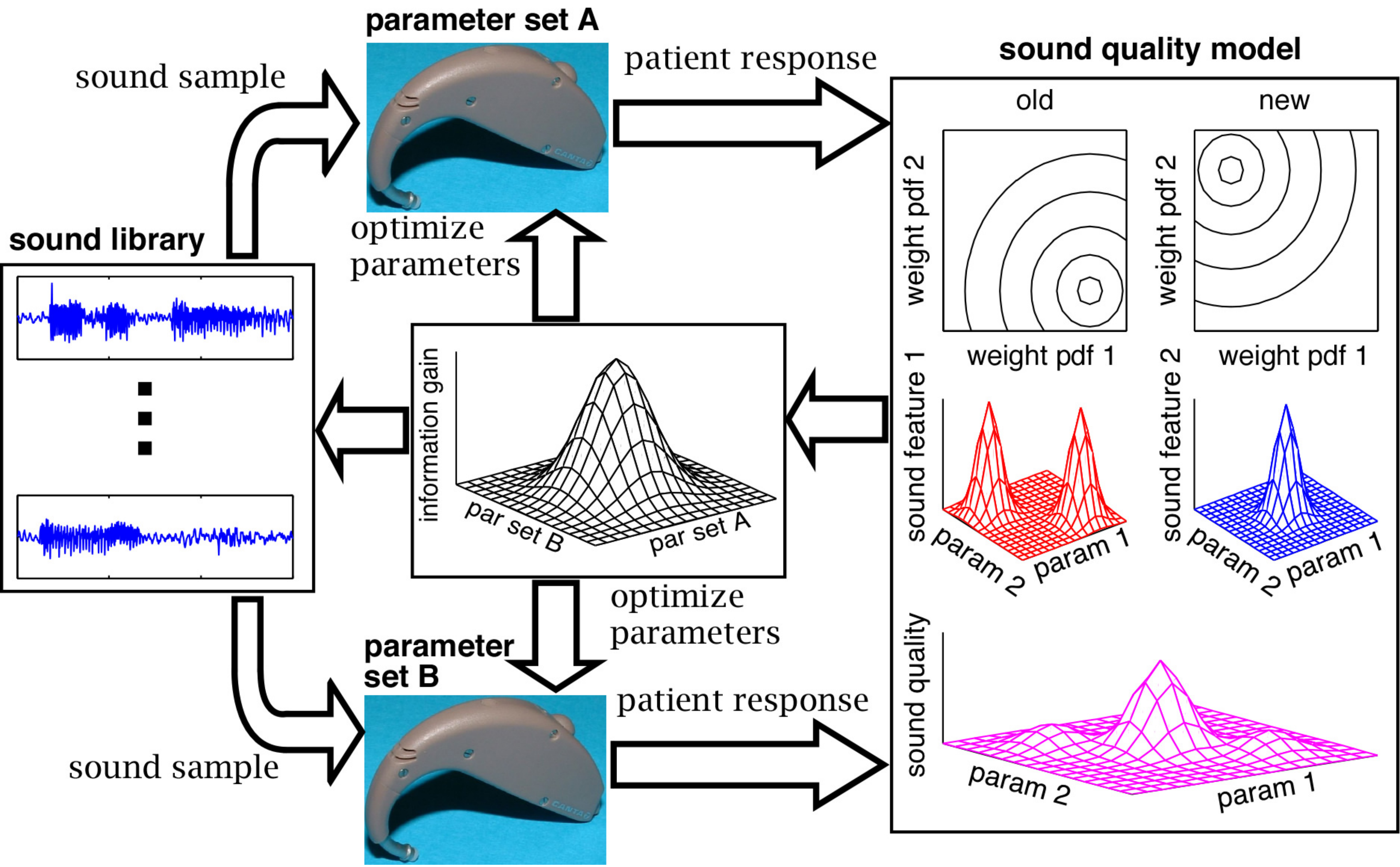
Solution: personalize the parameters by giving the patient or dispenser control.

What is HearClip?

- A 650k Euro research project funded by Stichting Technische Wetenschappen, a funding agency of the Dutch government.
- Name derives from Microsoft’s Clippy, a help system based on Bayesian Machine Learning.



HearClip: personalization from listening test



Sound quality from paired comparisons

- Data from Arehart, Kates, Anderson & Harvey JASA 2007
- 14 normal hearing and 18 impaired listeners
- 2 HINT sentences as speech material
- 3 distortion conditions: additive noise (from HINT CD), peak clipping and center clipping
- 8 levels for each distortion condition
- Each listener made (3*8)^2 = 576 paired comparisons
- Listeners picked the sound sample that sounded best (least distortion)

Exemplary sound stimuli

- Additive speech-shaped noise, signal-to-noise ratio of +4 dB

- Peak clipping at 0.1%: highest 99.9% of sound samples are clipped

- Center clipping at 80%: lowest 80% of sound samples are clipped

Pros and cons of Arehart-Kates data set

Cons

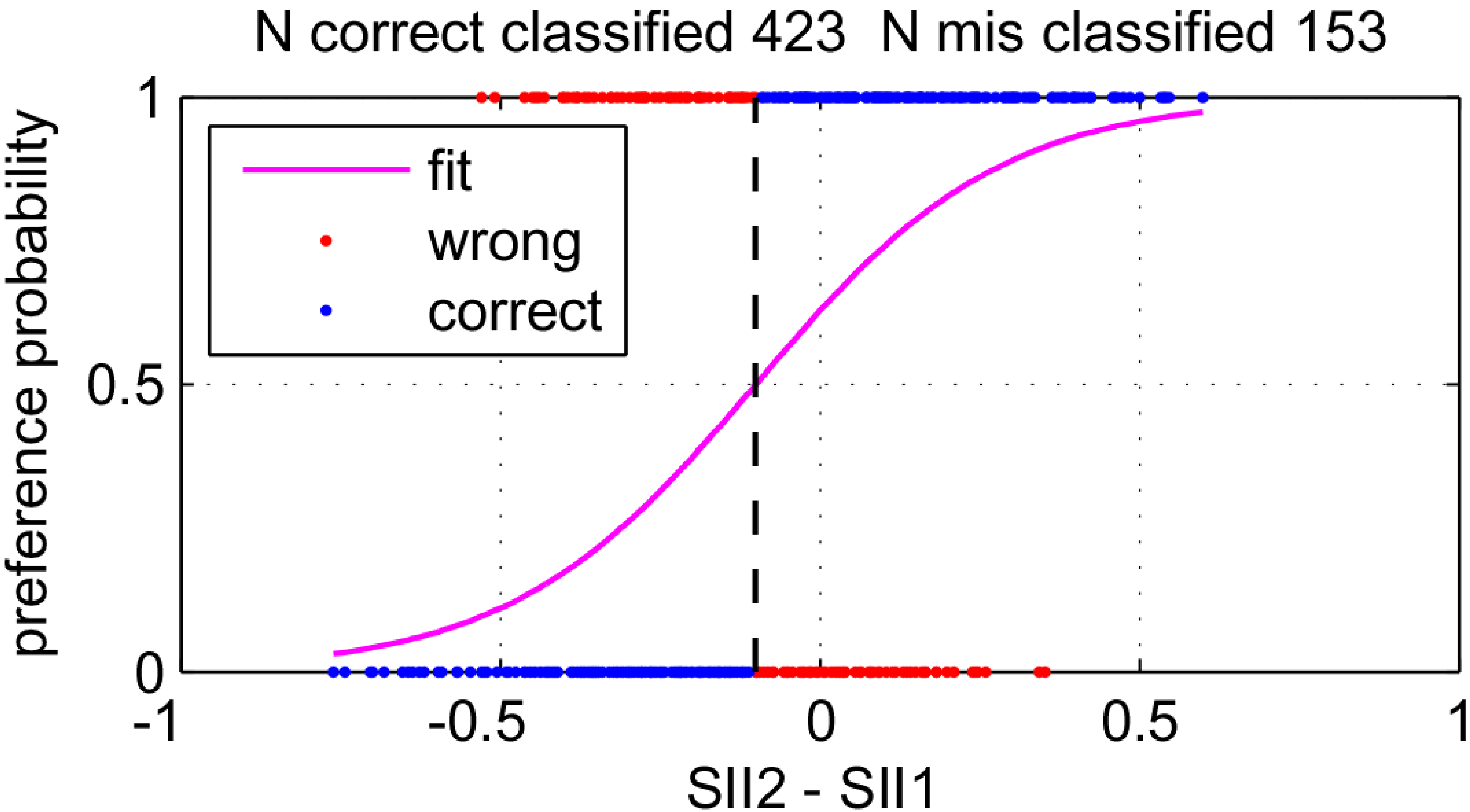
- Distortions have no trade-off: the optimal amount of noise is no noise, optimal amount of clipping is no clipping
- No mixture conditions with some clipping and some noise

Pros

- Different kinds of distortions compared
- Large data set with 32 listeners and 576 paired comparisons per listener

Predict response from SII

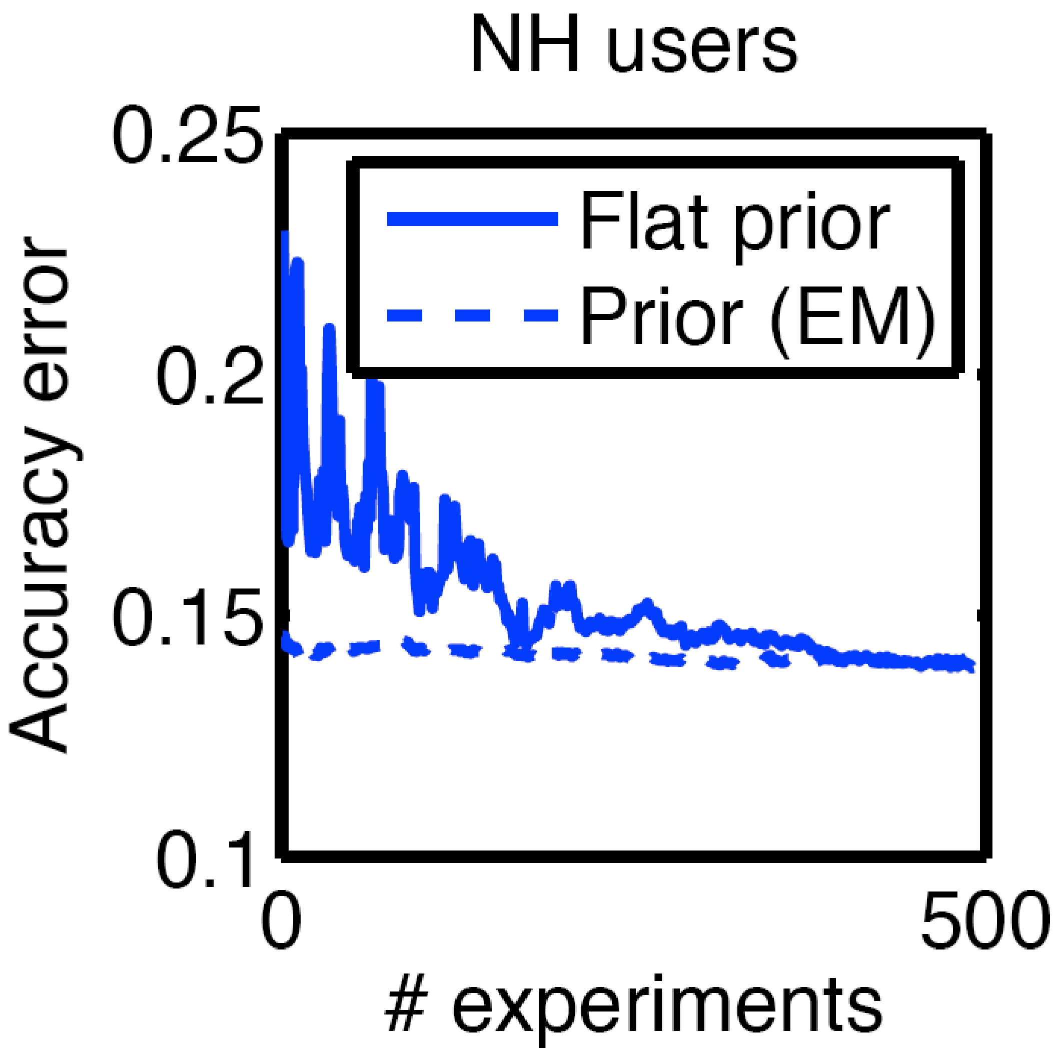
Error fraction = 153/(423+153) = 0.26



How to reduce the number of listening tests

- Use data from other listeners -> Bayesian hierarchical model
- Use a procedure to select the listening test that gives the most information -> active experiment selection

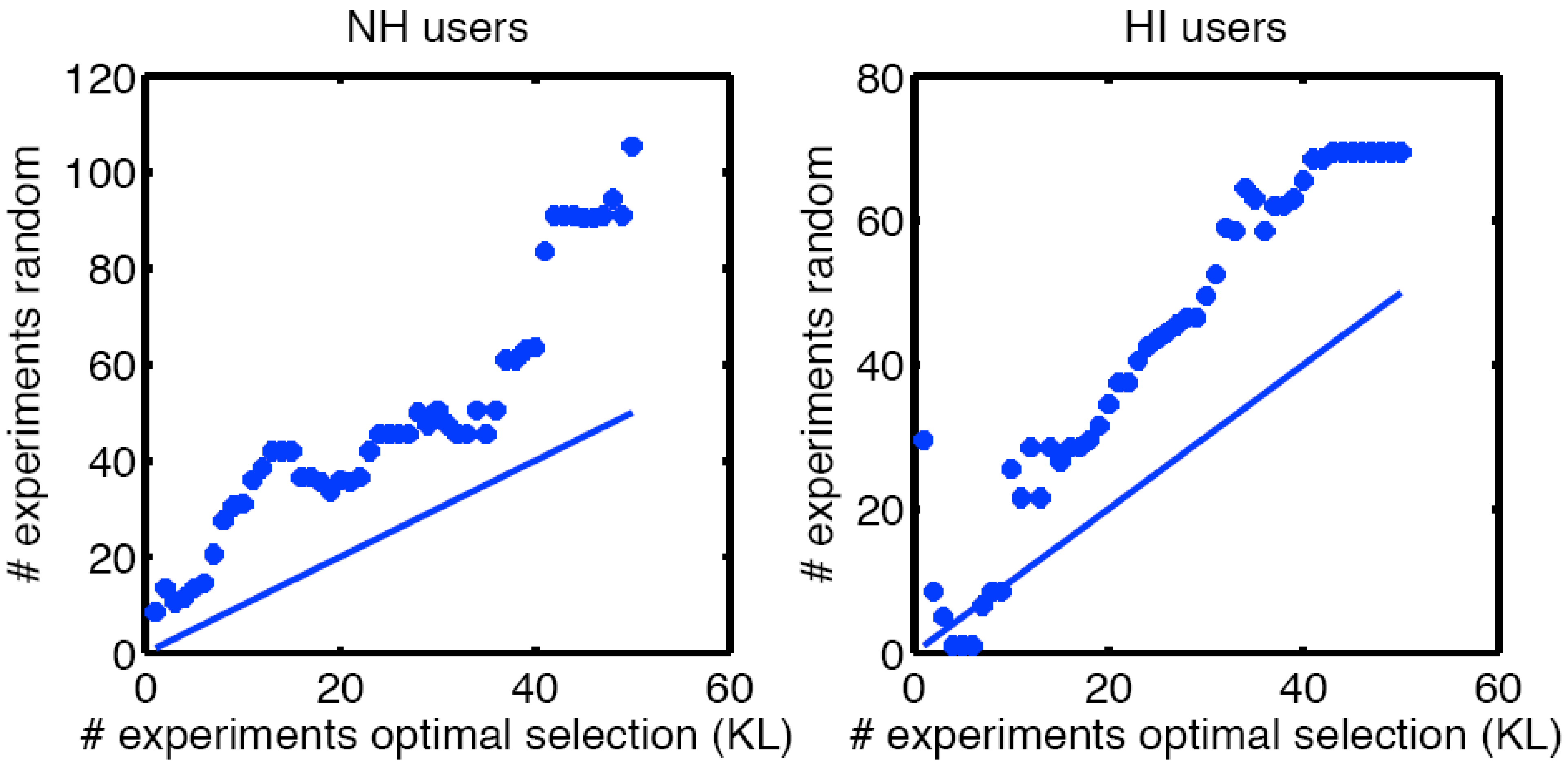
Use data from other listeners



Data from other listeners reduces error by 4% for 20-100 listening tests

Optimally select listening tests

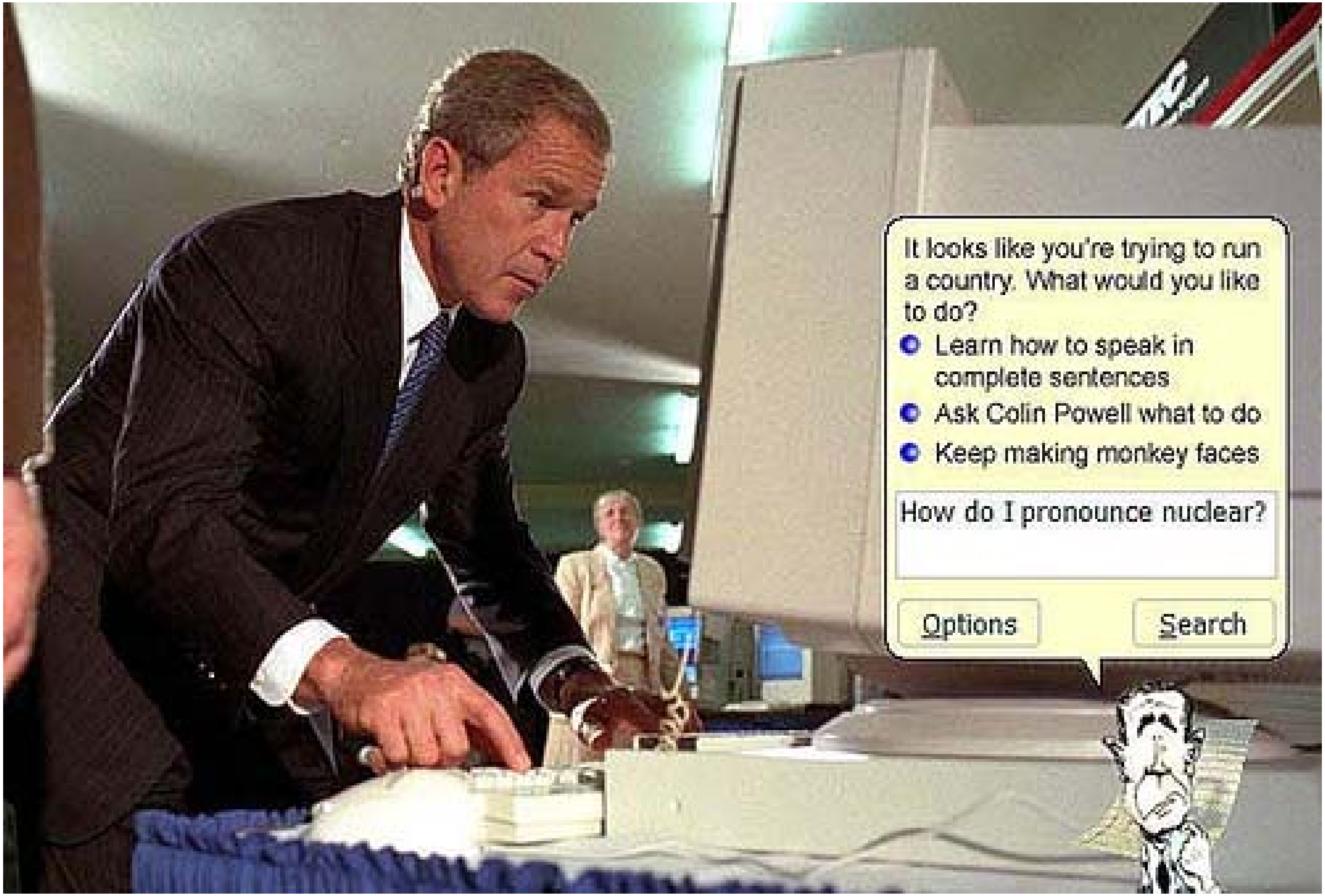
Benefit is a 50% reduction in number of listening tests for identical error



What next

- Evaluate other sound quality measures than SII (e.g. PESQ, PEMO)
- Use the personalized sound quality metric to optimize hearing aid parameters
- Collect response with distortions from an actual hearing aid algorithm, e.g. a noise suppression algorithm

Next … the return of Clippy



Conclusions

- Hearing-impaired (HI) show bigger differences in their quality measures than normal-hearing (NH) persons
- Using information from other listeners improves prediction error by 4% for a small number of listening trials (< 100)
- Optimal selection of listening test can reduce number of listening tests by 50% (relative to random selection).
- Prediction error is around 15% for NH and 20% for HI and needs improvement