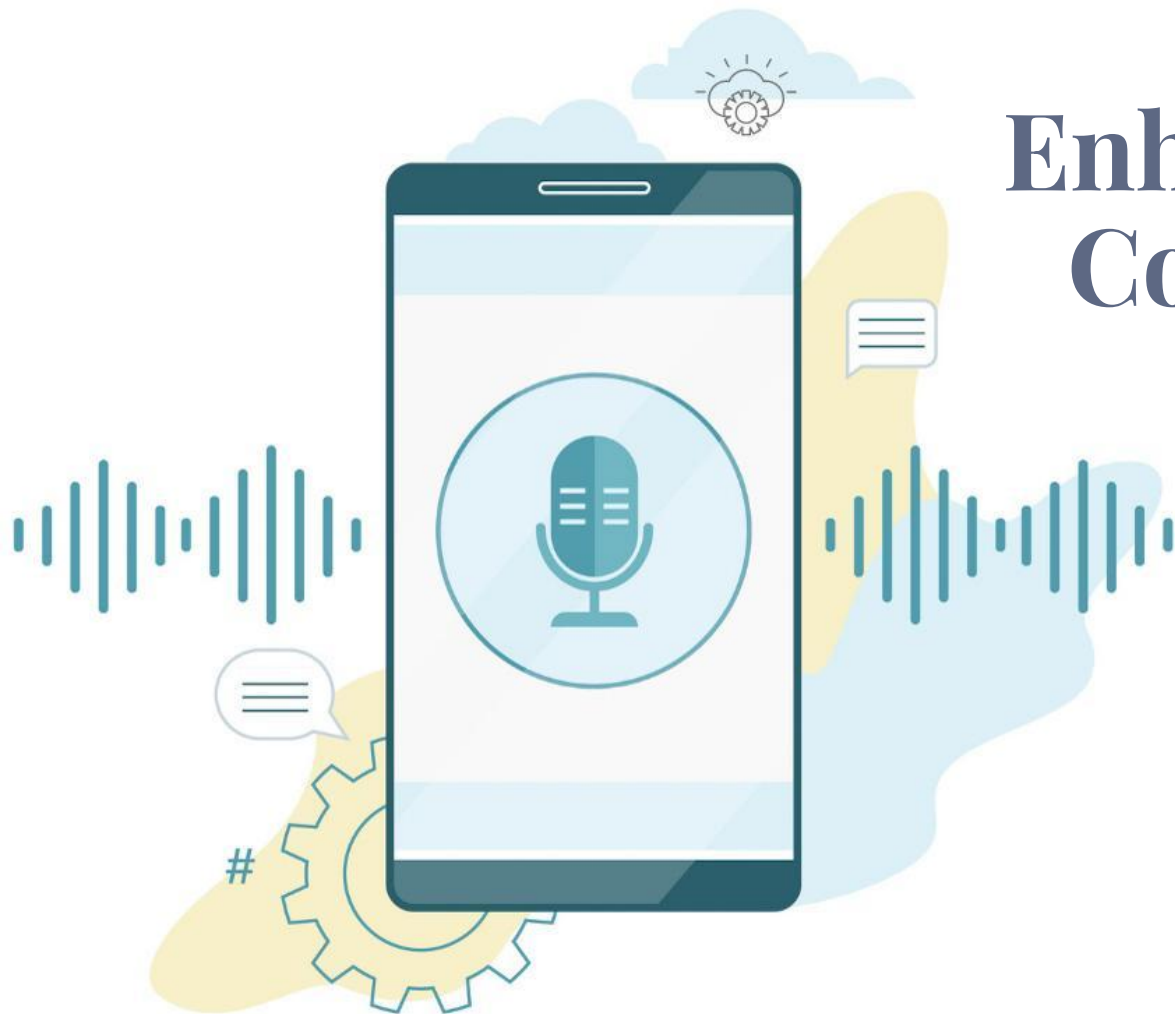


Enhancing Automated Voice Cognitive Assessment with Multiple ASRs

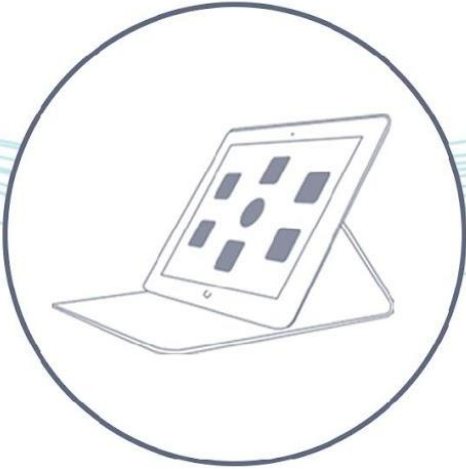
An AI powered word-game for detecting dementia

Nick Taptiklis



What *we* do

CAMBRIDGE
COGNITION



**Digital
Assessments**



**Science
Consultancy**



**Project
Management**

CANTAB *Mobile*

Our clinical dementia assessment tool

CE-marked, FDA-cleared and TGA-approved medical device



Projected Total Medical and Long-Term Care Costs and Cost Savings (in Billions of 2017 Dollars) by Diagnosis Scenario and Year

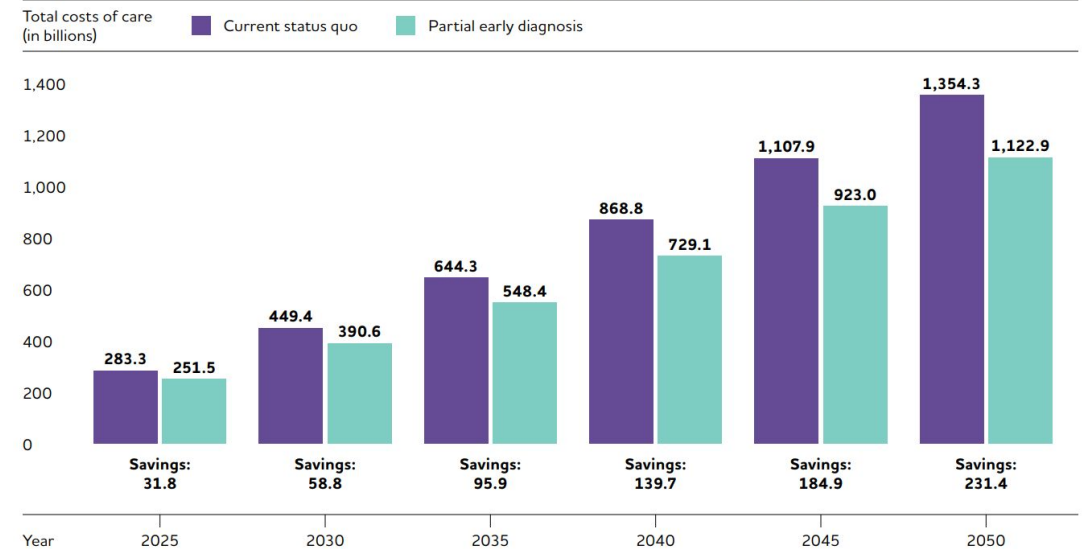


Figure 2. The Alzheimer's Association commissioned Precision Health Economics to conduct analyses on the projected savings from early diagnosis using The Health Economics Innovation Simulation (THEMIS) model. The graph is reproduced from page 65 of [Alzheimer's Association 2018 fact sheet](#).

Voice technology has become *mainstream*

Can it be harnessed for detecting dementia?

- Speech recognition research has shifted to deep-learning based approaches.
- This has powered a step-change in recognition quality, that has powered consumer speech devices.
- Can this technology be used to automate verbal cognitive assessment?

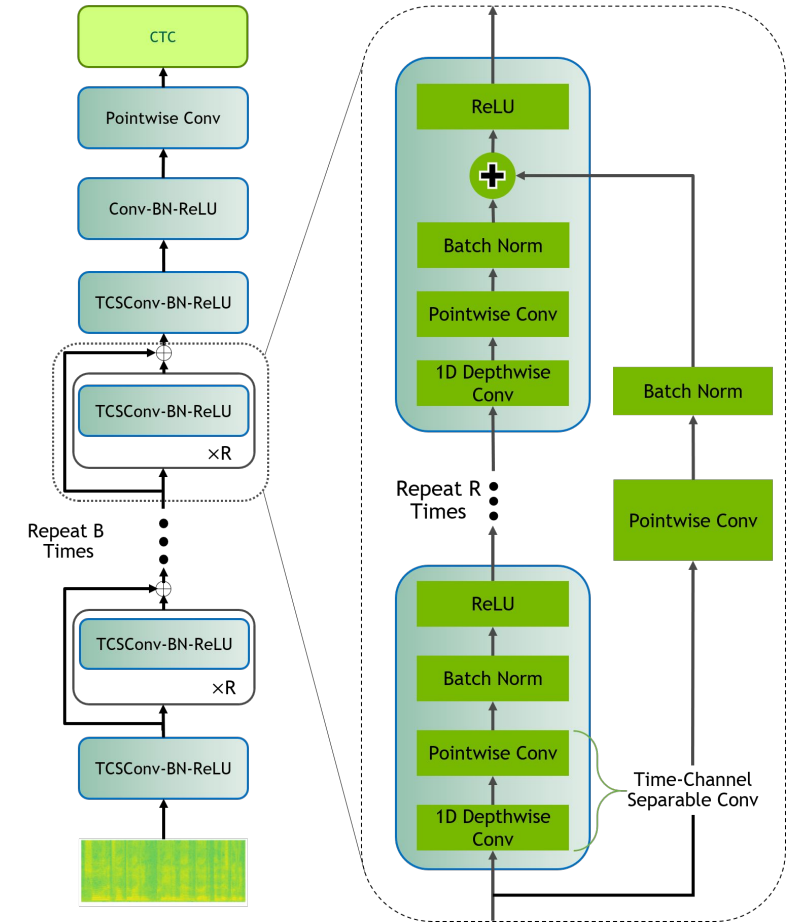


Figure 1: S. Krivan et al. 2020 doi: 10.1109/ICASSP40776.2020.9053889.

Verbal Paired Associates

A memory word-game targeting the neuropathology of Alzheimer's disease

- Alzheimer's pathology starts in the temporal lobes.
- This region is critical in forming a memory connection between items.
- We automated a word-game to test a patient's ability to encode an association between pairs of words.

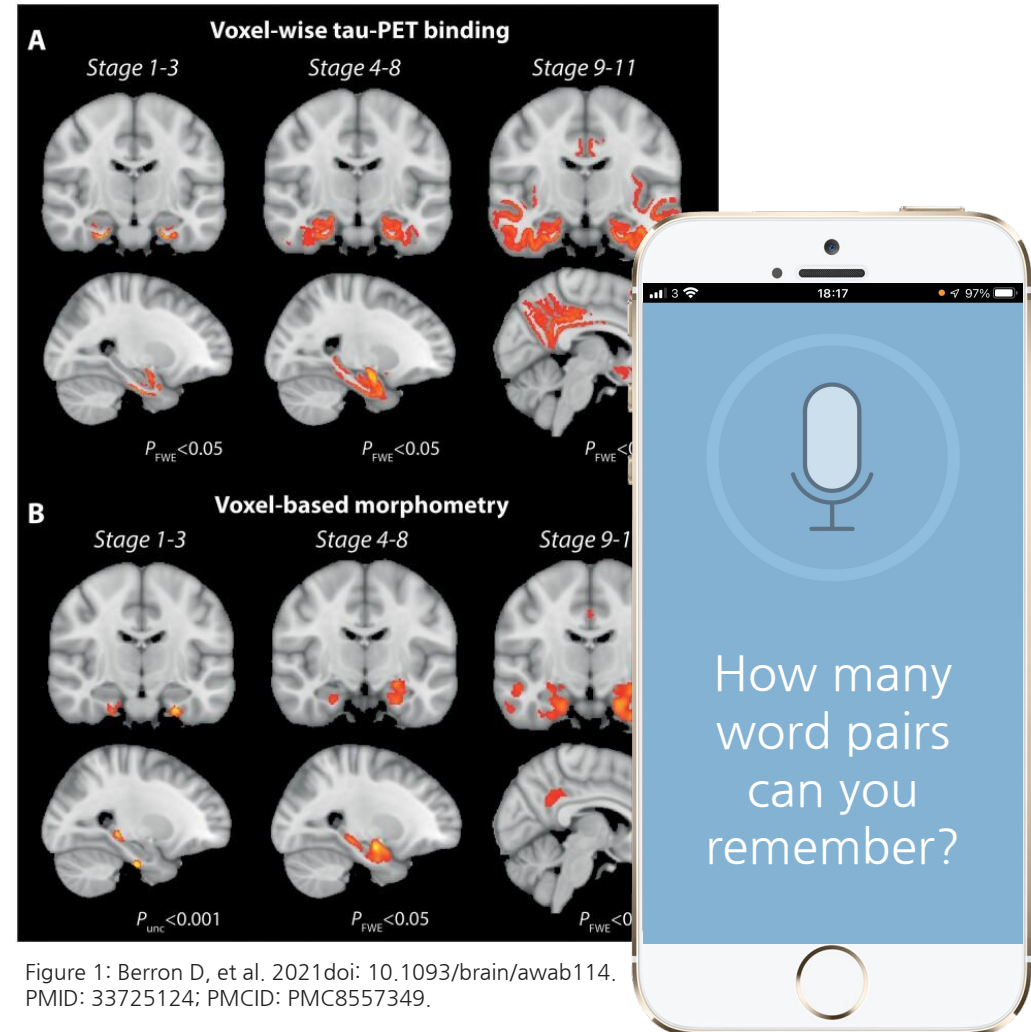


Figure 1: Berron D, et al. 2021doi: 10.1093/brain/awab114. PMID: 33725124; PMCID: PMC8557349.

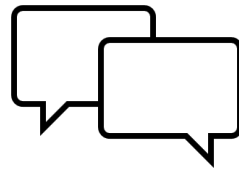
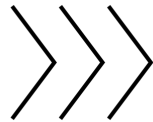
Verbal Paired Associates

AI pipeline

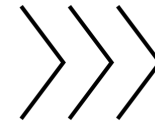
- Machine-learning generated input to the word game
- Automatic Speech Recognition to understand patient response
- Machine learning models of cognitive load extracted from acoustic features of the patient's voice



Word Pairs
Generation



Automatic
Speech
Recognition



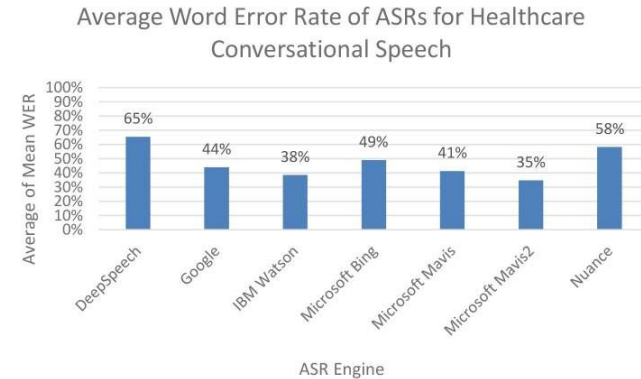
Acoustic
analysis of
cognitive load

The Automatic Speech Recognition (ASR) Challenge

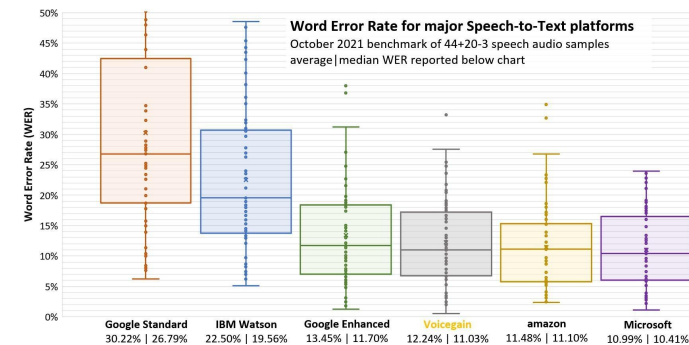
Word Error Rate

- No Single ASR sufficiently reliable.
- Commercial recognition services are a 'black box'.
- Commercial providers such as Google, Amazon, Microsoft have access to much more training data than open-source.

How can we use cloud-based black-box AI in a healthcare setting?



Kodish-Wachs, Jodi et al. AMIA Symposium vol. 2018 683-689.



Jacek Jarmulak, 2021.
<https://www.voicegain.ai/post/speech-to-text-accuracy-benchmark-october-2021>.

Independence *Assumption*

Achieving accuracy and robustness by aggregating multiple unreliable AI outputs

Assuming independently trained ASR systems

$$P(\text{ErrorGoogle} \mid \text{ErrorWatson}) = P(\text{ErrorGoogle})$$

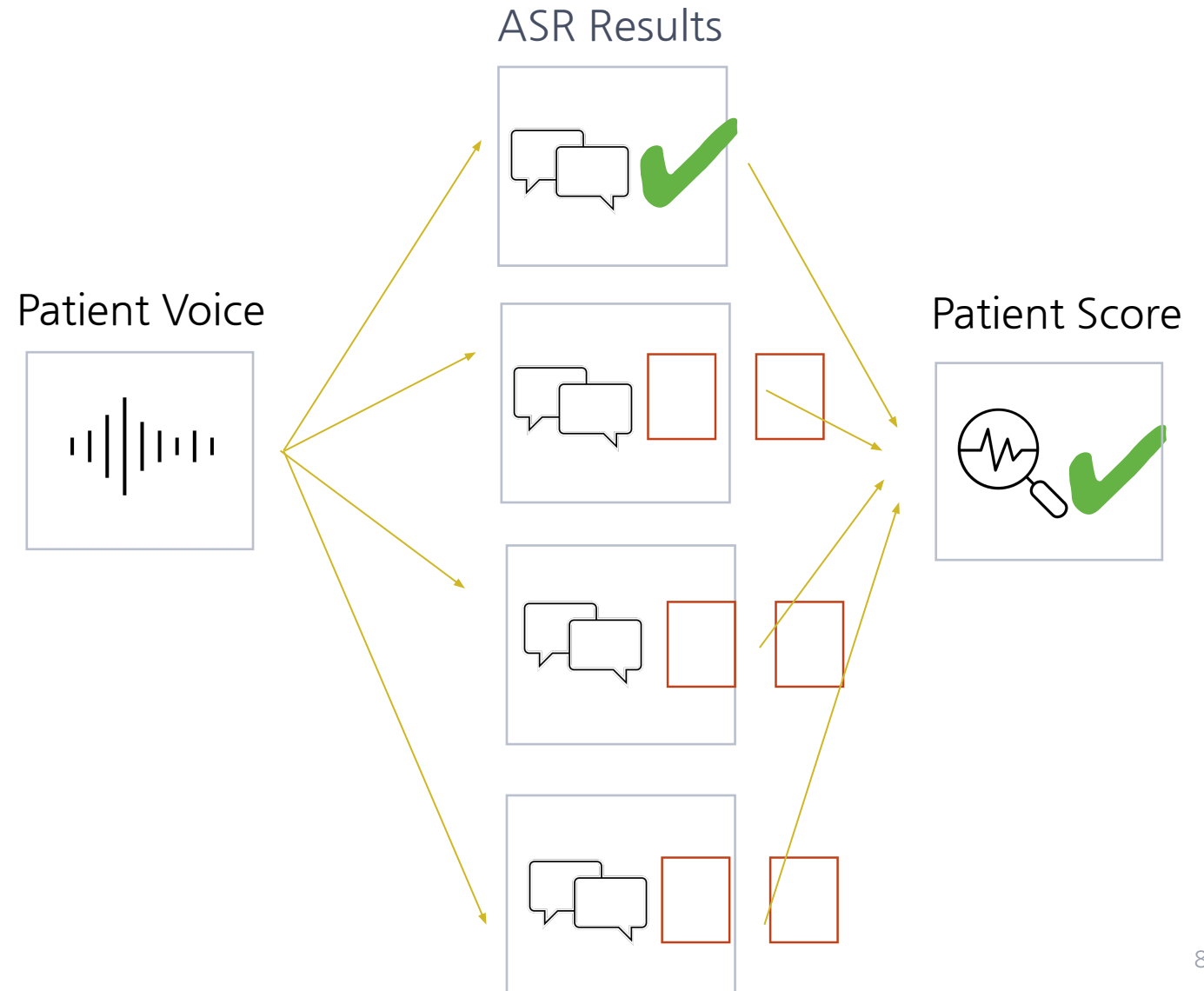
$$P(\text{ErrorWatson} \mid \text{ErrorGoogle}) = P(\text{ErrorWatson})$$

The joint probability of both systems erroring are

$$P(\text{ErrorGoogle}, \text{ErrorWatson}) = P(\text{ErrorGoogle}) P(\text{ErrorWatson})$$

Giving an aggregate accuracy:
 $= .44 \times .38 = 0.16$

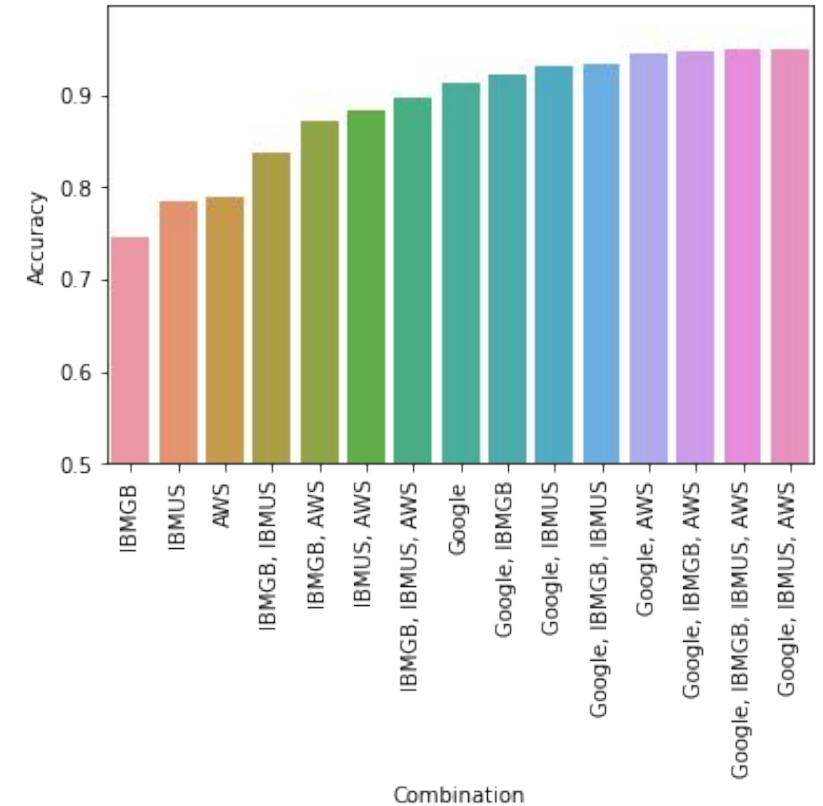
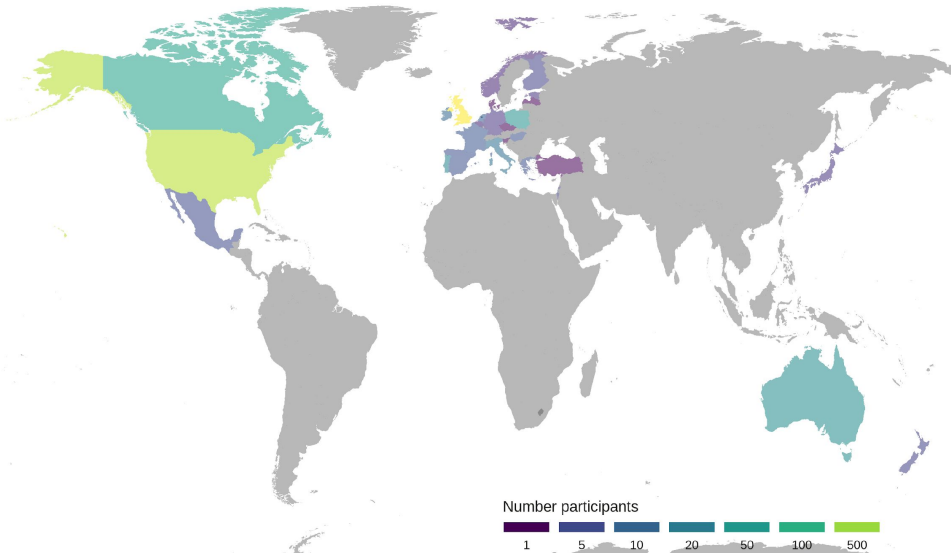
Adding a third recogniser:
 $= .44 \times .38 \times 0.49 = 0.08$



Validation Study

- We tested 5742 people from around the world on their own devices.
- We manually scored more than 3000 voice interactions.
- We tested our independence assumption by looking at ASR error patterns.

Country of residence

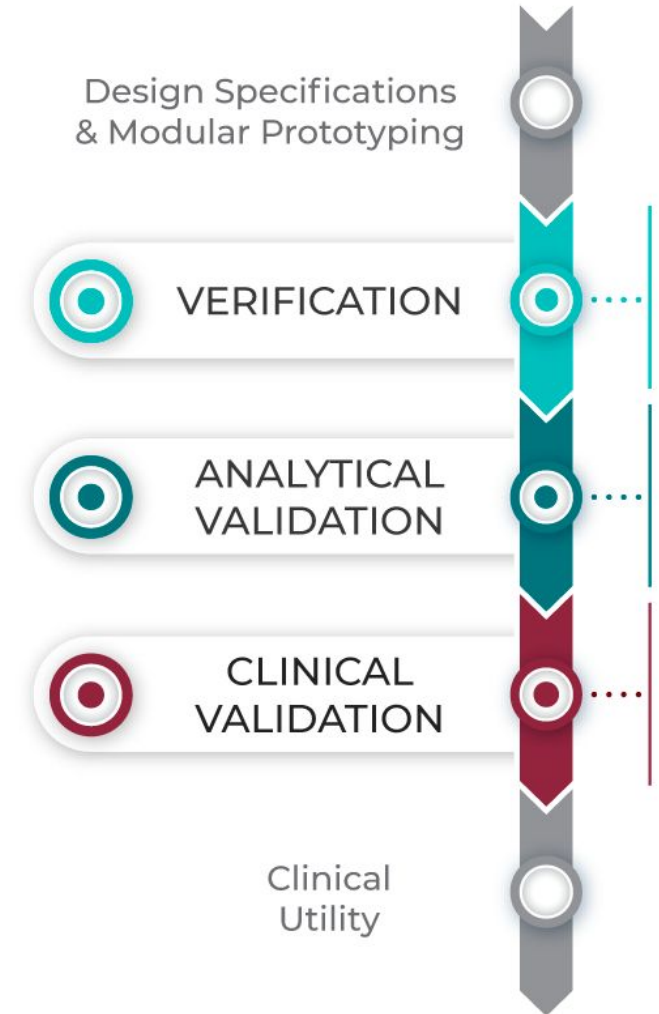


Cormack et al (2020) Accuracy of automated scoring of Verbal Paired Associates in a remote data collection context

Innovate UK

Conclusion

- Available today for pharmaceutical and academic research via Cambridge Cognition's cloud-based clinical trials platform.
- Clinical validation studies including brain imaging data starting soon.
- We are developing longitudinal models of clinically relevant change.



Thank you

info@camcog.com

CAMBRIDGE
COGNITION

