When do cochlear implant users 'give up'?

the impact of SNR, peripheral auditory sensitivity and central cognitive profile on CI users' speech recognition and listening effort

Yue Zhang[1], Amparo Callejon-Leblic[2,3], Ana M Picazo-Reina[3], Serafin Sanchez-Gomez[3]

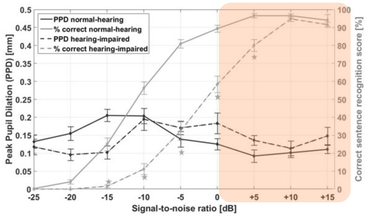
[1]Oticon Medical, Vallauris, FRA; [2]Oticon Medical, Madrid, ESP; [3]Virgen Macarena University Hospital, Seville, ESP;

Introduction

- Listening with Cochlear implant (CI) requires high effort.
- Factors contributing to elevated effort: poor spectral resolution, ***background noise***, etc..

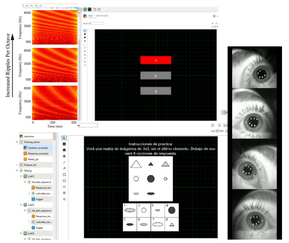
  Q1: Is it the same inverted 'U-shape' for NH/HI (Ohlenforst et al., 2017) and CI users?
- Great individual differences in CI users

  Q2: How individual differences at central and peripheral levels affect the 'U-shape'?



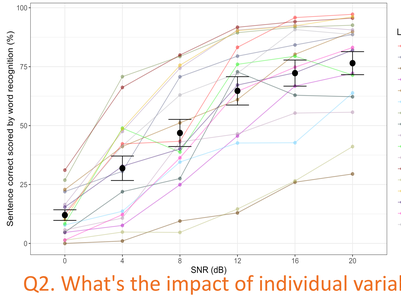
Methods

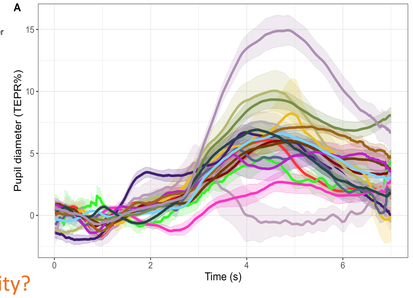
- 17 post-lingually deaf unilateral Cochlear implant users (Oticon Medical Neuro 2; age: mean=53.8yrs, sd=12.2yrs; gender: f=10)
- Spanish HINT ***sentence recognition*** in speech-shaped noise, at SNR steps of 0 dB, 4 dB, 8 dB, 12 dB, 16 dB and 20 dB; with concurrent ***pupillometry*** during sentence listening; subjective effort rating NASA-TLX
- ***Cognitive capacities*** and ***auditory acuity***: Nback, Progressive matrices, Stroop word-colour, spectral-temporal ripple test (SMRT)
- Individual differences: ***QoL*** (Nijmegen CI Questionnaire), ***clinical word recognition***, ***T-levels***, ***duration of CI***
- Experiments ran on Oticon Medical Experiment Platform (OMEXP), a custom extension on OpenSesame

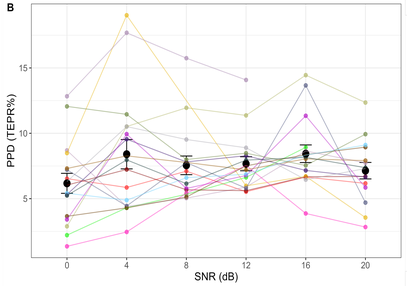


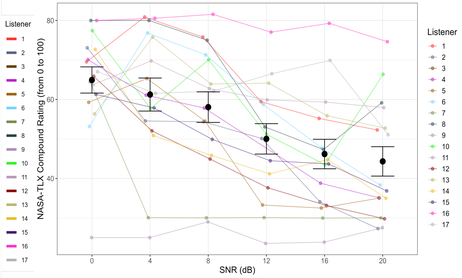
Results

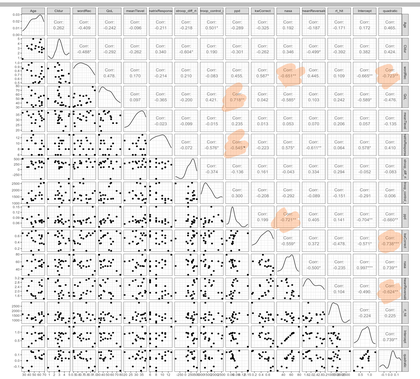
Q1. Is there an inverted 'U-shape' between task difficulty and pupillary response?









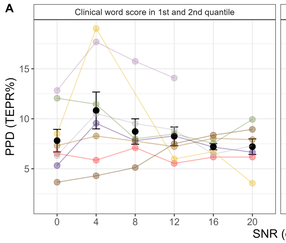


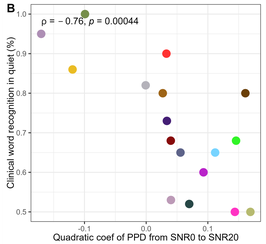
- Significant linear increasing trend in sentence recognition from SNR0 to SNR20 ($\chi 2$ = 112.7, df = 1, p<0.001; b = 9, SE=1.67, p<0.001)

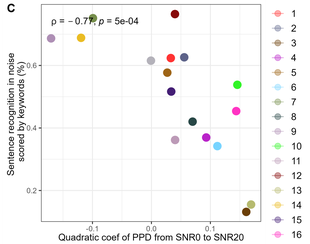
- No significant linear or quadratic trend in PPD from SNR0 to SNR20.

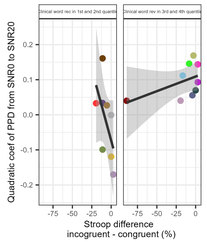
- Significant linear decreasing trend in NASA-TLX from SNR0 to SNR20 ($\chi 2$ = 18.55, df = 1, p<0.001; b=-0.77, SE=0.18, p<0.001)

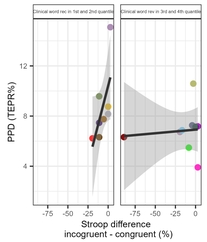
Q2. What's the impact of individual variability?

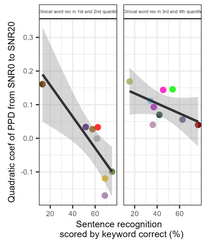


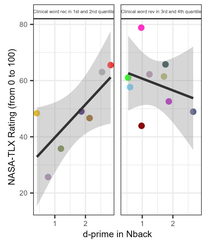












Individual factor	LDA Coefficient
Stroop – executive function	2.79
SMRT – spectro-temporal sensitivity	-2.39
Nback – WM efficiency	-0.70
Matrix – non-verbal intelligence	-0.39
CI duration	-0.11
Mean T-levels	-0.06
Age	0.03

- Better **matrix response** was correlated with smaller **average PPD** (S=1385.4, p =0.002, rho = -0.70).

- Higher **QoL** was related with bigger **average PPD** (t=4.41, df=14, r=0.76, p <0.001) .

- Higher **clinical word recognition** (S=1433.5, rho = -0.76, p<0.001) and **sentence recognition in noise** (S=1442, rho=-0.77, p<0.001) were correlated with more concave **quadratic increase** changes over SNR.

- Linear discriminant analysis showed the importance of individual factors in predicting top and bottom quantile CI users of clinical word recognition.

Conclusion

- The non-linear psychometric relation between SNR and PPD is not consistent at a group level. But after considering individual differences in speech recognition, similar psychometric relation was found.
- Individual differences in cognitive profile predict the psychometric relation, but differently for top and bottom performers, which seems to be consistent with past literature.
- Future studies need to understand what it the ecological meaning of this non-linear relation (i.e., onset of fatigue, point of disengagement etc).

References

Völter, C., Oberländer, K., Carroll, R., Dazert, S., Lentz, B., Martin, R., & Thomas, J. P. (2021). Nonauditory functions in low-performing adult cochlear implant users. Otology & Neurotology, 42(5), e543-e551.
Tamati, T. N., Ray, C., Vasil, K. J., Pisoni, D. B., & Moberly, A. C. (2020). High-and low-performing adult cochlear implant users on high-variability sentence recognition: Differences in auditory spectral resolution and neurocognitive functioning. Journal of the American Academy of Audiology, 31(05), 324-335.
Tamati, T. N., Ray, C., Vasil, K. J., Pisoni, D. B., & Moberly, A. C. (2020). High-and low-performing adult cochlear implant users on high-variability sentence recognition: Differences in auditory spectral resolution and neurocognitive functioning. Journal of the American Academy of Audiology, 31(05), 324-335.
Benz, Zachary, and Dixon, Kevin. Sandia Generated Matrix Tool (SGMT) v. 1.0. Computer Software. https://github.com/LauraMatzen/Matrices. USDOE. 24 Mar. 2010. Web. doi:10.11578/dc.20210416.34.
Ohlenforst, B., Zekveld, A. A., Lunner, T., Wendt, D., Naylor, G., Wang, Y., ... & Kramer, S. E. (2017). Impact of stimulus-related factors and hearing impairment on listening effort as indicated by pupil dilation. Hearing research, 351, 68-79.
Ohlenforst, B., Wendt, D., Kramer, S. E., Naylor, G., Zekveld, A. A., & Lunner, T. (2018). Impact of SNR, masker type and noise reduction processing on sentence recognition performance and listening effort as indicated by the pupil dilation response. Hearing research, 365, 90-99.

Because
sound matters

Contact: YUZA@oticonmedical.com