How variation in Cochlear Implant performance relates to differences in MAP parameters

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PCA Analysis

Higher speech audiometry scores appear associated with wider Dynamic Range

In this project we investigated T (threshold) and C (comfort) levels of 298 CI recipients at the Radboud university medical center.
The recipients were all **postlingually deaf adults**, and all tests were NVA CVC tests in quiet, at a presentation level of 65 dB SPL.

The first step performed was conducting **Principal Component Analysis** to turn the 44-dimensional dataset to a 4-dimensional one.
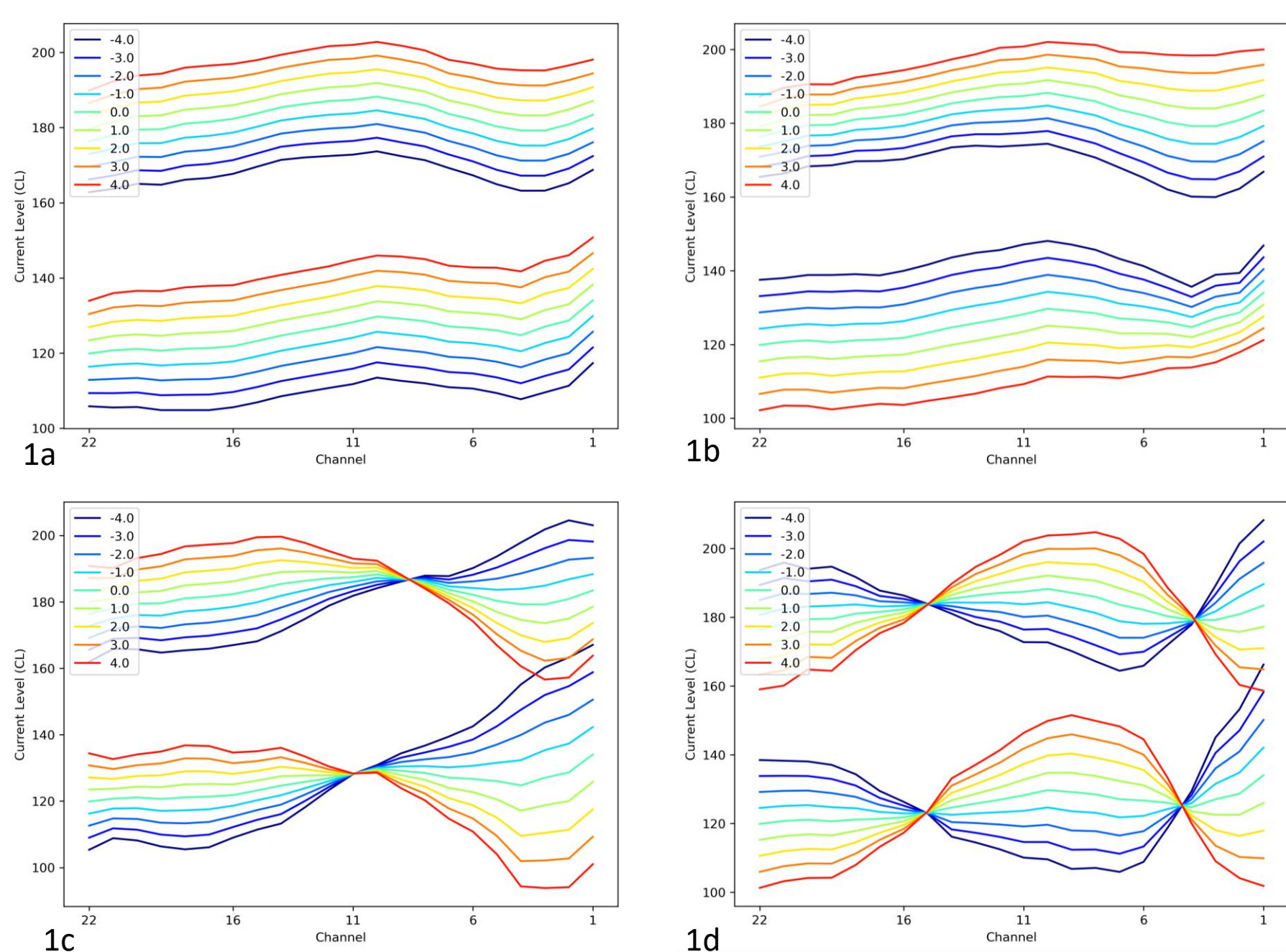

Figure 1: Explanations of the four PCA components. Figure 1a correlates strongly with the average T- and C-level, 1b with Electrical Dynamic Range (EDR), 1c with tilt and 1d with curvature.

We then separated the **top and bottom tertiles** of performance from the population: the former containing 100 recipients scoring higher than 69% estimated Word Score, and the latter containing 101 recipients scoring lower than 45%.
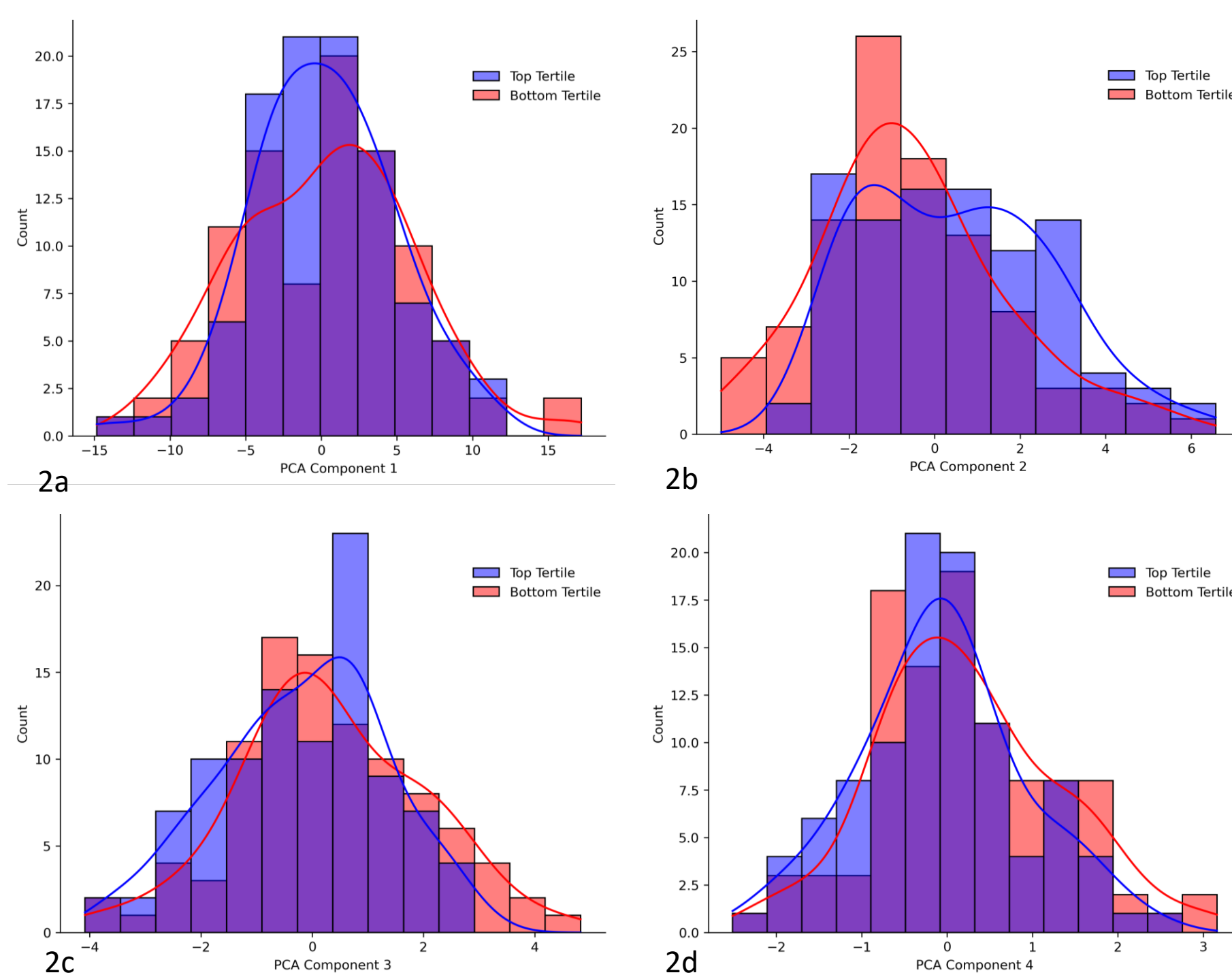

Figure 2: Distributions of the PCA parameters in the two populations

The only component for which a Mann-Whitney-Wilcoxon test showed a significant difference between the populations is the second one (p=0.001, see Figure 2b).
From Figure 1b we can see that this component mainly described the Electrical Dynamic Range (C-T level).

DR Analysis

The next step was to repeat the analysis on the same populations, this time precisely defining the aggregate values we were considering: T-levels, C-levels, EDR, and the tilt of T- and C-levels.

The Mann-Whitney-Wilcoxon test confirmed the **significant difference in EDR between the two populations (Top and bottom tertile)**.
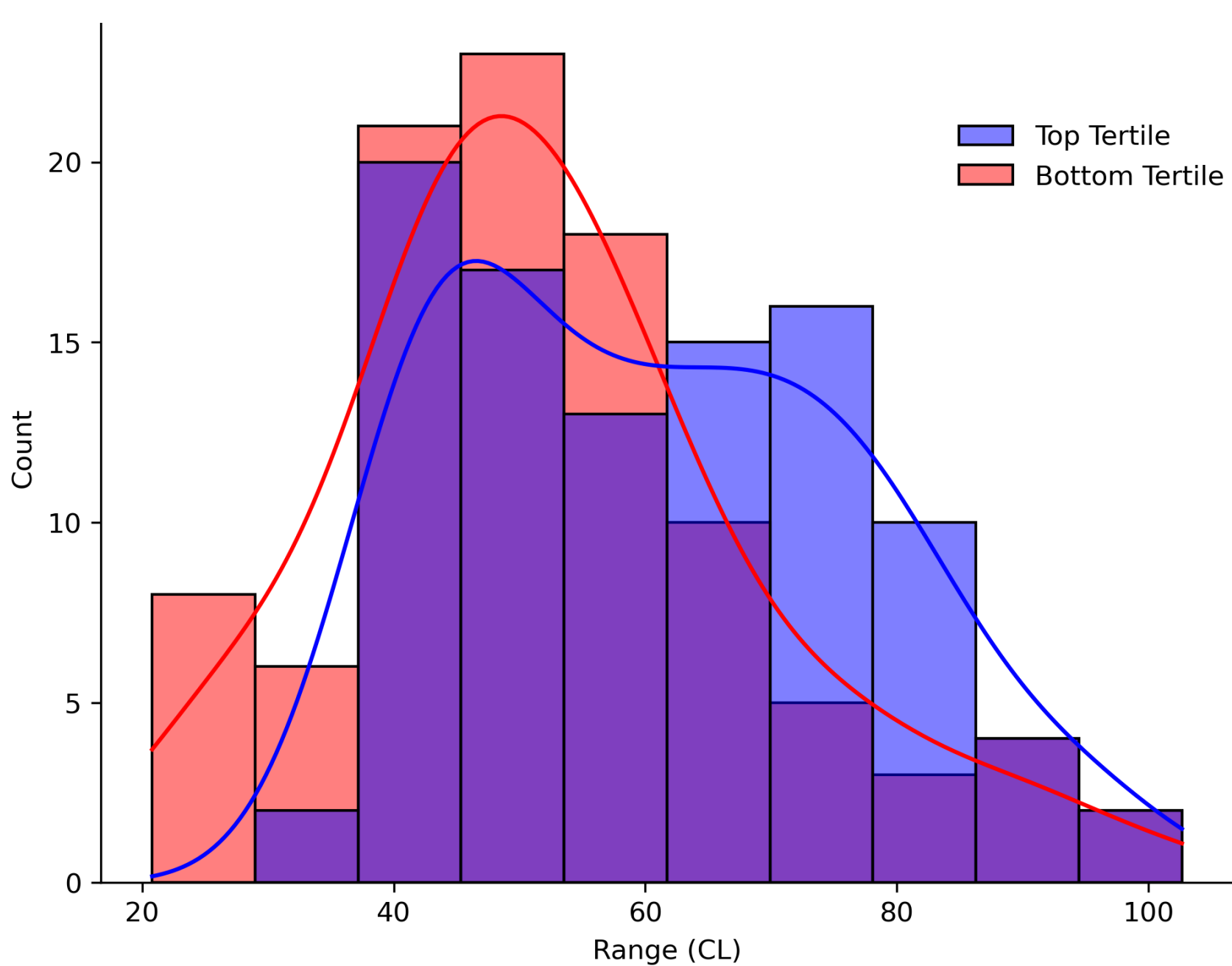

Figure 3: Distributions of dynamic range in the two populations

Conclusions

An analysis of the histogram and its Kernel Density Estimation curve appears to suggest that the top tertile population may be composed of two subgroups: one group showing a dynamic range of approx. 40 to 50 Current Levels (CL) and one showing a dynamic range of approx. 60 to 80 CL.
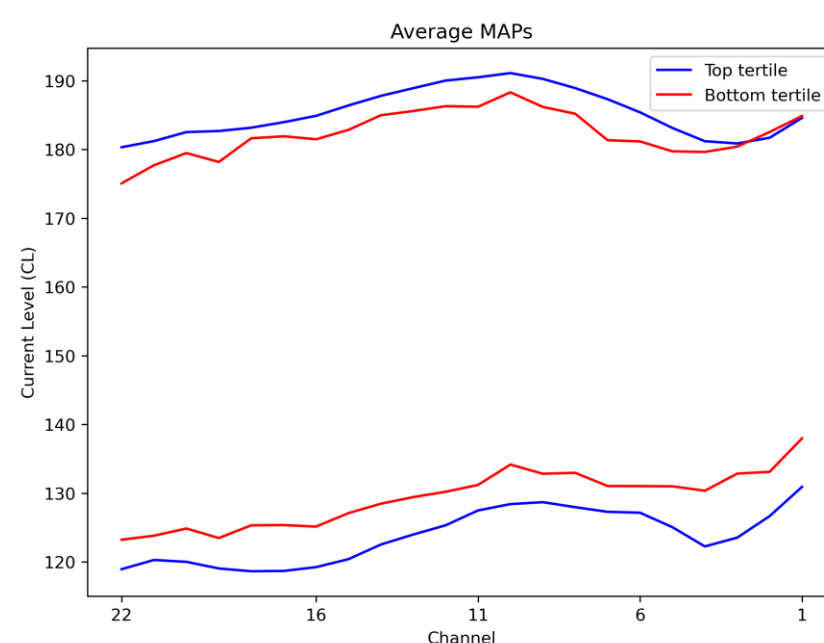

Figure 4: Average MAPs for the two populations

An association between EDR and Speech Audiometry scores has been shown before by both Kim[1] and de Graaff[2].
Further investigation may shed light on the causal relation between the two values: does better DR help some recipients, or are higher-scoring recipients able to make use of a wider DR?

There is also **the possibility of confounders,** such as neural health or native language, which may influence both DR and speech understanding. **This possibility must not be ignored**.

Additional research question: Does increased Dynamic Range improve the speech understanding of some CI recipients?
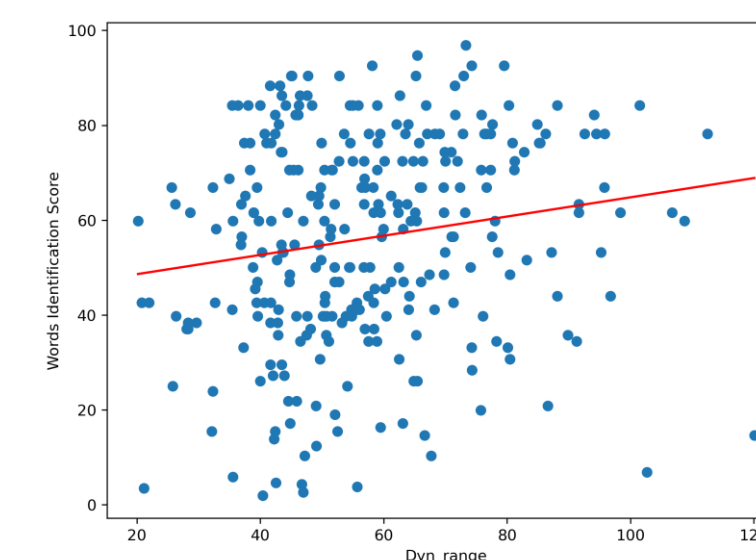

Figure 5: Dynamic range correlation with scores

1. Kim SY, Jeon SK, Oh SH, Lee JH, Suh MW, Lee SY, Lim HJ, Park MK. *Electrical dynamic range is only weakly associated with auditory performance and speech recognition in long-term users of cochlear implants.* Int J Pediatr Otorhinolaryngol. 2018 Aug;111:170-173

2. de Graaff F, Lissenberg-Witte BI, Kaandorp MW, Merkus P, Goverts ST, Kramer SE, Smits C. *Relationship Between Speech Recognition in Quiet and Noise and Fitting Parameters, Impedances and ECAP Thresholds in Adult Cochlear Implant Users.* Ear Hear. 2020 Jul/Aug;41(4):935-947

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