Self-Fit Generation of Wide Dynamic Range Compression Parameters for Hearing Aids

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I Objective

Can we make the user experience of fitting hearing aids (HAs) comparable to that of getting a pair of reading glasses at the neighbourhood pharmacy? We are developing hardware and software instruments in the Open-source Speech Platform (OSP), wherein the machine proposes HA parameters and the user provides feedback on the quality in an iterative loop [1]. This contribution describes use of OSP in research aimed at improving hearing aid fitting protocols.

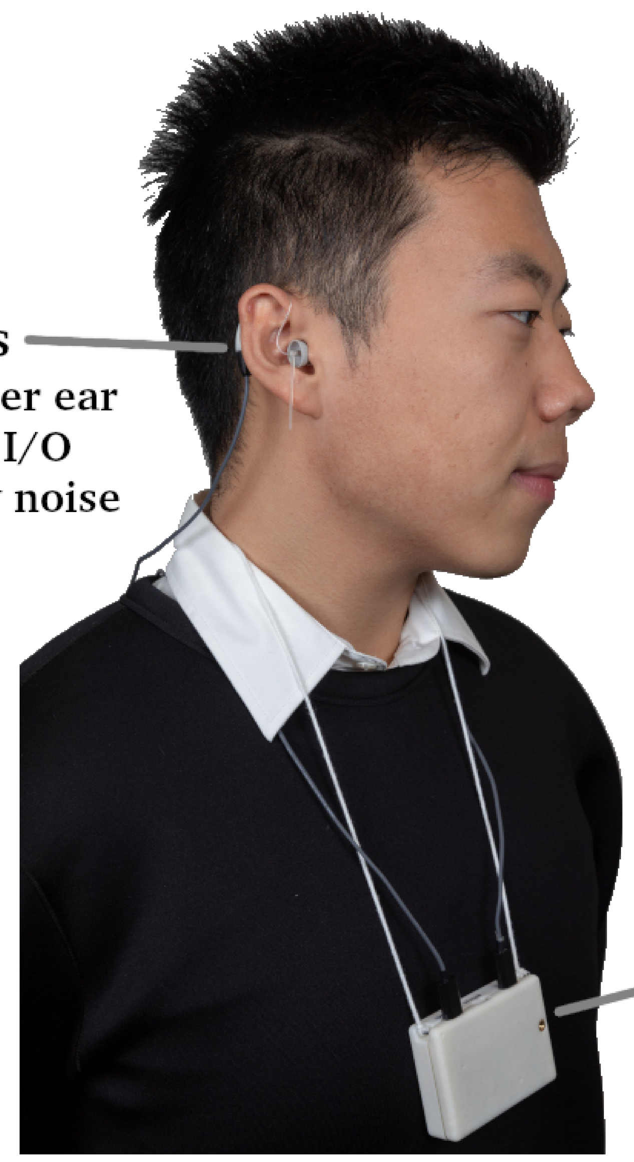

Fig 1: A user wearing the OSP wearable platform. The two hardware components shown are the behind-the-ear receiver-in-canal (BTE-RIC) transducers and the Processing and Communication Device (PCD).

II Approach

We consider two classes of HA parameters in the proposed research:

1. Those HA parameters for which the clinical community has developed collective insights on prescription protocols and their efficacy. Examples include:
   - Compression gains based on NAL-NL2 [2], DSL [3], etc.
   - Goldilocks search and select approach for Loudness, Volume and High frequency boost [4], and similar approaches.
2. The set of HA parameters for which prescriptive guidelines are still evolving. Examples include:
   - Release times associated with compression parameters [5].
   - Frequency lowering approaches and joint optimization of high frequency amplification [6].
   - Tuning of emerging signal processing approaches for noise management in multiple listening environments.

For both classes of HA parameters, we propose a simple, intuitive graphical user interface (GUI) to enable Human-in-the-loop (HITL) research, supported by extensible logic for the machine to propose alternative HA settings in contrast with the current settings.

III Methodology

III.a Getting User Feedback

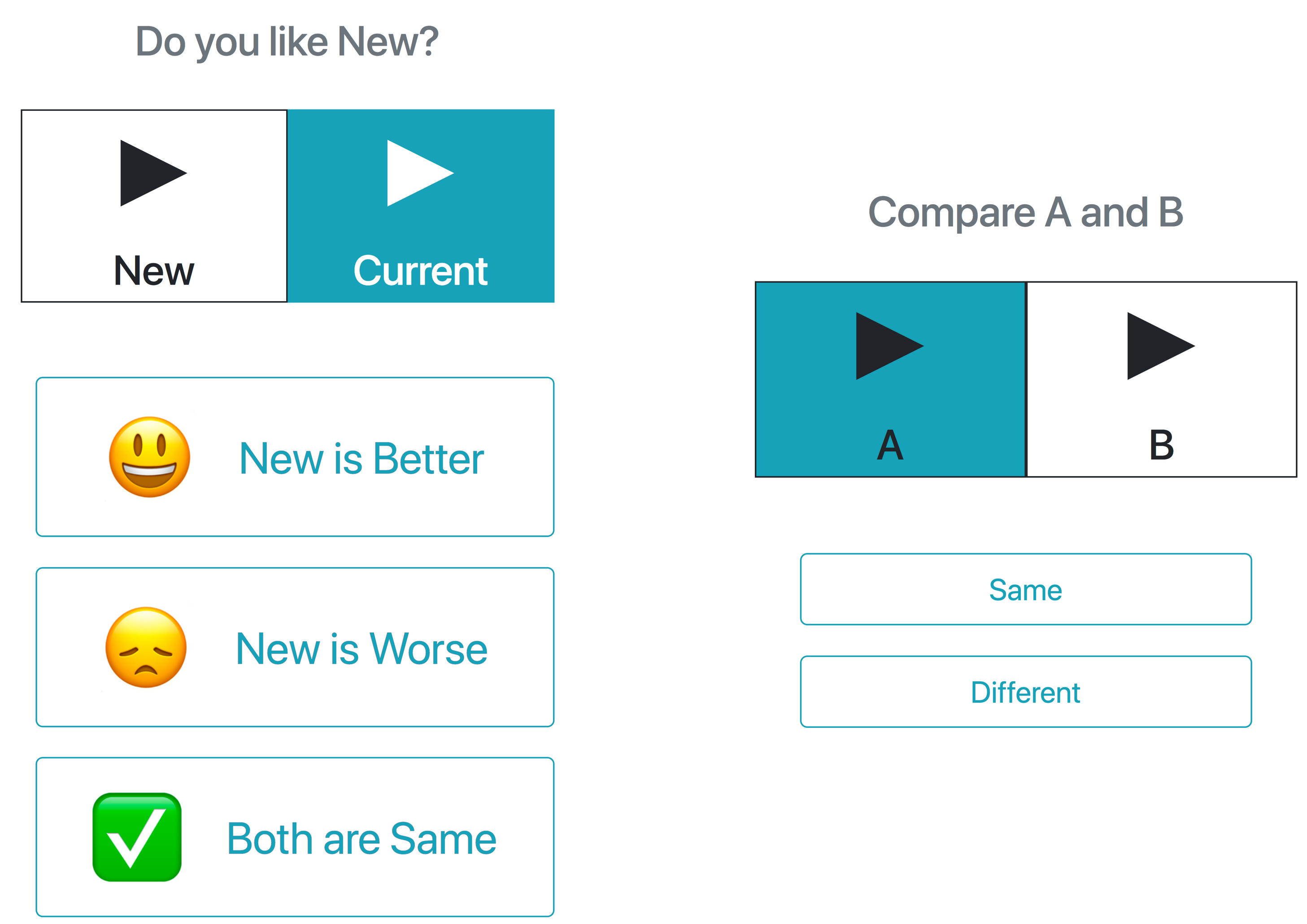

Fig 2: Example GUIs for user input. **(Left)** Quality Assessment. **(Right)** Just Noticeable Differences(JNDs).

III.b Machine Proposed Alternative HA parameters

1. For the HA parameters we have prior knowledge on user expectations, it is possible to organize the search space using simple search techniques. See Fig 3 (left) for an example of binary search for volume.
2. The above figure can be extended for multi-dimensional search such as low frequency slope, volume and high frequency shape [4].
3. We also utilized well known vector quantization (VQ) based clustering approaches to organize multi-dimensional compression parameters in a binary tree based search space structure.
4. For the emerging HA parameters with limited intuition on user preferences, we propose to use probabilistic approaches such as multi-arm bandit solutions from reinforcement learning approaches of machine learning.

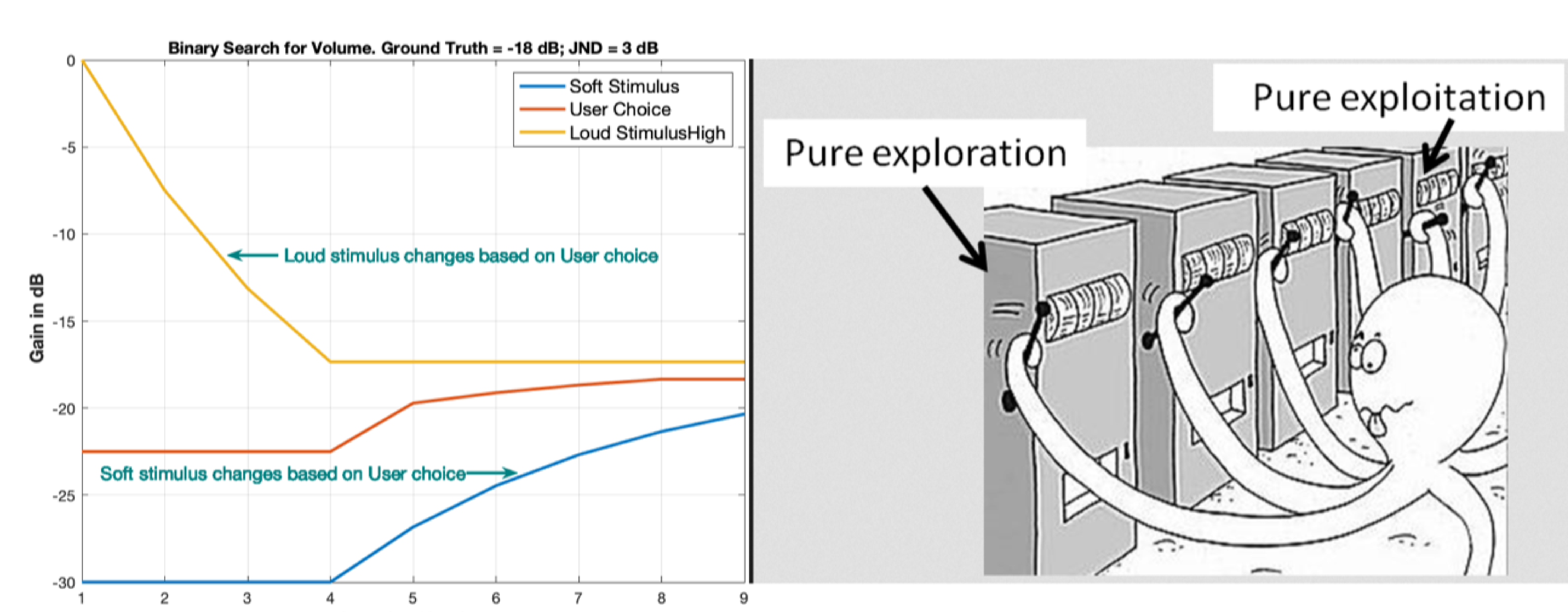

Fig 3: Search strategies for machine proposed HA parameters. **(Left)** Binary search for volume in $\mathcal{O}(2 \times lg(N))$ steps. Loud stimulus is lowered when user selects soft and soft stimulus is increased when user selects loud. **(Right)** Example of multi-arm bandit based approach in reinforcement learning. The machine conducts many trials under the hood to maximize a reward function and presents an alternative set of HA parameters. User provides reward based on perceived quality.

IV Results

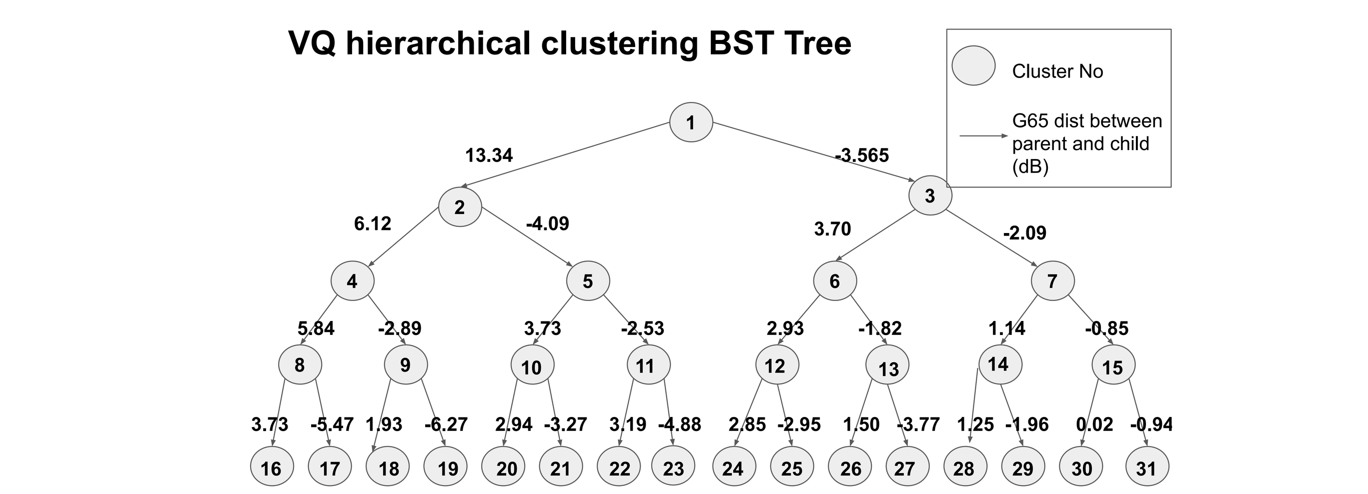

Fig 4: VQ codebooks based hierarchical clustering for binary tree search (BST) algorithm

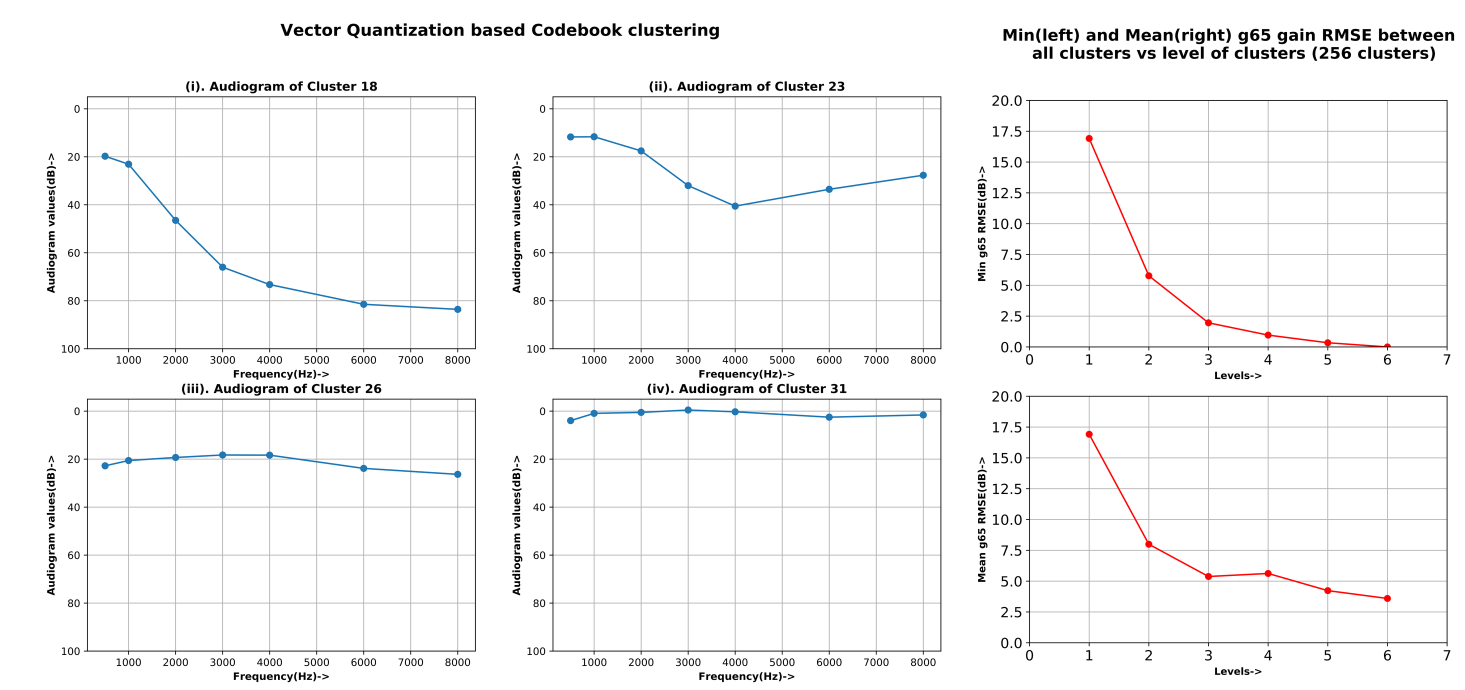

Fig 5: **(Blue)** Sample Hearing loss of different clusters (i). Severe sloping loss (ii). Moderate cookie-bite loss (iii). Mild flat loss (iv). Normal hearing; **(Red)** The RMSE values decrease with levels, with resolution of G65 gains becoming ∼0-1dB for two nearest clusters at higher levels

V Conclusions

In this contribution, we presented pairwise comparison tools for searching a given HA parameters space. We presented preliminary clustering results for the NHANES data-set. Subjective experiments are required to assess the the user effort and the achieved fitting accuracy.

VI Acknowledgements

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VII References

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