

Comparison of Psychoacoustic Measurements for Determination of Nonlinear Loudness Growth Functions

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INTRODUCTION

The fitting of hearing aids is highly important for the recovery of hearing impaired people, with loudness adaptations playing a crucial role. To get an impression of the loudness perception of individuals, methods of categorical loudness scaling can be used [1].

METHODS

A study conducted with 23 normal hearing participants aims to assess duration, repeatability and the ability to gather nonlinearities in loudness growth functions (LGFs) of different methods: Constant Stimuli (CS), Adaptive Categorical Loudness Scaling (ACALOS) and instantaneous scaling using Response Tracking (RT) for two stimulus durations (17 and 34 seconds). The experiments were carried out in an echoic chamber, using PsyWorks software for presentation of noise stimuli and response collection. Data preparation and analysis was conducted in RStudio.

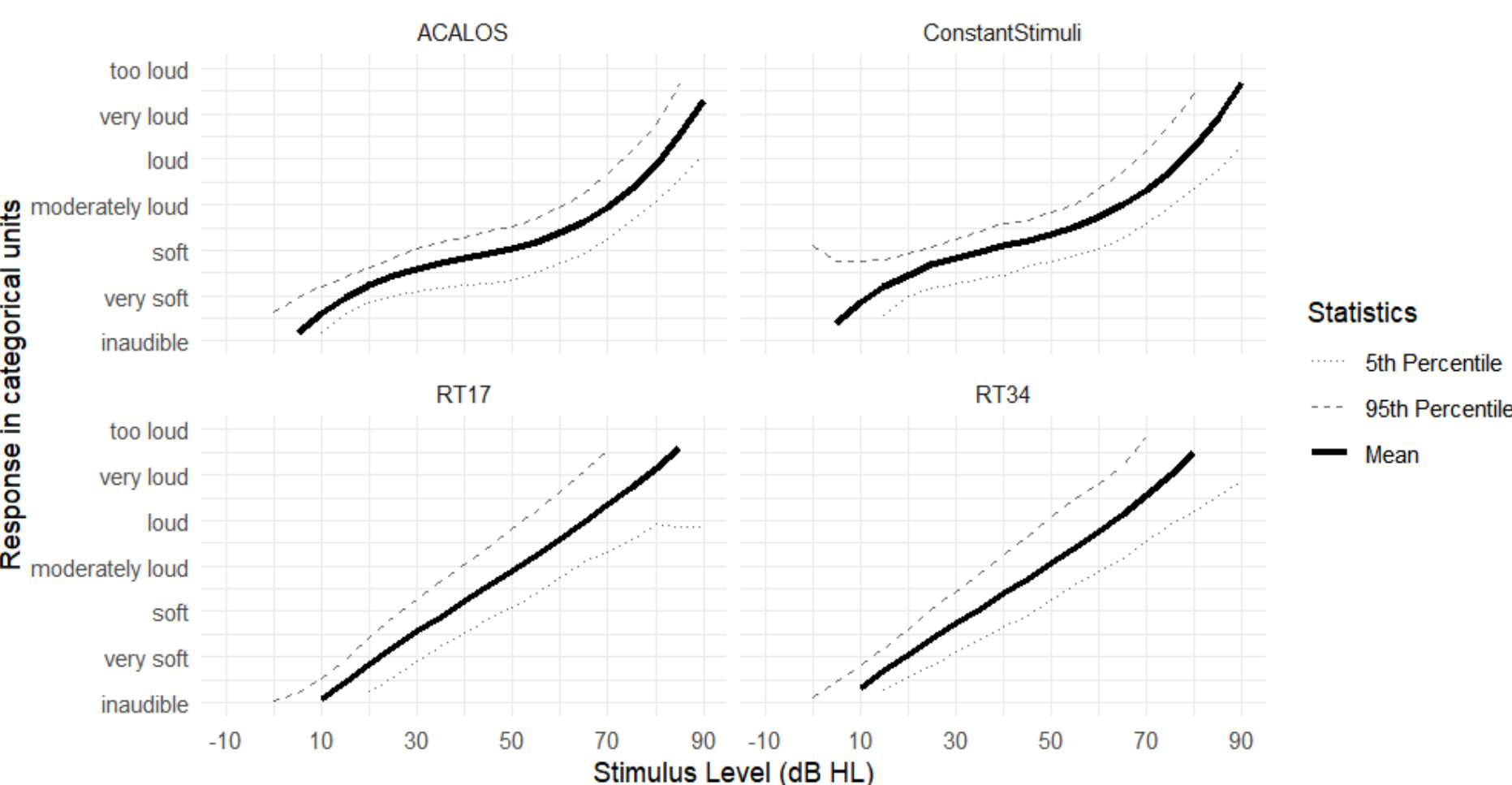


Fig 1: Typical results for LGFs yielded with each method for different participants (linear presentation) showing individual differences

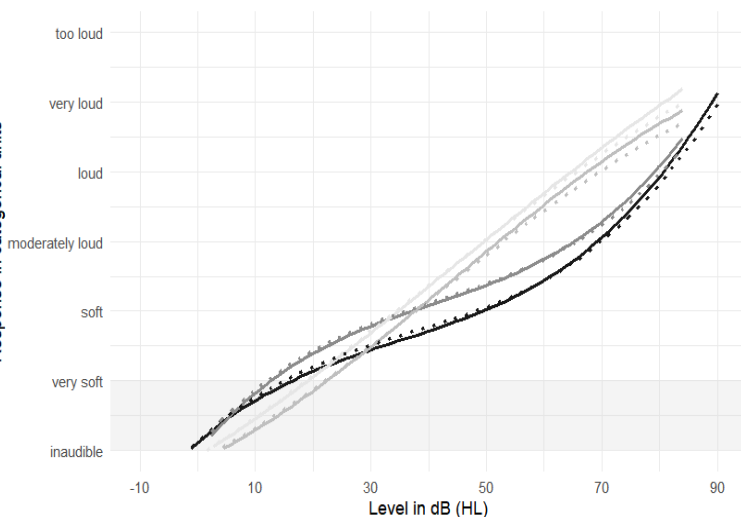


Fig. 2: Repeatability of all methods (if run 1 and 2 are similar → good repeatability)

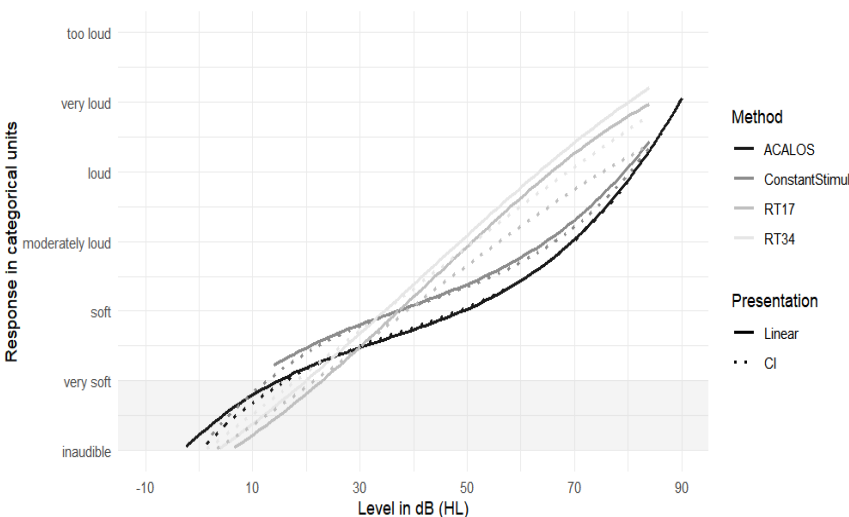


Fig. 3: Ability to gather nonlinear loudness growth of all methods (if linear and nonlinear presentation give similar LGF → good ability)

RESULTS

LGFs gathered exhibit large differences between participants with ranges up to 25 dB and RT showing more linear LGFs. In respect of duration RT with a 17 seconds stimulus had the shortest duration with about one minute to gather one LGF for three frequencies, whereas CS took an average of four and ACALOS five minutes. When it came to repeatability all methods were relative repeatable, with most differences below one category on the response scale and CS and ACALOS were significantly better than RT. Considering the ability to gather nonlinear presentation ACALOS and CS were significantly better than RT.

Tab. 1: Ranking of methods based on factor (1 = Best, 4 = Worst)

Factor	RT17	RT34	CS	ACALOS
Duration	1	2	3	4
Repeatability	3	3	1	2
Detection of nonlinear LGFs	4	3	1	2
User Acceptance	1	1	3	2

DISCUSSION

The variable amount of measuring points made the fitting of a curve into the raw data necessary. The LGFs gathered from each method were influenced by external factors, like the number of categories on the response scale and potential response bias due to individual strategies and instructions. Other factors that can influence LGFs are adaptation, anchoring, and contrast effects that impact how stimuli are perceived depending on their relative position and presentation range. In RT, the instantaneous judgment of loudness leads to biased response behavior and temporal offset due to reaction time. Comparability of methods was limited due to the different response scale used in ACALOS and a different presentation range for all methods inducing range effects. When using those methods in future studies, these results and limitations should be considered for the selection of an appropriate method to measure loudness growth functions for fitting purposes.