

# Self-reported listening effort predicts real-world amplification outcomes

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## INTRODUCTION

- Literature suggests the speech (SP) recognition scores can explain only 5% to 10% of variance in real world hearing aid outcome (e.g. Walden & Walden 2004, Brännström et al. 2014)
- Adding self-reported listening effort (LE) measures to clinical batteries has been advocated because it reflects what listeners feel and can be easily implemented with most speech recognition tests.
  - LE is often defined as the intentional allocation of mental resources to overcome obstacles in goal pursuit required to attend to, and understand an auditory message. (McGarrigle et al. 2014; Pichora-Fuller et al. 2016).
- However, the usefulness of self-reported LE ratings to predict real-world hearing aid outcomes is undefined.
- The purpose of this study was to explore how self-reported LE can predict real world hearing aid outcomes.

## METHODS

### Participants

- 111 adults, Aged 29 -79 yrs (mean = 67.7 yrs; SD = 9.3 yrs)
- 43 males and 68 females
- Bilateral hearing aid users who wore them for an average of 10.9 hrs per day (SD = 4.8 hrs)
- All participants were experienced hearing aid users (use ≥6 mos) who wore their own hearing aids during testing. Their settings were not manipulated for this study.

### Procedures

- Each participant completed self-report hearing aid questionnaires, speech recognition in noise and in quiet, and listening effort ratings with and without their hearing aids as part of a larger study.
- Testing was completed during a series of two, three-hour sessions as part of a larger study on hearing aid outcomes.

### Questionnaires

- 4 Inventories (APHAB, HHIE/A, DOSO, SADL) in 3 categories:
  - **Initial Disablement:** Unaided APHAB and Unaided HHIE/A
  - **Residual Disablement:** Aided APHAB and Aided HHIE/A
  - **Benefaction** (Humes 2006):
    - Difference between Aided and Unaided APHAB and Aided and Unaided HHIE/A
    - DOSO, SADL

### Speech (SP) Recognition

- Multilexical Sentence Test (MLST; Kirk et al. 2012)
  - Participants were seated in a calibrated sound field inside of a booth and were asked to repeat sentences in background noise.
- Speech perception tasks were completed in 16 conditions.
  - With and without hearing aids
  - Two SNRs
    - +8 dB (signal 65 dB SPL/Noise 57 dB SPL)
    - 0 dB (signal 75 dB SPL/Noise 75 dB SPL)
  - Two Modalities
    - Audiovisual (AV)
    - Audio Only (AO)
  - Two Noises
    - Speech-shaped noise
    - International Speech Test Signal (ISTS)



## METHODS

### Listening Effort Rating

- Participants subjectively rated their listening effort on a 21-point scale after each laboratory speech perception condition.

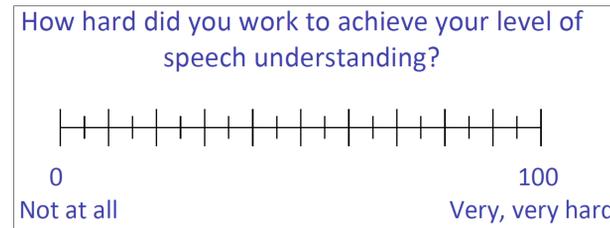


Figure 1. Listening Effort Scale(Wu et al. 2016): Higher ratings mean that more effort was exerted.

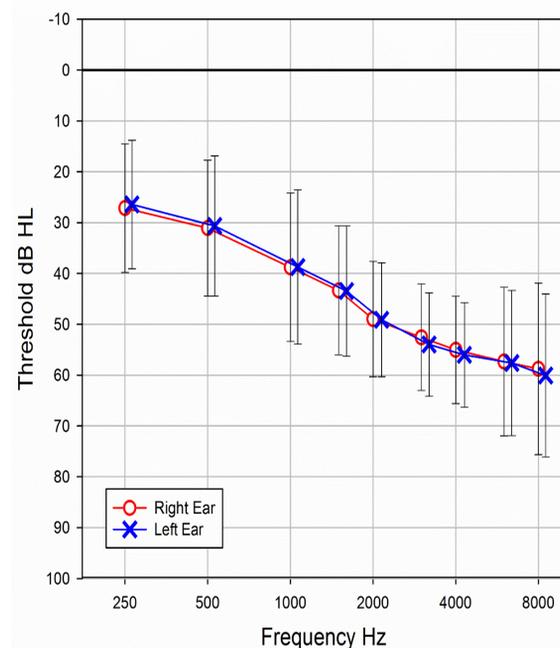


Figure 2. Composite audiogram of all study participants

Table 1. Speech Perception percent correct scores and self-reported Listening Effort ratings

	Visual Cues	Audiovisual				Audio Only				
		Noise	Speech-Shaped Noise		ISTS		Speech-Shaped Noise		ISTS	
			SNR	0	+8	0	+8	0	+8	0
Speech Perception	Aided		70.68	85.55	60.62	82.41	42.93	70.3	29.96	62.91
	Unaided		64.13	76.79	53.47	73.58	36.89	53.28	23.24	46.21
Listening Effort	Aided		73.59	52.18	83.62	60.21	87.13	65.5	93.7	74.36
	Unaided		94.13	77.32	84.68	74.33	74.18	58.64	84.04	63.23

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## RESULTS

### Predictor data reduction:

- Principle component analysis was conducted on six sets of data. Each data set has eight variables (2 SNR x 2 modalities x 2 noises)
  - **Unaided, aided,** and **benefit** (aided minus unaided) SP recognition score
  - **Unaided, aided,** and **benefit** (aided minus unaided) LE score
- For unaided and aided SP scores, only one factor was extracted (79.3% and 76.2% variance explained, respectively).
- For the rest of data set, two factors were extracted.
  - Example: aided LE. Factor 1 is loaded by easier test situations (+8 SNR or AV), while Factor 2 is loaded by more difficult conditions (0 dB SNR and AO). They are labeled as “Easy” and “Difficult” factors, respectively.

Visual Cues	Audiovisual				Audio Only				
	Noise	Speech-Shaped Noise		ISTS		Speech-Shaped Noise		ISTS	
		SNR	0	+8	0	+8	0	+8	0
Factor 1 “Easy”		.792	.903	.565	.919	.272	.879	-.038	.812
Factor 2 “Difficult”		.438	.002	.569	.075	.855	.156	.926	.381

Table 2. Factor Analysis of self-reported LE measured in 8 aided listening conditions.

### Correlation analysis

- For each factor, factor scores (standardized z-scores) were derived and used as predictors
- Three sets of analysis were conducted using correlation analysis:
  - **Unaided SP and LE factor scores** (including Easy and Difficult factors) predicting **Initial Disablement** (Unaided APHAB and unaided HHIE/A)
  - **Aided SP and LE factor scores** predicting **Residual Disablement** (Aided APHAB and aided HHIE/A)
  - **SP and LE benefit factor scores** predicting **Benefaction** (APHAB benefit score, HHIE/A benefit score, DOSO LE subscale, and SADL global score)

## RESULTS

- After controlling for age, hearing thresholds and working memory capacity
- **Unaided SP and LE factor scores** explained up to 7% and 2% of the variance of **Initial Disablement**, respectively.
  - **Aided SP and LE factor scores** explained up to 10% and 4% of the variance of **Residual Disablement**, respectively
  - **SP and LE benefit factor scores** explained up to 8% and 16% of the variance of hearing aid **Benefaction**, respectively.
  - For most analyses, SP and LE measured in easier environments (+8 dB SNR and/or with visual cues) explained more variance than SP and LE measured in more difficult environments. See Table 3 for examples (**LE benefit factor scores** predicting **Benefaction**).

	APHAB Benefit	HHIE/A Benefit	DOSO LE subscale	SADL Global
LE Benefit -- “Easy Factor”	.273*	.404*	.086	.057
LE Benefit -- “Difficult Factor”	.044	-.148	-.128	-.160
SP Benefit -- “Easy Factor”	.077	.222*	.124	.117
SP Benefit -- “Difficult Factor”	.15	.166	.244*	.298*

Table 3. Correlation Coefficients. \*Indicates significant explanation of variance at p value < 0.05

## DISCUSSION and CONCLUSIONS

- **Unaided** and **Aided** SP factor scores are better at predicting real-world disablement than **Unaided** and **Aided** LE factor scores, respectively (up to 10% of the variance is explained by SP).
- **LE benefit factor score** is better at predicting hearing aid benefaction than **SP benefit factor score** (up to 16% variance explained by LE)
  - This may result from **LE benefit factor score** eliminating differences in baselines (i.e. my rating of five is higher than your rating of eight)
- LE measures in “Easy” conditions explain more real-world variance than in “Difficult” conditions
  - which implies that “Easy” environments (+8 SNR or AV) are more ecologically relevant.
- Consistent with the literature, SP in our study explained up to 10% of the outcome variance; therefore self-report LE may be clinically useful in predicting real-world hearing aid outcome.

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