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The Role of Clinical Experience in the Perception of Children's Speech in the Presence of Background Noise

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Introduction

- The acquisition of /s/ and /ʃ/ involves their gradual articulatory and acoustic differentiation (Figure 1, Li, 2012). The standard tool for evaluating speech sound disorders is phonetic transcription. The categorical nature of phonetic transcription does not allow clinicians to measure fine phonetic distinctions within categories.
- If Li's findings extend to the learning of speech sounds in treatment, then the accurate assessment of fine phonetic detail is crucial to evaluating children's progress toward proper speech sound production. Acoustic analysis and articulatory measures can accurately track this progress, but currently they are ineffective as clinical tools due to the time it takes to complete them.
- Visual Analog Scaling (VAS, Figure 2) is a promising technique for performing gradient measures of children's speech production. VAS ratings correlate strongly with within-category acoustic variation (Julien & Munson, 2012; Urberg-Carlson & Munson, 2013) and have been shown to be even more strongly correlated when made by speech-language pathologists (SLPs) than by laypeople (Munson, Johnson, & Edwards, 2012, Meyer & Munson, 2013, this conference)
- Previous research has examined perception in quiet. For these measures to be useful clinically, they must be robust in the presence of background noise.

Research Questions

- This study evaluates the effect of background noise on SLPs' and laypeople's VAS ratings of children's /s/ and /ʃ/ productions in quiet and in background noise. Ratings are evaluated in terms of the effect of clinical training and background noise on the *reliability* of VAS ratings, the *correlation* of VAS ratings with sounds' acoustic characteristics, the extent to which VAS ratings are *biased* toward /s/ or /ʃ/, and the extent to which individuals provide a *continuous* VAS rating. We also examine whether measures of hearing acuity (pure tone thresholds and sentence intelligibility in noise) predict the effect of noise on VAS ratings.

Methods

Participants

Inexperienced Listeners: 20 adult listeners (11 women, 9 men); 18-50 years of age

Experienced Listeners: 10 adult listeners (9 women, 1 man, recruitment ongoing)

Visual Analog Scaling Task

Stimuli

- A range of child productions of the fricatives /s/ and /ʃ/ were taken from a corpus of 2-5 year old children's real-word-repetitions elicited by picture prompts in the παιδαλογος project (http://www.learningtotalk.org/?q=node/24/)
- Initial CVs were excised from real-word productions to minimize lexical bias.
- The peak frequency in the fricative (in ERB units) and the F2 frequency of the following vowel at onset were measured. Li (2012) showed that these change throughout development.

Procedures

- The speech sound stimuli were presented in quiet and in background noise at two SNRs, -3 dB and +6 dB SNR l (i.e., Figure 3)
- Participants were asked to rate the consonant along a visual analog scale labeled 'the "s" sound' on one end and 'the "sh" sound' on the other (Figure 2).

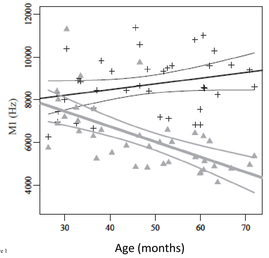


Figure 1

Figure 1 Mean M1 values of all the tokens for each individual child plotted against children's ages for each target fricative.
Note. best fit lines from linear regression models were overlaid on the data points together with 95% confidence interval bands. For Figures 3-5, the black regression lines and the associated 95% confidence interval bands are for target /s/ and the gray regression lines and 95% interval bands are for target /ʃ/ Figure from Li (2012

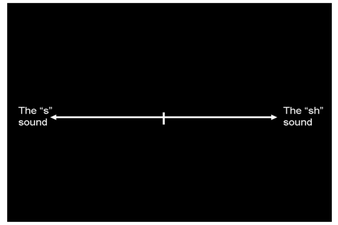


Figure 2. The visual analog scale displayed during the speech rating task. Participants were told to click along the line based on their perception of the speech token, with a perfect 's' represented on one end and a perfect 'sh' represented on the other.

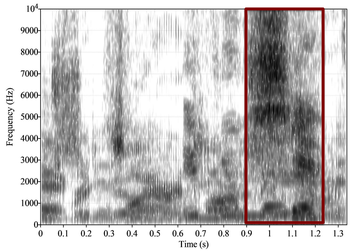


Figure 3 A consonant-vowel sequence taken from the word *ship* and presented in multitalker babble at +6 dB SNR

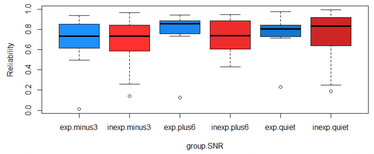


Figure 4. Reliability coefficients as a function of SNR for the experienced (*exp*) and inexperienced (*inexp*) groups at the three SNR.

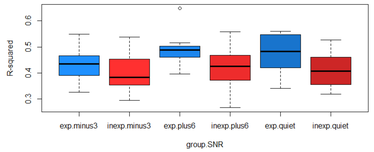
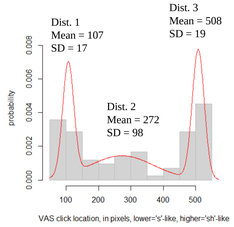
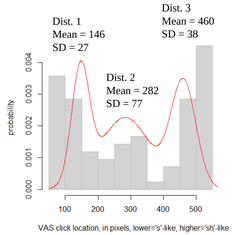


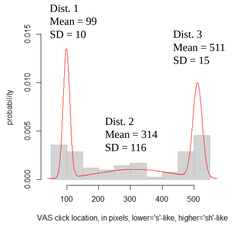
Figure 5. R^2 from individual-participants' quasipoisson regressions predicting VAS ratings from fricatives' peak frequency in ERB, and the F2 frequency of the following vowel at onset, plotted as a function of SNR for the experienced (*exp*) and inexperienced (*inexp*) groups at the three SNR.



Subject 2 (inexperienced), Quiet



Subject 11 (inexperienced), +3 dB SNR



Subject 18 (inexperienced), -3 dB SNR

Methods (continued)

Sentence Intelligibility in Noise

- Listeners were presented with 20 sentences from the Basic English Lexicon (Calandruccio & Smiljanic, 2012) at a -3 dB SNR using the same babble as was used for the stimuli. Their responses were typed by the first author on-line as they repeated them. Percent keywords corrected repeated was noted. The groups did not differ in this measure (M_{inex}=78%, M_{exp}= 75%)

Pure Tone Thresholds

- Standard audiometric procedures were used to calculate pure tone averages (PTAs) bilaterally at 0.5, 1, 2, and 4 kHz. The groups did not differ statistically significantly in left PTA (M_{inex}= 3.7 dB HL, M_{exp}=4.3 dB HL) or right PTA (M_{inex}=4.3 dB HL, M_{exp}=5.0 dB HL)

Analysis and Results

- Reliability was assessed by examining the correlation between first and second ratings as a function of group and SNR. The experienced listeners were statistically significantly more reliability at the +6 dB SNR (Figure 4).
  - **Experienced listeners make more reliable ratings than inexperienced listeners. This does not interact with SNR.**
- A series of quasipoisson regression analyses predicting VAS ratings from fricatives peak frequency and onset F2 were conducted separately for each listener at each SNR. The R^2 from those regressions is shown in Figure 5. The R^2 increased as a function of SNR and was higher for experienced listeners than for experienced ones. The β coefficients indicated that onset F2 influenced judgments more strongly in the quiet and +6 dB SNR condition than in the -3 dB SNR condition.
  - **Ratings were more accurate in quiet than in noise. Experienced listeners' ratings are more strongly predicted by the acoustic characteristics of the stimuli than are inexperienced listeners'. This does not interact with SNR.**
- Gaussian mixture models were used to decompose individual participants' ratings into three underlying response distributions (Figure 6). The mean and standard deviation of those distributions was tallied. The means of the experienced listeners' leftmost and rightmost (i.e., most "s"- and most "sh"-like) distributions were more extreme than those for the inexperienced listeners'. Moreover, their ratings for the middle distribution was more dispersed than were those for the inexperienced listeners.
  - **Experienced listeners use a wider range of the visual analog scale than do inexperienced listeners, and they label a wider range of stimuli as intermediate between /s/ and /ʃ/. This does not interact with SNR.**
- None of the dependent measures above correlated significantly with any of the audiometric measures (left PTA, right PTA, or keywords correct).
- **Conclusion: Visual Analog Scale ratings of children's /s/ and /ʃ/ are very robust to the presence of background noise. Clinical training is associated with ratings that are superior to those of inexperienced listeners in many key ways.**

Acknowledgments

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