**INDIVIDUALIZED TARGETS FOR ACOUSTIC BIOFEEDBACK TO TREAT RESIDUAL /r/ ERRORS**

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**INTRODUCTION**

The English /r/ sound is a late-emerging, matrically challenging sound; residual errors affecting /r/ may persist into adolescence, even after years of traditional therapy. Spectral acoustic biofeedback is a promising approach to treat persistent /r/ distortions. The English /r/ sound has a characteristically lower third formant frequency (F3) than vowels, which provides a robust target for speakers to match on visual display. Biofeedback using the Computerized Speech Lab (KayPentax, Model 4150B) is reported to be efficacious [1,2], but cost and training are barriers to widespread clinical uptake. Our lab is currently developing staRt, a free and open-source biofeedback app.

**Aim:** Adapt our protocol to be user-friendly (usable without specific training).

**Barrier:** The optimal F3 target for /r/ varies by age/sex/height of child. Selecting the best target requires some trial/error and expertise.

**Goal of this study:** Develop an algorithm that will automatically predict an appropriate F3 target for /r/ based on measurements from non-rhotic vowel sounds.

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**DERIVING FORMULA FOR PREDICTING F3 OF /r/**

**Background:**

Hagiwara [3] observed that F3 of /r/ typically falls within 60-80% of average F3 of adults’ vowels (/ɪ, ə,ʊ/).

Lee et al. [4] observed that F3s of perceptually incorrect /r/ sounds fell above the 80% upper boundary, while the few perceptually correct tokens fell below this boundary.

As 80% separates correct and incorrect /r/, we need to determine what point within 60-80% represents the best target for correct /r/.

**Children with correct /r/ following speech intervention have adequate number of correct and incorrect /r/ tokens to test 80% boundary and to find an appropriate target for /r/.

**Formula derivation:**

- Within 60-80% range, what scale factor (multiplier) brings us closest to the center of distribution of F3s of correct /r/ in a normative sample? [5]
- For each age/sex group, calculated average F3 of /ɪ, ə,ʊ/ (/l/ eliminated as outlier).
- Beginning at 0.7, lowered scale factor in increments of 0.1 until reaching F3 closest to average F3 of /r/ for each age/sex group.

**Process yielded scale factors of 0.72 for females and 0.68 for males.**

**REFERENCES**


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**STUDY 1 – CHILDREN WITH REMEDIATED /r/**

**Q1:** Do the predicted target values match actual F3 values observed in children whose /r/ misarticulation resolved during treatment?

- Selected two children with corrected vocalic /r/ from biofeedback intervention study [6]
- Measured F3 of /r/ and vowels (/ɪ, ə,ʊ/) from word probes elicited throughout study.
- Exploratory analysis: Applied .8 scale factor to compare observed F3s with Hagiwara/Boyce findings.

**Figure 3:** Correct/incorrect actual F3s of /r/ with scale factor of 0.8 and .72.

**Aim:**

- Autumn: 2021 incorrect tokens above cutoff & 15/15 correct tokens below cutoff.
- Lilianne: 14/15 incorrect tokens above cutoff & 14/17 correct tokens below cutoff.
- Findings: strongly consistent with previous research suggesting that .8 separates correct and incorrect /r/.
- For our major question (Q1), applied revised scale factors.
- Finding: F3 targets calculated from normative data were higher than observed F3s.

**This difference was statistically significant for Autumn (t(14) = 7.8, p < 0.01) and approached significance for Lilianne (t(16) = 1.83, p = 0.09).**

**Actual scale factors calculated to be .61 (Autumn) and .69 (Lilianne).**

**A1:** The scale factor derived from normative data for females is not low enough to predict the F3 of /r/ in children whose misarticulation resolved fully during treatment.

**Q2:** Why were F3 values predicted from our formula higher than actual F3s of /r/ in children whose /r/ misarticulation resolved during treatment?

- For each task, predicted target F3 of /r/ from vowel average /ɪ, ə,ʊ/.
- Compared predicted and actual F3 of /r/ for each child.

We explored these possibilities with TD individuals (n = 11, ages 9-15),

- Replicated phrase task used in normative study [3] and word task used in treatment study [6].
- For each task, predicted target F3 of /r/ from vowel average /ɪ, ə,ʊ/.

**Figure 4:** Predicted and actual mean F3 of /r/.

**• Predicted F3s were significantly higher than actual F3s, t(11) = 3.9, p = 0.001.**

**Q3:** Do actual mean F3s of /r/ in typically developing children fall within the broader 60-80% range?

**A2:** Predicted F3s were significantly higher than actual F3s, t(11) = 3.75, p = 0.003.

**A3:** Most actual mean F3s (10/11) did fall within broader 60-80% range, near the lower end.

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**CONCLUSIONS**

Results from Studies 1-2 suggest that a lower scale factor would more accurately predict F3 of /r/ in both samples.

- Using Study 2 sample (TD), we calculated the scale factors needed to predict actual F3s of /r/ in both tasks.
  - Females: 68 phrases, 69 words
  - Males: 63 phrases, 63 words
- We are currently investigating whether the noted sex difference in scale factor is robust.
- We will be using these further lowered scale factors as targets for app-based biofeedback intervention.
- The next goal is to implement automated calculation of targets using these scale factors.
- To be incorporated into setup protocol of staRt biofeedback app.

Predicting an individual’s F3 of /r/ from F3s of vowels contributes to an empirical understanding of /r/ acoustic properties and has direct clinical applications.

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**REFERENCES**


