A Visual Feedback Tool for German Vowel Production

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Aim of the Study

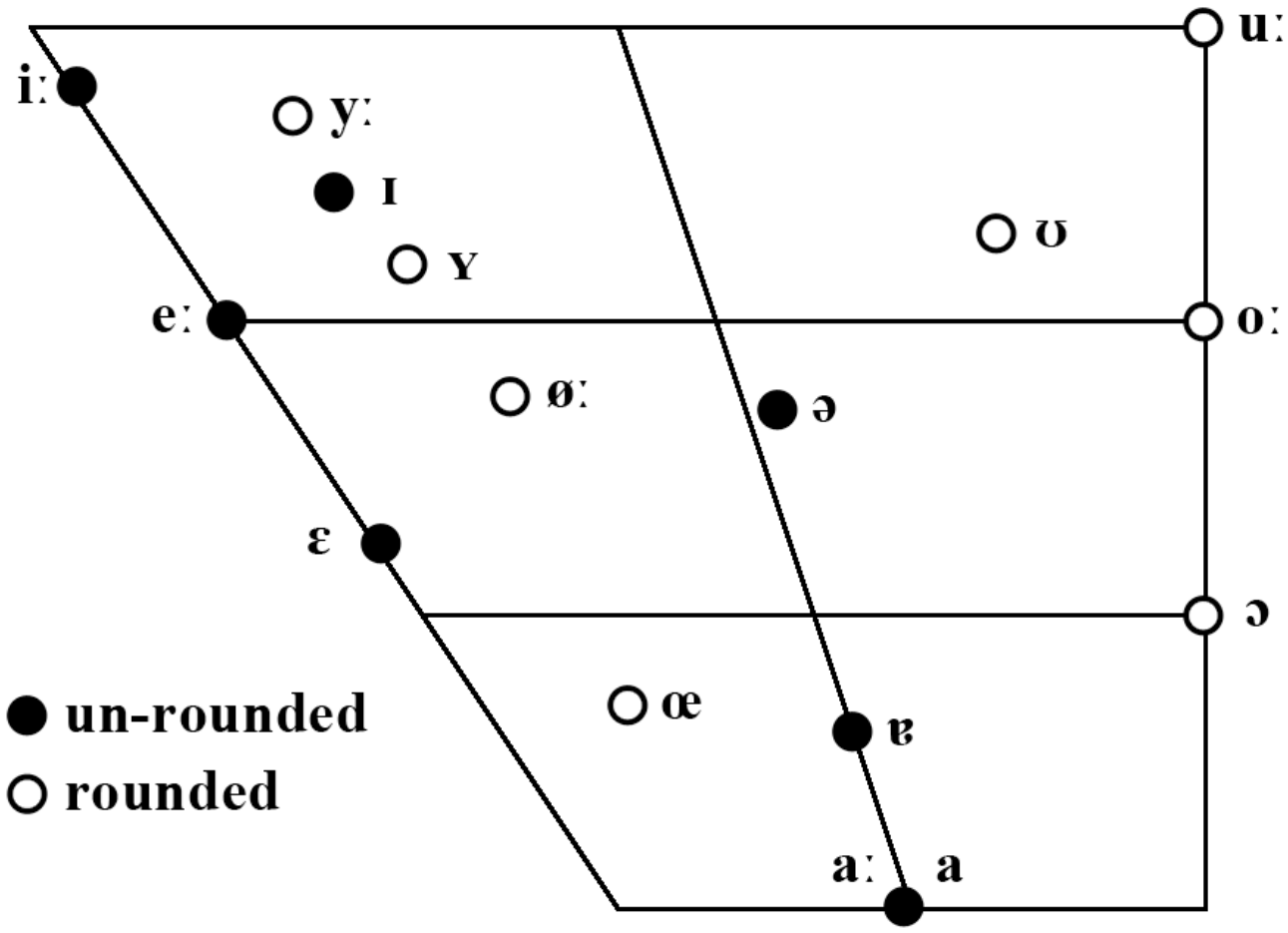
For non-native German speakers, correct vowel perception and production can be difficult due to a relatively large inventory of German vowels which are similar in their acoustic qualities and/ or duration and which do not exist in the foreign speakers' native phonology.

In order to help non-native German speakers improve both perception and production of acoustically similar vowels, we propose a prototype visual feedback tool which illustrates the differences between these sounds.

Outline

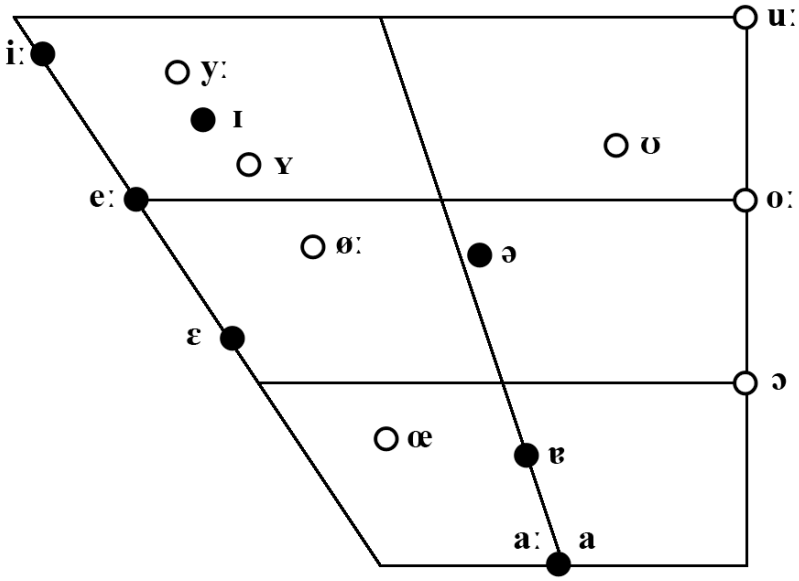
- Exploring the German vowel space
- Providing feedback
- System layout and functionality
- Vowel detection
- Discussion
- Live Demo (time permitting)

German Vowel Space



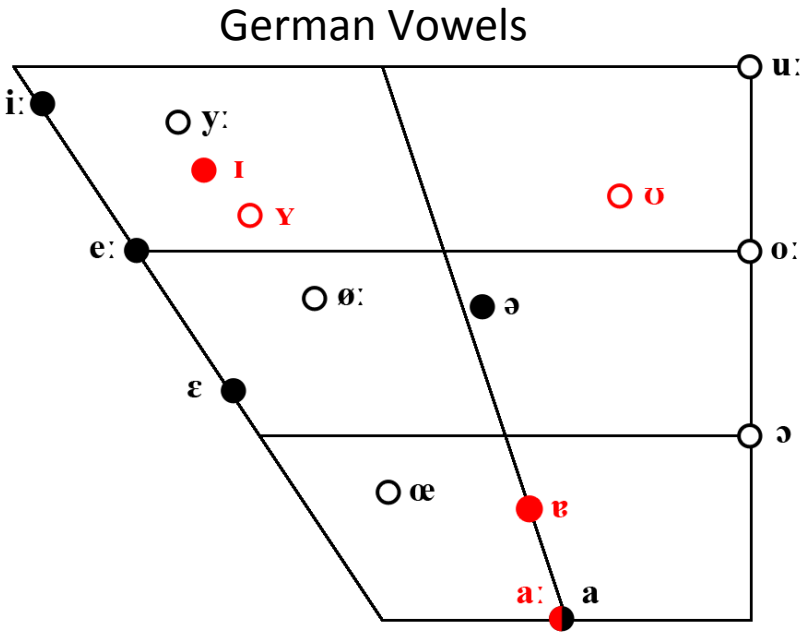
German Vowel Positions based on:
MANGOLD, Max. (2005). Der Aussprachewörterbuch (6th ed.). Mannheim etc.: Dudenverlag.

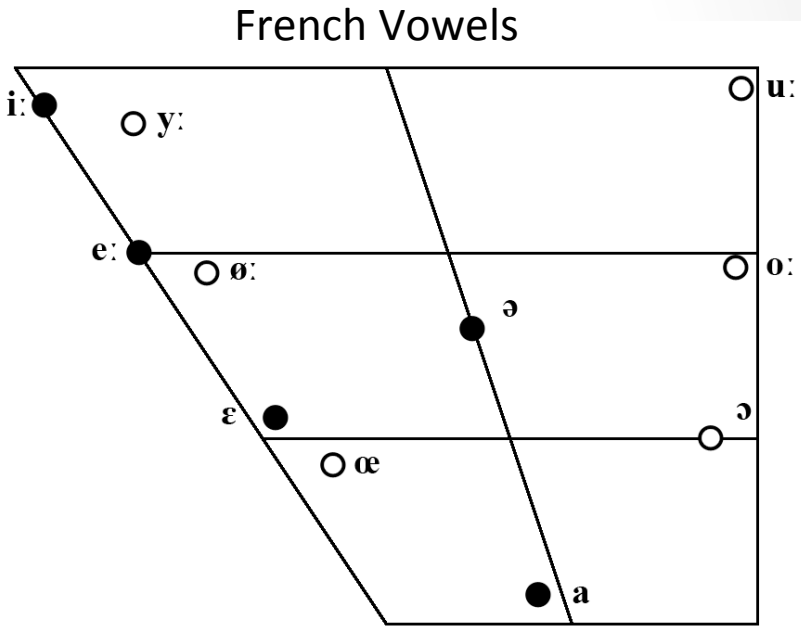
German Vowel Space



- Large inventory of vowels
- High vowel density in:
  - high/front region
  - mid/front region
  - high/back region
- Boundaries determined by both spectral and durational features

German Vowel Space



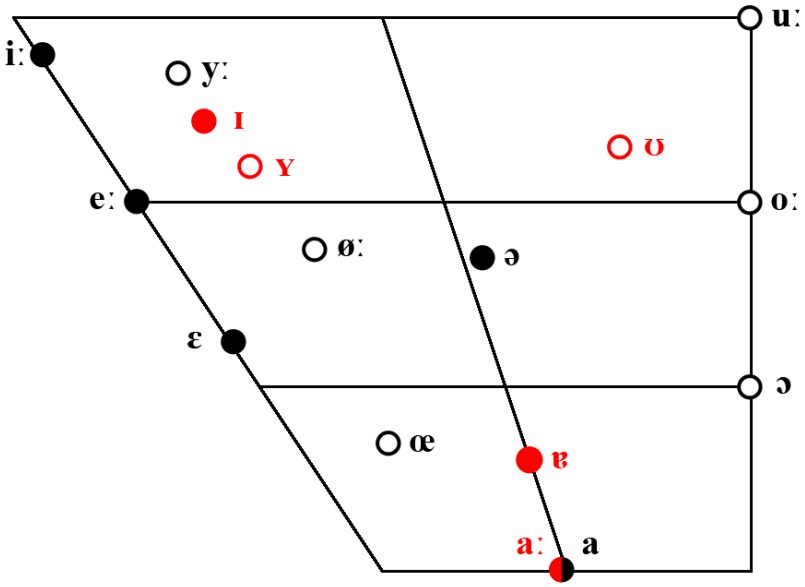


- Comparison of the German vowel space with the French vowel space

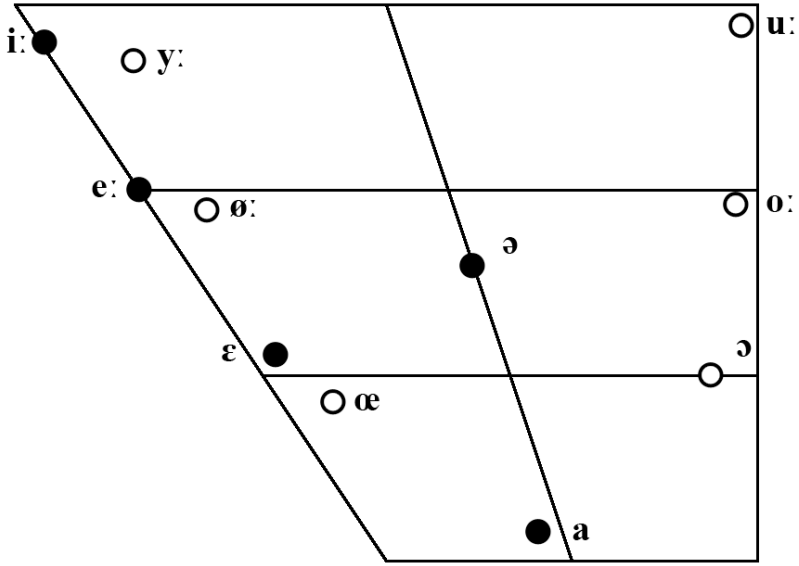
French vowel positions based on:
FOUGERON, Cecile and SMITH, Caroline L.: Illustrations of the IPA (1993). French. Journal of the International Phonetic Association 23 (2): 73–76.

German Vowel Space

German Vowels



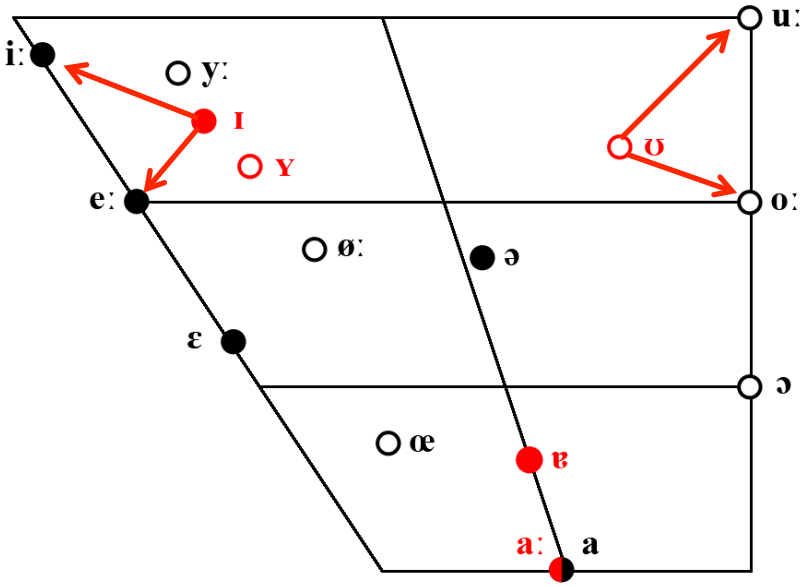
French Vowels



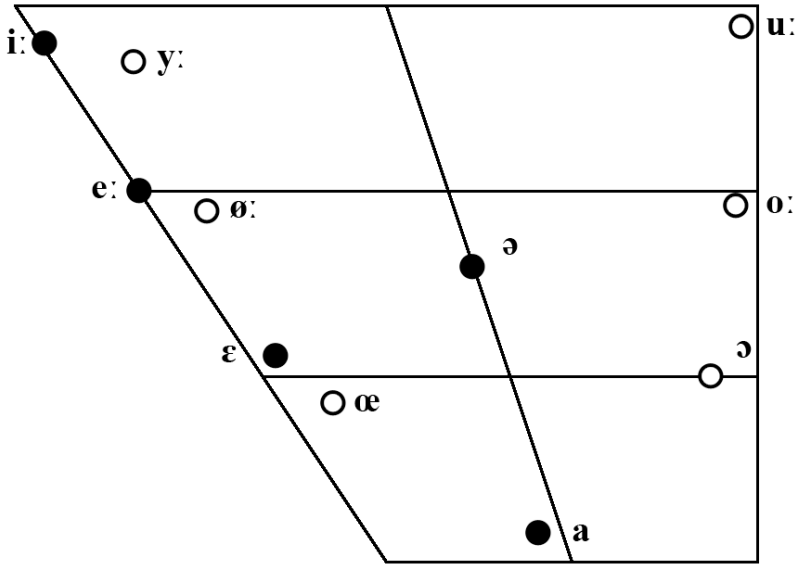
- Predicted difficulty in regions where novel German vowel categories can assimilate to existing French vowel categories

German Vowel Space

German Vowels



French Vowels



Examples:

$\mathrm{ɪ} \xrightarrow{\text{assimilates to}} \mathrm{iː}$ $\quad \mathrm{ɪ} \xrightarrow{\text{assimilates to}} \mathrm{eː}$

$\mathrm{ʊ} \xrightarrow{\text{assimilates to}} \mathrm{oː}$ $\quad \mathrm{ʊ} \xrightarrow{\text{assimilates to}} \mathrm{uː}$

German Vowel Space

The challenge:

In order for foreign language learners to create a new phonological category for an L2 vowel, they must be aware of the features which differentiate a foreign vowel from native vowel categories established in their L1 phonology (Flege 1995).

FLEGE, J. E. (1995). Second language speech learning: Theory, findings, and problems. Speech Perception and Linguistic Experience: Theoretical and Methodological Issues in Cross Language Speech Research, pp. 233–272. Timonium, MD: York Press Inc.

German Vowel Space

The learning process:

L2 learners weigh or prioritize features (e.g. spectral, durational) differently when forming a new vowel category, based on their L1 background (Escudero et al. 2009).

It is important to provide information about all relevant features when demonstrating the difference between German vowels, and not just the features prioritized by native speakers.

ESCUDERO, P., T. BENDERS and S. C. LIPSKI (2009). Native, non-native and L2 perceptual cue weighting for Dutch vowels: The case of Dutch, German, and Spanish listeners. Journal of Phonetics, 37(4):452–465.

Providing Feedback

The objective:

The development of a feedback tool which provides a visual representation of features which characterize German vowels.

The visual feedback should be used in tandem with a listening/ speaking exercise to improve a non native speaker's production and perception of German vowels.

Providing Feedback

What's an appropriate visual representation for vowels?

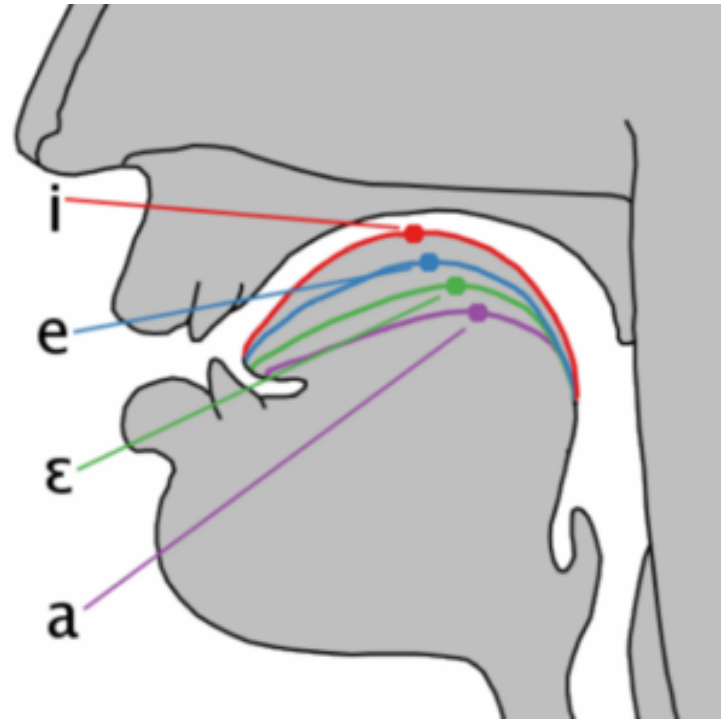


Image based on Jones, CC-SA liscence: http://creativecommons.org/licenses/by-sa/3.0/legalcode

Providing Feedback

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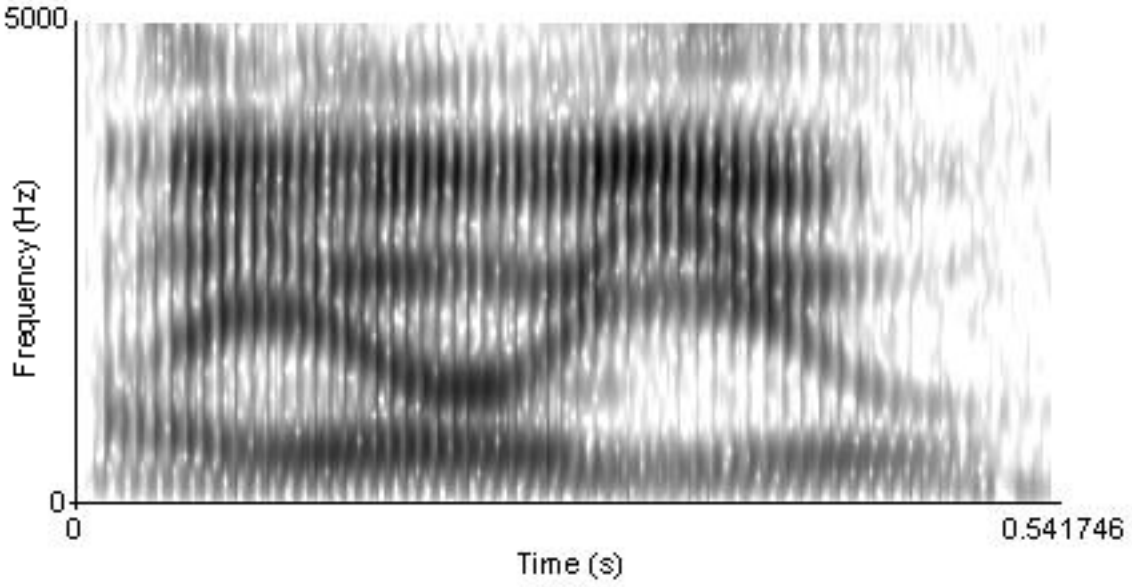


Image in public domain, via Wikimedia Commons

Providing Feedback

Criteria for useful visual feedback:

- No previous phonetic / linguistic knowledge required
- Depicts spectral and durational information
- Free from extraneous information
- Intuitive

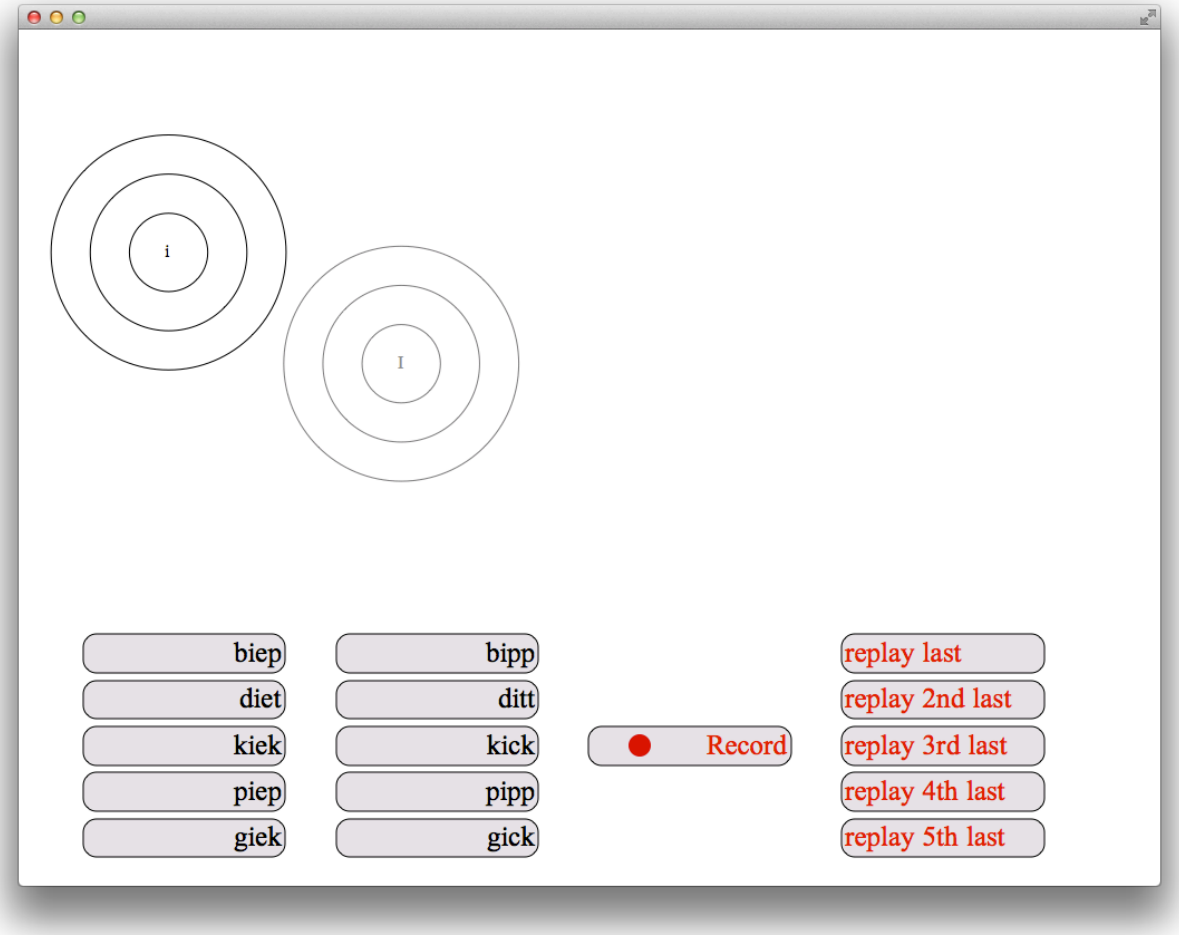
System Layout and Functionality

The system prototype was written as a script for `Praat` (Boersma & Weenink 2014)

- Allows for rapid prototyping of the user interface
- Provides built in signal processing features
- Limited control over visual layout

BOERSMA, P. and D. WEENINK (2014). Praat: doing phonetics by computer. Computer program (Version 5.3.64).

System Layout and Functionality



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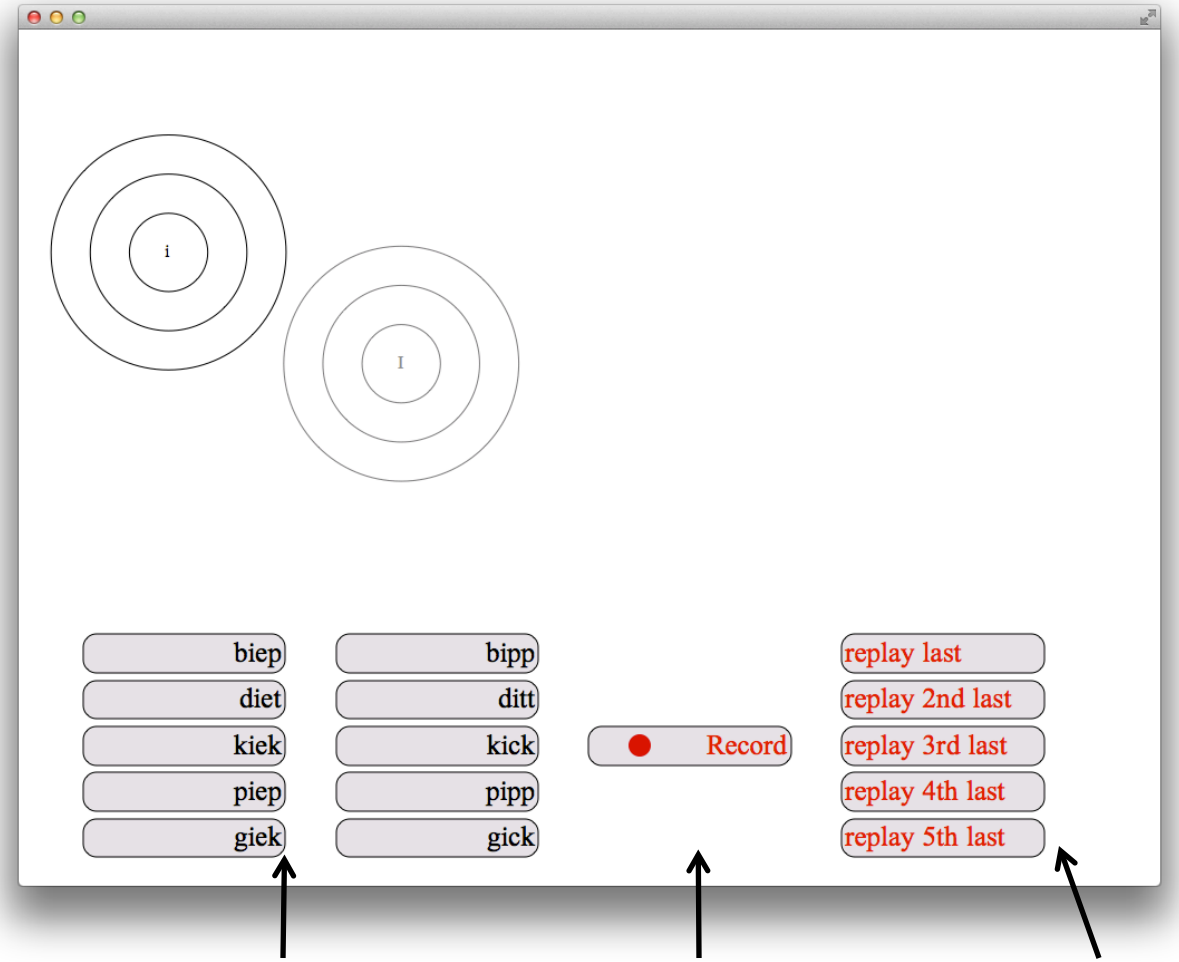
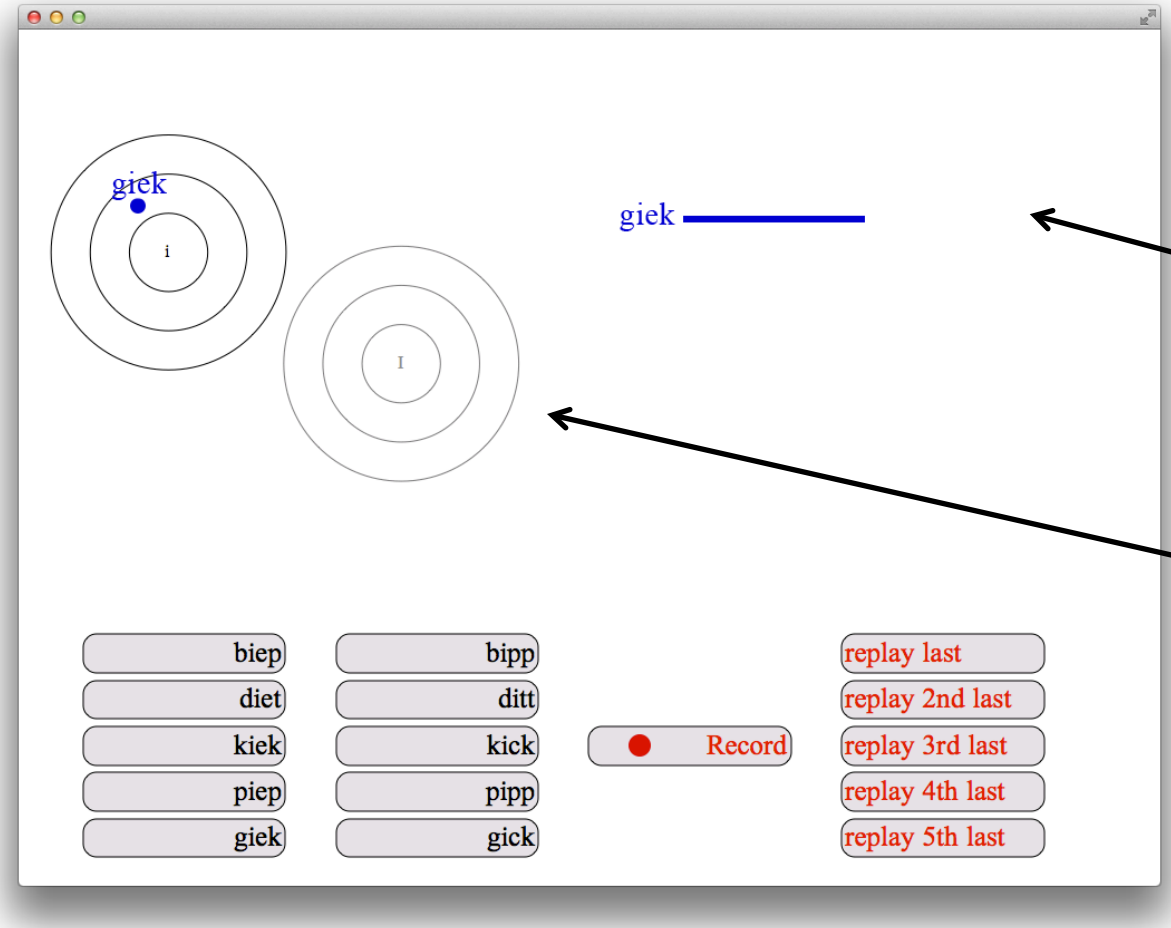


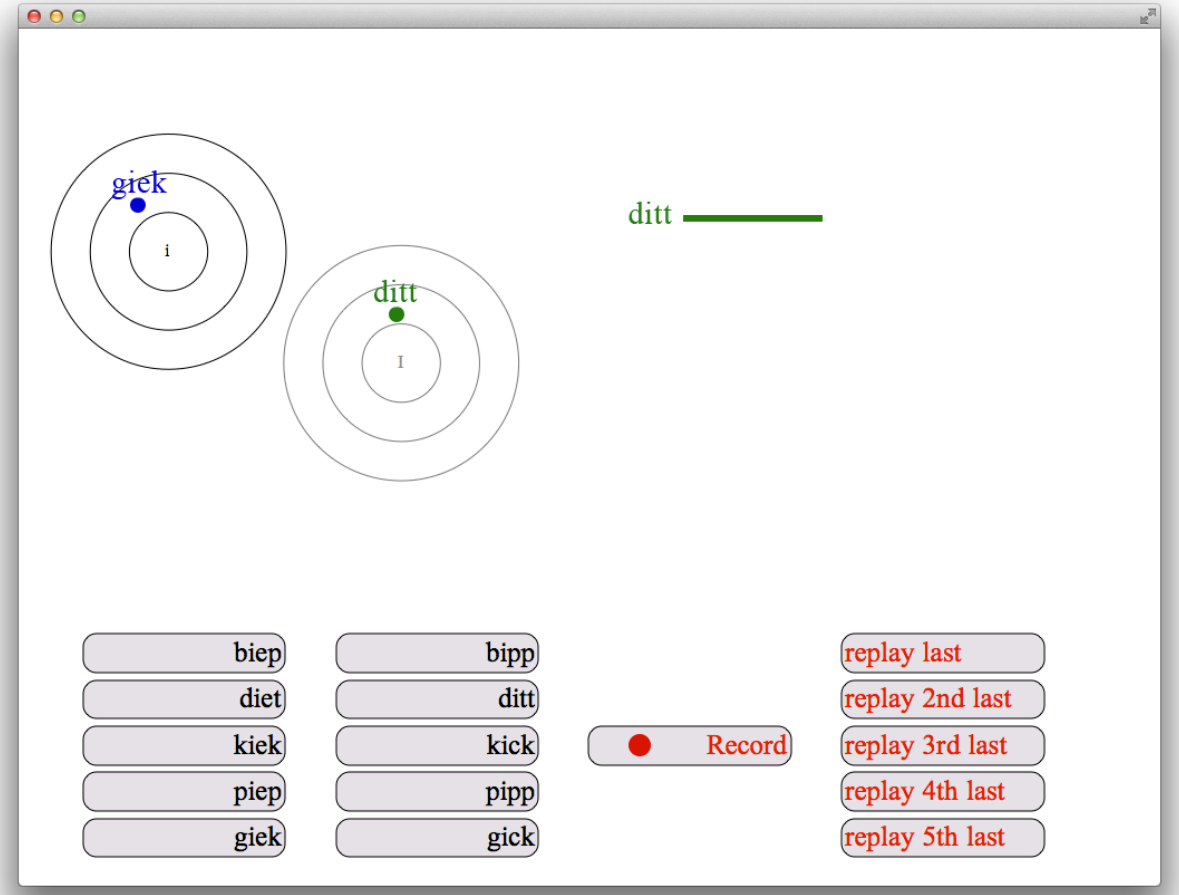
System Layout and Functionality



Duration Feedback Space representing absolute duration of vowel.

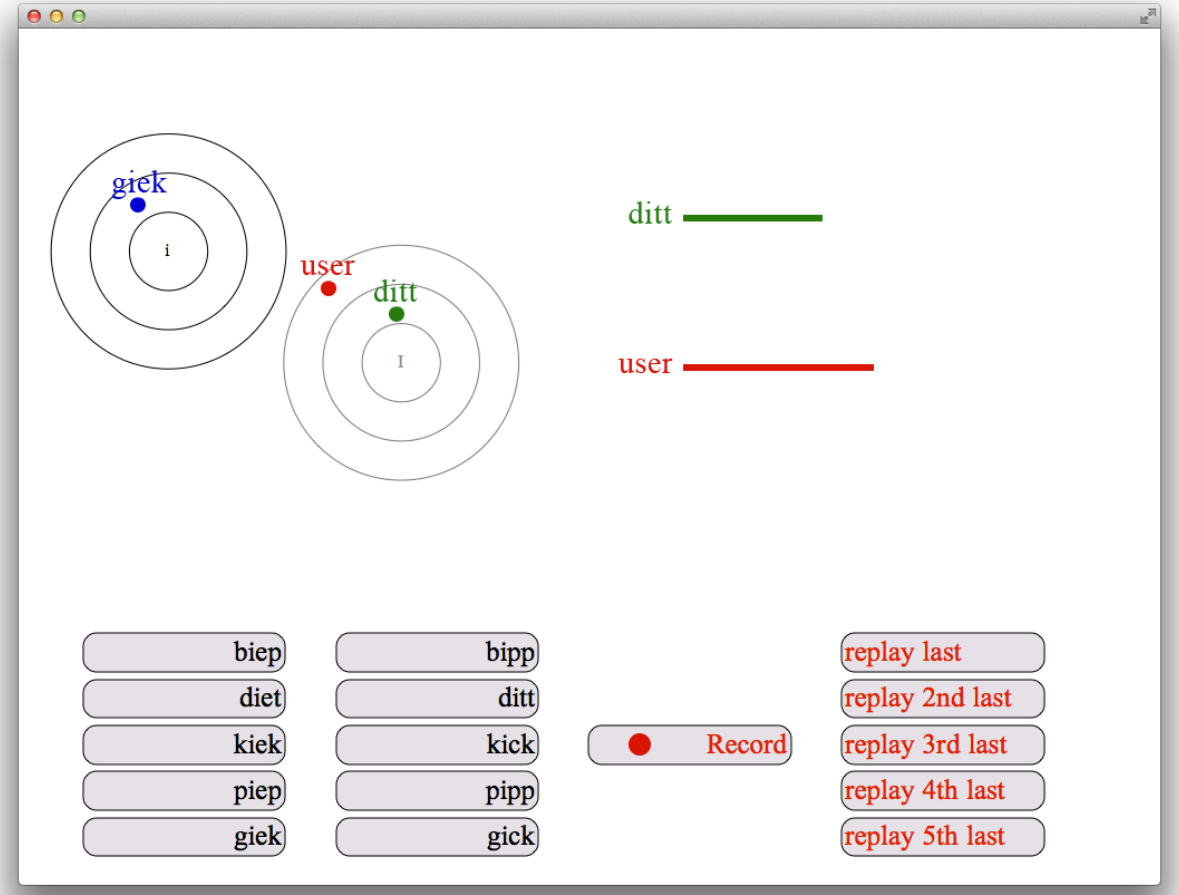
Acoustic Feedback Space representing the first and second formants.

System Layout and Functionality



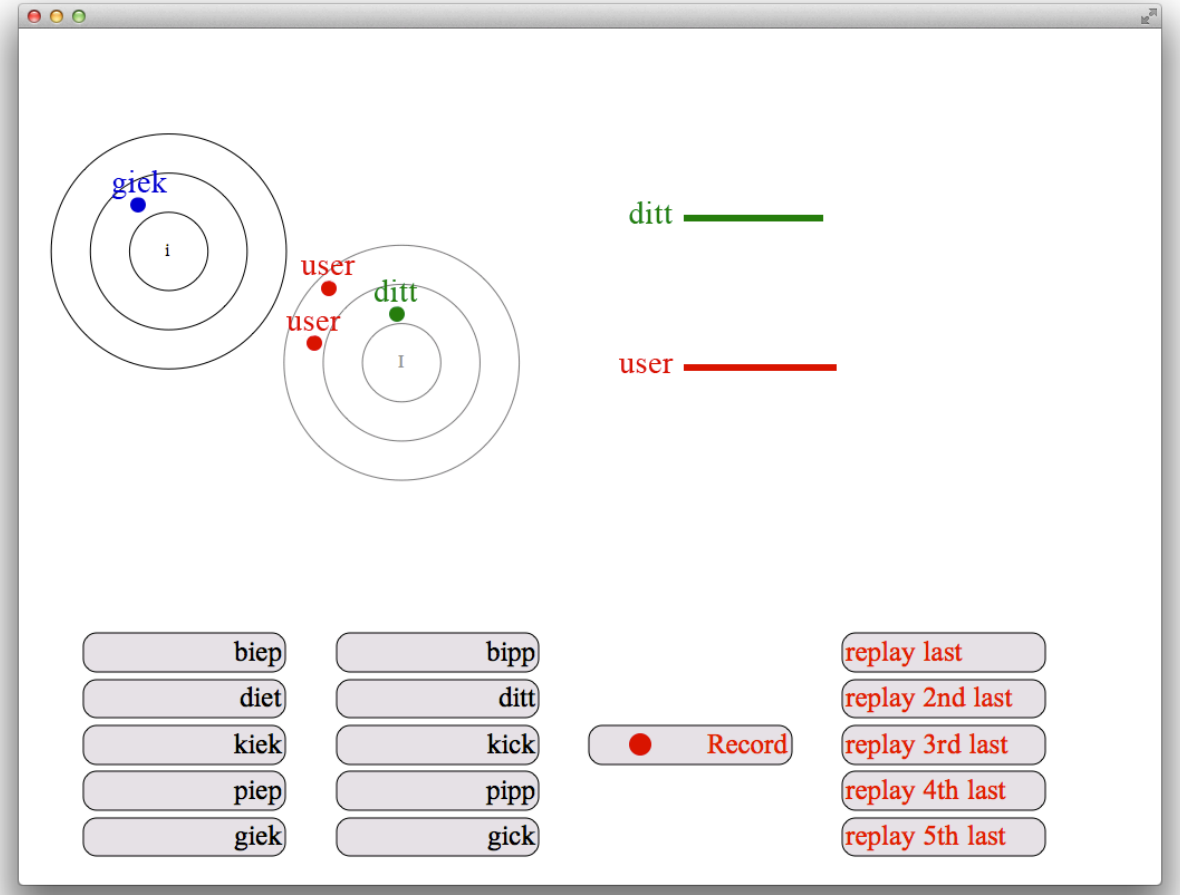
Each target vowel from the native speaker is labeled with text identifying the nonsense word, and color coded based on the vowel category.

System Layout and Functionality



After the user records his or her voice, he or she can see a point representing the acoustic quality, and a bar representing the duration.

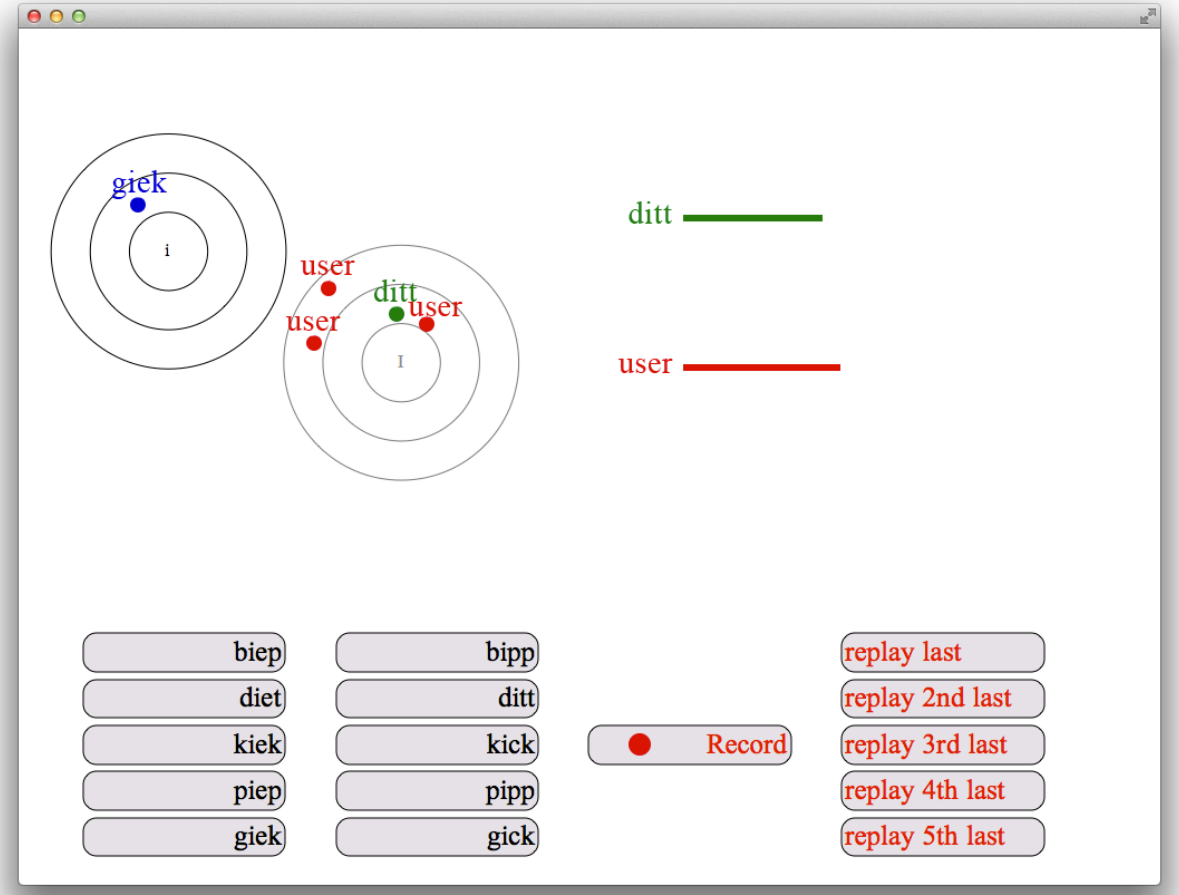
System Layout and Functionality



The user continues to make productions of the vowel until they approach a duration and acoustic quality similar to the target vowel.

Points from previous productions remain in the acoustic space, to show the user if he or she is getting closer to the target.

System Layout and Functionality



At any point the user may replay the native German productions.

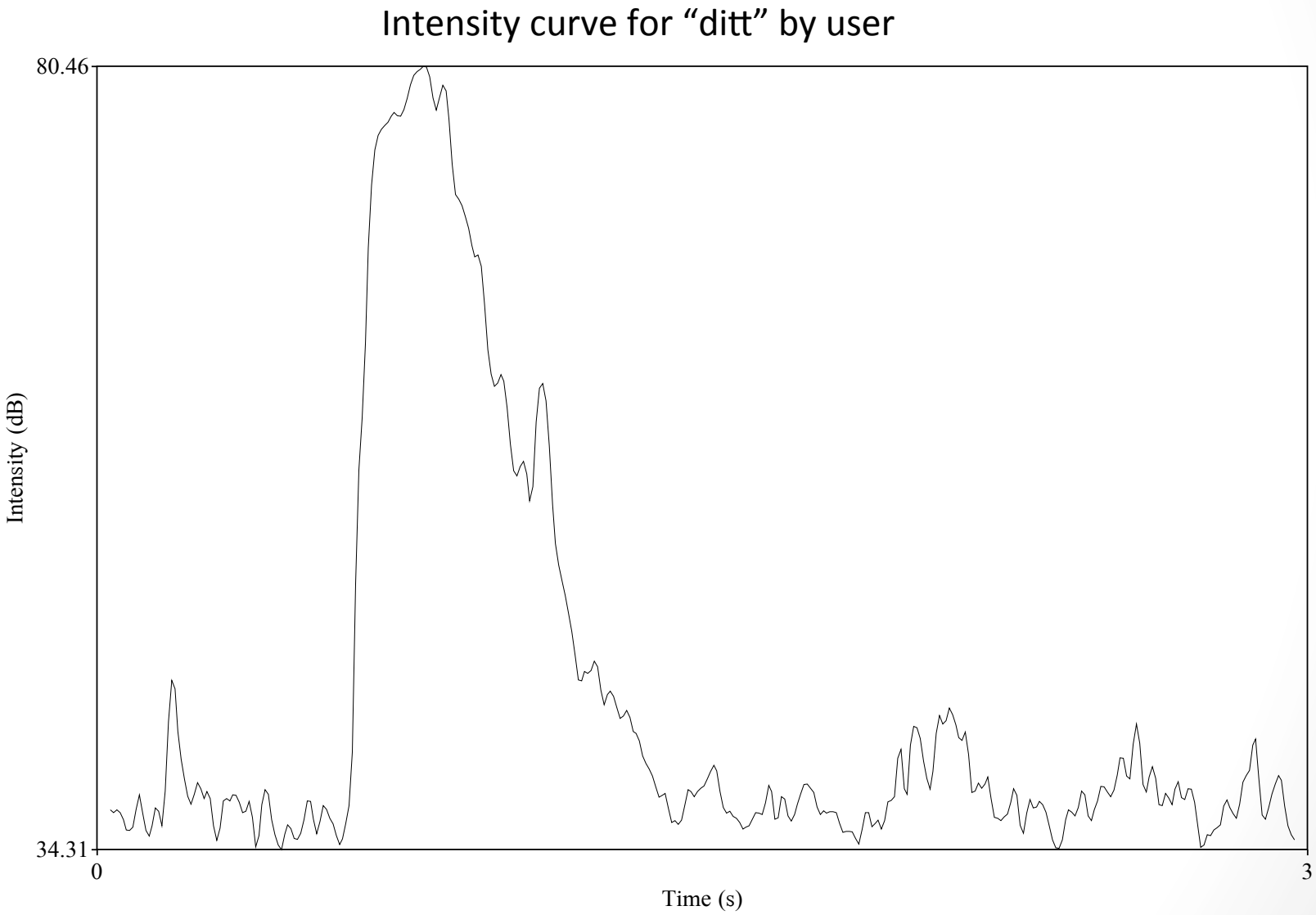
The user may also replay the five most recent productions, in order to review how the acoustic and durational qualities have changed.

Vowel Detection

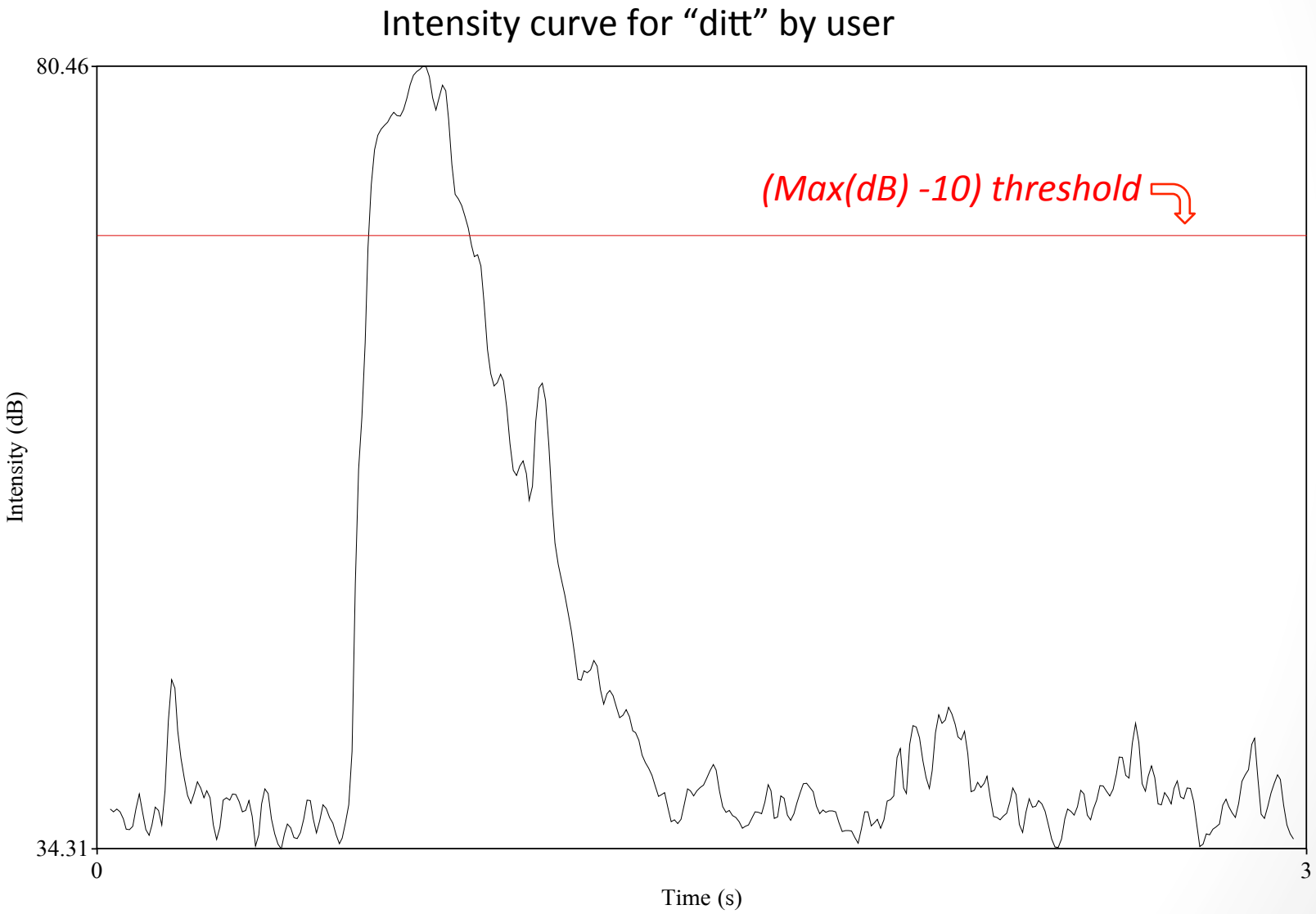
The prototype system relies on a naïve method of vowel detection:

- The system uses CVC nonsense words as carriers for the vowels.
- By placing the vowel between short duration, low intensity stop consonants the vowel can be identified as a sustained peak in intensity.
- An intensity peak of $\geq Max(dB) - 10$ with a duration of $> 40ms$ is selected as the vowel segment.
- Formant measurements are performed using the Praat find formant feature at the midpoint of the vowel.

Vowel Detection



Vowel Detection



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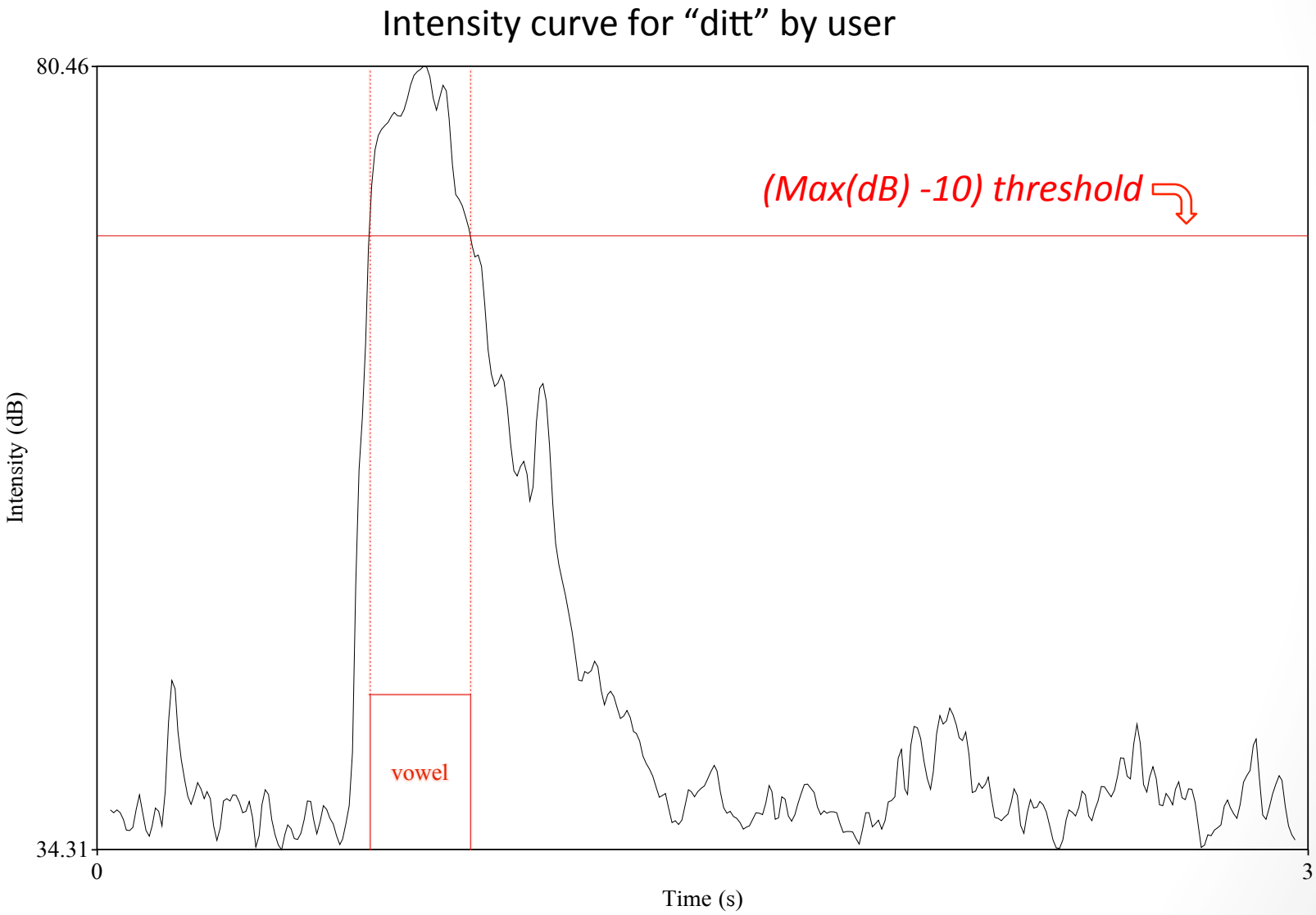

System Recap

- Provides visual feedback of spectral and durational features
- Encourages users to “play around” with different vocal tract configurations and durations until a target is reached
- Allows for visual and aural review of previous productions (excluding duration at present)
- Relies on naïve method of vowel identification

Discussion

Possibilities for future work:

- Implement a more robust vowel detection system for multi-syllable words and phrases.
- Adjust vowel targets to a speaker's individual acoustic space.
- Test the effectiveness of the feedback tool w.r.t. improved perception and production of German vowels.
- Collect user feedback on intuitiveness and ease of use for the visual feedback method.

Thank you!