How do infants pick out "high quality" vowel tokens when acquiring phoneme categories?

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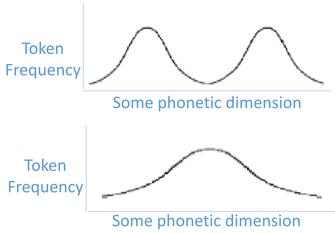
The Distributional Hypothesis

- How do infants acquire early phoneme categories at such an early age?
- **The Distributional Hypothesis**: Claims that infants acquire early phoneme categories by attending to frequency-based distributions in the ambient language

Number of frequency peaks = Number of phonemes

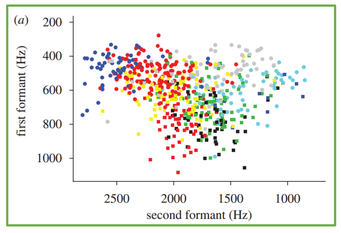


= 2 phonemes

= 1 phoneme

PROBLEM: Actual distributions in natural language are problematic for the Distributional Hypothesis

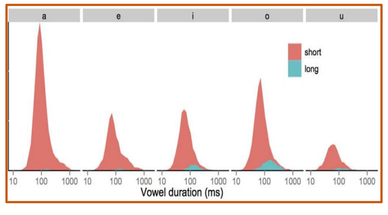
- Although influential, natural language exhibits large **category overlap**, which is problematic for the Distributional Hypothesis
- **Example 1**: English vowel qualities (Swingley, 2009)



Prediction: 11 clusters

Reality: No clear clusters in frequency

- **Example 2**: Japanese long and short vowels (Bion et al., 2013)



Prediction: 2 peaks per vowel

Reality: There are so many more short vowels than long vowels, that the second peak is often obscured

Adriaans and Swingley (2012) suggest that these cases may be solvable if infants only attend to **high quality tokens**

- Long in duration (z-score > 0.5)
- High pitch (z-score > 0.5)
- Large pitch change (z-score > 0.5)

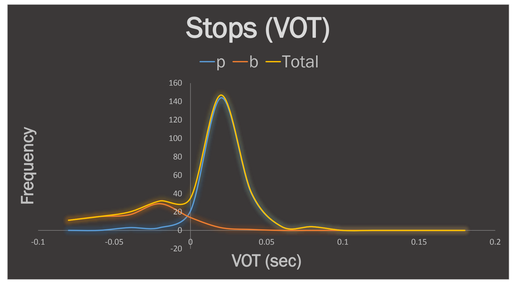
Research Questions

1. Do all phoneme categories exhibit large category overlap, or just ones that do not have an "anatomical landmark" (i.e. vowels/glides)?
2. For phonemes with large category overlap, does taking only the subset of **high quality tokens** resolve the issue of large category overlap?

Methodology

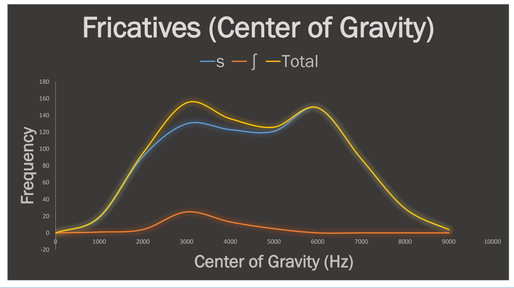
- Data collected from the infant-directed speech of a single male speaker in French using the CHILDES corpus (MacWhinney, 2000; Yamaguchi, 2007)
- Compare the distributions of the following (all are separate phonemes in French):
  - Stops / p b / (Voice Onset Time)
  - Fricatives / s ʃ / (Center of Gravity)
  - Glides / j ɥ w / (F2)
  - Vowels / i y u / (F2)

Stops and fricatives do not pose a problem for the Distributional Hypothesis



Prediction: 2 peaks

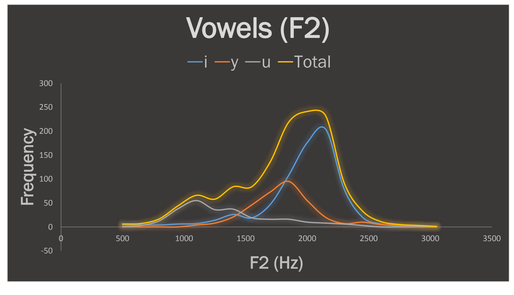
Reality: 2 peaks



Prediction: 2 peaks

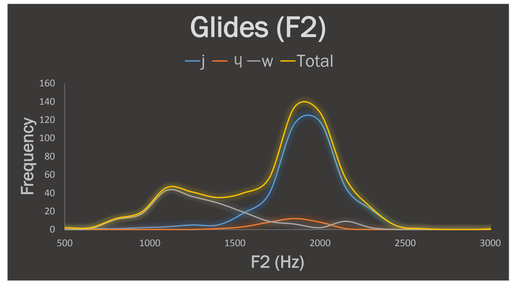
Reality: 2 peaks

Vowels (and glides) DO pose a problem for the Distributional Hypothesis



Prediction: 3 peaks

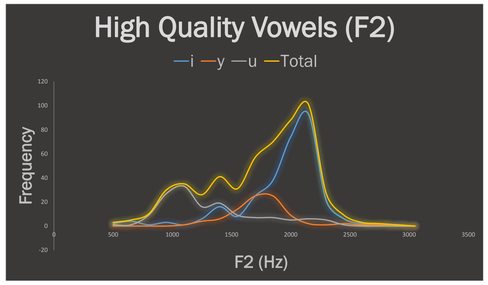
Reality: 3 peaks, but 1 in wrong location



Prediction: 3 peaks

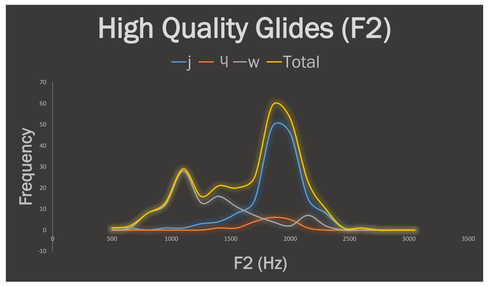
Reality: 2 peaks

...Even "high quality" tokens fail to exhibit the distributions predicted by the Distributional Hypothesis



Prediction: 3 peaks

Reality: 3 peaks, but 1 in wrong location



Prediction: 3 peaks

Reality: 3 peaks, but 1 in wrong location

Conclusion and Further Research

- There are (at least) two problems for the Distributional Hypothesis:
  - **First problem**: Cases in which there is a wide phonetic spread (i.e. for phonemes which do not have some "anatomical landmark" like vowels)
    - Example: English vowel qualities
  - **Second problem**: Cases in there are relatively few examples in the ambient language
    - Example: French high vowels/glides (current study) and Japanese long and short vowels
- The first problem may be solvable if we model only the "high quality" phonemes (i.e. long in duration, high pitched, large pitch change) (See Adriaans and Swingley, 2012)
- The second problem and its relationship to the first problem needs to be further studied. Some areas of further research might include:
  - Do infants behave similarly for the first and second cases? For example, do infants exhibit the perceptual magnet effect later for the second case than for the first case?
  - What other examples are there of the second case? Does this only occur for [-consonantal] phonemes? (i.e. vowels and glides)

Discussion

- This study only mapped phonemes with along one dimension: it may be the case that increasing the number of phonetic dimensions for the vowel and glide cases would result in three clear peaks/clusters (as predicted by the Distributional Hypothesis)
- How sensitive are infants to distributional information? For example, although the stop VOT's do exhibit two peaks, the /b/ peak is much less prominent. In fact, there is actually a third peak in the stop VOT's – is that very relatively small peak something that an infant would notice and need to be accounted for?

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