

Variability of /ð/ and /θ/ in the Casual Speech of Native English Speakers

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Abstract

This research focuses on the voiced interdental fricative /ð/ and the voiceless interdental fricative /θ/. In casual speech, many sounds are changed through reduction. In the case of fricatives, they are often reduced to stop-like fricatives. This research focused on the variations of /ð/ and /θ/ pronunciation in the casual speech of speakers in an AB/SK corpus. These variations were categorized as “fricative, stop-like, deleted, and other”. The significant results gathered were the distributions of the different variants and the difference in maximum intensity of the following sound and minimum intensity of the sound studied. The results indicate that the majority of /ð/ were deleted, while the majority of /θ/ were fricatives. This created reasonable data in order to better understand the behaviour of /ð/ and /θ/ in casual conversation.

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01.

Phonetics

The study of speech **production** and **perception**

Why Phonetics?

Phonetics analyzes how humans **anatomically produce** the sounds used in a language and the **characteristics** of those sounds. Many questions arise from these studies (UBC Visible Speech, 2015) :

- How do we make sense of those sounds (**perception**) (Tucker, 2021)?
- How do we **change our speech** in spontaneous conversation and how do we still understand it (Tucker, 2021)?
- How can we apply that knowledge to **speech recognition technology**?

But first, a **database** needs to be created on the behaviour of sounds in different circumstances. Therefore, **specific sounds in specific situations** are often analyzed.

Study of Sounds

How the **vocal folds** are **moving**
(UBC Visible Speech, 2015)

Voicing

The International Phonetics Alphabet is a language of **symbols** representing every **sound** (UBC Visible Speech, 2015).

IPA

Ex: /ʃ/ : sh (shop)
/ð/ : th (theft)

Place of Articulation

Where the airflow is interrupted (UBC Visible Speech, 2015)
Ex: by lips coming together, tongue & teeth

Manner of Articulation

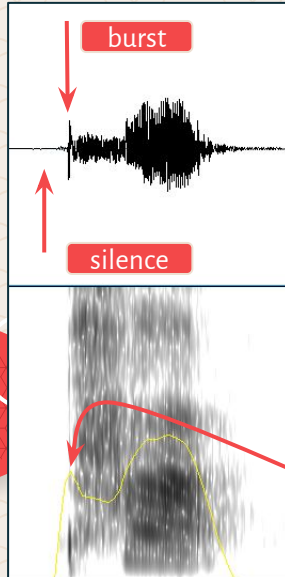
How the airflow is interrupted (UBC Visible Speech, 2015).
Ex: rapid release of air produces a sound

Main Manners of Articulation ●

As a classification for different sounds

Stop

Word: **pat**



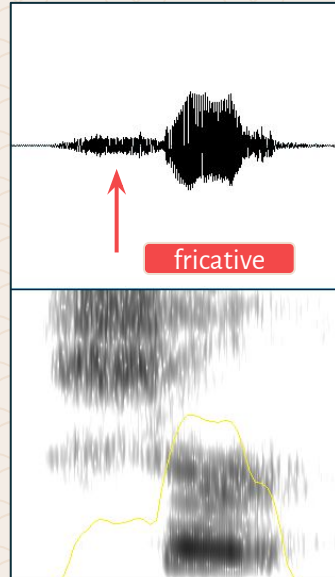
The sound "p" or /p/ is a **stop**.

On the waveform, it is identifiable by a **silence**, followed by a **sudden burst**.

The **intensity** will **increase** sharply.

Fricative

Word: **shirt**



The sound "sh" or /ʃ/ is a **fricative**.

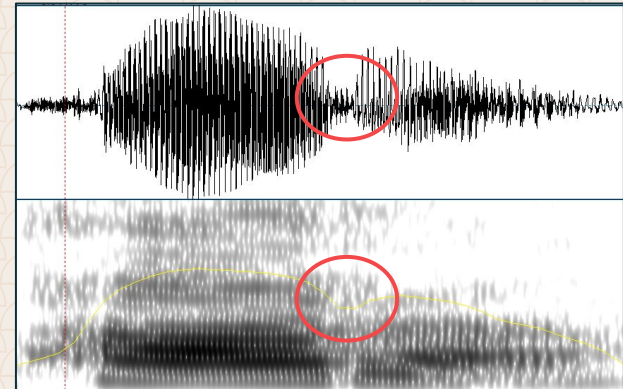
On the waveform, there will be a **condensed and quiet** section.

Tap

The spanish sound "r" or /r/ is a **tap**.

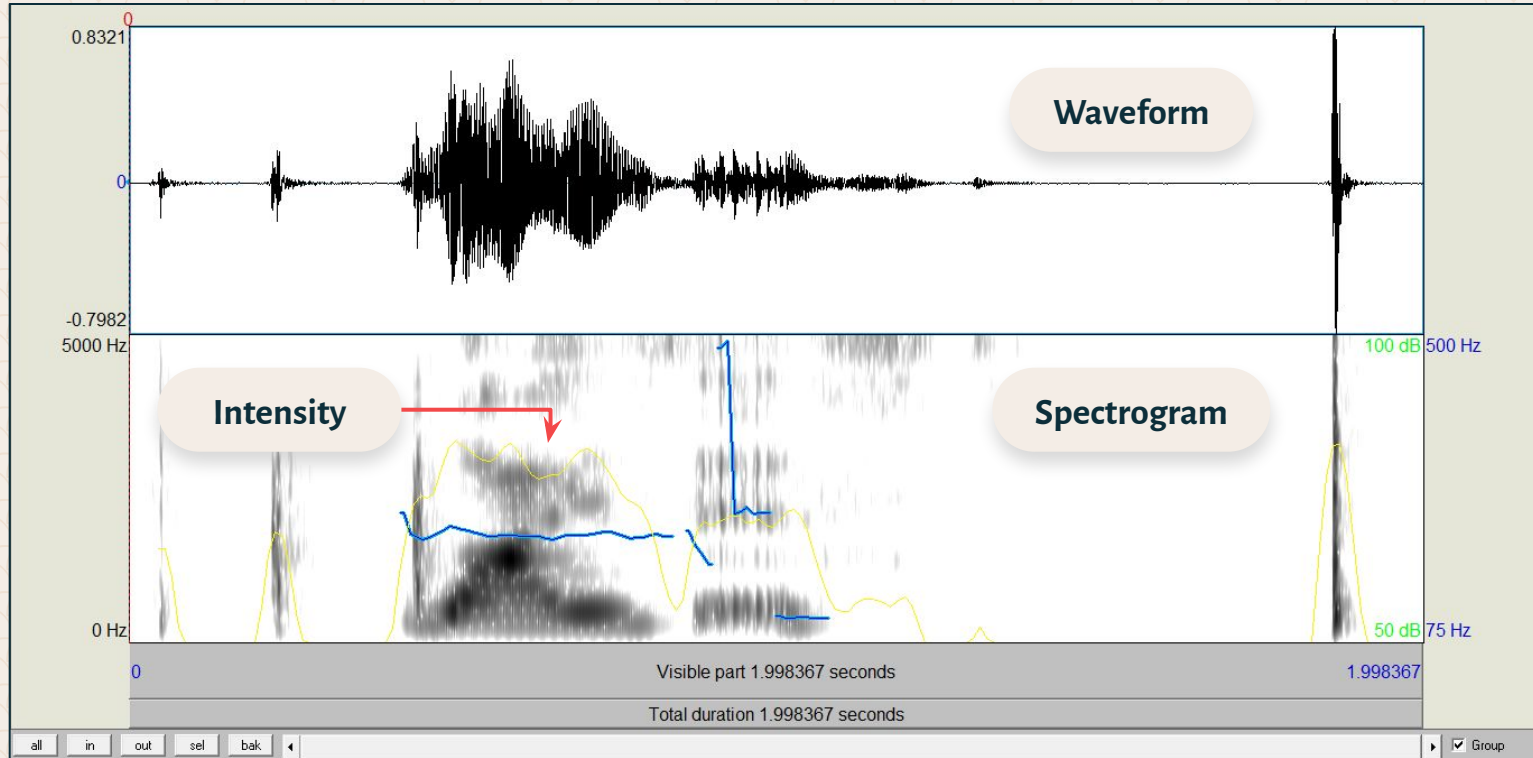
The waveform will be **lower**, the intensity will have a **drop curve**, and the spectrogram will have a **gap**.

Word: **para** (spanish)



Spectrograms

While the waveform is a 2D representation of sound, the spectrogram is a **3D image** of sound that allows for interpretation of **time**, **frequency**, and **intensity**.



02.

Research Topic

In casual conversation, how does the pronunciation of /ð/ and /θ/ differ?

Breakdown of topic

What are the variations of /ð/ and /θ/ in the casual speech of native English speakers?

Casual Speech, Variations and Reduction

Fricatives and /ð/ and /θ/

Why?

What is Spontaneous Speech, Reduction and Variations?

Spontaneous speech is considered any casual conversation where the speakers will be more relaxed with their pronunciations.

Reduction is a phenomenon often present in spontaneous speech. When comfortable, speakers will not pronounce every sound or letter in a word and will combine sounds or delete sounds. This process of accelerated and less exact speech is called reduction (Warner, 2019).

Variations occur in reduction since letters/sounds are pronounced differently. Whether a sound is absent or pronounced lazily, different versions of that same sound will occur. These differences have patterns and become variations (Warner, 2019).

What are the fricatives /ð/ and /θ/ ?

Fricatives are generally **reduced to stops** in spontaneous speech. They will often sound like **/d/ instead of “th”**. Otherwise, they can be completely **deleted** (Zhao, 2010).

/ð/ is a “th” in words like “the” or “that.”
/θ/ is a softer “th” in words like “theft” or “through.”

/ð/ and /θ/ are subjected to much variation because of their placement in words and the general pattern of reduction, which is to delete sounds not necessary for understanding.

Why is this research topic significant?

Knowledge of reduction in spontaneous speech is valuable because it occurs in the majority of speech. Its irregular nature means **speech recognition software crashes** when trying to understand it, **second language acquisition becomes more difficult** as the learning of multiple variations is an obstacle, and it simply introduces many more questions on **humans' ability to perceive sounds**.

- How are we capable of associating so many variants to one sound and make sense of it?
- How can we fill the gap of deleted sounds and still comprehend the meaning?

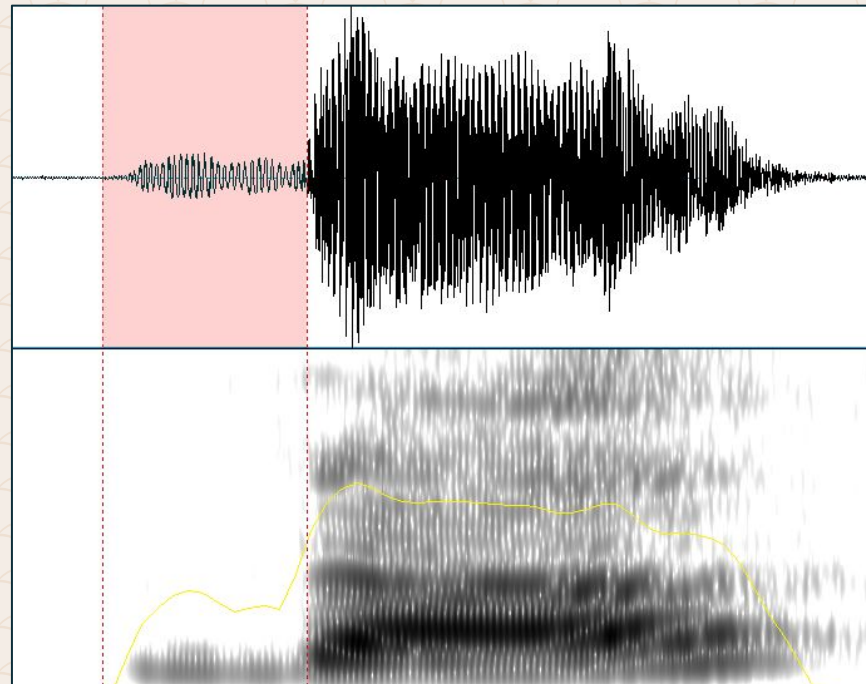
More specifically, fricatives have generally been **less studied**, especially in English casual speech. This lack of data makes it difficult for more studies to be conducted. Therefore, the following research will contribute a valuable first step towards broadening knowledge on fricatives.

Defining /ð/ DH

/ð/ is a voiced interdental fricative. This means:

- Voiced: **vocal fold vibration** is present
- Interdental: the **tongue and the upper and lower teeth** are used to produce this sound
- Fricative: the tongue will approach the top of the mouth but will not make contact and leave an **airflow**, which will make the sound

Ex: the, that



Zadnik, S. (2021). [Spectrogram created through Praat].

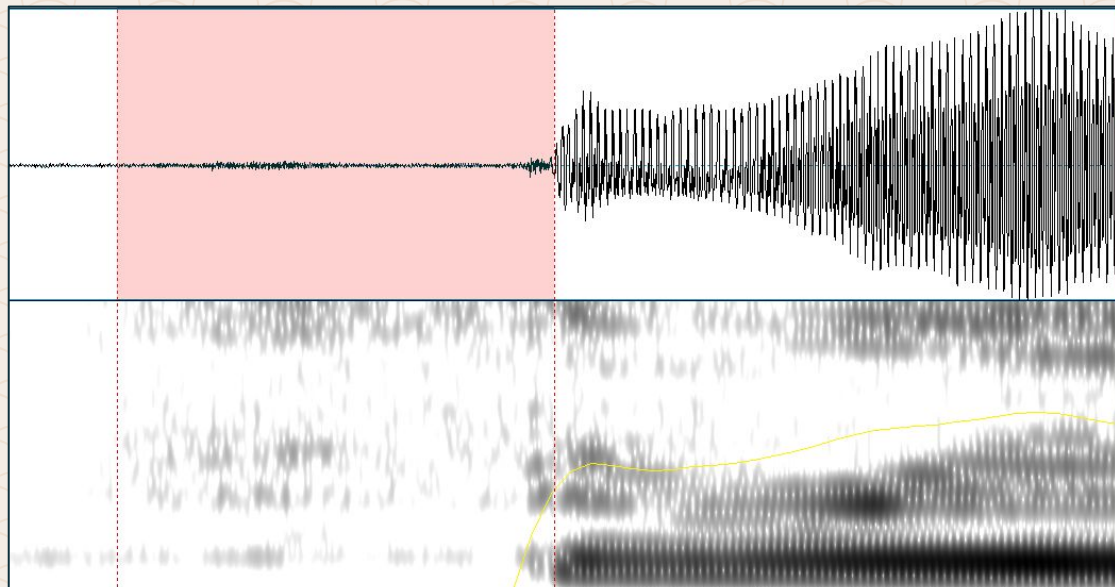
Defining /θ/ TH

/θ/ is a **voiceless interdental fricative**.

This means:

- Voiceless: there is **no vocal fold vibration**
- Interdental: the **tongue and the upper and lower teeth** are used to produce this sound
- Fricative: the tongue will approach the top of the mouth but will not make contact and leave an **airflow**, which will make the sound

Ex: through, theft



Zadnik, S. (2021). [Spectrogram created through Praat].

03.

Research Procedure

Process & Measurements

Steps

Data

A database (corpus) of **recordings of casual conversations** from a range of different speakers was used. This data includes the **audio** and the **text files** with the transcription. Both of these files were then imported into the program **Praat** where a **spectrogram** was created and analyzed.

Label

500 words beginning with /ð/ and /θ/ were extracted.

Following that, a **categorization system** had to be developed in order to label different **types of variations** (what type of sound was actually produced) in the pronunciation. Once that was established, every /ð/ and /θ/ was **labelled** and data was created.

Analyze

Once all /ð/ and /θ/ were labelled, a **script** (Perry and Tucker, 2021) was used to **extract** data and transfer it into **graphs/diagrams**.

The Data: SASE Corpus

In this research, the South Alberta and Saskatchewan Speech (SASE) Corpus was used for data. The corpus was created by taking audio-recordings of 24 native English speakers from southern Alberta and Saskatchewan (Wittrock, 2021).

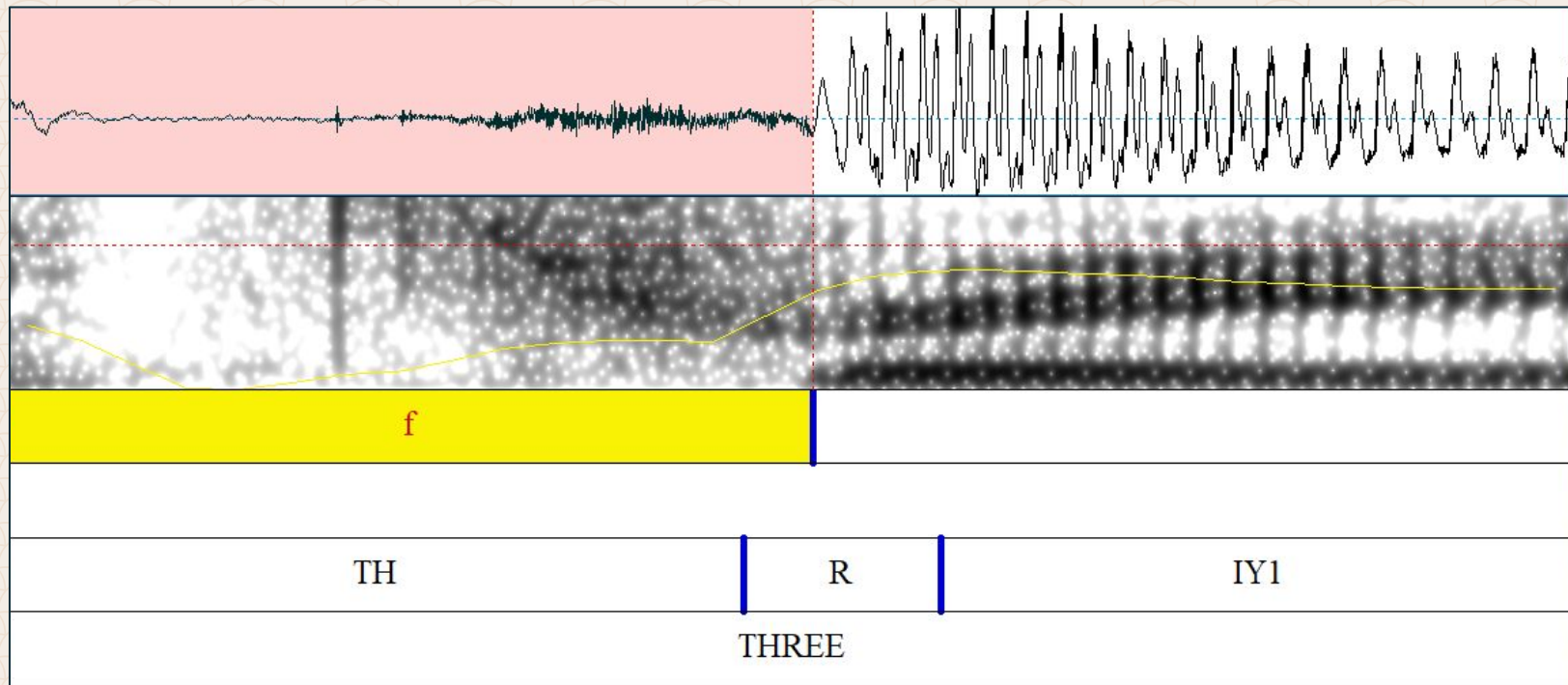
Speakers: There were 5 men over 40, 7 men under 40, 6 women under 40, and 6 women over 40. For the younger males, the average age was 21.92, for younger women it was 21.8, for older males the average age was 56.82, and for older women it was 55.83. As for demography, there were 13 participants reporting to have grown up in southern Alberta, 9 in southern Saskatchewan, and 2 in both provinces (Wittrock, 2021).

Recordings: The recordings were taken between May and July 2018 with “a Marantz digital recorder with a sampling rate of 44.1 kHz and an omnidirectional Countryman E6 earset” (Wittrock, 2021). Some disturbances and personal information were recorded and, subsequently, replaced with silence.

Method: Participants were asked for consent and were then recorded for approximately 25 minutes. Three different types of recordings were conducted: a word list, a passage reading, and a “sociolinguistic interview” (Wittrock, 2021) of around 20 minutes. **For the purpose of this research, only the interview was used as it provided “near-casual spontaneous speech”** (Wittrock, 2021).

The Labelling: Categorization

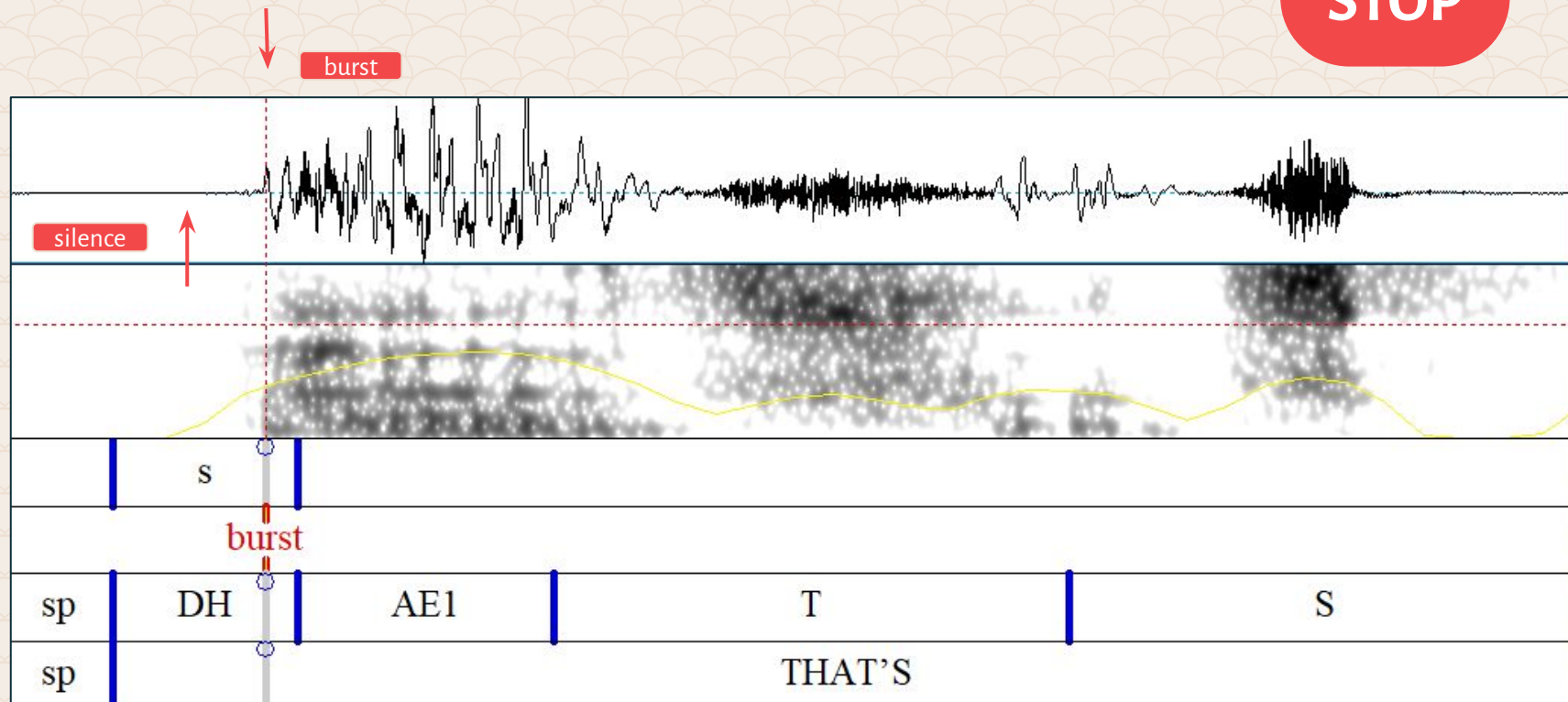
FRICATIVE



“TH” is how /θ/ is transcribed. In this case, /θ/ was actually **pronounced as a fricative**.

The Labelling: Categorization

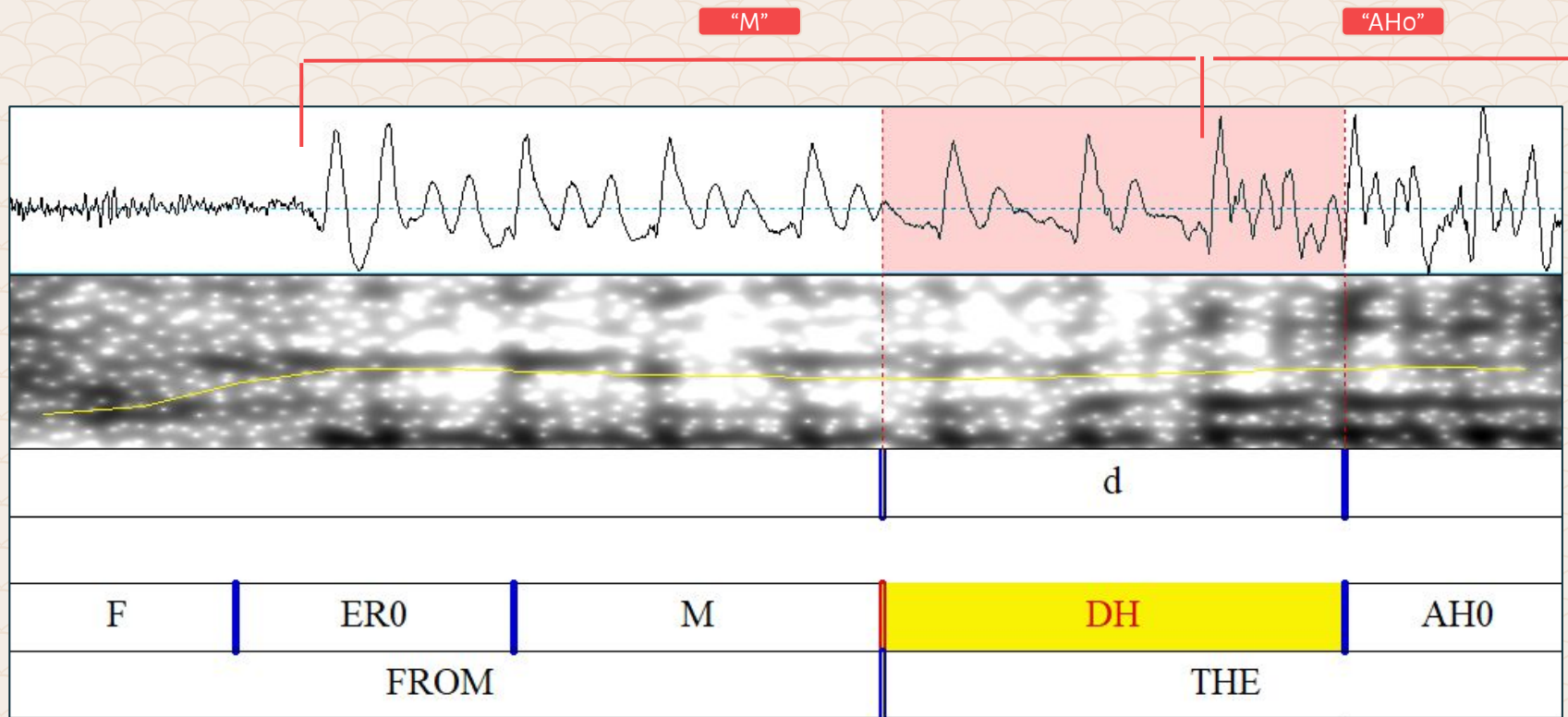
STOP



“DH” is how /ð/ is transcribed. As evident, although /ð/ was supposed to be pronounced, a /d/ **was actually produced**.

The Labelling: Categorization

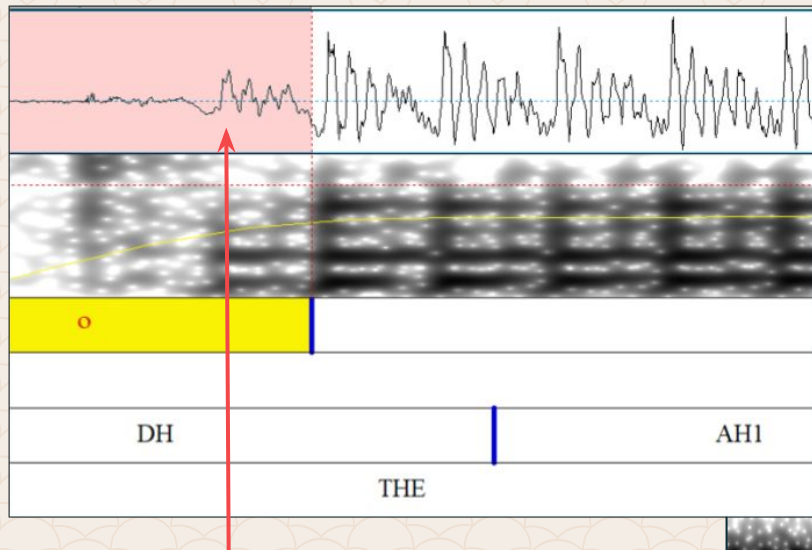
DELETED



"DH" is how /ð/ is transcribed. In this case, /ð/ was **not pronounced at all**. The section assigned to it is just "M" and "AHO."

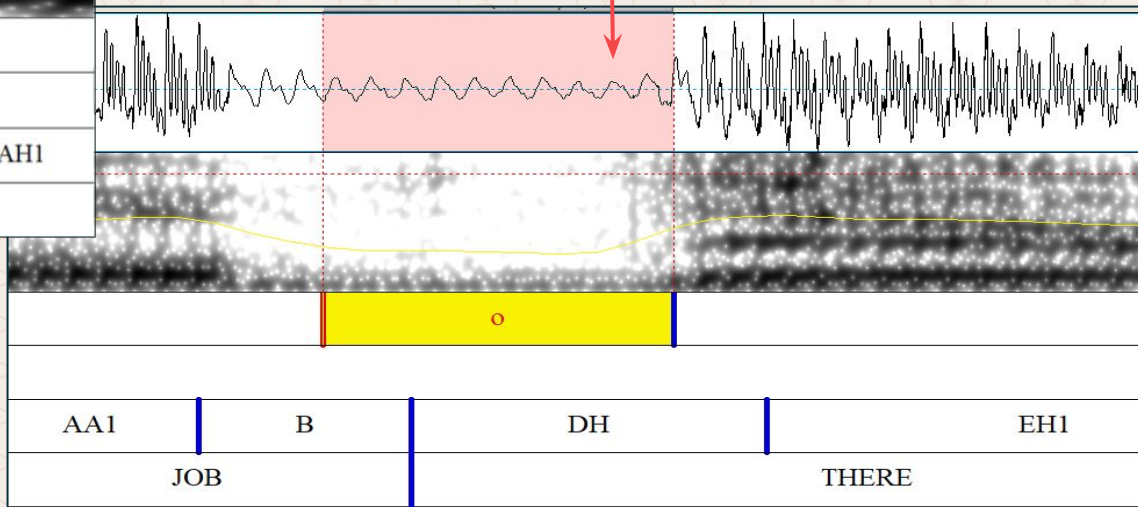
The Labelling: Categorization

OTHER



“DH” is how /ð/ is transcribed. Here, /ð/ **does not look like a stop or a fricative**, so it was labelled “other.”

“DH” is how /ð/ is transcribed. In this case, /ð/ does not look like a typical fricative, but is a separate sound of its own. Since it **does not fit into the set fricative appearance** though, it is labelled “other.”



The Labelling: Categorization

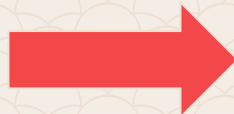


NOTE



Some of the fricative samples were left untouched and not labelled due to obstacles to clear analysis.

1. Some samples were clouded by white noise, meaning the spectrogram was inaccurate.
2. Other samples contained transcription errors. When too extreme, the alignment can not be corrected or the sounds can not be correctly identified.



Data Collected

A database of labelled and **categorized** /ð/ and /θ/ was now created and the data was ready to be sorted. Along with the categories, the boundaries around the sound allowed for measurement of **duration** and the **intensity** given by the spectrogram also meant it could be analysed.

The Analysis: Data Collection

HOW

- An **R script** (Perry and Tucker, 2021) that would sort through the data and extract the information needed was used.
- Once the data was collected, **diagrams** were made to represent the distribution of the data by code.
- After viewing the data, what was deemed **significant** was presented.



WHAT

- Amongst all the data extracted, those of most significance for this study were:
 - ◆ **Code**
 - ◆ **Difference in maximum/minimum Intensity**

04.

Results & Conclusion

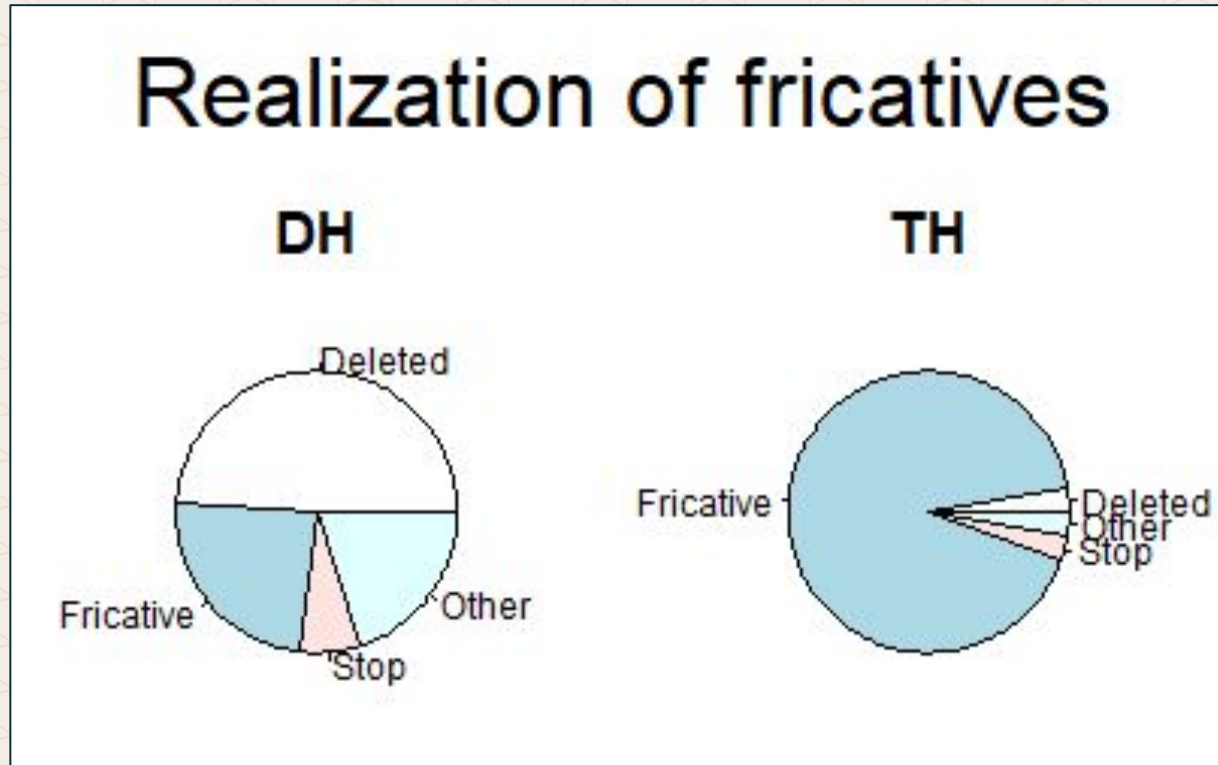
Data & Meaning

Number Distribution of Code (s,f,d,o) in /ð/DH and θ/TH

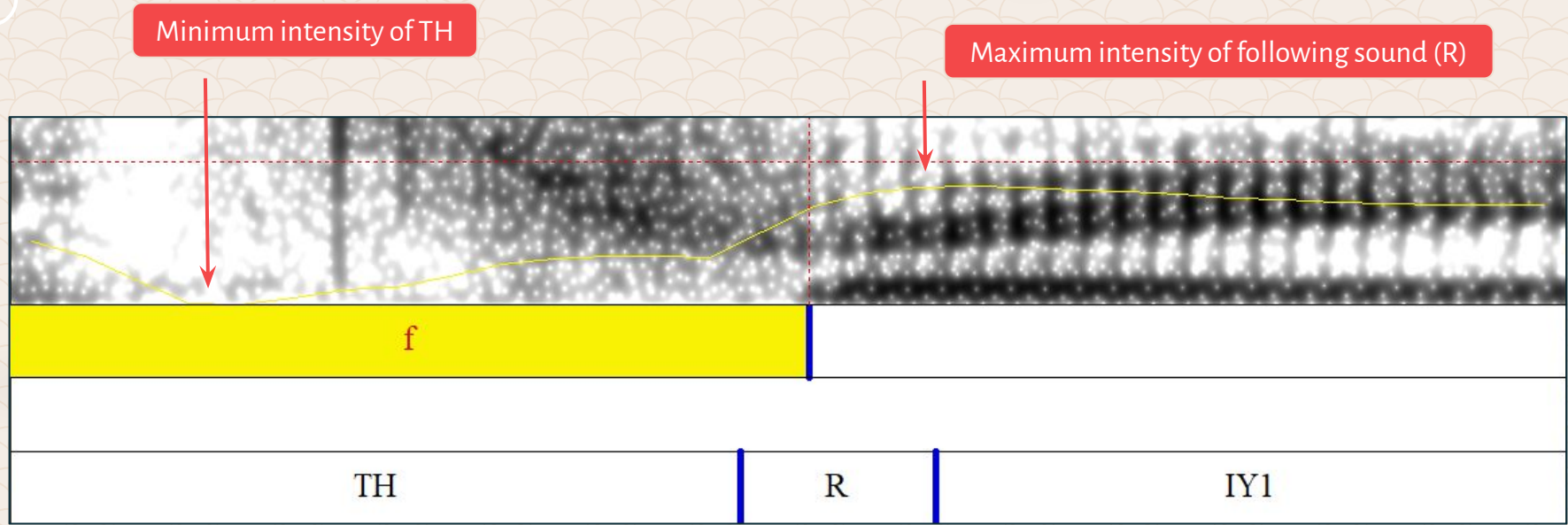
Sound	Data	Deleted	Fricative	Stop	Other
/ð/ DH	Raw Counts	191	94	27	78
	Percentages	48.97%	24.10%	6.92%	20.00%
/θ/ TH	Raw Counts	1	33	1	1
	Percentages	2.77%	91.66%	2.77%	2.77%

Chart Distribution of Code (s,f,d,o) in /ð/DH and θ/TH

Realization of fricatives



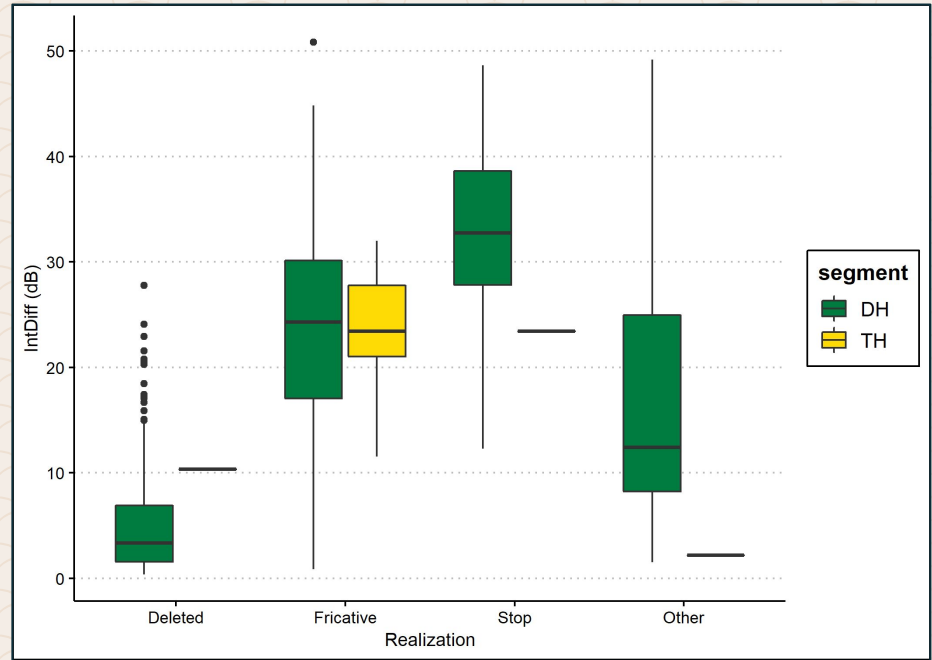
What is the difference between maximum and minimum intensity?



The intensity was measured for both the sound /ð/ and /θ/ and the vowel sound following it. Then, a difference between the two measurements was calculated and graphed. The data was separated by code and by sound (/ð/ or /θ/).

Difference between minimum intensity of segment and following word maximum segment

This data helps to show the type of sound that would follow /ð/ and /θ/ and also confirm the coding for /ð/ and /θ/ was correct. This data is expected, as deleted sounds were expected to show little difference in intensity, whereas sounds where a silence (very low intensity), which is present in fricatives and stops, is involved should have a larger difference. Overall, the data confirms our code is correct and represents the behaviour of sounds.



Perry, S.J. (2021). [Boxplot].

Conclusions & Future Use

The research conducted concluded that fricatives are indeed pronounced as fricatives or stops, are deleted, or are something else entirely in casual speech. The data showed overall that 45.07% were deleted, 29.81% were fricatives, 6.57% were stop-like, and 18.54% were other. This shows a trend in reduction and the need to further research the different ways /ð/ and /θ/ can be pronounced and what predicts this variation.

Fricatives are not commonly studied sounds and little data has been gathered on variations of /ð/ and /θ/ in English. Research is based on data, meaning this is a contribution to future research. This collection of data on the variability of /ð/ and /θ/ is a first step towards furthering our understanding of fricatives and reduction. While this serves as a good starting point for further research, a more detailed coding could be executed and further examination of the “other” category would provide more insight.

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