The Curious case of interdental fricatives

1 Introduction: Interdental Fricatives

With English having one of the highest counts of native speakers, as well as being widely spoken across the globe (Lewis et al., 2016), it is somewhat surprising that it contains what may be called an *exotic* set of phonemes. These of course are the interdental fricatives: /θ/ and /ð/. In data taken from UCLA's Phonological Segment Inventory Database (UPSID)[1], one can see that these phonemes do not show up cross-linguistically very often. Their distribution both in number of languages and percent of languages is shown in Table 1 below:

	Number of Languages	Percent of Languages
θ	18	3.99%
ð	22	4.88%

Table 1: Distribution of interdental fricatives

Because of this rareness, non-native speakers of English often struggle with the pronunciation of words containing interdental fricatives. Often, when presented with a word containing /θ/ or /ð/, they will replace it with a phoneme from their native inventory. Additionally, I should point out, a similar process occurs even with certain dialects of native

[1]Specifically, using a web interface developed by Henning Reetz at Goethe University Frankfurt that can be found here: `http://web.phonetik.uni-frankfurt.de/upsid.html`

English speakers (British, African American English). In all of these cases, a process occurs that preserves certain features of an underlying interdental fricative, while creating a segment that is either available in their native phonology (for non-native speakers), or more common (for native speakers).

There are three main processes that speakers are known to use when replacing interdental fricatives.

(1) /θ ð/ → /f v/

(2) /θ ð/ → /t d/ or /t̪ d̪/

(3) /θ ð/ → /s z/

The process in (1) is often referred to as TH-fronting. Here, the place of articulation (POA) moves forward to the labiodental position. All of the other features of the underlying interdental fricative appear to remain the same. In (2), a process known as TH-stopping occurs. Here, the underlying interdental (or sometimes dental) fricative becomes an alveolar or dental stop. In both instances, the underlying sound loses its continuancy and potentially its [+distributed] feature. This is somewhat less straightforward, but is apparent that the manner feature is changed while (most of) the place features remain the same. The final process shown above (3) has no common name that I know of, but I will be calling it TH-stridentizing. During this process, the underlying sound loses its [+distributed] feature while simultaneously gaining a [+strident] feature. In this case, it also keeps its continuancy. Because of this, this process is somewhat simliar to (1).

Throughout the rest of this paper I will look at these three processes using feature geometry to show how they are feature preserving in nature. Additionally, I will look at

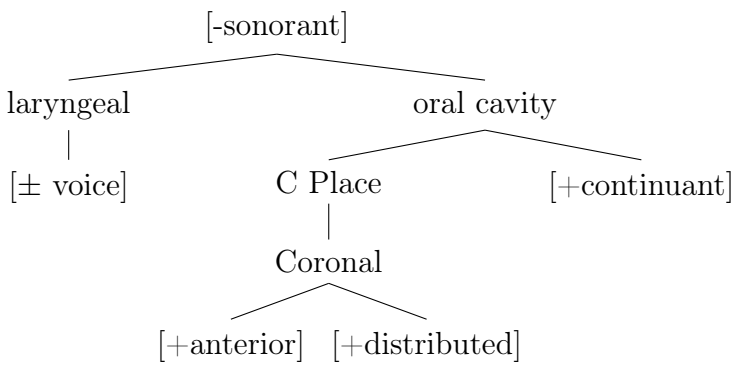
specific examples of each process as it is applied by different dialects of English.

2 Feature Geometry Rules and Representation

In this section I will use Clements and Hume (1996) feature geometry model to a) show the representation of the interdental fricatives and b) show the phonological processes that occur to change these segments into based on certain English dialects' rules. Most data in this section is taken from either *World Englishes* (Hopkins, 2013) or *The Routledge handbook of World Englishes* (Kirkpatrick, 2010). In each subsection I will begin by giving data that shows the phonological process and then formulate how this process would occur using feature geometry. A brief discussion of any theoretical implications will then be presented before they are expanded later.

To begin, example (4) shows how the interdental fricatives would be represented using feature geometry.

(4)



This is relatively straight forward, but I'd like to point out a few representation choices. The root node contains only designation for the [sonorant] feature. Due to the focus of this paper being on obstruents, it is unnecessary to mark the [vocoid] and [approximant] features

since all segments that have a minus value for [sonorant] have a minus value for those two features by default. Additionally, I have chosen to represent both the voiced and voiceless segments using one tree and designating it [±voice]. This was done primarily to save space and is somewhat misleading. As I will discuss later, it is not always the case that both of these segments pattern the same phonologically. Evidence for this will be provided in later sections. At the moment, I will begin to show the phonological processes discussed up to this point at work, beginning with TH-fronting.

2.1 TH-fronting

As proposed in example (1), TH-fronting occurs when /θ/ and /ð/ are phonetically realized as [f] and [v]. In Kirkpatrick it is claimed that TH-fronting is the second most talked about feature of UK English pronunciation after t-glottalization. There also are a fair number of factors that affect TH-fronting. This entry points to evidence that word-intial voiced interdental fricatives are resistent to TH-fronting. This is the first bit of evidence that indicates the voiced interdental /ð/ may have further restrictions that its voiceless counterpart does not.

A search of the Carnegie Melon University (CMU) pronouncing dictionary [2] shows that [ð] only appears in the onset position of function words. Because this class of words is so high frequency, there must be a stronger restriction on how speakers may treat it. Also, of note, is that there appear to be only 13 unique morphemes that start with this sound and around 50 total words that contain it in the word-initial onset position. These base morphemes can be seen in (5) below. It should also be mentioned that not all 13 on the list

[2] `http://www.speech.cs.cmu.edu/cgi-bin/cmudict`

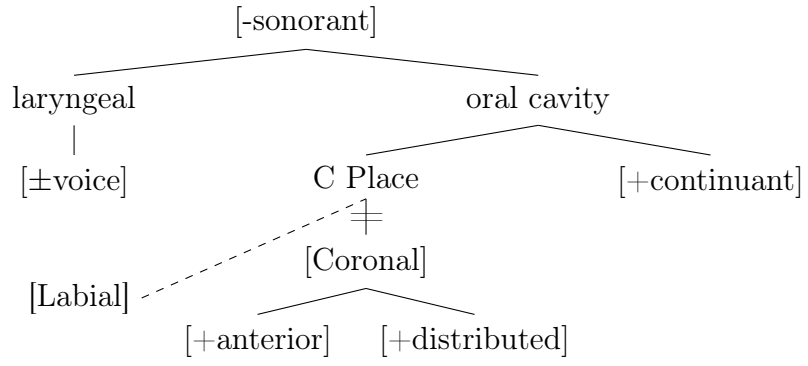
are still in regular use today. *Thence* and *thine* are especially egregious examples that are not used in regular speech today.

(5) Words/morphemes beginning with [ð]: *than, that, their, them, then, thence, there, these, they, this, thine, those, thus.*

With that in mind, I return to the claims made in Kirkpatrick. TH-fronting is claimed to occur most frequently at the end of words, less so word medially, and least frequently at the start of words. This makes sense for two reasons. First, with the restriction placed on voiced interdental fricatives not being able to undergo fronting in word-initial position it would make sense that overall the process would occur less in word initial position. This process could likely be generalized to more broadly restrict it from occurring in onset position. If that is the case, then secondly, word-medial (voice) interdentals that syllabify as onsets would also be restricted from undergoing the process.

Before moving any further I'd like to look at the feature geometry process that occurs for TH-fronting. In (6) below, the Coronal node is disconnected from the C-Place node and a Labial node is generated in its place. All other features remain unchanged.

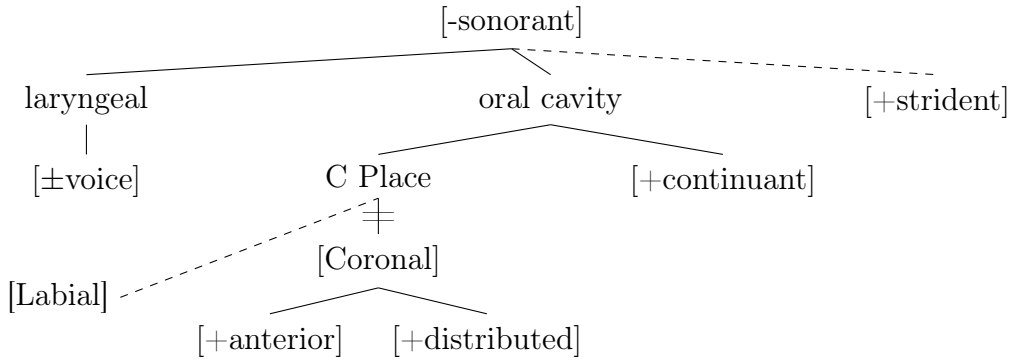
(6) /θ ð/ → /f v/



I have kept the [±voice] feature for now, though it should be noted that this process is

restricted from happening in word-initial position for the [+voice] variant. Because this is not a rule, but rather a representation of the process, I will continue to keep it for now. Especially since this process does indeed occur for both the [+voice] and [-voice] variants in both word-medial and word-final positions. Another item to address is the fact that the representation shown above in (6) is under equipped to differentiate between a bilabial fricative and a labiovelar fricative. Clements and Hume discuss this briefly in their article by suggesting that the [strident] feature 1) is linked under the root node and 2) will allow for contrast in language where there is minimul contrast between these sounds. An updated tree for this would simply add a strident node attaching to the root node.

(7) /θ ð/ → /f v/ (updated w/ stridency)



While this certainly complicates the process, it does fall in line with the process described in (3) where the interdentals become alveolar fricatives. I labeled it as TH-stridentization, but it appears that the addition of the [strident] feature may be necessary for TH-fronting as well. That being said, there is one other possible explanation for the process that doesn't involve the addition of a [strident] node.

Because English does not have bilabial fricatives in its phonology, it does not matter

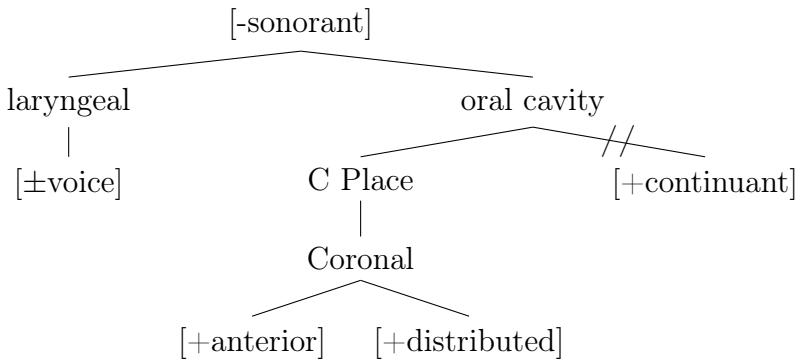
whether a [strident] node gets added or not. It will always be phonetically an [f] or a [v] simply due to those being the only fricatives available in the language that are [Labial]. To see if the addition of stridency is even necessary, it would be necessary to find a language that has contrastive labial fricatives and see how speakers of that language pronounce interdentals in English words. Even then, it could simply be language specific. There is no clear evidence that this is a universal process and because it is one of multiple processes, it would make sense for it not to be. With that in mind, the parallel of adding a [strident] feature to process (3) is intriguing. This will be discussed again in Section 2.3.

2.2 TH-stopping

While TH-fronting is primarily discussed in regards to UK English (and also AAE - more on this later), speakers of English from other countries around the world struggle with what to do with interdental (sometimes just dental) fricatives (Kirkpatrick, 2010). Most commonly, the segments are replaced by alveolar stops or fricatives, but sometimes the dental versions of those sounds. Additionally, word-initial voiced interdental fricatives are nearly always turned into stops as discussed in Section 2.1. Dialects of English that undergo TH-stopping include: Singapore , India (Malayalam, Nigeria, Caribbean, Brunei, Sri Lankan, Chicano, Belize, Honduras, and AAE (Kirkpatrick, 2010; Hopkins, 2013).

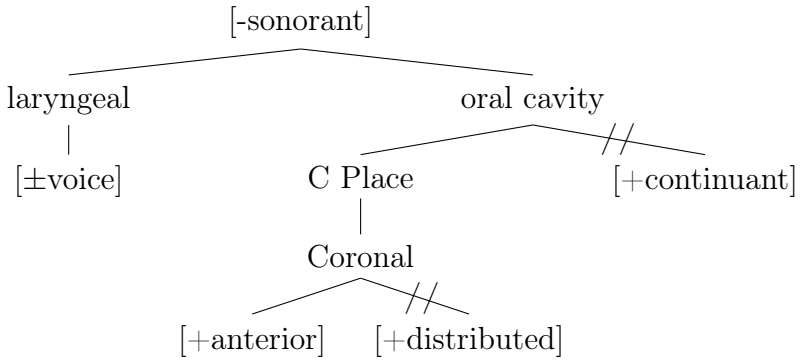
The most notable aspect of this process is that some dialects replace the underlying segment with a dental stop, while others realize it as an alveolar stop. If I continue to assume that the underlying representation of the interdental sounds is specified for both [anterior] and [distributed], the pronunciation as dental stops seems to make the most sense.

(8) /θ ð/ → /t̪ d̪/



Sri Lanken English is one dialect said to have dental realizations of stops when they undergo this process. As shown in (8), the main process that occurs is the disconnecting of the [+continuant] node. This likely implies that there is a default rule that makes all [-sonorant] segments [-continuant] if they are not specified for it. In this case, all other features are preserved from the underlying fricative segment. This includes the [anterior] and [distributed] specifications. This might suggest the need for specifying the [distributed] feature, but a closer look into Sinhalese (the main language spoken in Sri Lanka) may suggest otherwise. A look into the phonological segments of Sinhalese shows that they do not have alveolar stops, but instead only dental stops (Chandralal, 2010). That being said, they also have retroflex stops which fall under the [Coronal] node, but the contrastive nature can be explained with simply the [anterior] feature. Before discussing this further, I'd like to show what the process changing an interdental fricative into an alveolar stop would look like while keeping the [distributed] feature. While it is possible to show, the double process of disconnecting both the [continuant] and [distributed] nodes seems unnecessary. It also seems more logical that the continuancy value would change, but altering just one of the feature values under the [Coronal] nodes is a bit more suspect.

(9) /θ ð/ → /t d/



In example (9) this process of turning the underlying fricative into an alveolar stop is shown. This would work especially well if there was a language that had contrastiveness within the [distributed] feature. I will look back to native English to further prove my point. In English stops, there is no contrast of the [distributed] feature. I used it earlier to show the difference between /s/ and /θ/, but even then, it is not necessary if we take into account the [strident] feature. A look at the [Coronal] fricatives using only [anterior] and [strident] features shows an ability to distinguish the three segments without the aid of the [distributed] feature.

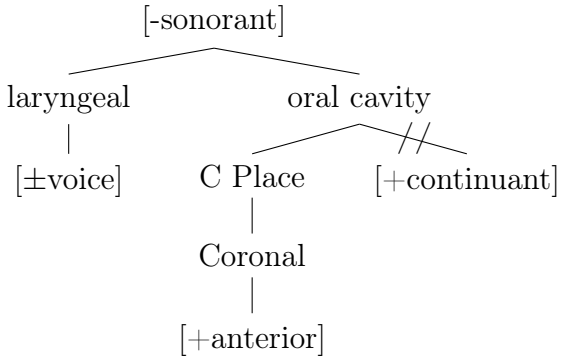
	[anterior]	[strident]
θ/ð	+	-
s/z	+	+
ʃ/ʒ	-	+

Table 2: Distinct Features of Coronal Fricatives in English

When the data in Table 2 is taken into account with the fact that English only has alveolar stops under the [Coronal] node, the [distributed] node seems unnecessary. This means that one rule should be able to account for both the alveolar and dental stops that

occur. The only process that is happening is the disconnection of the [continuant] node and a default rule making it [-continuant]. The [Coronal] node is only specified for [+anterior] in the underlying interdental fricative and the native language phonological inventory and constraints dictates whether it is pronounced as a [t] or [d] or [t̪] or [d̪]. An updated rule that takes this into account can be seen below.

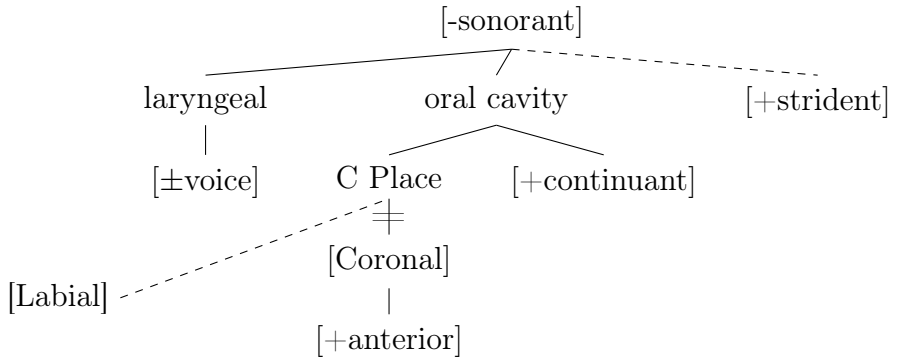
(10) Interdental Fricatives → language specific [+anterior] stops



2.2.1 Update to TH-fronting

With this new conclusion, I'd like to update the process from Section 2.1. While this largely does not affect the conclusions made earlier, it cleans things up and makes things clearer moving into Section 2.3. Additionally, it strengthens the parralels between TH-fronting and TH-stridentizing with the main difference being the change at the [C Place] node. Example (11) below shows the update process.

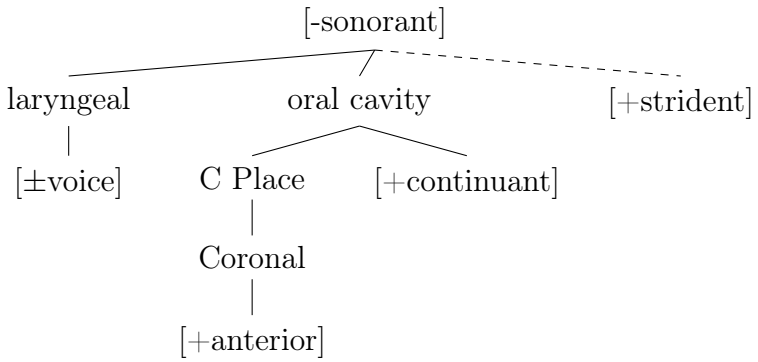
(11) TH-fronting process with removed [distributed] feature



2.3 TH-stridentizing

The final process that I will discuss is the one mentioned in (3) at the beginning of the paper. This is when underlying interdental fricatives become aveolar fricatives. There has been mention of this process in previous sections and at this point it should be obvious how TH-fronting and TH-stridentizing are related. The process for TH-stridentizing is shown below

(12) /θ ð/ → /s z/



As should be readily apparent at this point, the process is identical to TH-fronting with the only difference being the maintenance of the Coronal node under the [C Place] node. Back in Section 2.1 I claimed that there was an option for the TH-fronting that didn't involve

that addition of a stridency node due to there being only one [Labial] fricative. While that is certainly still the case, the addition of the stridency nodes connects both TH-fronting and TH-stridentizing together and suggests that they may be undergoing the same process.

2.4 Final Thoughts on Process

At this point, there is not much left to say about the theoretical representation of these processes. Throughout the preceding sections I have shown that there are simple ways to represent the change in pronunciation of interdental fricatives. All three of the processes that I discussed involved some amount of feature preservation. For TH-fronting, the manner largely remained the same while the place features changed. Additionally, a stridency feature was added to the root node which directly parallels what I have been calling TH-stridentizing. As was the case with TH-fronting all of the manner features for TH-stridentizing remain the same,but with this there is no change in the place features. The only addition is the [strident] node. Finally, TH-stopping preserved the place feature while disconnecting the manner feature.

A new question to think about moving forward is whether or not TH-fronting is its own two step process or if it is a separate process that is triggered by TH-stridentizing. There could be restrictions in certain dialects that prefer labiodental fricatives to alveolar fricatives, but at this moment I don't have enough data or information to accurately speculate. The other theoretical move made was to remove the [distributed] feature from all representations. This was primarily done to eliminate extra steps throughout the different processes. Additionally, the variation in dental and alveolar pronunciation of stops was explained away

by language specific phonological inventories. Without further knowledge and data from a language that indeed contrasts for the [distributed] feature, there is no point in making any claims on its relation to interdental fricatives and English.

3 Discussion

In this section I will discuss the processes established above and try to look at interdental fricatives as a whole. In addition to the replacement processes already established, I will briefly look at few final curiosities about the interdentals. Before that, though, I will show how the processes above map onto various sets of data. I will first look at African American English as it provides an interesting look at position specific rules. Then I will look at some data from a sociolinguistic study of L2 substitution of interdental sounds.

3.1 African American English

AAE undergoes both TH-fronting and TH-stopping depending on the position (Hopkins, 2013; Smitherman, 1998). Data from Hopkins suggests that world initial interdental sounds are produced as alveolar stops while labiodental fricatives are produced in word-medial and word-final positions. The examples are limited and somewhat puzzling as well. He includes one example where a word-final interdental becomes a stop. Specific examples from Hopkins can be seen in (13).

(13) AAE interdental replacement (taken from (Hopkins, 2013)). *Note that /y/ is used for the palatal glide [j]

these /diyz/

with /wit/

mother /məvə/

mouth /mawf/

Here you can see conflicting data in the pronunciation of *with* and *mouth*. No explanation is given other than it just happens for this word. This could be due to *with* being a function word which we already saw how this could prevent TH-fronting in word initial voiced interdental fricatives in UK English. Without more evidence it is hard to say precisely. Additionally, the word *mother* appears potentially problematic due to the interdental being in the onset position. This is likely explained away by the interdental being ambisyllabic. This likely means it is getting its phonetic cues from being in the onset of the first syllable and therefore undergoes TH-fronting and not TH-stopping.

Smitherman adds that word-initial /θ/ never undergoes a change while word-initial /ð/ always becomes a [d]. The latter of these facts continues to be consistent with what has already been established in that function words always become stops when being replaced. This continues to be a theme in that word class is affecting the phonology. It is peculuiar that AAE treats interdentals differently based on position, but based on the limited data shown, it appears that position isn't crucial as much as the class of the word is. Function words seem to have a specific requirement that if they change, they must become a stop. This becomes even more clear with the sociolinguistic data in the following section.

3.2 L2 English Speakers

Data in this section is taken from (Seibert, 2011). This is a PhD thesis that collected sociolinguistic data about how L2 speakers used interdental fricatives. He has data from Arabic, Cantonese, French, Portuguese, and Vietnamese speakers pronouncing different words and phrases that contain interdental fricatives. I will be looking at one speaker from each dialect reading the same section of what Seibert refers to as a "Dialogue Reading". This is considered a "casual task" where the speaker is reading a dialogue in English with another speaker of the same native language. The phrase that I will be analyzing is *keep/kept thinking through the*. This phrase was specifically chosen to highlight the fact that speakers are treating the voiced interdental in *the* - a function word - differently than the other voiceless interdentals in the phrase.

(14)

Language	*keep/kept thinking through the*
Arabic	kɛp θiŋkɪŋ θɾu ðə
Cantonese	kip fiŋiŋ ʧɹu də
French	kɛpfiŋkɛŋ frou ðɪ
Portuguese	kep feŋkɪŋ fruɾə
Vietnamese	kæp t^{h}iŋɪkɪŋ tɹu ɾə

In every example in (14) the interdental in *the* does one of three things. 1) It remains the same as we see in Arabic and French. Arabic is uninteresting due to none of the interdentals changing in the phrase, but French proves to be interesting. In the first two interdentals in the phrase, the speaker produces an [f] but does not continue the TH-fronting when they reach *the*. 2) The interdental fricative becomes a stop as seen in the Cantonese speaker.

Here we see some additional variation in how they pronounce the first two interdentals. The first gets fronted, but the second turns into an affricate. Could this be an occurance where both the TH-stopping and TH-stridentizing both occur to create an affricate? There is some evidence of affricates being represented as [-continuant] and [+strident] (Rubach, 1994). Regardless, once the speaker reaches the function word, they change it to an aveolar stop. 3) Finally, in Portuguese and Vietnamese we see *the* have its initial interdental turn into a tap consonant. There is likely some other rule that has happened to do this, but it makes much more sense to turn an alveolar stop into a tap than any fricative. This means that at one point in the derivation it became a stop.

The goal of this section was to show that speakers seem to know that they should be treating interdentals in function words differently than other interdentals. The data in this section shows that across languages this is occuring. There must be something in its representation that is making speakers treat it this way. Again, I could speculate further as to how this would occur theoretically, but I don't have enough data at this juncture.

3.3 Some Final Curiosities

There are two more minor curiosities involving interdental fricatives that I would like to point out. The first involves an interesting point brought up in Hopkins about Honduras English. The other looks at minimal pairs containing voiced and voiceless interdentals and specifically how the addition of a voiced feature turns nouns into verbs in some cases.

3.3.1 Voiced Interdental Word-Initial Deletion in Honduras English

Data from Hopkins (2013) claims, "The initital consonant in words like *than, that, they, this* and *these* is often omitted in informal style." Unfortunately, this is the only sentence about this topic. I would be more interested to see if they have any sort of stop deletion rules in word-initial position. I mainly point this process out as another oddity involving interdentals and specifically the treatment of the voiced variant in function words.

3.3.2 Minimal Pairs

This final bit of data looks at minimal pairs that contrast in voicing for interdental fricatives taken from KARAKAS and SÖNMEZ (2011). A condensed list is presented below. 12 pairs were given in the original paper, but I picked out four that show an interesting process.

(15) Voice contrastive interdental minimal pairs

/θ/		vs.	/ð/
sheath (n)	ʃiːθ	sheathe (v)	ʃiːð
teeth (n)	tiːθ	teathe (v)	tiːð
wreath (n)	ɹiːθ	wreathe (v)	ɹiːð
mouth (n)	maʊθ	mouth (v)	maʊð

What's interesting to me here is that voicing of the interdental fricative is acting like a morpheme that creates a verb from the base noun. I originally was looking for minimal pairs because I thought there weren't many. 12 is more than I thought there were, but is still a relatively low amount. I was hoping to gain some insight into why the voiced interdental fricative was behaving differently by seeing if they were either 1) non-contrastive or 2) very minimally contrastive (1-2 pairs). The discovery of these morphological process

surely doesn't help things and for now I will stick with the story that the word class is driving the variation in how interdentals are treated.

4 Conclusion

This paper had a goal of using feature geometry (Clements and Hume, 1996) to understand the various processes that speakers use when substituting sounds for the interdental fricatives. The three processes looked at included TH-fronting, TH-stopping, and what I call TH-stridentizing. The first of the main theoretical discoveries from that section include the removal of the [distributed] feature due to it being non-contrastive and adding an unnecessary step to go from an interdental sound to alveolar sound. The second discovery was the addition of the [strident] feature node for TH-fronting. While stridency is non-contrastive in English, the process mirrors TH-stridentizing and may even suggest that fronting is a separate phenomenon that occurs independently of TH-stridentizing. TH-stopping was explained to be the disassociation of the [continuant] node followed by a default rule that makes unspecified obstruents [-continuant]. This fact was somewhat glossed over, but the main point was to show the preservation of features when the continuancy assignment changes.

During this process, I noticed that many of these processes were reacting strangely to the voiced interdental fricative, especially when it was in the word-initial position. From there, I looked at data from AAE as well as sociolinguistic data of L2 speakers. This continued to show that speakers were treating the voiced fricative at the start of words differently than in other positions. I suggested that this was likely due to them being function words. These words either never changed (in the case of speakers whose native language was English) or

only changed to stops (for L2 speakers). The "importance" of these function words likely requires them to be "strong" in some sense. I finally showed two more curiosities that show that voiced interdental fricatives, especially in function words act strangely.

There are two major questions that remain after this work. The first of these involves the [distributed] feature. It would be nice to look at a language where this feature is contrastive in obstruents and see how the TH processes I propose work when they speak English. There is a chance that I would need to re-add this node which would add a step to the processes. The elegance of my one feature changing per process (TH-fronting in question) is the most ideal at this point. It is clear that for the dialects discussed, and especially standard English, that the [distributed] feature can be left off/unspecified.

The second question that remains is what do speakers know about word class in relation to the phonology? This paper is full of examples of speakers treating the voiced interdentals that appear word-initially differently than they do in other positions. Is there something in the UR that provides this information? The data from Section 3.2 is rather convincing being as speakers of multiple languages are all on record of treating this sound differently than other interdental sounds. Further analysis into word class in relation to phonological processes may ultimately prove insightful in this regard.

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