THE ACOUSTIC PHONETICS OF VOICED TH IN SEVEN VARIETIES OF L2-ACCENTED ENGLISH: FOCUS ON INTELLIGIBILITY

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The voiced interdental non-sibilant fricative [ð] produced by 10 native speakers of General American English (GAE) and 67 non-native speakers of English is analyzed quantitatively and acoustically. The quantitative data shows that GAE talkers produced [ð] accurately 88.09% of the time, substituted it with [d̪] 2.38%, and with [n̪] 9.52%. L2 talkers pronounced it accurately 47.51% of the time, substituted it with [d̪] 44.27%, with [z] 4.22%, with [s] 1.74%%, with [ɾ] 1.4%, and with [θ] .99%. A closer scrutiny of the distributional patterns reveals that all the substitutions occurred only in syllable onsets, but not intervocalically. An acoustic phonetic analysis indicates that [d̪] is by far the preferred substitute for [ð] because their intensities are perceptually indistinguishable. A relative functional load (RFL) analysis is done also to gauge the likelihood of unintelligibility if/when [ð] is replaced by [d̪], [z], or [v].

INTRODUCTION

The L2 phonology literature is replete with two hyperbolic claims about the pronunciation of voiced TH. The first gives the impression that native speakers of GAE consistently and predictably produce it as [ð]. The second assumes a priori and on the basis of piecemeal evidence that non-native speakers cannot produce it accurately (Jenkins 2000, pp. 137-138, Celce-Murcia et al. 2010, p.82, Lado and Fries 1954, p. 97-102, Prator and Robinett 1985, pp. 148-150, to mention only these). Quantitative and instrumental analyses of 444 occurrences of [ð] are done to see if these claims are supported linguistically.

DISTRIBUTION OF [Ð] IN WORLD LANGUAGES

To start with, let's familiarize ourselves with the distribution of [ð] in world languages. Maddieson (1984, pp. 43-45) found that [ð] occurred in only 21 (6.62%) of the 317 languages surveyed in UPSID (the UCLA Phonological Segment Inventory Database). In other words, [ð] is an uncommon sound. Table 1 shows that only two languages of the seven considered in this paper have [ð] in their phonetic inventory. In Spanish, it occurs as an allophone of /d/. It is also found in some dialects of Arabic.

The lack of [ð] in the languages under investigation raises the following questions:

1. Can L2 speakers of English whose native language(s) lack [ð] manage to produce it accurately?
2. If they cannot, what segments do they use to substitute for it?
3. Does the compensatory strategy used interfere with segmental intelligibility?

Table 1

Distribution of [ð]

Languages		Place			
		Labio-dental	Interdental	Alveolar	Palatal
English	**Manner**	v	ð	z	ʒ
Arabic		__	ð	z	__
Japanese		β	__	z	x
Korean		__	__	z	__
Mandarin		__	__	ʐ	__
Slavic		ʋ	__	z	ʒ
Somali		__	__	__	__
Spanish		β	ð	__	__

PREDICTED AND OBSERVED SUBSTITUTIONS

Hatten (2009) provides the data in Table 2 that helps answer the first two questions:

Table 2

Substitutes of [ð]

	Languages	[v]	[z]	[d̪]
1.	Afrikaans	✓		
2.	Brazilian Portuguese	✓		
3.	Canadian French			✓
4.	Cantonese		✓	
5.	Czech			✓
6.	Dutch			✓
7.	Egyptian Arabic		✓	
8.	French		✓	
9.	German		✓	
10.	Hebrew			✓
11.	Italian			✓
12.	Japanese		✓	
13.	Korean			✓
14.	Norwegian			✓
15.	Polish			✓
16.	Russian			✓
17.	Spanish			✓
18.	Swedish			✓
19.	Yiddish			✓
	Total	2	5	12

We see that [d̪] is by far the most common substitute for [ð]. The segment [z] is a distant second, followed further back by [v]. It must be noted that Hatten obtained his data by

soliciting opinions on Linguistlist.org. For this reason, his findings must be taken with a grain of salt.

METHODOLOGY

The methodology used in this study is based on the actual pronunciation of voiced TH obtained from 77 participants who read the following text: [1]

> *Please call Stella. Ask her to bring **these** things with her from **the** store: Six spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a snack for her **brother** Bob. We also need a small plastic snake and a big toy frog for **the** kids. She can scoop **these** things into three red bags, and we will go meet her Wednesday at **the** train station.*

The text contains six occurrences of [ð]: <the> x3, <things> x2, <brother> x1. The quantitative analysis is based on the impressionistic IPA transcriptions of [ð] made by trained phoneticians from George Mason University (GMU). The participants include seven native GAE talkers who attempted 42 [ð]s (7 x 6) and 67 L2 speakers of English (10 Arabic, 10 Japanese, 10 Korean, 10 Mandarin, 11 Slavic, 6 Somali, and 10 Hispanic talkers) who attempted [ð] 402 times (67 x 6). Figure 1 breaks down the percentages of accuracy as follows:
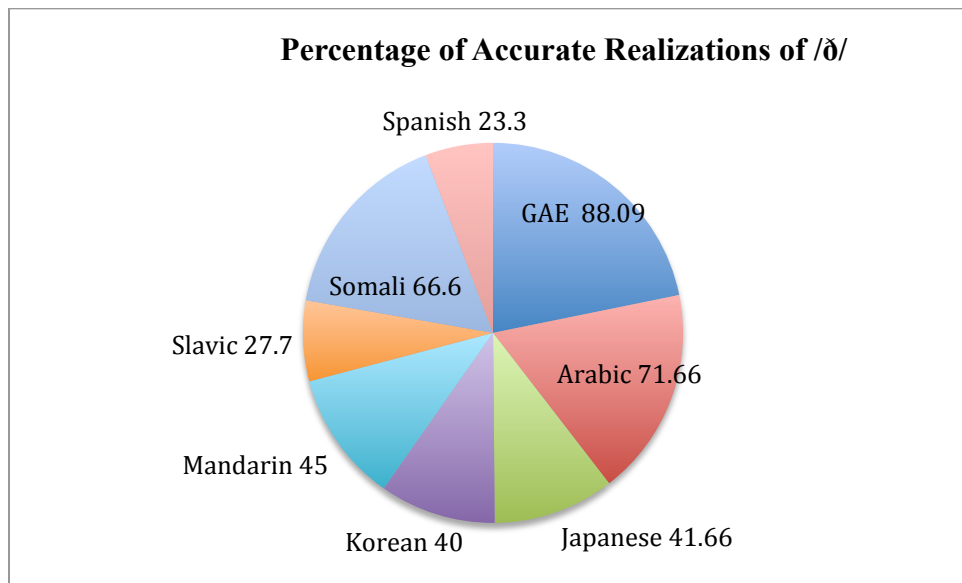

Figure 1. Production accuracy of [ð]

Three cursory observations are in order: first, not all native speakers produced [ð] accurately (11.91%). Secondly, many non-native speakers produced [ð] accurately

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(44.27%). Thirdly, the rate of accuracy in the production of [ð] varies by language group. Figure 2 highlights the segments used to substitute for [ð] and their frequencies:
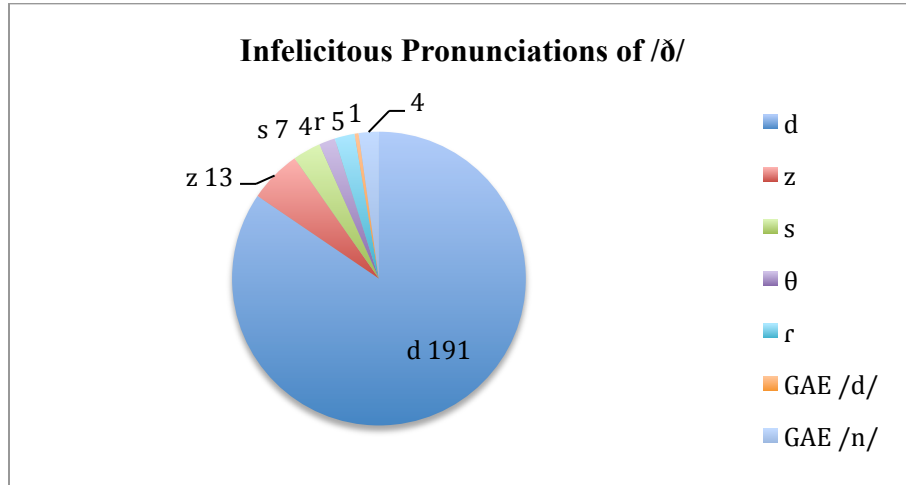
Figure 2. Segments substituted for [ð].

The impressionistic transcription data shows clearly that [d̪] is the preferred substitute for [ð], followed by [z], which is a distant second. It is worth noting that there is not a single case in the GMU transcriptions where [ð] is replaced by [v]. Miscellaneous substitutions include [ɾ], [s], and [θ].   They will not be addressed in this paper because I consider them to be slips of the tongue given their sporadic nature.

Variable Pronunciations of [ð] by GAE Talkers

The spectrogram in Figure 3 shows that a GAE talker, TN 23M, pronounces the TH of <these> in the phrase <these things> as a [d̪].

Figure 3. Spectrogram of [ð] Produced as [d̪]

The highlighted portion shows a weakly dentalized [d̪]. The lack of frication noise indicates that TN 23M does not produce the voiced TH as a fricative, but rather as a stop. There is mounting sociophonetic evidence that this pronunciation is widespread among GAE talkers. Several contributors to *American Voices: How Dialects Differ from Coast to Coast (2006)* have made comments in this regard. Newman (2006, p.85) has found this pronunciation in N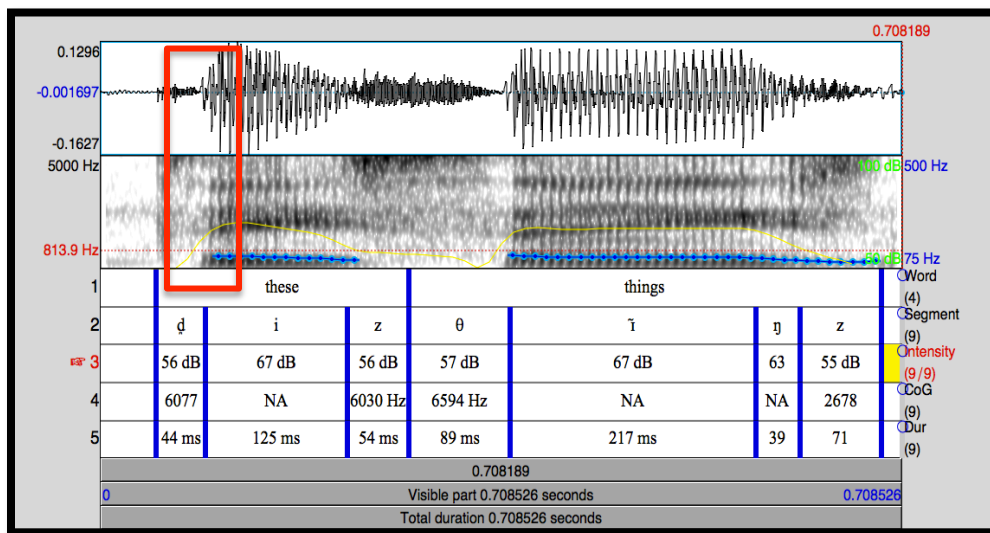ew York City. Simon (2006, p.132) writes that it is an unmistakable feature of the dialect of English spoken in Michigan's Upper Peninsula, and in Milwaukee. Frazer (2006, p.104) shows that it occurs in the speech of Finnish-Americans, Swedish-Americans, and Norwegian-Americans in Minnesota and Wisconsin. Eckert (2008, pp. 27-28) lists German-Americans, Cajuns, Polish-Americans, and Chicano speakers among the ethnic groups that pronounce [ð] as [d̪]. Zsiga (2013, p. 439) adds speakers of African American English to this list. In a nutshell, millions of GAE talkers routinely substitute [d̪] for [ð].

The sound [n̪] also appears as an allophone of [ð]. KY 89M and MN 143M each produce it twice as [n̪]. These realizations occur in <bring **th**ese things> and <from **th**e store>. The conditioning environment for this pronunciation can be stated formally as follows:

$$/ð/ → [n̪] / \ [+cons, +nasal] \ \_\_\_\_$$

Ogden (2009, p.128) notes that "For many speakers, [ð] in particular is highly variable in its manner of articulation, ranging through plosive, *nasal*, fricative, lateral approximant, and approximant articulations." The word "nasal" has been italicized for emphasis. The nasalization of [ð] is particularly noticeable in prepositional phrases such as <in the …>, <on the …>, <from the …> or with conjunctions in phrases such as <when the …>, <then the …>, or <than the …>.

Variable Pronunciations of [ð] in L2 Englishes

The 67 non-native speakers of English attempted a total of 402 [ð]s. They produced it accurately as [ð] 178 times. This also means that they mispronounced it 224 times (55.72%). In such instances, [ð] was overwhelmingly replaced by [d̪] 191 times (47.51%), and to a much lesser extent by [z] 13 times (3.23%). An instrumental analysis was performed on the various attempts of [ð] to see if there is any acoustic rationale for these substitutions. Various correlates were examined, but the one that is most relevant for this paper is intensity. Ladefoged and Maddieson (1996, p.139) contend that it is by far the most robust correlate for the study of fricatives.

Table 4

The Intensities of [ð]and its Substitutes

	five	please	these	Wednesday
Languages	v	z	ð	d̪
Arabic mean	66.31	68.19	68.36	70.70
Japanese mean	68.80	67.60	65.35	65.19
Korean mean	65.68	71.24	65.46	61.46
Mandarin mean	64.35	65.63	66.97	65.97
Slavic mean	60.55	63.54	67.10	61.68
Somali mean	62.31	67.43	68.17	63.14
Spanish mean	65.95	68.64	65.13	63.35
GAE mean	61.16	70.96	67.10	67.72

A comparison of the means and relative intensities shows that the acoustic distance
between [ð] and [d̪] on the one hand, and [ð] and [z] on the other, is less than 3 dB in
most cases. Decades of experimental acoustic research have shown that when two
sounds differ in intensity by 3 dB, they are barely distinguishable to the naked ear.
(Hasen 2001, p.41).   For two sounds to be perceived as aurally distinct, their relative
intensity distance must be ≥ 5dB. GAE talkers who substitute [d̪] (67.72 dB) for [ð]
(67.10 dB) do so because both sounds are indistinguishable acoustically. Polka et al.'s
study (2001:2193) confirms my findings. They found that [ð] (56.2 dB) and [d̪] (53.7
dB) were often substituted for each other.   This can be explained by the fact that the
relative intensity distance between them is below the 3 dB threshold.   The Fricative
Intelligibility Criterion (FIC) can help to explain why [d̪], [z], and to a lesser extent [v]
are often substituted for [ð]:

Fricative Intelligibility Criterion (FIC)

> A segment that is acoustically closely related to [ð] can be substituted for it
> without interfering with intelligibility if and only if that segment agrees with it in
> place of articulation, in voicing, and if the intensity distance between the two is ≤
> 3 dB.

Phonetically speaking, [d̪], [z] and [v] are legitimate substitutes for [ð] because they meet
all three criteria in FIC.

Intelligibility Assessment

We are now is a position to answer the third research question, namely, does replacing
[ð] with [d̪], [z], or [v] interfere with intelligibility?   This question is answered for each
individual segment by relying on Catford's (1987, pp. 87-100) relative functional load
(RFL) data.

Intelligibility of [ð] Pronounced as [d̪]

The segment [d̪] is substituted for [ð] more often than any other segments (191 times out of 402 occurrence, i.e., 47.51%). The segment [d̪] is a legitimate candidate because in all but Slavic and Somali-accented Englishes, it has perceptually the same intensity as [ð]. This suggests that L2 talkers derive their pronunciation cues from the intensity of the segment they hear. Another explanation for why [d̪] is the preferred substitute for [ð] may have something to do with the fact that it is widespread cross-linguistically. Maddieson (1984, p. 32, Table 2.5) notes that it is found in 316 of the 317 languages in the UPSID   Furthermore, substituting [d̪] for [ð] interferes minimally, if at all, with intelligibility. The relative functional load between them is 19% in word-initial position, and 5% at the end of words. Some words such as <they> vs. <day>, <then>, vs. <Dan>, <then> vs. <den>, <those> vs. <doze>, and <though> vs. <dough> that may cause misunderstandings (Higgins 2010). [2] However, the syntactic context in which they occur can reduce unintelligibility.

Intelligibility of [ð] Pronounced as [z]

The segment [z] is used to replace [ð] only 13 times (3.23%). Eight of the substitutions are made by Japanese 4M (three times), Japanese 12M (three times), and Japanese 13M (two times). The remaining five are by Mandarin 9M alone. Replacing [ð] with [z] does interfere with intelligibility at the beginning of words because the two segments are not contrastive in this position. Furthermore, the RFL between them is only 1% at the end of words. Words that can cause misunderstanding are <clothe> vs. <cloze>, <breathe> vs. <breeze>, <seethe> vs. <seize>, <teethe> vs. <teas>, <teethe> vs. <tease>, <tithe> vs. <ties>.   However, in all these instances, the syntactic context can help minimize unintelligibility. Even so, Jenkins' (2000:138) notes that this is a stigmatized substitution that "elicit responses of irritation when used with high frequency." Francophone learners of English should heed this admonition because they are prone to pronouncing most of their [ð]s as [z]s (Fromkin et al. 2014:2, Prator and Robinett 1985, p. 149).

Intelligibility of [ð] Pronounced as [v]

Table 2 lists Brazilian Portuguese as one of only two languages out 19 that substitute [v] for [ð]. When I presented this data to three Brazilian applied linguists who used to teach English as a Foreign Language in Brazil, they objected. They all stated without hesitation that their students and acquaintances routinely replace [ð] with [d̪]. Regardless, it is clear from the GMU data and from Hatten (2009) that [v] is not commonly used to substitute for [ð].   This calls into question the merits of Jenkins' (2000, p. 138) proposal that [v] be taught to L2 learners of speakers of English whose native languages lack [ð]. Her proposal is problematic for three reasons. First, it lacks strong empirical support. She made this proposal on the basis of piecemeal evidence from speech samples obtained from six L2 speakers representing only three language groups (Jenkins 2000, pp. 59-61, 84).   Secondly, since [v] is found in only 21.13% of the languages in UPSID, what should a teacher do if the student's L2 lacks [v]? Thirdly,

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[2] http://myweb.tiscali.co.uk/wordscape/wordlist/m<advinimal.html. Retrieved on October 2nd 2015.

aerodynamic factors explain why [v] is relatively infrequent in world languages. Johnson (2012, p. 156) remarks that it is articulatorily challenging to produce. These misgivings notwithstanding, if a speaker substitutes [v] for [ð], intelligibility is not likely to be compromised because the RFL between them is 11% in word initial positions, and 1% at the end of words. The only lexical minimal pairs or near minimal pairs that could cause intelligibility problems are words such as <further> vs. <fervor>, <clothes> vs. <cloves>, <loathes> vs. <loaves>, <slither> vs. <sliver>, <than> vs. <van>, and <then> vs. <van>. Here too the syntactic context can alleviate possible misunderstandings.

Pedagogical Implications

The impressionistic transcription data shows that all 67 attempts of [ð] in <brother> were successful irrespective of the talker's language background or level of proficiency. This is a significant finding of great pedagogical importance. It means that the difficulties associated with producing [ð] accurately are limited only to syllable onsets, but not to the intervocalic environment where it is produced with 100% accuracy. This finding has both curricular implications. L2 learners would do well if [ð] is first taught to them when it occurs between vowels. There are a dozen or so high frequency words such as <bother>, <breather>, <brother>, <either>, <farther>, <father>, <further>, <mother>, <other>[3], <rather>, <worthy> and <without> in which [ð] occurs intervocalically.   This list can be augmented with words such as <breathe>, <bathe>, <loathe>, <seethe>, <teethe>, <tithe>, and <writhe> in which the silent <e> gives the impression that [ð] occurs between vowels.   Once students have mastered the pronunciation of [ð] in this environment, the teacher can introduce it in syllable onsets.

SUMMARY

The preceding analyses have shown that voiced TH has variable pronunciations in both L1 and L2 English. Many GAE talkers produce it in three ways: some as [ð], some as [d̪], and others as [n̪]. The variant [d̪] is ethnolinguistically conditioned, whereas the variant [n̪] is phonologically conditioned. Most L2 speakers of English in this study replace [ð] with [d̪], and to a lesser extent with [z] when it occurs in syllable onsets. However, between two vowels, they produce it accurately 100% of the time. The choice of [d̪] or [z] as substitutes for [ð] is justified acoustically and cross-linguistically. These two segments have relative intensities that fall within the ≤ 3 dB threshold. This makes them practically aurally indistinguishable from [ð]. Cross-linguistically, [d̪] is best suited as a substitute for [ð] because it is found in more than 99% of the languages in UPSID. The substitutions do not compromise intelligibility because the relative functional loads between [ð], [d̪], and [z] are very low, even negligible. None of the 67 L2 talkers in this study replaces [ð] with [v]. There are two reasons for this. First, it is a relatively uncommon sound. Secondly, its aerodynamic properties make it hard to produce. Consequently, it should not be seen as a legitimate substitute for [ð].

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[3] Jenkins (2000, p.59) claims in Extract 2 that the talker pronounced <other> as [ɔd̪əɹ]. This transcription should be regarded as highly suspicious because she indicates in parentheses that it is unintelligible.

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REFERENCES

Catford, J. C. (1987). Phonetics and the Teaching of Pronunciation. In J. Morley (Ed.), *Current Perspectives on Pronunciation: Practices Anchored in Theory*. Washington, DC: Teachers of English to Speakers of Other Languages.

Celce-Murcia, M., Brinton, D. & Goodwin, J., with Griner, B. (2010). *Teaching pronunciation: A reference for teachers of English to speakers of other languages, 2nd Ed.*, New York: Cambridge University Press.

Eckert, P. (2008). Where do Ethnolects Stop? *International Journal of Bilingualism, 12* (1), 25-42.

Frazer, T. C. (2006). An Introduction to the Midwest English. *American Voices: How Dialects Differ from Coast to Coast*, ed. by Walter Wolfram and B. Ward, pp. 101-105. Malden, MA: Blackwell Publishing.

Fromkin, Victoria, Robert Rodman; and Nina Hyams. (2014). *An Introduction to Language, 10th ed.*, New York: Cengage Learning.

Hatten, David J. (2009). Substitution Patterns for English Inter-dental Fricatives by L1 Latin American Spanish-Speakers. Retrieved from: http://www.academia.edu/13539048/Substitution_Patterns_for_English_Interdental_Fricatives_by_L1_Latin on September 26, 2015. Ladefoged, P. & Keith K. (2015). *A course in phonetics*, 7th edition. Stamford, CT: Cengage Learning.

Higgins, J. 2010. Minimal Pair for English RP: Lists by John Higgins. http://myweb.tiscali.co.uk/wordscape/wordlist/m<advinimal.html. Retrieved on October 2nd, 2015.

Jenkins, J. (2000). *The Phonology of English as an International Language*. New York: Oxford University Press.

Johnson, K. (2012). *Acoustic and Auditory Phonetics, 3rd ed.,* Malden, MA: Wiley-Blackwell.

Koffi, E. (2015). The Pronunciation of Voiceless <TH> in Seven Varieties of L2
        Englishes: Focus on Intelligibility. *Linguistic Portfolios*, 4: 2-23. Available
        online at: http://repository.stcloudstate.edu/stcloud_ling/vol4/iss1/2/.

Lado, R. & Fries C. C. (1962). *English Pronunciation: Exercises in Sound Segments,
        Intonation, and Rhythm*.   Ann Arbor: The University of Michigan Press.

Maddieson, I. (1984). *Patterns of Sounds*. Cambridge Studies in Speech Science and
        Communications. New York: Cambridge University Press.

Newman, M. (2006). New York Tawk (New York City, NY. *American Voices: How
        Dialects Differ from Coast to Coast*, ed. by Walter Wolfram and B. Ward, pp. 82-
        87. Malden, MA: Blackwell Publishing.

Ogden, R. (2009). *An Introduction to English Phonetics*. Edinburg, Scotland: Edinburgh
        University Press Ltd.

Prator, Jr. C. & Robinett, B. (1985). *Manual of American English Pronunciation, 4th
        edition.* New York: Harcourt Brace & Company.

Zsiga, E.C. (2013). *The Sounds of Language: An Introduction to Phonetics and
        Phonology*. Malden, MA: Wiley-Blackwell.

APPENDIX
Inventory for [ð]

	These	The	Brother	the	These	The	Total	Total	Total	Total	Total
							[ð]	[d]	[v]	[n]	[ ]
KY150	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
KY89	[n]	[n]	[ð]	[ð]	[ð]	[ð]	4			2	
CA32	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
GA330	NA	NA	NA	NA	NA	NA					
MN143	[n]	[n]	[ð]	[ð]	[ð]	[ð]	4			2	
NY6	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
OR184	NA	NA	NA	NA	NA	NA					
TN23	[ð]	[ð]	[ð]	[ð]	[ð]	[d]	5	1			
TX286	NA	NA	NA	NA	NA	NA					
VA16	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
All total	42						37	1		4	

Total of expected [ð] = 42; total [ð] produced as [ð] 37 (88.09%); total [ð] as [d] 1 (2.38%) total [ð] produced as [n] = 4 (9.52%)

	These	The	Brother	The	These	The	Total	Total	Total	Total	Total
							[ð]	[d]	[s]	[z]	[θ/f]
Arabic 1F	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
Arabic 30F	[d]	[ð]	[ð]	[ð]	[ð]	[ð]	5	1			
Arabic 35M	[d]	[ð]	[ð]	[ð]	[ð]	[ð]	5	1			
Arabic 36M	[d]	[ð]	[ð]	[ð]	[ð]	[ð]	5	1			
Arabic 40M	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
Arabic 44F	[d]	[d]	[ð]	[ð]	[d]	[d]	2	4			
Arabic 46M	[d]	[d]	[ð]	[ð]	[d]	[d]	2	4			
Arabic 47M	[d]	[ð]	[ð]	[ð]	[ð]	[ð]	5	1			
Arabic 50M	[d]	[d]	[ð]	[d]	[ð]	[d]	4	2			
Arabic 51M	[ð]	[d]	[ð]	[d]	[d]	[ð]	3	3			

Total of expected [ð] = 60; total [ð] produced as [ð] 43 (71.66%); total [ð] produced as [d]: 17 (28.33%).

	These	The	Brother	the	These	The	Total	Total	Total	Total	Total
							[ð]	[d]	[s]	[z]	[θ]
Japanese 2F	[d]	[d]	[ð]	[d]	[ð]	[ð]	3	3			
Japanese 3F	[ð]	[d]	[d]	[ð]	[d]	[d]	2	4			
Japanese 4M	[d]	[z]	[z]	[ð]	[d]	[z]	1	2		3	
Japanese 5F	[ð]	[ð]	[ð]	[d]	[ð]	[ð]	5	1			
Japanese 8M	[d]	[ð]	[ð]	[ð]	[ð]	[ð]	5	1			
Japanese 9M	[θ]	[ð]	[ð]	[ð]	[ð]	[ð]	5				1
Japanese 10F	[d]	[d]	[ð]	[ð]	[d]	[d]	2	4			
Japanese 11F	[d]	[d]	[d]	[d]	[d]	[d]		6			
Japanese 12M	[d]	[z]	[z]	[z]	[d]	[s]		2	1	3	
Japanese 13M	[d]	[ð]	[ð]	[z]	[d]	[z]	2	2		2	
All total							25	25	1	8	1

Total of expected [ð] = 60; total [ð] produced as [ð] 25 (41.66%); total [ð] as [d] 25 (41.66%) total [ð] produced as [s] = 1 (1.66%); total [ð] produced as [z] = 8 (13.33%); total [ð] produced as [θ] = 1 (1.66%)

	These	The	Brother	the	These	The	Total [ð]	Total [d]	Total [v]	Total [f]	Total [θ]
Korean 1M	[d]	[d]	[ð]	[d]	[d]	[ð]	2	4			
Korean 2F	[ð]	[d]	[ð]	[d]	[d]	[ð]	3	3			
Korean 3F	[ð]	[d]	[ð]	[ð]	[d]	[d]	3	3			
Korean 4F	[d]	[d]	[ð]	[ð]	[d]	[ð]	3	3			
Korean 8F	[d]	[d]	[ð]	[θ]	[f]	[d]	1	3			2
Korean 9M	[ð]	[ð]	[ð]	[d]	[θ]	[d]	3	2			1
Korean 10M	[d]	[d]	[ð]	[d]	[d]	[d]	1	5			
Korean 11M	[d]	[d]	[ð]	[ð]	[ð]	[d]	3	3			
Korean 12M	[d]	[d]	[d]	[ð]	[d]	[d]	1	5			
Korean13F	[ð]	[d]	[ð]	[ð]	[ð]	[d]	4	2			
All total							24	33			3

Total of expected [ð] = 60; total [ð] produced as [ð] 24 (40%); total [ð] as [d] 33 (55%); total [ð] produced as [θ] = 3 (5%)

	These	The	Brother	the	These	The	Total [ð]	Total [d]	Total [z]	Total [ɾ]	Total [?]
Mandarin1F	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
Mandarin2F	[d]	[d]	[ð]	[ð]	[d]	[ð]	3	3			
Mandarin3M	[d]	[ð]	[ð]	[ð]	[ð]	[ɾ]	5			1	
Mandarin4F	d	d	d	d	[ð]	d	1	5			
Mandarin5F	d	?	d	[ð]	d	?	1	3			2
Mandarin6F	[ð]	[d]	[ð]	[ð]	[d]	[ð]	4	2			
Mandarin8M	d	n ?	ɾ	d	d	d	4			1	1
Mandarin9M	z	z	[ð]	z	z	z	1		5		
Mandarin12M	d	d	ɾ	[ð]	d	d	1	4		1	1
Mandarin19M	d	d	d	[ð]	d	d	1	5			
All total							27	21	5	3	4

Total of expected [ð] = 60; total [ð] produced as [ð] 27 (45%); total [ð] as [d] 21 (35%) total [ð] produced as [z] = 5 (8.3%); total [ð] produced as "others" = 7 (11.66%)

	These	The	Brother	The	These	The	Total [ð]	Total [d]	Total [v]	Total [ɾ]	Total [ ]
Croatian1F	[d]	[ð]	[ð]	[d]	[d]	[d]	2	4			
Croation2F	[d]	[d]	[d]	[d]	[d]	[ɾ]		5		1	
Croatian4M	[d]	[d]	[ð]	[d]	[d]	[ɾ]	1	4		1	
Croatian5F	[d]	[d]	[d]	[d]	[d]	[d]		6			
Croation6F	[d]	[d]	[ð]	[d]	[d]	[d]	1	5			
Serbian1F	[d]	[t]	[d]	[d]	[d]	[t]		4		2	
Serbian2M	[d]	[d]	[ð]	[ð]	[d]	[ð]	3	3			
Serbian6M	[d]	[d]	[ð]	[d]	[d]	[d]	1	5			
Serbian11M	[ð]	[ð]	[ð]	[d]	[ð]	[t]	4	1		1	
Serbian12F	[d]	[d]	[ɾ]	[d]	[d]	[d]	5				1
Serbian14F	[d]	[d]	[ð]	[d]	[d]	[d]	1	5			
All total							18	42		5	1

Total of expected [ð] = 66; total [ð] produced as [ð] 18 (27.7%); total [ð] as [d] 42 (63.3%); total [ð] produced as "others" = 6 (9.9%)

	These	The	Brother	the	These	The	Total [ð]	Total [d]	Total [v]	Total [θ]	Total [0]
Somali 1F	[d]	[ð]	[ð]	[ð]	[d]	0	3	2			1
Somali 2M	[ð]	[d]	[ð]	[d]	[d]	[d]	2	4			
Somali 3F	[d]	[d]	[ð]	[ð]	[d]	[d]	2	4			
Somali 4F	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
Somali 5M	[ð]	[ð]	[ð]	[ð]	[ð]	[ð]	6				
Somali 6M	[ð]	[ð]	[ð]	[ð]	[θ]	[ð]	5			1	
All total							24	10		1	1

Total of expected [ð] = 36; total [ð] produced as [ð] 24 (66.6%); total [ð] as [d] 10 (27.7%) total [ð] produced as [θ] = 1 (2.7%)

	These	The	brother	the	These	The	Total [ð]	Total [d]	Total [ɾ]	Total [v]	Total [ ]
Spanish 1M	d	d	[ð]	d	[ð]	d	2	4			
Spanish 2M	d	[ð]	ð	d	[ð]	d	2	4			
Spanish 4F	d	d	ð	d	[ð]	d	2	4			
Spanish 6M	d	d	ð	[ð]	[ð]	d	3	3			
Spanish 9M	d	d	ð	[ð]	d	d	2	4			
Spanish 11F	d	[ð]	ð	d	d	d	1	5			
Spanish 13F	d	d	ð	d	[ð]	d	1	5			
Spanish 14F	d	d	ð	ɾ	[ð]	d		5	1		
Spanish 16M	d	d	ð	[ð]	[ð]	d	3	3			
Spanish 20M	d	d	ð	d	d	d	1	5			
All total							14	45	1		

Total of expected [ð] = 60; total [ð] produced as [ð] 14 (23.3%); total [ð] as [d] 45 (75%); total [ð] produced as "others" = 1 (1.66%)