Deconstructing markedness in sound change typology:

Notes on θ > f and f > θ[1]

Juliette Blevins

CUNY Graduate Center

ABSTRACT

Many sound changes have been attributed to misperception (Ohala 1981, 1993). When two sounds A and B are perceptually similar, A can be misperceived as B and vice versa. One sound change attributed solely to perceptual similarity is θ > f (Blevins 2004). Misperception of [θ] as [f] yields θ > f, while hearing [f] as [θ] should lead to f > θ changes. Context-free shifts of θ > f are attested, but regular f > θ changes are rare. Recent research questions the existence of f > θ changes and the perceptual basis of θ > f changes. Historical, typological, experimental, developmental, and language contact data reviewed here support the original perceptual account of θ > f and f > θ, suggesting that the observed asymmetry can be explained phonetically and structurally, without reference to markedness (cf. Andersen 2008).

Keywords: Sound change, markedness, perceptual similarity, dental fricative

[1] This article is an updated version of earlier work on this topic, namely Blevins, Juliette. 2011. Perceptual similarity and sound change typology: Notes on θ > f and f > θ. Manuscript, CUNY, referred to in Blevins (2015), my chapter contribution to the *Oxford Handbook of Historical Phonology.* A later 2014 version of the same manuscript was in circulation, and I thank all those who offered suggestions for improvement.

1. Asymmetries in sound change typology

It has long been observed that there are asymmetries in sound change typology. A > B is common, but B > A is rare, as in the common debuccalization of s > h, but the rare strengthening of h > s. As our understanding of the phonetic bases of sound change deepens, more and more of these asymmetries can be attributed to phonetic explanation, eliminating reference to markedness (Blevins 2004, 2008, 2015; cf. Andersen 1989, 2001). For example, s > h is common because many instances of [s] are produced with spread vocal folds; weakening or loss of oral constriction yields [h]. In contrast, there is no simple phonetic explanation for h > s; strengthening of [h] may yield a non-laryngeal fricative, but the articulatory properties of this fricative typically reflect the secondary features of the original [h], with [s] expected only when [h] has a secondary articulation that is coronal/apical. No reference to markedness is necessary. [s] and [h] are equally "good" sounds, but articulatory properties of [s] make s > h common, while those of [h] make h > s rare.

One sound change that continues to invoke notions of markedness is θ > f: θ > f is attested in a range of language families, but f > θ is rare or unattested. Here I present data not discussed in earlier literature, and assess a range of explanations for the clear asymmetry, including: articulatory difficulty of [θ] (Wells 1982, Kjellmer 1995); lack of perceptual saliency of [θ] (Labov et al. 1968, Jones 2002) and perceptual similarity of [θ] and [f] (Harris 1958, Jones 2002, Blevins 2004). This case is of particular interest, since,

as noted as early as Sweet (1874: 10), θ > f does not have a clear articulatory basis and, in his terms, is "no doubt purely imitative". Can innocent misperception account for the observed asymmetry, or is a theory of markedness necessary to implement observed bias in the directionality of sound change?

2. Perceptual similarity and sound change: the case of θ > f

A common explanation for context-free sound change A > B is that A and B are perceptually similar sounds, so much so that A can be mistaken for B in the course of language acquisition (Ohala 1981, 1993). If A and B are easily confused with each other, the expectation is that, all else being equal, B > A should be just as common as A > B.

One apparent case of this kind is the sound change θ > f, [θ] a voiceless dental or interdental fricative, and [f] a voiceless labiodental fricative.[2] Context-free θ > f is best known as having occurred in a range of English dialects, including Cockney (Severtsen 1960, Wells 1982). Earlier literature on perceptually-based θ > f includes Rotuman, an

[2] We focus on voiceless sounds [θ] and [f] for several reasons, though similar observations hold for [ð] and [v]. First, since voiceless obstruents are, overall, more common than voiced obstruents, the highest frequencies of this change are expected with the voiceless pair. Second, it has been argued, for example, by Ohala (1983), that voicing is, to some extent, inhibited in sibilants and other fricatives that require high oral air pressure to maintain turbulence. The primary role of perception in this kind of sound change, then, should be more visible in shifts of θ > f or f > θ than their voiced counterparts. Finally, there is more data available in the experimental literature on perception and production of [θ] and [f] than [ð] and [v].

Oceanic language, where *t > *θ > f is hypothesized, the Veneto dialect of Italian where θ > f is ongoing (Blevins 2004: 134-135; Blevins 2006: 11-12).

Two other language families that show evidence of context-free θ > f are Semitic and Athabaskan. In the Southern Anatolian Siirt dialect of Arabic, original interdentals *θ, *ð, *ð' (emphatic) have become labiodentals /f, v, v'/: *fa'lab* 'fox' < *θa'lab; *vahab* 'gold' < *ðahab; *v'arab* 'he hit' < *ð'arab (Fischer and Jastrow 1980:50). In addition, incipient θ > f changes are reported for Shiite Hasaawi Arabic, Eastern Saudi Arabic, Bahraini (*falaafa* < θalaaθa 'three') and Tunisian Arabic (*fəmːa* < θəmːa 'there is') (Hetzron 1997: 275).

In at least one Northern Athabaskan language, a shift of θ > f has also occurred (Tharp 1972; Howren 1975; Rice 1989; Flynn and Fulop 2014). This sound change is of special interest since it is clearly not a merger. It appears to have occurred at a stage when the language lacked a labiodental series, or any labial obstruents. Northern Athabaskan/Early Slave is reconstructed with *θ and *ð from Proto-Athabaskan *s and *z respectively, but with no labiodentals or labial obstruents.[3] In the Dene Tha dialect of South Slave spoken from Northwest Alberta to northeast British Columbia these interdentals persist, but in the Tulita district of the Northwest Territories, Tulita-Slavey has undergone *θ, *ð > f, v. Compare: Dene Tha *θa*, Tulita *fa* 'sand'; Dene Tha *θɛ* -, Tulita *fɛ*- PERFECTIVE; Dene Tha *-ðáʔ,* Tulita *–va* 'mouth'; Dene Tha *–ðeʔ,* Tulita *–ve* 'liver' (Flynn and Fulop 2014).

[3] The full series of Proto-Northern Athabaskan dental obstruents includes plain, aspirated, and glottalized affricates *tθ, *tθ^{h}, *tθ', in addition to the plain fricatives *θ and *ð. The sound change described for *θ and *ð affected these sounds as simple segments, and, as release portions of the dental affricates. For purposes of cross-linguistic comparison, we focus on the simple changes involving *θ and *ð here.

Context-free θ > f sound changes are summarized in Table 1.[4] Each sound change in Table 1 appears to be an independent development. All are complete with the exception of the Veneto example. Though some, like the English case, have diffused, each is associated with a variety in which the change is unconditioned.

LANGUAGE/DIALECT	FAMILY/SUB-GROUP	SOUND CHANGE	DATA SOURCE
English/Cockney	Indo-European/Germanic	θ > f	Severtsen 1960
Rotuman	Austronesian/Oceanic	*t > *θ > f	Blust & Trussel 2013
Italian/Veneto	Indo-European/Romance	θ > f	McKay 1995
Arabic/Siirt	Afro-Asiatic/Semitic	θ, ð, ð' > f, v, v'	Fischer & Jastrow 1980
Slave/Tulita-Slavey	Athabaskan/Northern	θ, ð > f, v	Flynn & Fulop 2014

Table 1. Context-free θ > f sounds changes

As a context-free sound change, θ > f is not assimilatory, and cannot be attributed to coarticulatory effects. At the same time, it cannot be viewed as a gradual articulatory shift, since there is a change in active articulator, from tongue tip/blade in the production of dentals to lower lip in the production of labiodental sounds. Given its dissociation

[4] Recall that the investigation is limited to context-free cases of θ > f so as to ensure the central role of perception. Context-sensitive changes, like late pre-Latin θ > f in the context of labials (e.g. Latin *fu:mus* 'smoke' < *θu:mus*, cf. Greek *θumós* 'spirit' Hockett 1985: 271; Kümmel 2007: 193), may involve coarticulatory influence of the lips, or acoustic consequences of vowel context, weakening arguments based on misperception of [θ] as [f].

from articulatory origins, within the typology of Blevins (2004), θ > f exemplifies a pure case of CHANGE: sound change with a primary source in misperception.[5]

The perceptual account of θ > f is supported by a range of experimental data. In an early study where noise was used to mask stimuli, the highest confusion rates for English-speaking adults were found between [θ] and [f] and [ð] and [v], respectively (Miller and Nicely 1955). More recent studies continue to show high confusion rates for [θ] and [f], independent of whether [θ] is contrastive in a language or not (Johnson and Babel 2010). Infants also have some difficulty with this contrast. Though categorical perception is exhibited robustly for many other contrasts, pre-linguistic infants do not show the same facility in distinguishing interdental fricatives from their labiodental counterparts (Eilers and Minifie 1975; Eilers 1977; Levitt et al. 1988; Vihman 1996:60). Acoustic studies also demonstrate spectral similarity of interdental and labiodental fricatives, making their confusion unsurprising (e.g. Lambacher et al. 1997; Tabain 1998; Jongman et al. 2000).

Speech errors in the course of language acquisition also suggest perceptual confusion. In Dyson and Amayreh (2000), 50 children acquiring Educated Spoken Arabic are shown to have difficulty acquiring [θ]. Instead of pronouncing this sound, they use [t], [s] or [f]. At the age of 4;4, when /θ/ is being pronounced as [θ] most of the time, about 20% of tokens are still being pronounced as [f], suggesting that perceptual confusion, and not articulatory difficulty, is at work.

[5] Garrett and Johnson (2013: 72) suggest that all cases of θ > f are actually θ^{w} > f, where the original interdental fricative is produced with lip-rounding, and so, includes a labial gesture from the outset. See Section 6 for further discussion.

Finally, the perceptual similarity of [θ] and [f] is supported by other situations in which one sound is substituted for the other. In second language acquisition, speakers of European French and Japanese sometimes substitute [f] for English [θ] (Wenk 1979; Brannen 1998; Guion et al. 2000; Brannen 2011).[6]

3. θ > f without pre-existing /f/ ?

Numerous sound changes in the world's languages show evidence of structural analogy, occurring more often when their output is a pre-existing sound or sound pattern in the language in question (Blevins 2004: 154; Chitoran & Hualde 2007; Blevins 2009). For example, a significant factor in the historical reanalysis of short vowels as long vowels under compensatory lengthening is the pre-existence of long vowels in a language (De Chene and Anderson 1979; Kavitskaya 2002). Within Evolutionary Phonology, pre-existing categories can prime or bias categorization in the course of language acquisition, giving rise to historical patterns of this type (Blevins 2009). A reasonable question, then, is whether the θ > f sound change requires pre-existing /f/ in a language in order to take place.

The acquisition data from English and Arabic noted above suggests that the existence of labiodentals within a segment inventory might play a role in θ > f sound

[6] A relevant anecdote involves a famous TV host in Spain, the late Matías Prats Sr. The announcer was from Córdoba in southern Spain, and could not produce [θ]. He claims that at the beginning of his career he pronounced [f] instead, and nobody noticed (Montserrat Batllori, personal communication, 2009).

change, priming [f] by exposure to auditory data, and practice with articulatory routines in the early stages of acquisition (Hockett 1985: 273). Since early stages of English, Italian and Arabic all show phonemic /f/, data from Cockney, Veneto, and the Arabic dialects noted earlier would all be consistent with this kind of priming.

However, in Rotuman and Slave, θ > f sound change may have occurred without a pre-existing *f phoneme. In Rotuman, /f/ reflects Proto-Oceanic *t in directly inherited vocabulary, though /f/ has also entered the language through indirect inheritance in Polynesian loanwords (Biggs 1965). Table 2 illustrates Rotuman correspondences for the two distinct lexical strata.

PROTO-EASTERN OCEANIC	*p	*t	*k	*q	*l
Rotuman (Direct inheritance)	h	f (< *θ)	ʔ	ø	l
Rotuman (Indirect, via Polynesian)	f	t	k	ʔ	r

Table 2. Direct and indirect sound correspondences in Rotuman

In Table 3, reflexes of four Proto-Eastern Oceanic lexemes illustrate direct and indirect strata of the lexicon. In the case of /fau/ which is directly inherited, /f/ < *θ < *t; however /faka-/ reflects borrowing from another Eastern Oceanic language in which /f/ < *p, and /k/ < *k.

PROTO-EASTERN OCEANIC	*puke 'uncover'	*paka -CAUS	*taqu 'season'	*toqa 'brave'
Rotuman (Direct inheritance)	huʔe	--	fau	--
Rotuman (Indirect, via Polynesian)	--	faka-	--	toʔa

Table 3. Direct and indirect sound correspondences in Rotuman lexemes

While the Rotuman data could be interpreted as supporting θ > f without ambient [f], an alternative interpretation is possible. Given the clear evidence of Polynesian contact with Rotuman, the θ > f sound change could be a consequence of this contact. Speakers of a Polynesian language with /f/, acquiring Rotuman, would replace native pre-Rotuman *θ with the perceptually closest sound from their native inventory, /f/. If Rotuman *θ > f could be shown to pre-date the influx of Polynesian loans, this scenario could be ruled out. However, while all other regular sound changes must pre-date the entry of loans, including hypothesized *t > θ, *θ > f would be inert in the Polynesian lexicon, and therefore need not pre-date the influx of borrowings. In sum, Rotuman *θ > f could have occurred prior to the evolution of /f/ as a phoneme, in a language without labial obstruents, or, after the influx of Polynesian loans with /f/, as a consequence of this contact. In the first case, it would illustrate θ > f without pre-existing /f/. In the second, it would strengthen the case for perceptual similarity, linking *θ > f with L2 learners of Rotuman whose native language had /f/, but no /θ/, or Rotuman speakers with extensive exposure to Polynesian. In the contact situation, Polynesian /f/ could act as an external "perceptual magnet", resulting in an otherwise, unexpected sound change (Blevins 2017).

For Slave, it might at first seem clear that θ > f occurred without *f. Recall that Northern Athabaskan/Early Slave is reconstructed with *θ and *ð, but with no labiodentals or labial obstruents (Tharp 1972; Howren 1975; Rice 1989; Flynn and Fulop 2014). In the Tulita dialect of Slave, θ > f has occurred without prior existence of a labiodental series, or any labial obstruents at all. Nevertheless, as in Rotuman, contact may have introduced ambient labials into the linguistic landscape. French and English both have bilabials and labiodentals, and loans from both languages exist in Slavey. European contact in this area dates back to the early fur trade of the 17th century. Unless Slave θ > f can be argued to pre-date European contact, contact-induced change cannot be ruled out. More interesting, perhaps, is a possible influence from Inuit. While all Inuvialuktun varieties to the north of North Slavey have bilabial stops and /v/, Inuinnaqtun, bordering on Northern Slave to the northeast, is the only dialect where historical /ps/ clusters have evolved into /ff/.

To summarize, it may be the case that context-free θ > f occurs only when /f/ is pre-existing in the linguistic environment. Although Rotuman and Tulita Slavey did not directly inherit /f/, both languages have been in contact with languages that did have /f/. To date, there is no known case of a context-free θ > f sound-change where speakers have, arguably, had no exposure to [f]-sounds.

4. Frequency of θ > f

Perhaps because of the diffusion of θ > f within English dialects, or numerous instances of conditioned θ > f sound change, θ > f is sometimes classified as a relatively frequent sound change in contrast to f > θ, which is considered rare. Before turning to the question of f > θ and the issue of this asymmetry more generally, some notes on frequency within a large language family are offered in the hope that they may prove useful in assessing cross-linguistic frequencies.

The Austronesian language family may be a good starting point for the investigation of /f/ and /θ/ frequency, and the frequency of θ > f and f > θ sound change because Proto-Austronesian reconstructions are widely agreed upon, the language family is large with over 1,000 living descendants, and, most importantly for this study, Proto-Austronesian lacked both *f and *θ, but contained *p, a common source of [f], as well as *s and *t, both common sources of [θ]. Proto-Austronesian, then, may be viewed as a neutral starting point for exploring how often θ > f and f > θ sound changes arise, and the extent to which this can be related to the frequency of /f/ and /θ/ in phoneme inventories.

Rotuman, an Oceanic language, has undergone *t > *θ > f, as proposed above. However, θ > f is rare within the Austronesian language family. After reviewing a wealth of comparative materials, including the ever-growing *Austronesian Comparative Dictionary* (Blust and Trussel 2013), it appears that Rotuman is, in fact, the *only* instance of θ > f within this family of over 1,000 languages (Blust 2009). If only 1 out of 1,000 Austronesian languages shows θ > f, one may conclude that it is not a very common process. However, if we take into account the fact that only a small number of Austronesian languages have /θ/, expectations change.

Proto-Austronesian is not reconstructed with *θ. The most common source of /θ/ in Austronesian is dental *s, as in Thao, Papora, Dehu, Anejom, Ulithian, and Yapese. In To'amba'ita and closely related Mbaelelea and Mbaengguu, some /θ/s are from *s, but there is also evidence of word-initial excrescent /θ/, possibly from *y (IPA [j]) (cf. PMP *qasu, To'amba'ita /θasu/ 'smoke'). In Yapese and Ulithian, one source of /θ/ is *s, but as in pre-Rotuman, another source of /θ/ is *t. Table 4 includes all known Austronesian languages with phonemic /θ/, with historical source, where known, and information on /f/ for the same language. Overall, then, in a family of 1,000 or more languages, there are a dozen or so with /θ/ or */θ/, but no major subgroups reconstructed with *θ.

LANGUAGE(S)	SUB-GROUP (AREA)	SOURCE OF /θ/	HAS /f/ ?	SOURCE OF /f/
Thao	Western Plains (Formosan)	θ < *s	yes	f < *b
Papora	Western Plains (Formosan)	θ < *s	no	
Dehu	Oceanic/Loyalty Islands	θ < *s	yes	f < *p /…, other
Anejom	Oceanic/South Vanuatu	θ < *s	yes	??
Ulithian	Oceanic/Micronesian	θ < *s, θ < *T	yes	f < *p
Yapese	Oceanic	θ < *s, θ < *t	yes	??
To'amba'ita	Oceanic/SE Solomonic	θ < *s, θ < *y?	yes	f < *p /…
Mbaelelea	Oceanic/SE Solomonic	θ < *s, θ < *y?	yes	f < *p /…
Mbaengguu	Oceanic/SE Solomonic	θ < *s, θ < *y?	yes	f < *p /…
**Pre-Rotuman	Oceanic/Central Pacific	(f) <*θ < *t	maybe	Polynesian loans
**Pre-Pulo Annan	Oceanic/Micronesian	(ð) <*θ < *f	no (had)	*f < p
**Pre-Sonorolese	Oceanic/Micronesian	(ð) <*θ < *s	yes	f <*p

Table 4. Austronesian languages with /θ/

**See discussion in text

Of these dozen or so languages, Rotuman is the only to have undergone context-free *θ > f. Given that /θ/ in the Northern Malaita languages To'amba'ita, Mbaelelea, and Mbaengguu, appears to stem from a single innovation with shallow time depth, we could count these as a single instance of /θ/. If we do so, the data compiled in Table 4 suggests the rate of context-free *θ > f sound change for languages with /θ/ is approximately 1/10 or 10% in the Austronesian language family. This figure suggests that the view of *θ > f as common may be overstated. It may also be consistent with the observation that there is a strong correlation between *θ > f and pre-existing /f/.

5. Is there f > θ sound change?

Confusability of [f] and [θ] as evidenced in the early perception study of Miller and Nicely (1955) is attributed to the spectral similarity of these two types of sounds (Harris 1958; Ladefoged and Maddieson 1996; Tabain 1998). Given this similarity, and a model of sound change in which misperception can play a central role, f > θ sound change is also expected to occur. Two potential cases of f > θ (or f > θ > ð) have been reported in the literature, though neither in the context of general sound change typology.

Pulo Annan is a Chuukic language of Palau. Proto-Chuukic is classified as Micronesian, with Proto-Micronesian a subgroup of Oceanic, within the greater

Austronesian language family (Bender et al. 2003). In Pulo Annan, Proto-Chuukic *f is reflected as the voiced interdental fricative /ð/, as illustrated in Table 5.

PROTO-CHUUKIC	*faca 'pandanus'	* ŋafa 'fathom'	*faTu 'to weave'	*fida 'how many?'
Pulo Annan	ðasa-	ŋaða-	ðaðú-	ðite-
Chuukese	fache-	ŋafa-	féwú-	fite-
Ulithian	--	--	fasu-	feθa-

Table 5. Pulo Annan reflexes of Proto-Chuukic *f and *T with comparative data

I propose the changes *f > *θ > ð. The final shift, θ > ð, is independently motivated by /ð/ reflexes of Proto-Chuukic *T (= [s])in Pulo Annan and Sonsorolese, where the shared development is *T=[s] > θ > ð (op cit). Compare for example Pulo Annan *ðiði-,* Sonorolese *fiðu-,* Chuukese *fusu-,* all from Proto-Chuukic *fiTu- 'seven'.

A further suggestion is that Pulo Annan and Sonsorolese both underwent a late shift of *θ > ð as a consequence of Palauan contact. In Palauan, [θ] occurs only as an allophone of /ð/, usually in word-final position or word-initially before a consonant. It is not unreasonable to believe that first language speakers of Palauan would pronounce [θ] as [ð] in other positions of the word, resulting in the apparent context-free θ > ð sound change which is otherwise highly unusual and unexpected. Returning to *f > *θ > ð, we can now integrate *f > *θ into the wider typology of [f]/[θ] misperceptions, and

understand θ > ð voicing in the final stage as a more general consequence of Palauan influence, as just discussed.

Other potential cases of f > θ are described for several Spanish varieties, including Spanish of Castilla la Nueva by Moreno Fernández (1996), and the Spanish of Equatorial Guinea by Quilis (1996). In his chapter on Castilla la Nueva, Moreno Fernández states that:

> Las consonantes fricativas presentan en Castilla la Nueva aspectos interesantísimos, muchos de ellos compartidos con otros territorios hispánicos. El fonema /f/ se realiza como bilabial en buena parte de la región. En hablantes con pocos estudios se encuentran equivalencias acústicas del tipo *Celipe* 'Felipe', *cinca* 'finca', *escalazón* 'escalafón'. (Moreno Fernández 1996:.216)
>
> [The fricative consonants in Castilla la Nueva show very interesting features, many of which are shared with other Spanish-speaking regions. The phoneme /f/ is produced as a bilabial in a good part of the area. For speakers with little education one finds acoustic equivalencies like *Celipe* 'Felipe', *cinca* 'finca', *escalazón* 'escalafón' [tr. JB] , [where <c> / _ <i,e> and <z>/_<o> write [θ].]

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While this description may look like *θ > f, it appears to be sporadic, and is put into perspective by descriptions of other varieties. In particular, Quilis (1996) is illuminating. He describes a frequent *θ > f change: "Algunos hablantes, con relativa frecuencia, sustituyen el fonema /θ/ por /f/ [Some speakers, with relative frequency, substitute the phoneme /f/ for /θ/] [tr. JB]: [félja] *Celia*, [kamfjón] *canción*, [felestino] *Celestino*, ..."

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(ibid:384) He also notes that "Hemos encontrado con cierta frecuencia la pronunciación [θ] por [f] [We have found with some frequency the pronunciation [θ] for [f] [tr. JB]: [gáθas] *gafas*, [flasθémja] *blasfemia*" (ibid: 383). It appears in this and other Spanish dialects that the regular sound change, if any, is *θ > f (perhaps spreading areally in certain regions), and that instances of f > θ can be viewed as sporadic examples of hypercorrection.[7] If this is the case, Pulo Annan may stand as the only clear case of context-free f > θ sound change described to date. Or is it?

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Perhaps, dismissal of Palauan contact with Pulo Annan as a factor in *f > θ was too hasty. Even if Palauan lacked phonemic /θ/, an L1 speaker of Palauan might produce Pulo Annan [f] as [θ], since [θ] would have been the closest perceptual match to the target [f]. Indeed, recent theories of loanword phonology suggest that the best explanation for violations of native sound patterns in loanword phonology is viewing them as a result of phonetic decoding in the course of speech perception (Peperkamp 2004).

In sum, the typological landscape is somewhat bleak. There are no unambiguous examples of language-internal spontaneous, context-free *f > θ. And there are no clear examples of language-internal spontaneous, context-free *θ > f in languages that lack /f/. We are left with a conundrum. Though [f] and [θ] are perceptually similar, [f] is very rarely systematically misperceived as [θ], and [θ] is only systematically misperceived as [f] when /f/ is a pre-existing category in the mind of the speaker.

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[7] I am grateful to an anonymous reader for bringing this data and analysis to my attention.

6. Explanations

Most researchers are in agreement that context-free *θ > f sound change has a perceptual basis (Jones 2002; Blevins 2004; Flynn and Fulop 2014). An exception is Garrett and Johnson (2013: 71-72). They express uncertainty about attributing the frequency differences in θ > f vs. f > θ sound change to asymmetric misperception, and suspect that all instances of θ > f are actually θ^{w} > f, with the shift from a labialized sound to a true labiodental as a consequence of perceptual enhancement. Under their account, θ^{w} > f, occurs so that [grave] (labiality) will enhance [flat] (rounding).[8] They provide several reasons for their suspicions, none of which seem consistent with the full range of data available.

The first reason to suspect θ^{w} > f as opposed to θ > f is that in one variety of Glasgow English, where θ > f has diffused, there is a description of a labialized dental fricative. While this may be an accurate description of the phone, there is no evidence for labialization of dentals in Southern British English, Castillian Spanish, or varieties of Arabic which are precursors to θ > f shifts. In Arabic, the situation is more interesting. Recall that in the Southern Anatolian Siirt dialect of Arabic, all original interdentals *θ, *ð, *ð' (emphatic) have become labiodentals /f, v, v'/, including plain and emphatic interdentals. Since emphasis is contrastive in Arabic, and emphasis is classified as a [flat] feature, under the perceptual enhancement account we expect only the emphatic interdentals to undergo labiodentalization. A second observation Garrett and Johnson

[8] Enhancement is also invoked by Flynn and Fulop (2014) to account for the noted asymmetry. Under their account, [θ] and [f] share the acoustic-auditory feature [grave]. Since [f] is a better instance of a grave consonant than [θ], [θ] > [f] can be viewed as an enhancement of this feature.

(2013) offer is that there are conditioned interdental > labiodental fricative changes that take place in labial contexts. This, of course, is true. I have purposely excluded contextually conditioned sound changes from this discussion so as to ensure that perception, and not coarticulation, can be singled out as a primary factor.

At the same time, there is strong evidence against their perceptual enhancement account from perceptual studies of the θ/f contrast in different vocalic environments. Experiment 1 of Johnson and Babel (2010) compares English- and Dutch-speaking listeners in their similarity judgments of segment pairs, including [f] vs. [θ] in three distinct vowel contexts: a__a, i__i, and u__u. Interestingly, listeners from both groups had the highest similarity judgments for [f] and [θ] in a__a and i__i contexts; in the u__u context, similarity judgments for both groups were significantly lower (Figure 2, p.131). Similar findings are reported in Brannen (2011: 81-82) where speakers of Japanese, Quebec French, European French, and English all show significantly better discrimination of [f] vs. [θ] before /u/ than before /a/ or /i/. Assuming coarticulation in the u__u or __u contexts, Garrett and Johnson's (2013) hypothesis predicts worse discrimination: coarticulatory rounding of [θ] enhances its flatness, making it more grave, and hence more [f]-like. However, the pattern is the reverse. Coronal sounds before /u/ appear to be more distinctly coronal, and less labial-like. In sum, the evidence that Garrett and Johnson (2013) bring to support $\theta^{w} > f$ (instead of θ > f) as the true recurrent sound change is not compelling.

While most, then, agree that *θ > f has a perceptual component, explanations for the absence of *f > θ and the structure-preserving nature of *θ > f are disputed. Kjellmer (1995) makes a general argument that /θ/ is a marked segment, and therefore dispreferred

on articulatory and perceptual grounds to /f/. However, Jones (2002) questions this, and follows Miller and Nicely (1955) in suggesting a role for visual cues. Jones (2000: 5) suggests that infants may use visible lip movement as a cue for the weak frication of [f], and then invoke the same production strategy in attempting to produce the very similar acoustic target of [θ]. This suggestion has received experimental support. McGuire and Babel (2012) looked at the strength of audio and visual cues for /f/ and /θ/ identification in CV, VC and VCV contexts and found that that /θ/ is more variable than /f/ in both audio and visual conditions. Since this proposal relies on the pre-existence of /f/ in a language as a *visible* articulatory target, it is also able to explain why context-free *θ > f sound changes are nearly always mergers: if a language does not have /f/, the visible articulatory target will not be a factor, and, without it, no change will occur. In other words, though [f] and [θ] are confusable in noisy conditions, misperception alone does not appear strong enough to result in a sound change in either direction.

7. Markedness?

As similar sound changes from the world's languages are collected and catalogued, an extremely interesting landscape emerges. Most recurrent sound changes have clear phonetic explanations grounded in articulatory, aerodynamic, and/or acoustic properties of speech. In some rare cases, like the θ > f and possible f > θ sound changes catalogued here, a categorical shift appears to take place through innocent misperception, swayed,

perhaps, by visual input that biases the learner to use labiodental articulation to reach an approximate auditory target. The "markedness" of [θ] was thought to relate to the articulatory difficulty of interdental fricatives in contrast to labiodental fricatives (Wells 1982, Kjellmer 1995). However, McGuire and Babel's (2012) study may be more informative: they found greater variability for [θ] in contrast to [f], for both audio and visual conditions, suggesting that it is the stability of [f] (unrelated to articulatory effort or difficulty) that may play an additional role in its tendency to dominate categorization.

Recent work demonstrates the complexity of explanation when confronting asymmetries in sound change. In the case of θ and f, cross-linguistic phonemic distribution, variability in articulation, and visual cues present may all play a role. A theory of markedness treating /θ/ as marked and /f/ as unmarked falls short in many ways: it does not predict the many languages that have /θ/ but no /f/; it has little to say regarding the absence of θ > f in languages that do not already have /f/ as a category; and, it appears to duplicate the phonetic explanation above, which suggests that variability and instability of [θ] play a role in its liability to merge. While we must remain open to true evidence of markedness in phonological systems, as phonetic, historical and typological study of voiceless labiodental and interdental fricatives continues, we will be able to better assess other potential factors that may be involved in context-free changes of these sounds over time.

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