# THE INDETERMINACY/ATTESTATION MODEL OF METATHESIS

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This paper addresses three key observations relating to crosslinguistic patterns of metathesis. First, the order of sounds resulting from metathesis can differ from language to language such that a similar combination of sounds can be realized in one order in one language, but in the reverse order in another language. Second, for some sound combinations, only one order is commonly attested as the result of metathesis, while for other combinations, either order can be observed. Third, the acoustic/auditory cues to the identification of the sequence resulting from metathesis are often better than those of the expected, yet nonoccurring, order. These patterns receive a straightforward explanation when we consider the phonetic nature of the sounds involved as well as the speaker/hearer's knowledge of native sound patterns and their frequency of occurrence. Neither factor alone is sufficient to provide a predictive account of metathesis. This study shows, however, that by taking into account both factors, we are able to understand why certain sound combinations tend to undergo metathesis, why others are common results of metathesis, why patterns of metathesis differ across languages, and, importantly, why metathesis occurs in the first place.*

**1.** INTRODUCTION. Metathesis is the process whereby in certain languages the expected linear ordering of sounds is reversed under certain conditions. Thus, in a string of sounds where we would expect the ordering to be . . . *xy* . . . , we find instead . . . *yx* . . . . In the verbal system of the Dravidian language Kui (Winfield 1928), for example, the expected ordering of a stem-final consonant and suffix-initial labial is reversed just in case the stem ends in a velar stop (e.g. /bluk + pa/ [blupka] 'to break', cf. /gas + pa/ [gaspa] 'to hang'). While variation in the linear ordering of elements is typical in the domain of syntax, it is comparatively striking in phonology and differs in nature from most other processes which are typically defined in terms of a single sound, or target, that undergoes a change in a specified context.

The apparently distinct nature of metathesis has resulted in the perpetuation of what one might refer to as the METATHESIS MYTH, the commonly held view of metathesis as sporadic and irregular, restricted to performance errors, child language, or sound change. This view is regularly expressed in the linguistic literature, including the most up-to-date instructional texts and dictionaries (e.g. Crystal 1997, Spencer 1996).

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An important factor underlying this view relates to data.[1] Despite the fact that numerous cases of metathesis are reported in the literature, basic knowledge has been lacking concerning the full range of metatheses that are possible in language, under what conditions metathesis applies, why metathesis happens, and how metathesis interacts with other processes affecting sound structure. This information is critical to providing an accurate picture of the nature of metathesis. It is also of crucial importance for advancing our knowledge of language since developing an explanatory model of language is impossible without a clear understanding of the fundamental processes possible.

It is therefore significant that more recent studies are bolstering the previously existing literature to create a solid empirical foundation for the study of metathesis.[2] These works include crosslinguistic surveys (e.g. Bailey 1970, Blevins & Garrett 1998, Grammont 1933, Hock 1985, Hume 1998, 2001, Janda 1984, Langdon 1976, McCarthy 1989, Mielke & Hume 2001, Semiloff-Zelasko 1973, Silva 1973, Ultan 1978, Wanner 1989), in-depth studies of metathesis in individual languages or language families (e.g. Alexander 1985, Besnier 1987, Black 1974, Butskhrikidze & van de Weijer 2001, Delancey 1989, Duménil 1983, 1987, Hume 1997b, Hume & Seo 2004, Isebaert 1988, Keyser 1975, Laycock 1982, Lyche 1995, Malone 1971, 1985, McCarthy 2000, Montreuil 1981, Powell 1985, Shaver & Shaver 1989, Smith 1984, Sohn 1980, Thompson & Thompson 1969, Timberlake 1985), and experimental work exploring psycholinguistic influences on metathesis (e.g. Fay 1966, Makashay 2001, Winters 2001). An online database of metathesis cases is also being developed and will ultimately contain information on all reported cases of metathesis.[3] It is clear from these studies that while metathesis is less common than processes such as assimilation and deletion, it can nonetheless occur productively in a wide range of languages.

Yet, despite this large body of literature, to date there is no unified, explanatory account of why metathesis occurs, why it favors certain sound combinations, and why we obtain the output that we do. One reason for this relates to the observation that crosslinguistically, metathesis can appear to be random due to the fact that a string of sounds can be realized in one order in one language but in the opposite order in another language, as pointed out by Blevins and Garrett (1998). Consider metathesis involving a glottal consonant in Balangao, Hungarian, Pawnee, and Basaa. As I outline below, in the first two languages, the glottal is realized after a consonant, while it surfaces before a consonant in the last two.

In Balangao, vowel deletion leads to the juxtaposition of two consonants (e.g. /baŋad-an/ [baŋdan] 'time of returning'). When this would give rise to the glottals

[1] An additional factor relating to the perpetuation of the metathesis myth concerns the nature of phonological theories. In linear and nonlinear phonological theories, there is a principled reason to resist recognizing metathesis as a legitimate phonological process of segment reversal: extending the theory to account for the inherently distinct nature of metathesis has the potential of opening 'a Pandora's box of implausible-seeming . . . processes' (Janda 1984:92). Indeed, Webb (1974) claims that metathesis does not exist as a regular phonological process in synchronic grammar. For additional discussion, see Hume 2001.

[2] A more comprehensive listing of references for metathesis can be found at http://www.ling.ohio-state.edu/~ehume/metathesis/bibliography/.

[3] The complete database is housed in the Department of Linguistics at the Ohio State University. For a listing of metatheses in the database as well as information on each case, see the metathesis website: http://www.ling.ohio-state.edu/~ehume/metathesis/.

[ʔ, h] occurring before a nasal or oral plosive, the expected ordering of the sound combination is reversed, and the glottal occurs after the plosive, as in 1 (Shetler 1976).

(1) Balangao

| INPUT | SURFACE | EXPECTED ORDER | GLOSS |
|---|---|---|---|
| ʔi-hɨgɨp | ʔighɨp | *ʔihgɨp | 'bring in' |
| pʌhɨd-ɨn | pʌdhɨn | *pʌhdɨn | 'allow, accept' |
| gɨhɨb-ɨn | gɨbhɨn | *gɨhbɨn | 'burn it' |
| ma-hɨdɨm | madhɨm | *mahdɨm | 'night' |
| CV-ʔopat | ʔopʔat | *ʔoʔpat | 'four each' |
| CV-ʔɨnɨm | ʔɨnʔɨm | *ʔɨʔnɨm | 'six each' |

A similar pattern is observed in Hungarian, though forms that undergo metathesis are limited to stems with [h] and an approximant. The relevant forms are a subclass of morphemes whose last nucleus alternates with Ø; the vowel has traditionally been analyzed as epenthetic and is subject to vowel harmony (e.g. /bokr/ [bokor], [bokr-ot] 'bush.NOM/ACC', /term/ [terem], [term-et] 'hall.NOM/ACC'). Given the order of the glottal before the approximant in the dative forms in 2, the expected linear order of the sounds in the plural is glottal + approximant. The order is reversed, however, with the glottal consistently occurring after the consonant (Vago 1980, Kenesei et al. 1998, Siptár & Törkenczy 2000).

(2) Hungarian

| DATIVE | PLURAL | EXPECTED ORDER | GLOSS |
|---|---|---|---|
| tehernek | terhek | *tehrek | 'load' |
| peheynek | peyhek | *pehyek | 'fluff' |
| keheynek | keyhek | *kehyek | 'chalice' |

Metathesis in Pawnee is almost the mirror image of that observed in Hungarian. In this case, the expected sequence /r + h/ is reversed so that the glottal is positioned before the consonant, as shown in 3 (Parks 1976).

(3) Pawnee

| INPUT | SURFACE | GLOSS |
|---|---|---|
| ti-ir-hisask-hus | tihrisasku | 'he is called' |
| ti-a-huraːr-hata | tahurahrata | 'it's a hole in the ground' |
| ti-ur-haːk-ca | tuhrakca | 'a tree is standing' |

A glottal is also realized postvocalically in Basaa, a more general case of the metathesis observed in Pawnee. In Basaa, metathesis involves the glottal fricative of the indirective causative morpheme and a stem-final consonant (Schmidt 1994). The causative marker is analyzed as /-aha/, with the initial vowel alternating with Ø. The full morpheme is realized following a CVCVC stem, as in 4a. After a CV or CVC stem, the initial vowel of the marker is absent, shown in 4b and 4c respectively. Metathesis can be seen in the set of examples in 4c where the expected ordering of the consonant and glottal fricative is reversed. Other forms with consonant clusters in 4a show that metathesis does not affect all consonant types (tones have been omitted for simplicity).

(4) Basaa

| | UNSUFFIXED | INDIRECT CAUSATIVE | NOMINALIZED | GLOSS |
|---|---|---|---|---|
| a. | kobol | koblaha | koblak | 'peel' |
| | pidip | pidɓaha | pidɓak | 'hate' |
| | aŋal | eŋlaha | aŋlak | 'tell' |
| b. | ce | ciha | cek | 'destroy' |
| | lɔ | loha | lɔk | 'arrive' |
| | ha | heha | hak | 'put' |
| c. | lɛl | lehla | lɛlɛk | 'cross' |
| | teŋ | tihŋa | teŋek | 'tie' |
| | ɓon | ɓuhna | ɓonok | 'promise' |
| | ɓɔl | ɓohla | ɓɔlɔk | 'burst' |
| | at | ehda | adak | 'unite' |

The sample of metathesis cases just presented illustrates the challenge for any explanation of metathesis: metathesis can appear to be random crosslinguistically since two elements can surface in one order in one language but in precisely the opposite order in another language.

A predictive theory of metathesis must also account for the observation that within the set of attested metatheses, sound combinations can differ with respect to whether one or both orders of the sounds is generally attested as the result of metathesis crosslinguistically. As we just saw, for instance, when one of two consonants involved is a glottal, neither order of the sounds seems to be favored crosslinguistically; rather, both orders are observed emerging as the result of metathesis, depending on the language. Metathesis involving homorganic liquids and nasals also seems to fall into this category; the result of metathesis may be nasal + liquid or liquid + nasal, again depending on the language. Old Spanish and Chawchila serve to illustrate.

Metathesis in Old Spanish, shown in 5a, was conditioned by vowel syncope in the future and conditional formations of the verb which resulted in the contiguity of /nr/ (examples are given for future forms of the verb). The metathesized form competed with one in which an obstruent stop was realized between the nasal and liquid. While both coexisted in all forms of the future and conditional in Old Spanish, only the variant with the intrusive consonant has survived in Modern Spanish (Wanner 1989, Martinez-Gil 1990). In Chawchila (5b), metathesis is attested in the intensive possessor suffix which displays two alternants, [-ilin] and [-inl-] (Newman 1944; see related discussion in Stonham 1990). The VCVC alternant occurs word-finally while the VCC variant is realized before a vowel-initial suffix. Newman (1944) reports that the same process takes place within the unanalyzable noun theme, although no examples are provided. While the linear ordering of similar consonants in the two languages changes by metathesis, the order of the output differs: in Old Spanish, the nasal is prevocalic and the liquid preconsonantal, while the reverse order is found in Chawchila.

(5) a. Old Spanish

| INFINITIVE | FUTURE (1SG) | EXPECTED ORDER | GLOSS |
|---|---|---|---|
| poner | porné, pondré | *ponré | 'to put' |
| tener | terné, tendré | *tenré | 'to have' |
| venir | verné, vendré | *venré | 'to come' |

b. Chawchila

| | |
|---|---|
| tiht$^{h}$ilin | 'one with many head lice' |
| patt$^{h}$ilin | 'body-louse' |
| cawaːʔan patt$^{h}$inli | '[he] shouted at the one with many body-lice' |

There are also sound combinations where only one order is typically observed as the result of metathesis. For example, when an intervocalic stop and fricative are involved, the stop consistently surfaces before a vowel (Steriade 2001, cf. Silva 1973, Makashay 2001). Consider Udi metathesis in 6. When a coronal plosive (oral stop or affricate) would be expected to precede a coronal fricative or affricate through morpheme concatenation, the stop consistently surfaces instead after the strident consonant. Examples from the language's verbal morphology illustrate. The last four forms demonstrate that a noncoronal consonant does not metathesize with a following sibilant.

(6) Udi (Schulze 2002)

| | INPUT | SURFACE | GLOSS |
|---|---|---|---|
| | tad-esun | tast'un[4] | 'to give' |
| | t'it'-esun | t'ist'un | 'to run' |
| | etʃ-esun | eʃtʃ'un | 'to bring' |
| | bafd-sa | bafst'a | 'falling into' |
| | bot'-sa | bost'a | 'cutting' |
| | etʃ-sa | eʃtʃ'a | 'bringing' |
| | tat'und-eʃa | tat'unʃt'a | 'they (let) bring' |
| cf. | ak'-esun | ak'sun | 'to see' |
| | aq'-esun | aq'sun | 'to take' |
| | lap-esun | lapsun | 'to put on' |
| | tʃalx-sa | tʃalxsa | 'knowing' |

A similar pattern is exemplified by metathesis in Faroese and Lithuanian. Where a postvocalic fricative followed by two stop consonants would be expected, we find instead the fricative flanked by the two stops. This can be seen for Faroese in 7, where a velar stop metathesizes with an adjacent coronal fricative just in case it is followed by another stop consonant (Lockwood 1955, Jacobson & Matras 1961, Rischel 1972, Hume & Seo 2004).

(7) Faroese

| FEM. SG. | MASC. SG. | NEUT. SG. | EXPECTED ORDER | GLOSS |
|---|---|---|---|---|
| baisk | baiskʊr | baikst | *baiskt | 'bitter' |
| fɛsk | fɛskʊr | fɛkst | *fɛskt | 'fresh' |
| rask | raskʊr | rakst | *raskt | 'energetic' |

A similar pattern can be observed in Lithuanian, illustrated in 8 by a comparison of the third person singular past imperfective verb forms with those of the imperative and infinitive. In the former the order is fricative + stop, while in the latter the order is reversed, giving stop + fricative (Kenstowicz 1972, Ambrazas 1997, Hume & Seo 2004).

(8) Lithuanian

| 3SG. PAST IMPERF. | IMPER. SG. | INFIN. | EXPECTED ORDER | GLOSS |
|---|---|---|---|---|
| plʸeske | plʸeksk | plʸeksti | *plʸeskti | 'flash intensely' |
| tvʸeske | tvʸeksk | tvʸeksti | *tvʸeskti | 'flash briefly' |
| breʃko | brekʃk | brekʃti | *breʃkti | 'break (of dawn)' |
| brizgo | briksk | briksti | *briskti | 'fray' |

[4] There are two additional facts about the data that should be noted: first, syncope of unstressed /e/ provides the context for metathesis, and second, the coronal stop is realized as voiceless and glottalized after a consonant.

In both Faroese and Lithuanian, the expected order is altered so that the fricative is positioned between the two stops. To my knowledge, there are no attested cases of metathesis where a stop shifts from postvocalic to interconsonantal position (e.g. /Vkst/ → *[Vskt]).

The direction of metathesis involving intervocalic sonorant and stop consonants also favors one order: given a sequence of two intervocalic consonants, $VC_1C_2V$, the obstruent typically occurs in $C_2$ position, the sonorant in $C_1$.[5] For example, in Elmolo, a lowland East Cushitic language, metathesis occurs in the plural formation of nouns (Zaborsky 1986). One type of plural is formed by the addition of the suffix /-o/, as in 9a. When the medial or final consonant of a bisyllabic noun is a (nongeminate) liquid, the vowel of the last syllable elides, as in 9b. But metathesis occurs when the obstruent stop would otherwise occur in $C_1$ position, as shown in 9c.

(9) Elmolo

| | SINGULAR | PLURAL | GLOSS |
|---|---|---|---|
| a. | karris | karriso | ‘cheek’ |
| | ēk | ēko | ‘fire’ |
| | nān | nāno | ‘harpoon’ |
| | or | oro | ‘tree’ |
| b. | ilik | ilko | ‘tooth’ |
| | tʃilik | tʃilko | ‘foot’ |
| | elem | elmo | ‘sheep’ |
| | elon-te | elno | ‘cowry shell’ |
| c. | tikir | tirko | ‘catfish’ |
| | deker | derko | ‘horn’ |
| | mukul | mulko | ‘iron’ |

A similar pattern is observed for Sidamo in 10, where a root-final obstruent and a following nasal metathesize; the nasal is realized as homorganic with the adjacent obstruent. Metathesis systematically occurs before suffixes beginning with /n/, the only suffix-initial sonorant in the language (Hudson 1975). A similar process is observed in other Ethiopian languages such as Darasa, Gedeo, Hadiyya, and Kambata (Hudson 1975, 1995).

(10) Sidamo

| INPUT | SURFACE | GLOSS |
|---|---|---|
| hab-nemmo | hambemmo | ‘we forget’ |
| gud-nonni | gundonni | ‘they finished’ |
| dod-nanni | dondanni | ‘he will run’ |
| it-noommo | intoommo | ‘we have eaten’ |
| has-nemmo | hansemmo | ‘we look for’ |
| duk-nanni | duŋkanni | ‘they carry’ |
| ag-nummo | aŋgummo | ‘we drank’ |
| ag-no | aŋgo | ‘let’s drink’ |
| ag-ni | aŋgi | ‘he drank’ |

In the examples just cited, an obstruent occurs by metathesis between a sonorant consonant and a vowel (VSonObstV). Cases in which the result of metathesis has the obstruent

[5] This type of metathesis has been used as evidence for the SYLLABLE CONTACT LAW, which requires the sonority of the coda to be greater than that of the following onset (Vennemann 1988). See Hume 1998, 2001 and Hume & Seo 2004 for arguments against this analysis of metathesis and Seo 2003 for arguments against the syllable contact law more generally.

positioned before the sonorant consonant (VObstSonV) are less common, though not unattested. Of the thirty-seven cases of consonant/consonant metathesis examined that involve morphophonemic alternations in synchronic grammars, eleven involve obstruent/sonorant combinations. In ten of these cases, the obstruent occurs by metathesis prevocalically after the sonorant consonant (VSonObstV), while in one, the Costanoan language Mutsun, the obstruent occurs postvocalically before the sonorant (see the discussion in §4).

It has also been observed that acoustic/auditory cues to the identification of the sequence resulting from metathesis are often better, or optimized, compared to those of the expected, yet nonoccurring, order (Hume 1998, Steriade 2001). Cases involving obstruent stops provide a clear example of this type of pattern. It is well established that obstruent stops depend heavily on contextual cues such as release burst and formant transitions for the identification of their manner and place of articulation (see §2.3). Thus, the occurrence of stops in a context in which these cues are present should be preferred to their occurrence in a context in which the cues are absent or partially masked. In this view then, prevocalic position can be considered preferable to preconsonantal position since both release burst and transition cues are present in the former context. Similarly, adjacency to a vowel is preferable to nonadjacency to a vowel. Of interest here is the observation that these are precisely the contexts to which stops commonly shift by metathesis. As just seen for stop/fricative metathesis in Faroese and Lithuanian, the stop surfaces after a vowel instead of between two consonants. A stop/fricative sequence is also involved in Udi, illustrated in 6, with the stop occurring in prevocalic position. Similar patterns are observed in Elmolo (9) and Sidamo (10), where a stop shifts to prevocalic position at the expense of nasals and liquids. These cases represent a recurring pattern in metathesis: a consonant with potentially weak phonetic cues often emerges in a context in which the cues are more robust than they would have been in the expected, yet nonoccurring, order. An explanatory account of metathesis must also account for this observation.

In the preceding discussion, I have illustrated a number of interrelated observations concerning metathesis. First, the direction of change in metathesis can differ from language to language. Thus, a similar sound combination can be realized in one order in language A, but in the reverse order in language B. Second, for some sound combinations, only one order of the sounds is generally observed crosslinguistically as the result of metathesis, while either order seems just as likely to be attested for other combinations. Third, the acoustic/auditory cues to the identification of the sequence resulting from metathesis are frequently better, or optimized, compared to those of the expected, yet nonoccurring, order. A successful model of metathesis should be able to provide an explanatory account of each of these observations.

As I show in §§3 and 4, these patterns receive a straightforward account when we consider two important factors: (i) the nature of the sounds involved, and (ii) the influence of existing patterns in the language. To anticipate this discussion, I suggest that for metathesis to occur, two conditions must be met. First, there must be indeterminacy in the signal, with indeterminacy defined as a function of: (i) the listener's experience with the elements involved (e.g. sounds, sound sequences, morphemes, words, etc.), and (ii) the quality of information in the signal as determined by the types of sounds involved, the context in which they appear, the phonetic cues present, and so on. Second, the order of elements opposite to that occurring in the input must be an attested structure in the language. Indeterminacy sets the stage for metathesis, and the knowledge of the sound patterns of one's language influences how the signal is processed and, thus, the

order in which the sounds are parsed. To be specific, the order inferred from the signal is consistent with that which occurs most frequently in the language. This proposal is consistent with Fay's (1966:88) earlier speculations regarding metathesis: 'when listeners hear speech that is expected to be in the native language, their perceptual identifications are directed by their knowledge of sequential probabilities in the language as well as by the acoustic stimulus'.

Support for this approach comes first from the metathesis patterns themselves, but also from a large body of research in phonetics, phonology, historical linguistics, and psycholinguistics. For example, at the heart of the proposed account is the assumption that an individual's knowledge of his/her language, including its patterns of usage, is an effective predictor of the direction of metathesis. Support for this proposal comes from extensive research demonstrating that listeners are sensitive to the frequency of the words, sounds, and sound combinations of their language (see, among others, Bybee 1985, 2001, Frisch 1996, Frisch et al. 2000, Lindblom 1990, Luce 1986, Makashay 2001, Pierrehumbert 1994, Pitt & McQueen 1998, Saffran, Aslin & Newport 1996, Saffran, Newport & Aslin 1996, Vitevitch & Luce 1999). This approach also builds on earlier, primarily diachronic, studies of metathesis that point to the influence of a language's sound patterns on metathesis (Grammont 1933, Hock 1985, Ultan 1978). The proposal that indeterminacy is a necessary prerequisite for metathesis draws on a large body of research in phonetics, phonology, and historical linguistics showing the importance of acoustic and auditory cues in shaping phonological systems (see, among others, Bladon 1986, Blevins & Garrett 1998, Côté 1997, Fay 1966, Flemming 1995, Hume 1998, Hume & Johnson 2001a,b,c, Jun 1995, Liljencrants & Lindblom 1972, Lindblom 1990, Mielke 2002, 2003, Ohala 1981, 1993, 1996, Padgett 2001, Silverman 1995, Steriade 1995, 1997, 2001, Winters 2001, Wright 1996, 2001). A key aspect of the proposal developed in this paper, however, is that neither the phonetic nature of the sounds involved nor one's familiarity with native sound sequences ALONE is sufficient to provide a fully predictive account of metathesis. Rather, it is by taking into account BOTH factors that we are able to understand why certain sound combinations tend to undergo metathesis, why others are favored as the result of metathesis, why patterns of metathesis differ across languages, and, importantly, why metathesis occurs in the first place.

The data used in this study are drawn from a database of thirty-seven cases of consonant/consonant metathesis, supplemented by cases of consonant/vowel metathesis when relevant (note that some languages have more than one metathesis). While the proposal in this paper is intended to extend to all types of metathesis, the emphasis is on consonant/consonant metathesis due largely to the fact that while there is considerable documentation regarding metatheses involving a consonant and vocoid (see e.g. Blevins & Garrett 1998, Hume 1997b, McCarthy 2000), less is known about the general patterns of consonant/consonant metathesis. Most of the cases discussed involve metatheses that can be observed as (morpho)phonological alternations or as variable realizations of a particular order of sounds in the synchronic grammar of a language. In some instances metathesis is observed with great regularity throughout a language, while in others metathesis may involve only a handful of words. I consider both types of data as valid for the present study since my interest is in understanding the factors underlying why and how metathesis occurs. Questions relating to how metathesis is to be formalized within phonological theory or how a single occurrence of metathesis generalizes and spreads throughout a language are all important, yet are not ones that I specifically

address here. I refer the reader to the references cited throughout this article for relevant discussion of these issues (see also n. 2).

**2.** BACKGROUND. Speech processing plays a key role in the explanation of metathesis developed in this article and, in this regard, two important factors that bear on the processing of speech sounds figure centrally. The first relates to the knowledge that we have of our native language, that is, our language experience. Processing speech is facilitated by our experience with, among other things, the words, morphemes, sounds, and sound sequences that make up our native language, as well as the frequency with which these elements occur. The second factor concerns the quality of the information that occurs in the speech signal as determined by the types of sounds involved, the phonetic cues available for the identification of the sounds, and so forth. As I discuss in §2.1 below, given the inescapable influence of one's language knowledge, a sequence of sounds with identical phonetic cues may be parsed differently by different listeners (of different languages or even of the same language). Each of these points is developed in greater detail below, thereby providing a basis for the discussion of metathesis to follow.[6]

**2.1.** LANGUAGE EXPERIENCE AND LANGUAGE USAGE. How a particular auditory speech signal is parsed by a hearer is influenced not only by the acoustic/auditory information present, but also by the knowledge that the individual has of his or her language (Lindblom 1990, Luce 1986). Strong evidence in support of this view comes from psycholinguistic research in first and second language acquisition, and speech and word processing.

It is well established that infants are born with the ability to discriminate sounds that contrast in their native language as well as those that do not (Aslin et al. 1981, Best et al. 1988, Polka & Werker 1997, Streeter 1976, Trehub 1976, Werker et al. 1981, Werker & Tees 1984, 1999). Shortly thereafter, however, the effects of native-language influence can be observed.[7] For example, research shows that by four months of age, infants being brought up in a monolingual environment are able to distinguish their native language from a similar yet unfamiliar language (see Werker & Tees 1999). By six months, infants show sensitivity to language-specific grammatical information (Shi et al. 1998) and a preference for the prosodic system of their native language (Jusczyk 1997). The early influence of language experience on the parsing of the speech signal is also observed by a decline in the infants' ability to discriminate between sounds that do not serve a contrastive function in their language. For example, the well-known studies of Werker and colleagues (Werker et al. 1981, Werker & Tees 1984) reveal that six-to-eight-month-old English-learning infants were able to distinguish place of articulation contrasts in Hindi, just like Hindi adults. English-speaking adults, however, had particular difficulty distinguishing the retroflex/dental place contrast. Of significance is the finding that by ten to twelve months of age, English-learning infants were no longer able to discriminate the nonnative contrast, thus behaving in a manner similar

[6] It is beyond the scope of this paper to discuss the many principles involved in the processing of speech sounds. I refer the reader to works such as Bladon 1986, Bregman 1990, and Johnson 1997 for in-depth discussion of the principles of auditory and acoustic phonetics and how these principles relate to parsing information in the speech signal.

[7] Native-language influence may occur even in utero or shortly after birth. Research by Moon and colleagues (1993) shows that infants as young as two days old display a preference for listening to their native language, be it English or Spanish.

to English adults.[8] The influence of language experience is also revealed by the infant's ability to distinguish familiar vs. unfamiliar elements within their own language. Jusczyk and Aslin (1995) show that by seven and a half months of age, infants are able to show a preference for familiar vs. unfamiliar words. Similarly, by nine months, infants can discriminate speech sound sequences that occur more frequently from those that occur less frequently within their own language (Jusczyk & Luce 1994).

It is important to note, however, that the decline in perceptual abilities due to native-language experience is not equally pronounced for all consonantal distinctions; infants and adults have been shown to maintain their ability to discriminate some nonnative phonetic contrasts (Best 1994, Best et al. 1988, Werker & Tees 1984). The results from Best et al. 1998 reveal that the distinction between apical and lateral Zulu clicks remains distinguishable to ten-to-twelve-month-old infants as well as to adults. These findings are taken to indicate that the decline in perceptual sensitivities is limited to sounds that are similar to the sounds of the infant's native language (Best 1994). Thus, the evidence from first language acquisition shows clearly that native-language familiarity enables us to fine-tune our ability to process the words and sounds of our language. One consequence of this fine-tuning for second language acquisition is that listeners are more adept at perceiving sounds of their native language than those of a second language acquired later in life (e.g. Dupoux et al. 1997, Francis & Nusbaum 2002, Polka & Werker 1994).

Psycholinguistic research in speech and word processing also shows that the ability to process speech is facilitated by a listener's familiarity with various dimensions of the native language's phonological system. This includes the language's sounds (Pitt & Samuel 1990), phonotactics (Hallé et al. 1998, Massaro & Cohen 1983, Pitt 1998, Pitt & McQueen 1998), patterns of contrast (Dupoux et al. 1997, Harnsberger 2001, Hume & Johnson 2003, Lahiri & Marslen-Wilson 1991, Otake et al. 1996), and syllable structure (Cutler & Norris 1988, Pallier et al. 1993, Pitt et al. 1998, Treiman & Danis 1988). For example, listeners are biased to parse consonant clusters that are phonotactically impermissible into permissible sequences (Hallé et al. 1998, Massaro & Cohen 1983, Pitt 1998). Pitt (1998) found that an epenthetic schwa is more likely to be perceived between the consonants of phonotactically illegal consonant clusters (e.g. [tlæ] → [təlæ]) than legal clusters (e.g. [træ] → [təræ]).

Phonological contrast also impacts speech processing by influencing the amount of attention paid to the cues of sounds that occur in the language. Otake and colleagues (1996) investigated the role of nasal place of articulation on the processing of place in a following stop consonant by Japanese and Dutch subjects. They found that Japanese listeners made use of place cues in a nasal consonant to obtain information about the place of articulation of a following stop. Dutch listeners, in contrast, ignored place information in a preceding nasal when processing the place identity of a following stop consonant. As the authors point out, these findings reflect the different phonological status accorded place of articulation in preconsonantal nasals in the two languages. In Japanese, a nasal is obligatorily homorganic with a following stop (Vance 1987). Conversely, while place assimilation does occur between a nasal-stop sequence in Dutch, it does not have the obligatory status it has in Japanese; assimilation fails to occur both within and across word and syllable boundaries. As the authors conclude, 'place of articulation in a nasal is a reliable source of information about a following

[8] Infants' decline in sensitivity to native-language contrast for vowels can occur even earlier for vowels (six months of age) than for consonants (Kuhl et al. 1992).

stop for Japanese listeners, and they make use of it; it is less reliable for Dutch listeners, and it is not used' (Otake et al. 1996:3841). Similarly, Hume and colleagues (1999) tested the perceptual salience of stop place of articulation in the context CV for native speakers of Korean and American English. The results revealed that listeners' sensitivity to information contained in the vowel transition following the consonant was significantly greater for Korean listeners than it was for American English listeners. The explanation offered for this finding relates to differences in the system of phonological contrasts in each language. Unlike English, Korean contrasts tense, lax, and aspirated stops, a contrast that is cued in part by the amplitude of aspiration (Kim 1994). Due to these phonological contrasts, Korean listeners learn to focus greater attention on the interval of time following the stop-release burst, that is, on the vowel transitions.

These studies underscore the important fact that since languages differ in terms of their lexicons and phonologies, the influence of linguistic knowledge on the way that a speech signal is parsed is necessarily language specific. We learn to focus our attention on the phonetic cues that are important for distinguishing the meaningful elements of our language while ignoring those that are not. This can then yield a considerable degree of language specificity when it comes to processing speech sounds. Thus, when presented with identical sound stimuli, speakers/hearers with different linguistic experiences can process stimuli in different ways. The language-specific bias in speech processing has important implications for understanding metathesis, as I discuss in more detail in §§3 and 4, since it means that a signal may be parsed in different ways depending on the native-language experience of the speaker/hearer.

Familiarity with the USAGE of elements that make up one's language also influences speech processing. How words are parsed is affected by factors such as their frequency of occurrence, the number of neighboring words that are phonetically similar to them, the predictability of the sequences of sounds in the word, and how familiar they are to the listener (Frisch et al. 2000, Luce 1986, Luce & Pisoni 1998, Pitt & McQueen 1998, Pollack et al. 1959, Savin 1963, Vitevitch & Luce 1999). With respect to word frequency, for example, the higher the frequency of a word, the higher its probability of being correctly recognized (Luce 1986). Bybee (2001) claims that this is because high-frequency words have increased lexical strength due to repetition; little-used items will tend to fade in strength and grow more difficult to access. She also argues, based on a range of experimental evidence, that type frequency (as opposed to token frequency) is an important determinant of productivity (Baayen & Lieber 1991, Bybee 1985, 1995, Moder 1992, Wang & Derwing 1994). Frequency of individual sounds and sound sequences also impacts recognition in infants and adults (Bush 2001, Coleman & Pierrehumbert 1997, Makashay 2001, Pierrehumbert 1994, Pitt & McQueen 1998, Pitt & Samuel 1990, Saffran, Aslin & Newport 1996, Vitevitch & Luce 1999). The relative acceptability of nonsense words with occurring and nonoccurring phonotactic patterns has been shown to be based on the distribution of the patterns in the lexicon; patterns with high type frequency are judged by listeners to be more acceptable (Bybee 2001, Pierrehumbert 1994, Vitevitch & Luce 1999).

**2.2.** THE NATURE OF SPEECH SOUNDS. As discussed in §2.1, how one parses an auditory signal is strongly influenced by native-language experience. One's ability to discriminate sounds is also dependent on the speech sounds in question. Recall Best's (1994) conclusion that one reason why Zulu clicks remain distinguishable to older infants and adults is because they are dissimilar to sounds in the native language; a decline in perceptual sensitivities is limited to sounds that are similar to those of the native lan-

guage. The findings also suggest that some speech sounds are simply more salient than others. That is, the inherent quality of the phonetic cues of some sounds make them easier to identify than others, with clicks being examples of the former and retroflex stops being examples of the latter. This underscores the importance of the nature of speech sounds to the parsing of an auditory signal, as I outline below.

**2.3.** PERCEPTUAL SALIENCE. As is evident, the presence of phonetic cues is crucial for the identification of a speech sound. The better the cue package, the more information there is about the sound, and the easier the sound is for a listener to identify (for related discussion, see Steriade 1995, 1997, Wright 1996). Phonetic cues are determined by two principal factors: the nature of the sound in question and the context in which it occurs. Since sounds that differ articulatorily can have different acoustic/auditory cues, the precise nature of the sound in question is crucial.

Also critical to determining the quality and quantity of a sound's phonetic cues is context, such as position in a word or phrase, neighboring sounds, prosodic prominence, and so on. Context can determine whether a cue is present or absent, as well as the degree to which a particular cue is manifested. Consider burst release in stops, for example. Prevocalically, the burst release of a stop is always present, regardless of language. Phrase-finally, on the other hand, a stop may or may not be released, the choice of which is determined on a language-by-language basis. In Korean, for example, stops are unreleased in this position, while in English the burst is optional. Context can also determine the degree to which a particular cue is present. A cue may be diminished as a consequence of masking from adjacent sounds (Byrd 1994). For example, the release burst of a stop may be masked by the frication of a following consonant, or the frication of [h] may be masked by that of an adjacent fricative (Mielke 2003). The occurrence of a sound in an unstressed, as opposed to stressed, syllable can also result in weak cues due to, among other factors, compressed duration of formant transitions and segment-internal cues. Compressed duration may also be relevant to the occurrence of a consonant in preconsonantal, as opposed to word-final, position. Beckman and Edwards (1990), for example, found that segments in word-final position are generally longer than those in word-medial position, with lengthening being even more evident at the end of an intonational phrase. If greater duration is at issue, it is reasonable to assume that a consonant's perceptual cues carry more information and are thus more salient in word-final than in word-medial coda position.

As detailed in Wright 1996, some sounds are more dependent than others on contextual cues to their identification. To illustrate, compare the perceptual cues to place and manner of articulation for stops and fricatives.

(11) Perceptual cues to obstruent stops

| TYPE | CUE | SEGMENT-INTERNAL OR CONTEXTUAL CUE |
|---|---|---|
| manner: | silence | internal |
| | release burst | contextual: consonant release |
| | transition duration | contextual: VC, CV transitions |
| place: | F2 transition | contextual: VC, CV transitions |
| | burst spectrum | contextual: consonant release |

As shown in 11, stop consonants are heavily dependent on contextual cues for their identification, in particular, release burst and vowel formant transitions. Note that place of articulation is entirely dependent on contextual cues. As Blumstein and Stevens (1979) point out, when both vowel transition and burst are present, the spectral characteristics for a particular place of articulation are enhanced relative to the characteristics

that exist for either one of the components separately. Further, identification of place of articulation is less accurate in unreleased stop consonants than in released ones (Blumstein & Stevens 1979, Halle et al. 1957, Malécot 1956, Stevens & Blumstein 1978, Wang 1959). Since release bursts are always present for stop consonants at the onset to a vowel, prevocalic position is favorable for the perceptibility of a stop. In preconsonantal position, in contrast, bursts are frequently lacking. Prevocalic position is also favored for stops since CV transitions provide better cues than VC transitions (Fujimura et al. 1978). Further, since, from an auditory perspective, auditory nerve fibers show a greater response at the onset of a stimulus signal than at the offset, a prevocalic stop is expected to be more salient than a postvocalic one (Bladon 1986, Mielke 2002, Wright 1996, though see Steriade 1995 on retroflexion).

Compared to stop consonants, fricatives have stronger internal cues to both place and manner of articulation, as displayed in 12. They are therefore less dependent on context for information regarding their identity and, as a result, they generally fare better in poorer contexts (Wright 1996).

(12) Perceptual cues to fricatives

| TYPE | CUE | SEGMENT-INTERNAL OR CONTEXTUAL CUE |
|---|---|---|
| manner: | frication noise | internal |
| | noise duration | internal |
| place: | frication spectrum | internal |
| | frication amplitude | internal |
| | F2 transition | contextual: VC, CV transitions |

Context can also provide modulation in the signal, thus facilitating the identification of speech sounds. Kawasaki (1982) and Ohala (e.g. 1992, 1993) propose that sharper changes in the speech signal serve to increase the salience of cues in the portion of the signal where the modulation takes place: the greater the magnitude of the modulation, the better a given signal is detected. Consequently, larger modulations survive better than smaller ones since, as Kawasaki points out, if two sounds in a sequence are acoustically and auditorily similar, they would be subject to confusion.

The acoustic and auditory cues of a given speech sound are thus determined both by the nature of the sound in question and by the context in which it appears. As a result, two speech sounds occurring in exactly the same environment, produced in an identical manner by speakers with identical vocal tracts, can be expected to generate the same acoustic and auditory cues. Yet, as already noted, we are all familiar with some language and, as Lindblom (1990:408) states, 'if we know a certain language, we can not help imposing that knowledge on the signal'. We can therefore conclude that how an individual parses an auditory signal is a function of the quality of the speech sounds involved as well as, importantly, the individual's native-language experience.

**2.4.** SUMMARY. A key factor influencing how speech is processed is the knowledge that an individual has of his or her language. This naturally includes familiarity with the elements that make up the language as well as their patterns of usage, including frequency of occurrence. Speech processing is also dependent on the nature of the sounds involved and the context in which the sounds occur. As I show, each of these factors plays a key role in explaining observed patterns of metathesis.

**3.** INDETERMINACY. As just discussed, the way that a speech signal is parsed is strongly influenced by one's native language. Particularly important for our understanding of metathesis is the finding that this influence is strongest when information specify-

ing a sound or sound sequence is indeterminate (Pitt & McQueen 1998).[9] Indeterminacy in this context relates to one's ability to parse a given speech signal which, as we have seen, is determined both by the listener's native-language experience and by the nature of the speech sounds involved. I define indeterminacy concerning the order of speech sounds in 13:

(13) INDETERMINACY OF ORDER describes a state in which there is insufficient information concerning the linear ordering of the elements involved. Indeterminacy is a function of two factors:
   a. the listener's experience with the elements involved (e.g. sounds, sound sequences, morphemes, words, etc.);
   b. the quality of information occurring in the speech signal (e.g. the types of sounds involved, the context in which the sounds occur, the phonetic cues available, etc.).

When there is indeterminacy, a listener is biased to parse the signal in a manner consistent with the attested patterns of his/her language. Pitt and McQueen (1998), for example, found that the transitional probabilities of voiceless alveolar and postalveolar fricatives at the end of nonwords influenced listeners' identification of an ambiguous fricative as well as that of the following stop consonant. This is consistent with the findings of Vitevitch and Luce (1999), which reveal segment and sound sequence probabilities to be most influential when listeners are presented with unfamiliar words. Recognition of familiar words, on the other hand, tends to be influenced more by competition with similar sounding words in the language, rather than by sublexical (e.g. phonotactic) patterns. Indeterminacy thus forces the listener to rely on language experience to parse the signal.

Significantly, similar conclusions can be drawn regarding the role of indeterminacy in the identification of linear order. In Broadbent and Ladefoged's (1959) investigation into the perception of order, they found that experience with sounds and sound sequences facilitates identification of the order in which sounds occur. Warren (1982: 119) notes that 'perception of speech and music seems to involve initial recognition of groupings consisting of several sounds. If required, component sounds and their orders may be inferred from these familiar sequences, even though they cannot be perceived directly' (see also Makashay 2001 on the perception of obstruent order in English).

These studies provide insight into why metathesis occurs and why languages differ with regard to the sounds that undergo metathesis and the sequences that emerge as a result. First, a listener makes use of his/her knowledge of native-language patterns to facilitate the identification of the order of sounds. Second, this influence is strongest when information about ordering is indeterminate, in which case the order is inferred. It is thus reasonable to conclude that for metathesis to occur, there must be indeterminacy in the speech signal (Fay 1966). Further, how the signal is parsed depends on the

[9] John Ohala (e.g. 1981, 1993) has pointed to the importance of indeterminacy (or, in his terms, AMBIGUITY) as a key factor in a listener's misapprehension of the speech signal, the basis of sound change in his view. The ideas in this article build on his important work in this area. Importantly, however, my approach differs in that an individual's knowledge of the elements of his/her language and their usage are given a central role. Thus, in my view, how a listener interprets, or parses, a speech signal is language specific rather than universal, as Ohala assumes.

Blevins and Garrett (1998) and Steriade (2001) also note that indeterminacy in the input is involved in metathesis (they use the term ambiguity). They follow Ohala's approach and, consequently, language usage does not play a key role in their proposals.

listener's native-language experience; specifically, the sequence resulting from metathesis corresponds to one with which the listener has had the most experience.

The impact of native-language familiarity on speech processing is strongly supported by crosslinguistic research, which in turn gives us insight into some of the metathesis patterns seen in §1. For example, Mielke's 2003 study of the perception of [h] by listeners with different native-language backgrounds underscores language specificity in processing speech. His results show that in both prevocalic and postvocalic position, /h/ is significantly more perceptible to Turkish and Arabic listeners than to English and French subjects ($p < 0.001$). Further, prevocalic /h/ is significantly more perceptible to English subjects than to French subjects ($p = 0.009$). These results reflect the sound patterns in the languages and, consequently, the degree of familiarity that the listeners have with the sequences in question. Turkish and Arabic listeners have the highest degree of familiarity with sequences involving /h/ given that the glottal occurs both before and after consonants in those languages. English listeners have less experience in this regard since /h/ is limited to prevocalic position, while French subjects are least familiar since /h/ does not occur in the language at all.

Mielke's results concerning the crosslinguistic perception of /h/ provide insight into observed patterns of metathesis involving glottal consonants. In some languages, as was shown for Hungarian and Cebuano, the temporal organization of an intervocalic glottal/consonant input is resolved with the glottal being realized in $C_2$ position. In Pawnee and Basaa, however, the mirror-image is found. Of particular interest is the observation that the input order in each case is a nonoccurring or infrequent sequence in the language. I would suggest that the listener's sensitivity to the sequence is weak in these cases due to the listener's low degree of familiarity with the input. Listeners learn to focus attention on meaningful cues in the signal, and to ignore others. Consequently, if the order of sounds in the input is unfamiliar to the listener, he/she may not be tuned to the cues that can aid in identifying the sound combination. We then correctly predict that listeners with different native-language backgrounds will process sound combinations differently if in one language the sequence occurs while in the other it does not. Yet, familiarity need not be considered all or none. Consistent with psycholinguistic studies, the listener is biased to parse the signal in a manner consistent with the most robust or frequent pattern in cases in which both orders of a given sequence occur in a language. This claim is developed in more detail in §4.

**3.1.** QUALITY OF INFORMATION IN THE SPEECH SIGNAL. That indeterminacy is a factor in metathesis is also evidenced by observations concerning the types of sounds that metathesize. They fall into two general, yet overlapping, categories. The first is characterized by diminished perceptual salience, while the second involves temporal resolution. The defining phonetic characteristics of the sounds in these two categories are key sources of indeterminacy in the temporal organization of the sounds in question.[10]

**3.2.** DIMINISHED PERCEPTUAL SALIENCE. Indeterminate sound sequences resulting from diminished perceptual salience involve either similar sounds and/or those where the phonetic cues to the identification of at least one of the sounds is masked.

[10] My focus regarding indeterminacy relates to an auditory signal, though I speculate that indeterminacy in a visual signal could also result in parsing symbols in a way other than is presented. Factors contributing to indeterminacy in a visual domain include, among others, reading rate, visual quality of the text, visual capabilities of the reader, the reader's familiarity with the word or sound sequence, and so on.

I begin with similarity. Since modulation in the speech signal contributes to the salience of a sound's phonetic cues and hence to the identification of the sound itself (Kawasaki 1982, Ohala 1992, 1993), acoustic/auditory similarity between sounds can have the effect of diminishing the degree of distinctiveness of the sounds, thereby making them and their order less easily identifiable (Hume 1998).

That acoustic/auditory similarity is an important conditioning factor in metathesis comes from the observation that of the thirty-seven cases of consonant/consonant metathesis examined in this study, 35% involve sounds that are highly similar acoustically and auditorily. In the majority of cases, the two sounds agree in sonorancy, differing only in place and/or manner. The importance of shared values for sonorancy in perceived similarity of sounds is consistent with Mohr and Wang's (1968) study of consonant similarity in English. Their findings reveal that the pairs of consonants judged to be most similar were those that shared the major class feature [sonorant], differing only in the value for voicing, place, or continuancy. Fay (1966) also found temporal discrimination between segments to be poorest in sequences of two nasals or two liquids, a finding he attributes in part to similarity in the resonant frequencies of the sounds in each pair.

Metathesis involving two sonorant consonants is not uncommon, being attested in Georgian (Butskhrikidze & van de Weijer 2001, Hewitt 1995), Chawchila (Newman 1944; see related discussion in Stonham 1990), Old Spanish (5a), Deg (Crouch 1994, Hume 1997b), Aymara (Davidson 1977), and Turkana (Dimmendaal 1983), among other languages. Ordering reversals involving two fricatives occur in, for example, Hixkaraya (14), and involving two stops in Kui (Winfield 1928), Kuvi (Israel 1979), Mokilese (Harrison 1976), and Classical Greek (Lejeune 1972). Homorganicity is a condition on metathesis in Modern Hebrew (15) and Udi (6), among others. Identity in place is also crucial in Rendille (Heine 1976, 1978, Hume 1998, Oomen 1981, Sim 1981, Zaborsky 1986) and Bedouin Arabic (Al-Mozainy 1981, Al-Mozainy et al. 1985). In both cases, metathesis involving a pharyngeal consonant is restricted to words in which the consonant is adjacent to a pharyngeal vowel. Metathesis in Turkana is especially interesting since conditions on similarity extend beyond the consonants involved: in addition to the metathesizing sounds having the same value of sonorancy, the relevant consonants must also be adjacent to identical vowels, as in [ŋakɛmɛra] ~ [ŋakɛrɛma] 'mole', [ŋikwaŋɔrɔmɔka] ~ [ŋikwaŋɔmɔrɔka] 'kind of tree' (Dimmendaal 1983).

Diminished perceptual distinctiveness can also result from the masking of meaningful phonetic cues that listeners could use to identify the sounds involved. Given the discussion in §2.3 concerning the dependence of stop consonants on contextual cues for the identification of place and manner, it is not surprising that over one-third of the consonant/consonant metathesis cases examined involve a stop consonant. Recall that stop consonants are heavily dependent on release burst and vowel formant transitions as cues to their place and manner. In fact, place is entirely dependent on these contextual cues. Since release bursts are always present for stop consonants at the onset to a vowel, prevocalic position is a favorable position for the perceptibility of a stop. In preconsonantal position, in contrast, bursts are frequently masked. The observation that a stop/consonant sequence is reordered so that the stop emerges instead before a vowel is thus to be expected. Representative cases occur in Elmolo (9), Fur (Jakobi 1990, Mielke & Hume 2001), Modern Hebrew (15), Oromo (Lloret-Romanyach 1988), Sidamo (10), and Udi (6). Given the importance of vowel transitions for the identification of a stop's place of articulation, the patterns observed in Faroese (7) and Lithuanian

(8) are also unremarkable. Recall that the stop is expected to be sandwiched between two consonants, yet surfaces adjacent to a vowel in the output. In each of these cases, the masking of important phonetic cues to the manner and especially place of articulation of a stop consonant contributes to indeterminacy in the signal, thus creating a favorable context for metathesis to occur.

**3.3.** TEMPORAL RESOLUTION. Blevins and Garrett (1998) observe that glottals, liquids, and glides are commonly involved in metathesis. While their study focuses largely on consonant/vowel metathesis, their claim is well supported by data from cases of consonant/consonant metathesis. At least one of the consonants is glottal in Balangao (1), Basaa (4), Cebuano (Bunye & Yap 1971, Wolff 1972), Cherokee (Foley 1980), Estonian (Kiparsky 1967), Hanunoo (Conklin 1953, Mielke & Hume 2001), Harari (Leslau 1963, Semiloff-Zelasko 1973), Hixkaryana (14), Hungarian (2), Mandaic (Macuch 1965, Malone 1971, 1985), Pawnee (3), and Twana (Semiloff-Zelasko 1973). A glide metathesizes with a consonant in Chawchila (Newman 1944), Cherokee (Foley 1980), Kota (Emeneau 1967, 1970, Semiloff-Zelasko 1973), and Yagua (Powlison 1962, Semiloff-Zelasko 1973). A liquid is involved in Chawchila (Newman 1944), Deg (Crouch 1994, Hume 1997a), Elmolo (9), Gidole (Black 1974), Hungarian (2), Mandaic (Macuch 1965, Malone 1971, 1985), Pawnee (3), and Rendille (Heine 1976, 1978, Hume 1998, Oomen 1981, Sim 1981, Zaborsky 1986), among others. Note that in some cases more than one type of consonant is involved. Drawing on Ohala's research on dissimilation, Blevins and Garrett's account incorporates the insight that glottals, liquids, and glides have cues of relatively long duration or, as Ohala (1993:251) calls them, 'stretched out' features. The burst release of a stop is a good example of a cue that would NOT fit in this category. Since stretched out cues tend to extend over a domain which may encompass adjacent sounds, it can result in the overlap of important phonetic cues, potentially creating indeterminacy about the onset and offset of the sounds involved. An example of this type of overlap can be seen in Figure 1 in the spectrogram of an /h/-vocoid cluster, drawn from the ViC corpus of spontaneous American English speech.[11] Both the vocoid and glottal fricative have stretched out features

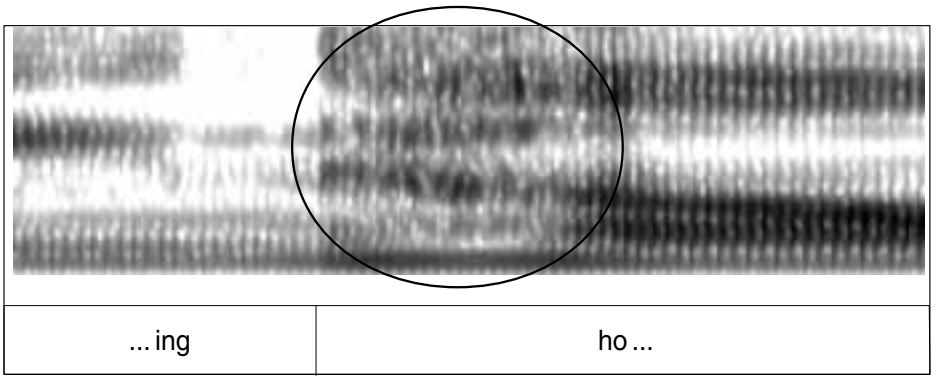


FIGURE 1. Spectrogram of a portion of the phrase 'being home', with the overlapping acoustic cues for the glottal fricative and vowel encircled.

[11] http://vic.psy.ohio-state.edu/

(frication for /h/ and formant structure for the vocoid), which results in the overlapping of acoustic cues.

Unlike the cases of metathesis conditioned by cue masking or acoustic/auditory similarity, diminished perceptual salience seems less of an issue in the case of the glottal fricative and vocoid in Fig. 1. Cues to both segment types are present in the signal (frication on the part of /h/, and formant structure for the vocoid). Furthermore, the cues are qualitatively different. In cases of this type, indeterminacy is an issue of temporal resolution relating to the onset and offset of the respective consonants.[12]

If we are on the right track in assuming that metatheses conditioned by lack of temporal resolution involve sounds with qualitatively different cues, this would underscore once again the importance of context in understanding the relevant conditions underlying the indeterminacy. For example, despite the fact that /h/ is produced with a stretched out feature, the case of Hixkaryana 'h + fricative' metathesis seen in 14 may be best classified under the category of diminished cue perceptibility, given that both sound types exploit frication as the key perceptual cue to their identification. In this language, metathesis occurs when a morpheme-final /s/ or /ʃ/ would be expected to be followed by morpheme-initial /h/ due to vowel loss. (The bilabial fricative, the only other fricative in the language, does not cooccur with /h/.)

(14) Hixkaryana (Derbyshire 1979, 1985)

| INPUT | SURFACE | EXPECTED ORDER | GLOSS |
|---|---|---|---|
| ahosɨ-hira | ahohsɨra | *ahoshɨra | 'not catching it' |
| w-ama-ʃe-haka | wamahʃaka | *wamaʃhaka | 'let me cut it down' |

This, of course, does not rule out the possibility that more than one factor may contribute to indeterminacy in the signal. In Modern Hebrew and Udi metatheses, for example, both sounds are obstruents and the burst release of the stop would be potentially masked in the input. In Chawchila and Old Spanish nasal/liquid metathesis, both consonants are sonorants, and of these, the liquid can be said to have a stretched out cue. Though many more cases could be cited, the point is that the less easily identifiable the sounds and their order are, the greater the possibility that the sequence will be inferred based on the listener's knowledge of the elements of his/her language. Of course, indeterminacy will be even greater when, in addition, the elements in the signal (e.g. sound sequences, words) are less familiar to the listener.

**3.4.** SUMMARY. In the preceding discussion I have argued that indeterminacy in the speech signal provides a favorable context for metathesis to occur. A listener's experience with the elements heard, as well as the nature of the sounds involved, contributes to his or her ability to extract information regarding the order of the sounds from the signal.

**4.** ATTESTATION. In this section, I focus on the sequences resulting from metathesis. As I show, native sound patterns exert a strong influence on the direction of metathesis.

[12] Temporal indeterminacy between sounds in which the relevant cues are qualitatively different may relate to the concept of auditory-stream segregation (Bregman 1990). This refers to the phenomenon whereby separate auditory continua or streams are created among similar auditory cues and remain perceptually separated without temporal cross-linking (see Warren 1982 for related discussion). Bregman and Campbell (1971) found auditory-stream segregation for sequences of six tones made up of two clusters of three low-frequency and three high-frequency tones. Their findings suggest that subjects had more difficulty identifying the order of tones across clusters than within a cluster.

In fact, a second condition on metathesis is that the structure resulting from metathesis be attested in the language. As outlined in §3, this proposal is strongly supported by experimental studies investigating the perception of order. Crucially, it is also supported by observed patterns of metathesis. It is worth noting that this approach is consistent to an extent with earlier proposals suggesting that by metathesis, uncommon language structures are replaced by more common ones (see e.g. Grammont 1933, Ultan 1978, Hock 1985). Importantly for the proposal developed here, however, the (un)commonness of a given structure is determined on a language-specific basis.[13]

Attested cases of metathesis strongly support this conclusion. To my knowledge, the output of metathesis consistently conforms to an existing structure in the language. Note, however, that the level of generalization over which the relevant structure is defined may differ. This is consistent with Dell and colleagues' claim that 'patterns in language occur at many levels of generality and . . . the processing system is sensitive to all of these levels . . . . The claim that language processing is sensitive to patterns at many levels of generality is hardly controversial' (Dell et al. 2000:1356). With respect to metathesis, the relevant structure may be defined in terms of specific qualities of sounds or be larger in scope. In Lithuanian and Faroese, for example, the relevant generalization involves stops and coronal fricatives (Hume & Seo 2003), while in Mutsun the specific sequence involving /k/ and /m/ is relevant (see 16). In Kuvi, by contrast, the level of generalization refers both to the place of articulation of the consonant and, more generally, to the classes of consonants and vowels (alternatively defined as the prosodic level). The direction of metathesis is thus constrained by the sound system of the language in question. While this finding may not seem surprising, it is significant in that it means that the direction of metathesis is not arbitrary. It also suggests that, in principle, any order of two segments is a potential output of metathesis, provided that the reordered sequence forms an attested structure in the language.

The view just outlined makes strong predictions about what a preferred metathesis output can be. When only a single order of some combination of sounds is attested in a language, the predicted output will be consistent with that order. For example, in a language with the sequence [VhCV] but not [VChV], a listener will be biased to parse a signal containing a temporally ambiguous intervocalic consonant/glottal combination as [VhCV]. Thus, if metathesis occurs, the preferred output will be [VhCV], as in Pawnee (3) and Basaa (4). Conversely, with only [VChV] as the attested order, the prediction is that a speech signal with an intervocalic consonant/glottal combination will be parsed as [VChV], as in Balangao (1), Hungarian (2), and Cebuano (Wolff 1972). Similar observations hold for many other languages with metathesis: only a single order of a given sequence of sounds is attested and this corresponds to the order observed as the result of metathesis (e.g. Hanunoo, Hixkaryana, Lithuanian, Faroese, Udi, Sidamo, Elmolo, Georgian, Rendille, and Chawchila).

This approach also makes clear predictions regarding the preferred sequence when both orders of a combination of sounds are attested in the language. Drawing on the finding that listeners are sensitive to the transitional probabilities of sounds in their

[13] One might take this a step further and suggest that markedness is language specific, a position I support. For new evidence in favor of this view, see Hume & Tserdanelis 2002 and Hume 2002, 2003.

language, the prediction is that when both sequences are attested in a language, the listener will be biased toward the most robust sequence, that is, the one with the highest frequency. The more a sequence occurs, the more the speaker/hearer is exposed to it and the more fine-tuned the processing system becomes with regard to that sequence. Evidence for this claim comes from metathesis in, among other languages, Balangao, Cebuano, Modern Hebrew, Mutsun, and Kuvi.[14]

Recall from 1 that in Balangao metathesis, the expected ordering of a glottal [ʔ, h] before a nasal or oral plosive is reversed, thus yielding a plosive-glottal output (Shetler 1976), for example, /pʌhɨd-ɨn/ [pʌdhɨn] *[pʌhdɨn] 'allow, accept', /CV-ʔɨnɨm/ [ʔɨnʔɨm] *[ʔɨʔnɨm] 'six each'. While glottals are not strictly excluded from preconsonantal position, the overwhelming tendency is for them to occur prevocalically, as in [heet], [manhamal], [lehet], [qaho], and [bʌtʔong]. Preconsonantal glottals, however, are highly restricted, occurring only at morpheme boundaries (e.g. /manoʔ-na/ [manoʔna] 'chicken, his'), as geminates (e.g. [ahhahayat] 'just returned home'), or in reduplicated forms (e.g. [pahpah] 'hit to knock something down', [paʔpaʔ] 'touch, as of sugar, and then touch something else, leaving some').

In the Cebu City dialect of Cebuano, the sequences /ʔC/ and /hC/ are also realized as [Cʔ] and [Ch] (e.g. /káʔun-a/ [kanʔa] 'eat it', /luhúd-an/ [ludhan] 'kneel on'). In other dialects, the glottal remains in preconsonantal position. As predicted, the shift observed in the Cebu City language variety is consistent with observed patterns in the dialect. In Wolff's (1972) lexicon of approximately 7,500 words, preconsonantal [ʔ] occurs in only eight lexical items, and [h] occurs in none. The preconsonantal glottal fricative is rather common morpheme-internally, occurring in 132 forms, but the glottal stop is rare in this position. The preconsonantal glottal stop does frequently occur in polymorphemic words, however (John Wolff, p.c.). Thus, the shift of the glottal from preconsonantal to postconsonantal position is consistent with the most robust glottal/consonant pattern in the dialect.

The direction of change observed in the well-known metathesis of Modern Hebrew is also consistent with this approach. In the language, binyan 5 of perfective verbs typically has the form [hit]-verb, as shown in 15a (the prefix /t/ agrees in voicing with an adjacent obstruent); /h-/ is a perfective prefix, /-t-/ is the binyan 5 morpheme, and /i/ is epenthetic (Bat-El 1989, 1992). When the stem-initial consonant is a strident coronal (/c, s, z, ʃ/), however, the /t/ of the prefix occurs to its right, as in 15b (Bat-El 1988, 1989). While the sequence [t] + [strident] occurs in the language, Bat-El (1988, p.c.) reports that it is considerably less common than the opposite order; it is restricted to tautomorphemic forms such as [hi-tsis] 'he fermented' and nonverbal forms like [tʃuva] 'reply'.

[14] I am basing my claims regarding the robustness of a given sequence in each of the languages discussed in this section on the state of the language at the present time (or at the time the description of the language was written). An obvious critique of this methodology is that the current state of the language may not be identical to the way it was when metathesis was first triggered in the system. Admittedly, this is not the ideal situation but one must make do with the resources available. This should not undermine the validity of the claims being made for any of the languages, however, given the robustness of each of the patterns reported.

(15) Modern Hebrew

| | INPUT | SURFACE | GLOSS |
|---|---|---|---|
| a. | hi-t-nakem | hitnakem | 'he took revenge' |
| | hi-t-raxec | hitraxec | 'he washed himself' |
| | hi-t-balet | hidbalet | 'he became prominent' |
| | hi-t-darder | hiddarder | 'he declined, rolled down' |
| | hi-t-kabel | hitkabel | 'it was accepted' |
| b. | hi-t-sader | histader | 'he got organized' |
| | hi-t-zaken | hizdaken | 'he grew old' |
| | hi-t-calem | hictalem | 'he took pictures of himself' |
| | hi-t-ʃamer | hiʃtamer | 'he preserved himself' |

The influence of native-language patterns on metathesis can also be heard in some varieties of American English in the variable pronunciation of *t-l* in the word *chipotle*, the Latin American name for a particular kind of pepper and, recently, for a chain of Mexican restaurants. Both orders of the final two consonants can be heard, even in the speech of the same American English speaker: *chipotle* (the original order) or *chipolte* (the innovative order). This pattern is consistent with the claims made in this paper. The two sounds involved are archetypical 'metathesis sounds' and thus contribute to indeterminacy: /t/ with perceptually vulnerable cues and /l/ with stretched out features. Notice also that in the original form of the word, *chipotle*, the stop occurs in preconsonantal position, a perceptually weak context for a stop. Another factor that may contribute to indeterminacy is unfamiliarity with the borrowed word. Recall that sound sequence probabilities are most influential when listeners are presented with unfamiliar words (Vitevitch & Luce 1999). With indeterminacy, the order of sounds is inferred based on experience, with the bias towards the most robust order. As predicted, although both /tl/ and /lt/ occur intervocalically in English, an examination of their text frequencies in the online MRC Psycholinguistic database of English (Wilson 1988) reveals that /tl/, the original form, occurs in sixty-seven words, while the innovative /lt/ sequence occurs in 356 words.[15]

In the examples just presented, the sequence of sounds resulting from metathesis not only corresponds to the more frequent order of some combination of sounds, but the sequence also arguably has more salient acoustic/auditory cues than the original order. In each case a stop or glottal consonant surfaces in prevocalic rather than preconsonantal position, which, all else being equal, can be deemed the more perceptually favorable context. The observation that the sequences that emerge by metathesis are frequently better perceptually than their unmetathesized counterparts should not be surprising since clusters with better cues are generally more stable, thus occurring in more lexical entries in a language than clusters with poorer cues (Makashay 2001).

Crucial for the approach to metathesis developed in this paper, however, is the view that speech processing is not universal; listeners with different language experiences may parse the same sequence of sounds in different ways. Thus, we would expect to find so-called 'non-optimal' sequences resulting from metathesis as well. Metathesis in Mutsun and Kuvi serves to illustrate.

Metathesis in the Costanoan language Mutsun, as shown in 16, involves the commonly occurring nominal thematic plural suffix, which has two alternants: [-mak] and [-kma] (Okrand 1977).

[15] The MRC Database is a machine-usable dictionary containing over 150,000 words with up to twenty-six linguistic and psycholinguistic attributes (e.g. pronunciation, part of speech, word frequency; Wilson 1988).

(16) Mutsun

| | | |
|---|---|---|
| ruːk | ruːk-mak | ‘string’ |
| huːs | huːs-mak | ‘nose’ |
| wimmah | wimmah-mak | ‘wing’ |
| kahhay | kahhay-mak | ‘head louse’ |
| ʔinnis | ʔinnis-mak | ‘son’ |
| rukka | rukka-kma | ‘house’ |
| tʃiri | tʃiri-kma | ‘paternal aunt’ |
| rumme | rumme-kma | ‘rivulet’ |
| sinni | sinni-kma | ‘child’ |
| relo | relo-kma | ‘clock’ |
| huttu | huttu-kma | ‘belly’ |
| sipruna | sipruna-kma | ‘tule root’ |

The locative suffix displays a similar pattern, with the alternants [-tak] and [-tka].

(17)

| | | |
|---|---|---|
| ʔurkan | ʔurkan-tak | ‘mortar’ |
| loːt | loːt-tak | ‘mud’ |
| pappel | pappel-tak | ‘paper’ |
| pire | pire-tka | ‘world, land’ |
| rukka | rukka-tka | ‘house’ |
| siː | siː-tka | ‘water’ |
| paːrani | paːrani-tka | ‘hill’ |

In both the nominal thematic and locative suffixes, the final consonant and vowel metathesize; the CCV alternant occurs after vowel-final stems while the CVC alternant occurs after consonant-final stems. By comparing the two morphemes in 16 and 17, it can be seen that a further change is involved in the nominal thematic suffix. Not only do the variants differ with regard to whether they end in an open or closed syllable, but the linear ordering of the consonants changes as well: in the allomorph [-kma], [k] precedes [m], while in [-mak], [m] precedes [k]. If we were to follow the pattern of the locative [Ctak, Vtka], we would expect the nominal thematic suffixes to be [Cmak, *Vmka]. Instead, we find [Cmak, Vkma].

There is no absolute prohibition against clusters consisting of nasals and heterorganic obstruents in the language (e.g. [ʔamʃi] ‘so that’, [namti] ‘to hear’, [janpu] ‘to praise oneself’), although some are more common than others. Clusters of [mk] are very rare, occurring in only a few words including [omkon] ‘maggot’ and [hemkon] ‘to set (sun)’. The opposite order [km], however, is attested in many words in addition to those seen in 16 (e.g. [sukmu] ‘smokes, verb’, [yaːkmun] ‘in the east’, [wakmenne] ‘grandmother’). These findings are consistent with the view that the direction of change in metathesis is influenced by the patterns of usage in the language.

Mutsun labial/velar metathesis is of particular interest since it provides a case opposite to what would be expected from a strictly phonetic cue-based approach (cf. Hume 1998, 2001, Steriade 2001). Recall from §2.3 that the most favorable position for a stop consonant is before a vowel, since auditory nerve fibers show a greater response in this position, CV transitions provide better cues than VC transitions, and the release burst of the stop is consistently present. Yet, in Mutsun metathesis, unlike cases such as Sidamo, Elmolo, and others, the stop surfaces preconsonantally. Accounting for these differences is straightforward when the sound patterns of each language are taken into account. In Sidamo, for example, sequences of V[stop][nasal]V are nonoccurring, while in Mutsun they are common. Conversely, sequences of V[nasal][stop]V are robust

in Sidamo, while restricted in Mutsun. This strongly suggests that the goal of metathesis is not to improve the overall psychoacoustic (i.e. universal) cues of a sequence, but, rather, conforming to the patterns of usage of a given language is key.

Consider next metathesis in the Dravidian language Kuvi, where the sequence CVCCV is realized as CCVCV (Israel 1979); metathesis thus results in a change in the prosodic structure of words. Krishnamurti (1978) points out that this metathesis goes back at least two millennia and affected languages of the south central branch of Dravidian including Telugu, Gondi, Konda, Kui, Kuvi, Pengo, and Manda. The change is most widely attested in Kui (ninety-eight forms) and Kuvi (fifty-nine forms). (In some of these forms, the initial consonant was also deleted.) Krishnamurti notes that there are an additional nineteen forms in Kui and twenty-three in Kuvi with lexical free variation, which he states represents subdialectal variation within that language. According to Krishnamurti the sound change spread gradually, lexically and geographically, over the centuries and continues to spread in Kui and Kuvi. In several words that underwent metathesis the effects persist as morphophonemic alternations, or as variable realizations of a word, as in the Kuvi forms shown in 18. I focus my discussion on Kuvi primarily because metathesis continues to affect new words in the language, though similar conclusions can be assumed to hold for Kui (and the other languages affected).

(18) Kuvi

| | | | |
|---|---|---|---|
| doɽva | ~ | dɽova | 'basket' |
| paɽka | ~ | pɽaka | 'armpit' |
| paɳva | ~ | pɳava | 'firstborn' |
| muɳka | ~ | mɳuka | 'urine' |

| INPUT | SURFACE | EXPECTED ORDER | GLOSS |
|---|---|---|---|
| ɖōri-ka | ɖrōka | *[ɖōrka] | 'ropes' |
| mīɳu-ka | mɳīka | *[mīɳka] | 'fish' |
| pēɳu-ka | pɳēka | *[pēɳka] | 'lice' |

Kuvi metathesis is of particular interest since the structure resulting from metathesis would appear to be less optimal than the nonmetathesized structure. Of relevance is the observation that the consonant involved in metathesis is a sonorant apical (dental/alveolar: /n r l/; retroflex: /ɳ ɽ/).[16] Steriade (1995) argues that the most salient cue to apicality is in the V-C transition (specifically the locus of F3) and that postvocalic position is more favorable than prevocalic position for the perception of apicals. Phonological evidence supporting this claim comes from languages in which place neutralization involving apicals occurs in prevocalic position but place is preserved in postvocalic position where the phonetic cues are more salient. The observation that Kuvi metathesis involves the shift of an apical from postvocalic to postconsonantal, prevocalic position

[16] In other languages, the context has been generalized to include all apicals (see Krishnamurti 1978). For this reason, traditional descriptions of the metathesis often refer to the process as 'apical displacement'. Krishnamurti (1978), for example, assumes that it is the quality of being apical that is the most important factor underlying the metathesis discussed here. He suggests that the shift of the apical away from preconsonantal position is to avoid assimilation to the following consonant. I argue, on the contrary, that when the sound change originated it was the property of being a liquid that was crucial. The fact that all liquids were apicals was perhaps incidental. Further, I do not assume that metathesis is teleological in nature, as discussed most specifically in §5. Independent evidence against the view that apicality is the relevant property comes from the observation that stems with a final apical nasal did not originally undergo metathesis. In fact, in most of the Dravidian languages where this metathesis occurred, nasals were completely excluded even as more words underwent metathesis.

runs counter to this view. The pattern is consistent, however, with the claims made here where indeterminacy and sequence attestation play a key role.

Recall that indeterminacy is a function both of the nature of the sounds involved and of the frequency with which a structure occurs in the language. With regard to the first point, it is significant that only liquids, all of which were apical (dental/alveolar, retroflex), initially participated in metathesis (Krishnamurti 1978:n. 4). The consonants undergoing metathesis in Kuvi have since been generalized to include the nasal as well. Recall from §3.3 that liquids and vocoids both involve so-called stretched out acoustic cues (Blevins & Garrett 1998, Ohala 1993). We may assume that this property, in addition to the overall similarity of these two classes of sounds, contributes to indeterminacy regarding the onset and offset of a liquid and vowel. Although the context for metathesis now includes nasal apicals, the similar sonorant properties of these consonants can also contribute to indeterminacy.

Evidence also suggests that the structure that underwent (or undergoes) metathesis is less frequent than that resulting from the change. Krishnamurti (1978) notes that sequences undergoing metathesis were all followed by a consonant, as in the examples in 18, meaning that the metathesized consonant was in a closed syllable. While both VCCV and VCV sequences occurred in the language, there was and continues to be a clear predominance of word-internal open syllables. Based on Israel 1979, the text frequency for word-initial open syllables in Kuvi is 1,535 while for closed it is 736. Thus, closed syllables are not disallowed; they are simply dispreferred. We also know that the sequence liquid + vowel was already attested and was therefore in competition with the unmetathesized vowel + liquid sequence since, according to Krishnamurti and as pointed out by a referee, a previous sound change positioning an intervocalic liquid in initial position had already occurred: VLV > LV, as in Proto-Dravidian **uru* > **ru* 'to burn' (Kondi-Kui-Kuvi-Pengo-Manda). Krishnamurti argues that this change resulted from the weakening of an unstressed initial vowel (see Blevins & Garrett 1998 for discussion of similar cases). The order liquid + vowel also conforms to the general preference for consonant-initial words in the languages.

The facts surrounding Kuvi metathesis strongly support the model of metathesis developed in this article. The sounds involved and the patterns of usage provide a favorable context for metathesis to occur. That the resultant sequences are resolved as the order C**CV**CV is consistent with generalizations about the frequency of sequences involving apical sounds, in particular, and of consonants and vowels in open vs. closed syllables, more generally. Of course, each time metathesis affects a word in Kuvi, the frequency of open syllables increases, thus further strengthening the bias towards this pattern of sounds (for related discussion see Bybee 2000).

Before concluding the discussion of Kuvi, it is worth commenting on Israel's (1979: 14) observation that new word-initial consonant clusters are entering the language as a result of metathesis. In other words, the dispreference for the sequence CVCCV as opposed to CCVCV (or more accurately: VCC as opposed to VCV) results in the creation of previously unattested consonant sequences at the beginning of the word (CCVCV). It is important to point out that this observation is not inconsistent with the claims made here. It does, however, underscore the fact that a listener's sensitivity or bias towards one structure may have consequences that affect the structure of the language more generally. Informally speaking, in the present case, the bias towards an open syllable (VCV) outweighs the bias towards words beginning with a single consonant (see the literature on optimality theory, e.g. Prince & Smolensky 1993, for relevant discussion regarding the formal representation of competition within a language sys-

tem). While I leave further discussion of the underlying factors influencing a listener's bias towards one pattern or another for a future time, it seems reasonable to assume that the same factors that underlie indeterminacy (information quality, pattern frequency) are also relevant in this case.

**5.** METATHESIS OBSERVATIONS REVISITED: EXPLANATIONS. As I have discussed, the key predictors of metathesis are part universal, part language specific. The universal component draws on the raw psychoacoustics of the sound combination at issue, while language specificity is brought in by the influence of a speaker/hearer's native language. By taking into account both factors, straightforward answers to the observations raised at the beginning of this article, repeated in 19, can be provided.

(19) Observations:
   a. The acoustic/auditory cues to the identification of a sound sequence are frequently improved by metathesis.
   b. For some sound combinations, one order is favored crosslinguistically as the result of metathesis.
   c. The direction of metathesis can differ from language to language such that either order of a given sound combination can emerge as the result of metathesis in some language.

Consider first the observation that by metathesis, the acoustic/auditory cues to the identification of a sound sequence are frequently improved. For example, many cases of metathesis are attested in which a sound that depends heavily on contextual cues, such as a stop, is realized in a position where the cues to its identification are strengthened. This observation receives a straightforward explanation when we take into account the nature of a metathesis input, on the one hand, and the types of sequence most apt to influence the processing of segmental order, on the other. Considering the input, recall that the most important predictor of metathesis is indeterminacy, which is a function of information in the signal and language experience. Indeterminacy may thus result from diminished perceptual salience due to similarity between the sounds, or the masking of perceptual cues. Temporal indeterminacy can also result from lack of clarity about the onset or offset of sounds due to stretched out cues and/or a low degree of familiarity with the word, morpheme, or sound sequence in the signal. Each of these scenarios can produce a context favorable for metathesis. But what kinds of sound combinations are NOT likely to undergo metathesis? Clearly, the answer must be those sequences that lack indeterminacy, in other words, those with sufficient information about the identity of the sounds and their order.

By taking into account the nature of the input, it then becomes clear that one reason why many metatheses involve an improvement in perceptual salience is because the candidate most likely to undergo metathesis is one with weaker cues. A second reason relates to the observation that clusters with poorer cues also tend to be less stable in a language system and occur in fewer words than those with stronger cues (Makashay 2001). Given the view that the output of metathesis corresponds to the sequence with the highest frequency, it then follows that if sequences with poorer cues are less frequent, the observed cases of metathesis with non-optimal outputs will also be less commonly attested.

The first point in 19 thus finds its explanation in the following observations. First, sounds with robust cues are not good candidates for metathesis though ones with poorer cues are. Second, sounds with robust cues tend to be more frequent in a system and thus will have a greater impact on the processing of the speech signal. The infrequency

of 'non-optimized' metatheses then stems from the fact that the phonetic cues of the input signal would need to be better than the output. However, clusters with good cue packages are less likely to be indeterminate and less likely to undergo metathesis. This then suggests that the reason that improved perceptual salience is a characteristic of so many cases of metathesis is simply an artifact of the nature of sequences that undergo metathesis and those that influence how an indeterminate speech signal is parsed (cf. Hume 1998, Steriade 2001). In other words, metathesis is not teleological.

This view of metathesis also provides a straightforward explanation of the second observation: for some sound combinations, one order is favored crosslinguistically as the result of metathesis. This is exemplified by cases involving plosives/fricatives. As we have seen, the stop typically metathesizes to a context with better perceptual cues, resulting in a perceptually optimized sequence. Metatheses involving these same kinds of sounds but where the stop shifts from an arguably better context to a worse one are less common. The reason for this should be clear: sounds occurring in a context with strong cues tend to provide sufficient information to allow the sounds and their ordering to be identified. Thus, the reason one order is favored in such sequences is that, all else being equal, only one order of the sounds generally displays indeterminacy. For other types of sound combinations, indeterminacy may arise regardless of the order in which the sounds occur, due to the nature of the sounds and/or the context in which they occur. Common examples include sounds sharing the same manner and/or place features, and sounds with phonetic cues of long duration, as we have seen.

The third observation concerns the apparent randomness of metathesis: the direction of metathesis can differ from language to language such that either order of a given sound combination can emerge as the result of metathesis in some language. As we have seen, however, the direction of metathesis is not arbitrary when two important factors are taken into account: indeterminacy in the signal and the influence of native sound patterns on speech processing. Recall that this influence is strongest when information specifying a sound or sound sequence is indeterminate. Greater crosslinguistic variability is then correctly predicted in those cases where indeterminacy arises regardless of the order of the sounds. In addition, since languages differ both in terms of their constituent parts as well as in terms of their patterns of usage, it is also correctly predicted that the output of metathesis will differ according to the impact that the sound patterns have on the way speakers/hearers of different languages process an indeterminate speech signal.[17]

[17] A referee suggests Ossetic metathesis as a potential problem for the proposals made here. The relevant data is laid out in Hock 1985 (see also Cheung 2002), where it is pointed out that metathesis of an obstruent-sonorant occurred both word-finally (e.g. **(ha-)abra- > arv* 'sky', **tʃaxra- > tsalx* 'wheel', **agra- > alʁ* 'extremity, tip') and word-initially (e.g. **drau- > ərdu* 'hair', **brātā > ərvad* 'brother', **brūka- > ərfug* 'eyebrow'). The word-initial outputs of metathesis were then, it is assumed, repaired by vowel epenthesis. The referee notes, following Hock (1985), that metathesis in word-initial position is highly marked, as it would create an initial sonorant-obstruent sequence. It is also assumed that regular metatheses are structurally motivated, for example, by a sonority-based requirement. Since the assumption that metathesis gave rise to a word-initial sonorant-obstruent consonant cluster was problematic for the sonority-based view, an additional mechanism was invoked to account for this case, such as generality of application.

It is important to point out that markedness, in the sense of a universal principle, is not crucial to the proposals made in the present article. The relative commonness of a given pattern is, in my view, determined on a language-specific basis (see Hume & Tserdanelis 2002, Hume 2002, 2003 for related discussion). What is important for the account of metathesis developed here is whether or not the innovative structure is attested in the language. The observation that obstruent-sonorant sequences metathesized in Ossetic, even in absolute word-initial position, is consistent with this view since sonorant-obstruent sequences were existing articulatory routines in the language.

**6.** CONCLUSION. In this article, I have focused on one aspect of the study of metathesis: the factors that favor and disfavor its occurrence. As I have shown, a unified and predictive account is viable when both universal and language-specific factors are taken into account. The universal component draws on the psychoacoustics of the sound combination at issue and the context in which it occurs, while language specificity results from the influence of a speaker/hearer's knowledge of sound patterns in the native language. I have also argued that two conditions are necessary for metathesis to occur: first, there must be indeterminacy in the signal, and second, the structure that would result from metathesis must already be attested in the system. Indeterminacy sets the stage for metathesis, and a speaker/hearer's knowledge of the sound system and its patterns of usage influence how the signal is processed and, thus, the order in which the sounds are parsed. The greater the indeterminacy, the more the speaker/hearer must rely on native-language knowledge to infer the temporal ordering of the sounds.

An important assumption in this paper is that metathesis has its roots in speech processing. Support for this view comes in part from the observation that the sequence resulting from metathesis conforms to an existing pattern in the language. Additional evidence comes from the findings of Mielke and Hume (2001) concerning the influence of word recognition on crosslinguistic patterns of metathesis. The findings of that study confirm the view that ordering reversals are dispreferred at the beginning of a word or root, and that metathesis overwhelmingly involves adjacent sounds. Both word position and proximity have been shown to be significant factors conditioning speech processing (Connine et al. 1993, Cutler et al. 1985, Hall 1992, Marslen-Wilson 1989, Marslen-Wilson & Zwitserlood 1989).

While it is hoped that this study advances our knowledge of metathesis, it nonetheless goes without saying that many issues remain to be addressed. For example, it is clear that the role of experience plays a key role in predicting metathesis, given its influence on speech processing. Yet, language use involves production as well; considering the potential interplay of language experience and production on metathesis may also prove fruitful. That this is an area worth investigating is suggested by Dell and colleagues (2000:1365) who confirm that:

> each utterance of a syllable tunes the language production system to favor the production of that and similar syllables. The effect of this tuning endures longer than a single trial, and it accumulates with the tuning associated with other utterances. The overall effect is to adapt the production system to recent experience . . . The phonology is projected preferentially from those parts of the lexicon that are most accessible, such as recently experienced sound forms.

It is thus reasonable to assume that a less practiced articulatory routine, whether it involves coordinating the elements of a single sound or of a sequence of sounds, is less precise and perhaps more difficult. The result is a bias towards more practiced articulatory routines. With respect to metathesis, this would suggest that low-frequency

The additional assumption that obstruent-sonorant sequences metathesized in absolute word-initial position in Ossetic is not required, however. According to Cheung (2002), at the time when metathesis took place, Ossetic did not tolerate forms beginning with a consonant cluster. Vowel epenthesis was one strategy used to repair such ill-formed structures. Importantly, epenthesis occurred with ALL initial clusters, not just those that were subject to metathesis, for example, **xʃapā* > *əxsavə/əxsəvə* 'night', **ɣdzar-ja-* > *aʁdzəlyn* 'to pour down, drip'. This then means that it is entirely reasonable to assume that the metathesizing sequence was postvocalic when metathesis occurred. Thus, the change from obstruent-sonorant to sonorant-obstruent consistently occurred postvocalically whether finally or medially within the word.

or nonoccurring sound sequences would tend to lose out to more practiced sequences. I leave the implications of this topic for our understanding of metathesis open for future research.

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