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PREDICTING METATHESIS: THE AMBIGUITY/ATTESTATION MODEL[1]

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Abstract

This paper addresses three important observations relating to cross-linguistic patterns of metathesis. First, the direction of change in metathesis can differ from language to language such that a similar sound combination can be realized in one order in one language, but in the reverse order in another language. Second, for some sound combinations, one order is favored cross-linguistically as the output for metathesis, while for others, one order occurs just as frequently as the other. Third, the acoustic/auditory cues to the identification of the sequence resulting from metathesis are frequently better, or optimized, as compared to those of the expected, yet non-occurring, order. These patterns receive a straightforward account when we consider the nature of the sounds involved, and a speaker/hearer's native language knowledge. It is argued that for metathesis to occur, two conditions must be met: first, there must be ambiguity in the signal and second, the order of sounds opposite to that occurring in the input must be attested in the language. With respect to this last point, it is shown that an individual's knowledge of his/her language, including its patterns of usage, is an effective predictor of metathesis. Support for this approach comes from the metathesis patterns themselves, as well as a large body of research in phonetics, phonology, historical linguistics and psycholinguistics. While neither the phonetic nature of the sounds involved nor knowledge of native sound sequences and their usage is sufficient to provide a fully predictive account of metathesis, this study shows that by taking into account both factors, we are able to understand why metathesis occurs, why it favors certain sound combinations, and why we obtain the output that we do. Implications of the present study for phonology, the nature of Optimality theoretic constraints in particular, are noted in the final section.

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1. INTRODUCTION

The focus of this paper is on metathesis, the process whereby in certain languages, under certain conditions, the expected linear ordering of sounds is reversed. 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, 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' (Winfield 1928). While variation in the linear ordering of elements is typical in the domain of syntax, it is comparatively striking in phonology, differing in nature from most other phonological processes which are typically defined in terms of a single sound, or target, which 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, as evidenced by the following sampling of citations:

> "[Metathesis] frequently occurs in all languages as a type of speech error and is a common feature of child phonology." (Spencer 1996: 68). "Metatheses are well recognized in historical linguistics...but they can also be seen in performance errors, in such tongue-slips as *aks* for *ask*, or in the phenomenon of 'spoonerisms'." (Crystal 1997:240). "Metathesis has generally been treated as a minor sound change. Sporadic and irregular, examples of metathesis are often treated as if labeling it were explaining it." (Powell 1985: 106). "Rules of metathesis are rarely productive. This is why they are most likely to be discussed from the point of view of historical linguistics; and even there, their sporadic nature gives them a definitely marginal character. Synchronically, metathesis is viewed more as a performance factor responsible for spoonerisms and other erratic surface deviations." (Montreuil 1981: 67).

An important factor underlying this view relates to data;[2] 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

[2] An additional important factor relating to the perpetuation of the "metathesis myth" concerns the nature of phonological theories. In both 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).

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 the advancement of linguistic theory since without a clear understanding of the fundamental processes possible in human language, developing an explanatory model of language is impossible.

However, recent studies are bolstering the previously existing literature to create a solid empirical foundation for the study of metathesis.[3] These works include cross-linguistic surveys (see 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 1989; 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; Isebaert 1988; Keyser 1975; Laycock 1982; Lyche 1995; Malone 1971, 1985; McCarthy 2000, Montreuil 1981; Powell 1985; Seo & Hume 2001; 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.[4] From these studies it is clear that while metathesis is less common than processes such as assimilation and deletion, it can nonetheless occur as a regular process 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 stems from the observation that cross-linguistically, 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 & Garrett (1998). Consider metathesis involving a glottal consonant in Balangao, Hungarian, Pawnee and Basaa. As I briefly outline just below, in the first two languages, the glottal is realized after a consonant while in the last two, it surfaces before a consonant.

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

[3] A more comprehensive listing of references for metathesis can be found at http://www.ling.ohio-state.edu/~ehume/metathesis/bibliography.
[4] See footnote 12.

(1) Balangao

Input			*Output*	*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(Red)	+	ʔo'pat	[ʔopʔat]	*ʔoʔpat	'four each'
CV(Red)	+	ʔɨnɨm	[ʔɨnʔɨm]	*ʔɨʔnɨm	'six each'

We observe a similar pattern in Hungarian though metathesis is limited to stems with [h] and an approximant. The relevant forms are a subclass of a larger class of morphemes whose last nucleus alternates with ɸ; the vowel has traditionally been analyzed as epenthetic (and subject to vowel harmony), e.g. /bokr/ [bokor], [bokr-ot] 'bush; bush + ACC', /term/ [terem], [term-et] 'hall; hall + ACC'. Given the order of the glottal before the approximant in the nominative and dative, the expected linear order of the sounds in the plural is glottal + approximant. The order is reversed, however, with the laryngeal consistently positioned before the vowel (Vago 1980; Keresei, Vago & Fenyvesi 1998; Siptár & Törkenczy 2000).

(2) Hungarian

	Dative	*Plural*	*Expected order*	*Gloss*
teher	teher-nek	terh-ek	*tehrek	'load'
pehey[5]	pehey-nek	peyh-ek	*pehyek	'fluff'
kehey	kehey-nek	keyh-ek	*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

/ti + ur + he:r + ɸ /	tuhre	'he is good'
/ti + ir + hisask + :hus/	tihrisasku	'he is called'
/ti + a + hura:r + hata + ɸ/	tahurahrata	'it's a hole in the ground'
/ti + ur + ha:k + ca + ɸ/	tuhrakca	'a tree is standing'

A glottal is also positioned postvocalically by metathesis in Basaa, a more general case of metathesis found 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 ɸ.

[5] The glide in *pehey* 'fluff' and *kehey* 'chalice' was historically [ʎ] (M. Torkenczy, p.c.).

Following a CVCVC stem, the full morpheme is realized, as in (4a). After a CV (4b) or CVC (4c) stem, the marker surfaces as [ha]. Metathesis can be seen in the final set of examples where the expect ordering of the consonant and glottal fricative is reversed. Forms with the nominalization marker [ak] ~ [k] show that a stem-final consonant only metathesizes with [h].

(4) Basaa

	Unsuffixed	*Indirect Causative*	*Nominalized*	*Gloss*
a.	kóbôl	kóblàhà	kóblàk	'peel'
	pídʃîp	pídʃà hà	pídʃà k	'hate'
	kɔ́hɔ̂l	kóhlàhà	kɔ́hlàk	'shave'
	sògòp	sùgʃà hà	sògʃà k	'rinse mouth'
	áŋâl	éŋlàhà	áŋlàk	'tell'
b.	cé	cíhâ	cêk	'destroy'
	lɔ̀	lòhà	lɔ̀k	'arrive'
	há	héhâ	hâk	'put'
	sɔ́	sóhâ	sôk	'escape'
c.	lɛ́l	léhlà	lɛ́lɛ̂k	'cross'
	tèŋ	tìhŋà	tèŋèk	'tie'
	ʃón	ʃúhnà	ʃónôk	'promise'
	ʃɔ́l	ʃóhlà	ʃɔ́lɔ̂k	'burst'
	àt	èhdà	àdàk	'unite'

A predictive theory of metathesis must also account for the observation that within the set of attested metatheses, sound combinations pattern asymmetrically with respect to whether one or both orders are generally attested cross-linguistically.[6] As we just saw, when one of the consonants is a glottal, neither order of the sounds seems to be particularly favored cross-linguistically. Rather, we observe both as outputs of metathesis. Metathesis involving liquids and nasals also seems to fall into this category; either the liquid or the nasal may surface in C_2 position, depending on the language, as exemplified by Old Spanish and Chawchila just below.

Metathesis in Old Spanish, shown in (5a), is conditioned by vowel syncope in the future and conditional formation of the verb which resulted in the contiguity of /nr/ (examples are given for future forms of the verb although similar observations hold for the conditional). The metathesized form competed with one in which an obstruent stop was realized between the nasal and liquid. While both co-existed in all forms of the future and conditional, only the variant with the intrusive consonant has survived in Modern Spanish (Martínez-Gil, p.c.; Wanner 1989). 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

[6] To my knowledge, this observation has not been previously reported in the literature.

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 change by metathesis, the order of the output differs: in Old Spanish, the nasal is prevocalic, the liquid preconsonantal, while in Chawchila, we find the reverse order.

(5) a. Old Spanish

Infinitive	*Future (1st p. sing)*		
poner	porné, pondré	*[ponre]	'to put'
tener	terné, tendré	*[tenre]	'to have'
venir	verné, vendré	*[venre]	'to come'

b. Chawchila

tihṭilin	'one with many head lice'
paṭṭilin	'body-louse'
cawaːʔan paṭṭinl-i	'[he] shouted at the one with many body-lice'

For other sounds combinations, metathesis generally goes in one direction. For example, when an intervocalic stop and fricative are involved, the stop consistently surfaces before a vowel (Steriade 2001). Consider Udi metathesis. When, through morpheme concatenation, we would expect a coronal plosive (oral stop or affricate) to precede a coronal fricative or affricate, the stop consistently surfaces instead after the strident consonant. Examples from the language's verbal morphology in (4) illustrate. The last five forms demonstrate that a non-coronal consonant does not metathesize with a following sibilant. I know of no cases of synchronic metathesis in which /VstV/ is realized as [VtsV], though a few diachronic cases are reported (see Silva 1973, Makashay 2001**).**

(6) Udi

	/tad - esun/[7]	[tast'un][8]	'to give'
	/t'it' - esun/	[t'ist'un]	'to run'
	/eč - esun/	[ešču̇n]	'to bring'
	/bäčükd - sa/	[bäčükstʼa]	'lightning'
	/bafd - sa/	[bafst'a]	'falling into'
	/bot' - sa/	[bost'a]	'cutting'
	/eč - sa/	[eščʼa]	'bringing'
	/muč-sa/	[muščʼa]	'kissing'
	/ar-ne-c-sa/	[arresc'a]	'(s)he is sitting'
	/tat'und- eša	[tatʼunštʼa]	'they (let) bring'
cf.	/ak' + esun/	[ak'sun]	'to see'
	/aq' - esun/	[aq'sun]	'to take'

[7] Syncope of unstressed /e/ provides the context for metathesis.
[8] The coronal stop is realized as voiceless and glottalized after a consonant.

/lap - esun/	[lapsun]	'to put on'
/čap'b - sa/	[čap'bsa]	'hiding'
/čalx - sa/	[čalxsa]	'knowing'

A similar type of unidirectional metathesis is exemplified by sound patterns in Faroese and Lithuanian. Where we would expect a postvocalic fricative followed by two stops, we find instead the fricative flanked by the two stops. This can be seen in (7) for Faroese where a velar stop metathesizes with an adjacent coronal fricative /s/ just in case it is followed by another stop consonant (Lockwood 1955; Jacobson & Matras 1961; Rischel 1972; Seo & Hume 2001).

(7) *Faroese*

Fem. sg.	*Masc. sg.*	*Neut. sg.*	*Expected order*	*Gloss*
baisk	baiskor	baikst	*baiskt	'bitter'
fɛsk	fɛskor	fɛkst	*fɛskt	'fresh'
rask	raskor	rakst	*raskt	'energetic'

Lithuanian differs from Faroese in that any coronal fricative can undergo metathesis, as shown in (8). The pattern can be seen, for example, by comparing the third person singular past imperfective verb forms with those of the imperative and infinitive. In the former, the order fricative + stop emerges while in the latter, the order is reversed, giving stop + fricative (Kenstowicz 1972; Ambrazas 1997; Seo & Hume 2001).

(8) *Lithuanian*

3sg. Past imperf.	*Imper. sg.*	*Infin.*	*Expected order*	*Gloss*
pl^{y}eske	pl^{y}eksk	pl^{y}eksti	*pl^{y}eskti	'flash intensely'
tv^{y}eske	tv^{y}eksk	tv^{y}eksti	*tv^{y}eskti	'flash briefly'
breško	brekšk	brekšti	*breškti	'break (of dawn)'
brizgo	briksk	briksti	*briskti	'fray'

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 mirror image cases 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: the obstruent typically occurs in C_2 position, the sonorant in C_1.[9] 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 the forms 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 (b). As shown

[9] Phonologically, this type of metathesis has been accounted for in terms of syllable contact, whereby the sonority of the coda is greater than that of the following onset (see, e.g. Vennemann 1980).

in (c), however, metathesis occurs when an obstruent stop would otherwise occur in C_1 position.

(9) Elmolo

	Singular	*Plural*	*Gloss*
a.	karris	karris-o	'cheek'
	kunuf	kunuf-o	'fingernail'
	ek	ek-o	'fire'
	nan	nan-o	'harpoon'
	or	or-o	'tree'
	ser	ser-o	'rain, cloud'
b.	ilik	ilk-o	'tooth'
	čilik	čilk-o	'foot'
	elem	elm-o	'sheep'
	elon-te	eln-o	'cowry shell'
c.	tikir	tirk-o	'catfish'
	deker	derk-o	'horn'
	mukul	mulk-o	'iron'

A similar pattern is observed in Sidamo, 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; see related discussion in Rice 1992, Vennemann 1988). A similar process is observed in other Ethiopian languages such as Darasa, Gedeo, Hadiyya and Kambata (Hudson 1975, 1995).

(10) Sidamo

Input	*Surface Form*	
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, the obstruent surfaces prevocalically, preceded by a sonorant consonant. The reverse ordering is also attested though such patterns are rare. For example, in the Costanoan language Mutsun, the expected order [VmkV] is reversed, with the oral stop occurring in C_1 position — section 3.2.

The preceding examples illustrate a number of inter-related 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, one order is favored cross-linguistically as the output for metathesis. A third observation emerges with respect to this last point in particular: it is frequently the case that the acoustic/auditory cues to the identification of the sequence resulting from metathesis are better, or optimized, as compared to those of the expected, yet non-occurring, order (Hume 1998; Steriade 2001). A successful model of metathesis should be able to provide an explanatory account of each of these observations.

As will be shown, these patterns receive a straightforward account when we consider two important factors: a. the nature of the sounds involved, and b. the influence of existing patterns in the language. To anticipate the discussion below, I suggest that for metathesis to occur, two conditions must be met. First, there must be ambiguity in the signal involving a combination of sounds. Second, the order of sounds opposite to that occurring in the input signal must be attested in the language. If these two conditions do not hold, metathesis is unlikely to occur.[10] Ambiguity sets the stage for metathesis; 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.[11] 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, as will be shown below. It is also supported by a large body of research in, among other fields, 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 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; Luce 1986; Lindblom 1990; Pierrehumbert 1994; Pitt & McQueen 1998; Saffran, Aslin & Newport 1996; Saffran, Newport & Aslin 1996; Vitevich and Luce 1999; Makashay 2001). This approach is also consistent with earlier, primarily diachronic, studies of metathesis that point to the influence of a language's structure on metathesis (Grammont 1933; Hock

[10] I say 'unlikely to occur' rather than 'will never occur' since extra-linguistic factors such as social pressure can always take a sound change in an unexpected direction. For relevant discussion, see, e.g. Janda & Joseph (2002) and references therein.

[11] This approach differ's from Ohala's (e.g. 1971) misperception hypothesis in that the proposal in this paper is couched in terms of speech processing rather than speech perception and, as such, is not limited to the auditory medium. Consequently, we do not rule out the possibility that metathesis could result from misparsing a written as opposed to a spoken utterance (see section 3.1).

1985; Ultan 1978). The proposal that ambiguity is a necessary prerequisite for metathesis builds 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; Wright 1996, 2001; Ohala, e.g. 1992; Padgett 2001; Flemming 1995; Huang 2001; Hume 1998; Hume & Johnson 2001a, b; Jun 1995; Lindblom, e.g., 1990; Mielke 2001; Silverman 1995; Steriade 1995, 1997, 2001; Winters 2001). As will be seen, neither the phonetic nature of the sounds involved nor one's familiarity with native sound sequences is sufficient to provide a fully predictive account of metathesis. I intend to show, however, that by taking into account both factors, we are able to understand why metathesis occurs, why it favors certain sound combinations, and why we obtain the output that we do.

The data used in this study are drawn from a database of 34 cases of synchronic consonant/consonant metathesis, supplemented by cases of synchronic consonant/vowel metathesis and diachronic metathesis when relevant.[12] While the proposal in this paper is intended to account for all types of metathesis, the emphasis is on consonant/consonant metathesis due to the fact that while there is considerable documentation regarding metathesis involving a consonant and vocoid (see, e.g., Blevins & Garrett 1998, McCarthy 2000, Hume 1997b), less is known concerning the general patterns of consonant/consonant metathesis.

The layout of this paper is as follows. In the following section I provide relevant background information then turn to metathesis showing how perceptual salience and native language knowledge enable us to predict why ordering reversals of sound combinations occur, and why they emerge in the order that they do. Implications of the present study for phonology, the nature of Optimality theoretic constraints in particular, are noted in the final section.

2. BACKGROUND

There are two important factors bearing on the processing of speech sounds that figure centrally into the account of metathesis developed in this paper. The first relates to the nature of the speech sounds themselves and, in particular, the perceptual salience of the acoustic and auditory cues to their identification. The second concerns how these cues are parsed by the hearer. Processing speech is facilitated both by information appearing in the signal but, also, from the knowledge that we have of our language (Lindblom 1990). This knowledge includes, among other information, the words, sounds, and sound sequences that make up the language, as well as the frequency with which these elements occur. Thus, while acoustic and auditory cues appearing in the signal may be considered largely universal,[13] lexical influence is language specific. As such, a sequence of sounds with identical phonetic cues may be parsed differently by

[12] The database is housed in the Department of Linguistics at the Ohio State University. Portions of this database are available on the metathesis website: http://www.ling.ohio-state.edu/~ehume/metathesis.

[13] This is the case given the assumption that the specific sounds in question are identical phonetically and occur in the same context (see section 2.1).

listeners of different languages. Each of these points is developed in greater detail just below, thereby providing a basis for the discussion of metathesis to follow. [14]

2.1 PERCEPTUAL SALIENCE

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 to identify (for related discussion, see e.g. 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. This is obviously the case for sounds belonging to different phonetic and phonological categories, such as stops and fricatives. It is equally important for sounds which might be considered to be the same from a phonological perspective.

Consider retroflex consonants, for example. While retroflex sounds may pattern in a similar manner phonologically in different languages, if it is the case that these "same" sounds are produced in different ways, the acoustic signal associated with them is expected to differ as well. This is the case with retroflex consonants in Telugu, Tamil and Hindi. Ladefoged and Bhaskararao (1983) found that the Hindi/Urdu speakers have a different articulatory target for their retroflex stops than do speakers of the other two languages. As they point out,

> "It is not that there are two, and only two, possible gestures for retroflex consonants. Instead there is a continuum going from a very retroflex sound of the kind used by speakers of Telugu and Tamil, through a slightly retroflex sound of the kind that occurs in Hindi, to a non-retroflex sound involving the tip of the tongue such as English alveolar [d]. The Telugu sounds made with the underside of the tip of the tongue may be at or near the endpoint of this continuum. But the Hindi speakers use an articulation somewhere near the midpoint of the continuum. They choose to make their stops just slightly behind the alveolar ridge, so that they are not like the Telugu stops, but nor are they like the lingual stop in other languages such as English." (p. 299)

Also critical to determining the quality and quantity of a sound's phonetic cues is context, e.g. position in a word or phrase, quality of neighboring sounds, prosodic (non-) prominence, etc. 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

[14] 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 words such as Bladon 1986, Bregman 1990 and Johnson 1997 for in-depth discussion of the principles of auditory and acoustics phonetics and how these principles relate to parsing information in the speech signal.

example. Preceding a vowel, 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 being 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 19xx). 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 2001). The occurrence of a sound in an unstressed, as opposed to stressed, syllable can also result in weak cues due to, e.g., 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 & Edwards (1990) 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, in particular, is entirely dependent on contextual cues. As Blumstein & 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, Stevens & Blumstein 1978, Halle et al. 1957, Malécot 1956, Wang 1959). 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, on the other hand, bursts are frequently lacking. Prevocalic position is also favored for stops since CV transitions provide better cues than VC transitions (Fujimura, Macchi, and Streeter 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, Wright 1996, Mielke 2001; though see Steriade 1995 on retroflexion).

As 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, 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, 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." As outlined just below, knowledge of native language patterns also has a strong impact on how we process phonetic cues.

2.2 THE INFLUENCE OF PHONOLOGICAL KNOWLEDGE ON PROCESSING SPEECH

Speech processing is influenced not only by the acoustic/auditory cues present in the speech signal, but also by the knowledge that we have of our language (see, e.g. Lindblom 1990; Luce 1986). Research in first and second language acquisition has shown that native language familiarity enables us to fine-tune our ability to process the words and sounds of our language. Perceptual learning occurs as babies' perceptual systems become tuned to language-specific phonetic patterns, such as typical vowel formant ranges (e.g. Best, 1994; Kuhl, et al., 1992). One consequence of this fine-tuning is that listeners are more adept at perceiving sounds of their native language than those of

a second language acquired later in life (Best et al. 1988; Dupoux et al. 1997; Francis & Nusbaum 2002; Polka & Werker, 1994).

Speech processing is facilitated by a listener's familiarity with his/her language's phonological system, including sounds (Pitt & Samuel 1990), phonotactics (Halle et al. 1998, Massaro & Cohen 1983, Pitt 1998; Pitt & McQueen 1998), patterns of contrast (Lahiri and Marslen-Wilson 1991; Otake et al. 1996; Dupoux et al. 1997; Harnsberger 1991; Hume & Johnson 2002), and syllable structure (Cutler 1976; Finney et al, 1996; Pallier et al, 1992; Pitt et al, 1998; Treiman & Danis, 1988). For example, listeners are biased to parse consonant clusters that are phonotactically impermissible into permissable sequencs (Halle et al. 1998, Massaro & Cohen 1983, Pitt 1998). Pitt 1998 found that an epenthetic schwa was 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. For example, Otake et al. (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 concerning the place of articulation of a following stop. Dutch listeners, on the other hand, 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 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).

These studies underscore the important fact that since languages differ in terms of their lexicons and phonologies, the influence of linguistic knowledge on speech processing is necessarily language specific. We learn to focus our attention on the phonetic cues that are important for distinguishing the meaningful elements of the language while ignoring those that are not. This then yields 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, as seen above. The language specific bias in speech processing has important implications for predicting the direction of metathesis since it means that a signal may be parsed in different ways depending on the linguistic system of the speaker/hearer.

Familiarity with the *usage* of elements that make up one's language also influences speech processing. As Makashay 2001 points out, the perception of words is affected by their frequency of occurrence, the number of neighboring words that are phonetically similar to them, the predictability of the segment sequences, and how familiar they are to

the listener, among other factors (Pollack et al 1959, Savin 1963, Luce 1986, Luce and Pisoni 1998, Pitt and McQueen 1998, Vitevitch and Luce 1999, Frisch, Large and Pisoni 2000). With respect to word frequency, for example, the higher the frequency of a word, the higher is its probability of being correctly recognized (Luce 1986; Sereno and Jongman 1997). 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 & Liebber 1991, Bybee 1985, 1995,; Lobben 1991, Moder 1992, Wang and Derwing 1994). Frequency of individual sounds and sound sequences also impacts recognition in infants and adults (Coleman and Pierrehumbert 1997; Makashay 2001; Pitt & McQueen 1998; Pitt & Samuel 1990; Pierrehumbert 1994; Saffran et al 1996; Vitevich et al 1997; Vitevitch & Luce 1998, 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; Vitevich et al 1997).

2.3 SUMMARY

As outlined above, speech processing is dependent on a number of factors, including the nature of the sounds involved and the context in which the sounds occur. It is also facilitated by the knowledge an individual has of his/her language. This naturally includes familiarity with the elements that make up the language but also their patterns of usage, including frequency of occurrence. As I show just below, each of these factors plays an important role in predicting the metathesis.

3. PREDICTORS OF METATHESIS

In this section, we shift our focus to discussion of the factors predicting the likelihood of metathesis. As noted above, I argue that for metathesis to occur, two conditions must be satisfied. First, the information concerning a combination of sounds in the input must be ambiguous. Second, the order of sounds opposite to that which occurs in the input must be attested in the language. If these two conditions do not hold, metathesis is unlikely to occur.[15] Ambiguity in the signal sets the stage for metathesis; an individual's knowledge of his/her sound system and its patterns of usage influence how the signal is processed and thus, the order into which the sounds are parsed.

[15] This is not intended to suggest that *every* time these conditions are met, metathesis will occur; these are *necessary* but not *sufficient* conditions. Just as all instances of co-articulation do not result in phonological assimilation, not all sound combinations with the factors outlined below will result in metathesis. Clearly, other factors, both cognitive and social, must be taken into account. Despite the importance of this topic, it extends beyond the goals of the present paper.

3.1 THE INPUT: AMBIGUITY

When we consider the input, the most important factor determining the likelihood of metathesis occurring is ambiguity regarding a given sound combination (see Fay 1966; Blevins & Garrett 1998; Steriade 2001). Support for this claim comes first, from the observation that in many languages, the ordering of a cluster of sounds is variable, suggesting confusion regarding the temporal organization of the sounds. The pairs of sounds involved in these cases are representative of those found in regular metathesis processes, to be seen further below. For example, in the Peruvian language Aymara, in roots with an adjacent labiovelar glide [w] and sonorant consonant, the sounds occur in both orders ([mw] and [wm] are impossible consonant clusters in the language) (Davidson 1977).

(13) Aymara

čilwi	~	čiwli	'baby chick'
k'anwa	~	k'awna	'egg'
čaʎwa	~	čawʎa	'fish'
qiʎwa	~	qiwʎa	'gull'
qarwa	~	qawra	'llama'
t'arwa	~	t'awra	'wool'
pirwa	~	piwra	'bin'

In Mokilese, the order of labial and velar stops varies within the speech community (Harrison 1976, p.c.). According to Harrison's observations, there is no evidence for selecting one variant as more basic than the other.

(14) Mokilese

apkas	~	akpas	'now'
dipkelkel	~	dikpelkel	'to stumble'
kapki:la	~	kakpi:la	'to drop'
ap^{w}kan	~	akp^{w}an	'in a little while'
ep^{w}ki	~	ekp^{w}i	'hundred'

Drachman (1969) reports that in the Salishan language, Twana, variation occurs in the temporal ordering of a glottal stop and an adjacent consonant or vocoid, as in (15).

(15) Twana

héʔd	~	hédʔ	'a long time'
scóʔb	~	scóbʔ	'crab-apple'
dəčáʔd	~	dəčádʔ	'where'
bəščáʔd	~	bəščádʔ	'louse'
c'ałáʔd	~	c'ałádʔ	'coal'
słóʔb	~	słóbʔ	'soup'

hoʔólʔ	~	hoʔóʔl	'really'
sqwəbáyʔ	~	sqwəbáʔe	'dog'
dəxwláwʔbəd	~	dəxw-láʔobəd	'strainer'
pálʔel	~	páʔlel	'resurrect'

Variation in the linear ordering of sounds is also reported in Amharic (Appendix), Turkana (see p. 17), and Ayacucho Quechua (Appendix), among many other languages.[16]

A second source of evidence for the claim that ambiguity in the input is a necessary condition for metathesis comes from the types of sounds involved in metathesis. As will be detailed just below, targets of metathesis can be classified into two general, yet overlapping, groups. The first group is characterized by diminished perceptual salience: the sounds involved are acoustically/auditorily similar and/or important phonetic cues to their identification are masked (Hume 1998). In the second group, perceptual salience is less of an issue since information about the identity of the sounds is present in the signal and the types of phonetic cues exploited for the two sounds are qualitatively different. Rather, the issue is one of temporal resolution and involves sounds with phonetic cues of relatively long duration (Blevins & Garrett 1998). As I show just below, the defining phonetic characteristics of these classes of sounds are key sources of ambiguity concerning the temporal organization of the sounds in question.

A third type of evidence comes from the observation that the input sequence either occurs infrequently in the language or does not occur at all. Low sequence familiarity not only contributes to ambiguity in the input, it is also an important predictor of the output of metathesis. Ambiguity is thus conditioned by both universal (psychoacoustic cues of the sounds) and language specific factors (the listener's familiarity with the sound combination).

As evident in the preceding discussion, our focus is on ambiguity in an auditory signal though I speculate that ambiguity in a visual signal could also result in misparsing the order of sounds. Factors contributing to ambiguity 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, etc.[17]

3.1.1 DIMINISHED PERCEPTUAL SALIENCE

Ambiguous sound sequences resulting from diminished perceptual salience involve either similar sounds or those where acoustic/auditory cues to the identification of at least one of the sounds is potentially masked.

Consider first similarity. Given, as discussed in section 2.2, that modulation in the speech signal contributes to the salience of a segment's cues and hence, the identification

[16] Variation also occurs in lexical items in some varieties of English, as is well known. In the region where I live, for example, variation can be heard in the ordering of sounds of words such as, preserve ~ perserve, secretary ~ secertary, Chipotle ~ Chipolte (name of a Mexican restaurant), among others. Variation occurs both within the speech of a single speaker as well as across speakers.

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). It is important to keep in mind, however, that while low salience is an important source of ambiguity, it is reasonable to assume that at least some information concerning the identity of both sounds must be present in the signal for metathesis to occur; that is, for the order of two sounds to be misparsed, at least some information about the two sounds needs to be available.

That acoustic/auditory similarity is an important conditioning factor in metathesis comes from the observation that of the 34 cases of synchronic 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 & 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 synchronically in Georgian (Appendix), Chawchila (3b), Old Spanish (5a), Deg (Appendix), Aymara (13) and Turkana (see just below), and diachronically in Classical Greek (Appendix), among other languages. Ordering reversals involving two fricatives occur sychronically in Hixkaraya (16), between two stops in Kui (Appendix), Kuvi (Appendix) and Mokilese (14), as well as diachronically between stops again in Classical Greek (Appendix). Homorganicity is a condition on metathesis in Modern Hebrew (17) and Udi (6), among others. Identity in place is also crucial in Rendille (Appendix) and Bedouin Arabic (Appendix) where metathesis involving the pharyngeal fricative is restricted to words in which the pharyngeal 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 followed by identical vowels, e.g. ŋa-kɛ̀mɛ̀r-à ~ ŋa-kɛ̀rɛ̀m-à 'mole', ŋi-kwaŋɔ̀rɔmɔk-à ~ ŋi-kwaŋɔ̀mɔrɔk-à 'kind of tree' (Dimmendaal 1983).

Diminished perceptual distinctiveness can also result from the masking of acoustic/auditory cues to the identification of at least one of the sounds involved. Given the discussion in section 2.2 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 C/C metathesis cases examined involve a stop consonant. Recall from above, 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, on the other hand, bursts are frequently masked. It is to be expected then that a stop occurring in preconsonantal position shifts to prevocalic position by metathesis, as exemplified by cases in Fur (Appendix), Modern Hebrew (17), Udi (6), Oromo (Appendix), Sidamo (10) and Elmolo (9). 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 to be expected. Recall that in these cases the stop is sandwiched between two consonants in the input, yet surfaces adjacent to a vowel in the output. In each of these cases, masking of important phonetic cues to the manner and especially place of articulation of a stop consonant contributes to ambiguity in the signal, thus creating a favorable context for metathesis to occur.

3.1.2 TEMPORAL RESOLUTION

Blevins & Garrett's (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, synchronic as well as diachronic. At least one of the consonants is glottal in Pawnee (3), Hixkaryana (16), Balangao (1), Basaa (4), Cebuano (Appendix), Cherokee (Appendix), Estonian (Appendix), Hanunoo (Appendix), Harari (Appendix), Hungarian (2), Mandaic (Appendix) and Twana (15). A glide metathesizes with a consonant in Chawchila (Appendix), Cherokee (Appendix), Kota (Appendix), Yagua (Appendix), and Zoque (Appendix). A liquid is involved in Elmolo (9), Gidole (Appendix), Hungarian (2), Mandaic (Appendix), Pawnee (3), Rendille (Appendix), Deg (Appendix) and Chawchila (5b, Appendix), among others. As will be noticed by these listings, in some cases more than one type of consonant is involved. Drawing on Ohala's research on dissimilation, Blevins & 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 ambiguity concerning the onset and offset of the sounds involved. An example of this type of overlap can be seen below in the spectogram below of an /h/-vocoid cluster, drawn from the ViC corpus of spontaneous American English speech.[18] Both the vocoid and glottal fricative have 'stretched out' features (frication for /h/ and formant structure for the vocoid) and in this case results in overlapping of acoustic cues.

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

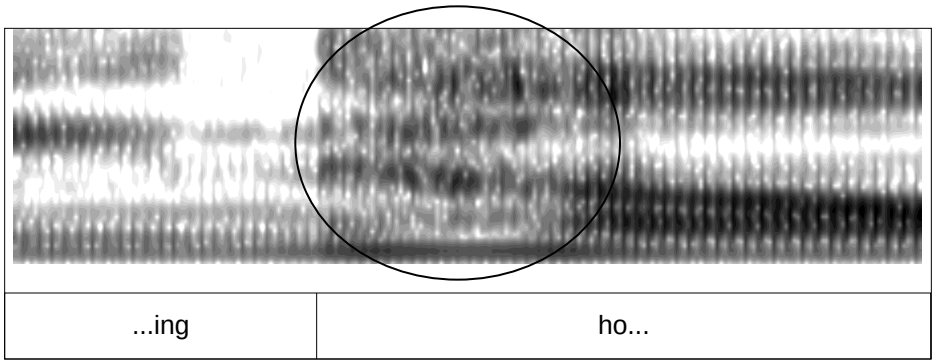

Figure 1: Spectogram of a portion of the phrase 'being home', with the overlapping of acoustic cues for the glottal fricative and vowel encircled.

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 Figure 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 then ambiguity is caused less by weak perceptual cues and more by ambiguity concerning the onset and offset of the respective consonants; that is, it is an issue of temporal resolution.[19]

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 ambiguity. For example, despite the fact that /h/ is produced with a 'stretched out' feature, the case of Hixkaryana 'h + fricative' metathesis seen in (16) 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 /**S**/ would otherwise be followed by morpheme-initial /h/ as the result of morpheme-final vowel loss. (The bilabial fricative, the only other fricative in the language, does not co-occur with /h/.)

(16) Hixkaryana (Derbyshire 1979, 1985)

ahosɨ + hira	ahohsɨra	*ahoshira	'not catching it'
w + ama+ʃe +haka	wamahʃaka	*wamaʃhaka	'let me cut it down'

[19] Temporal ambiguity 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 phenomena 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 & 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.

Of course, this does not rule out the possibility of more than one factor contributing to the ambiguity of a sound combination. For example, in Modern Hebrew and Udi metatheses, both sounds share the same feature value [-sonorant], 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 misparsed.

3.1.3 SEQUENCE FAMILIARITY

In our discussion of factors contributing to ambiguity, the focus thus far has been on the phonetic cues of the sounds involved without taking into account language specific influences on speech processing. Yet, as discussed in section 2.3 that how a listener processes the acoustic/auditory cues of a given sound is influenced by knowledge of native sound patterns. Listeners learn to focus attention on the relevant cues in the signal, and to ignore others. Consequently, if the order of sounds in the input does not occur in the language, the listener may not be tuned to the cues that may aid the listener in identifying the sound combination. We then expect listeners of different languages to process sound combinations differently if in one language the sequence occurs, while in the other, it does not.

These are precisely the findings of cross-linguistic research in speech perception. For example, Mielke's (2001) study of the perception of [h] in different phonological contexts by listeners of languages with different degrees of familiarity with these sequences 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 the 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 perception of /h/ cross-linguistically provide insight into observed patterns of metathesis involving the glottal. In some languages, such as 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, on the other hand, we find the mirror-image. Of particular interest is the observation that the input order in each case is a non-occurring or infrequent sequence in the language. I would suggest that due to the listener's low degree of familiarity with the input in these cases, the listener's sensitivity to the sequence is weak, thus adding to ambiguity contributed by raw psychoacoustics of the sounds themselves. While native language

knowledge is an important factor predicting what kind of sound sequence is likely to undergo metathesis, the discussion below will show this knowledge to be perhaps even more instrumental when we consider the nature of the output.

3.1.4 SUMMARY

In the preceding discussion I have argued that ambiguity in the input signal provides a favorable context for metathesis to occur. Factors relating to the phonetics of the sounds in conjunction with the viability of the sound sequence in the language contribute to a listener's ability to extract information regarding the order of the sounds from the signal.

3.2 THE OUTPUT: SEQUENCE ATTESTATION

Turning now to the output, we shall see that native sound patterns exert a strong influence on the direction of metathesis. In fact, a second condition predicting the likelihood of metathesis is that the order of sounds opposite to that occurring in the input is attested in the language. As I outline just below, this proposal is strongly supported by observed patterns of metathesis as well as by experimental studies investigating the perception of order. This approach is also consistent with earlier proposals suggesting that by metathesis, uncommon sequences of sounds are replaced by more common ones (see, e.g., Grammont 1933, Ultan 1978, Hock 1985). Importantly, the (un)commonness of a given sequence is determined on a language specific basis.

Consider first the experimental evidence. As discussed in sections 2.2. and 3.1.3, the way that a signal is processed is strongly influenced by one's native language. Particularly important for our purposes is the finding that this influence is strongest when information specifying a sound or sound sequence is ambiguous (Pitt & McQueen 1998). In such a case, a speaker/hearer is biased to parse an ambiguous signal in a manner consistent with the attested patterns of the language. This is relevant for the identification both of sounds and their order. With respect to the former, McQueen & Pitt (1998) 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. Similar conclusions can be drawn regarding the identification of order. In Broadbent & 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, Wickelgren 1969 on the role of inference in perceiving order). These studies suggest that a speaker/hearer makes use of his/her knowledge of native language patterns to facilitate identifying the order of sounds. This influence is strongest when information about ordering is ambiguous, in which case it is inferred, based on native sound patterns.

This conclusion is consistent with Makashay's (2001) study of the perception of obstruent order in English. Makashay used a lexical decision and repetition task based on naturally spoken American English words to test the effects of acoustic and lexical information on the perception of order. He presented subjects with words containing word-medial obstruent clusters of the shape (C)*VCCV(C)*, e.g. napkin. Stimuli were created by reversing the order of consonants in the medial cluster, thus creating metathesized non-words corresponding to actual English words, e.g. 'whiksy' from 'whisky', 'taski' from 'taxi'. Clusters varied in terms of their spoken and written frequencies, as well as in terms of the quality of the phonetic cues of the cluster. The subjects' task was to determine, as quickly as possible, whether the stimulus was a word of English. For subjects to identify the stimuli with metathesized clusters as a real word, it would require undoing the re-ordering of a medial cluster. The results indicate that clusters that occur less frequently and have poorer perceptual cues were more quickly identified by subjects as word-like than those clusters that occur with greater frequency and have better cues (see also Vitevitch and Luce 1999). The observation that less frequent clusters with poorer cues were more easily 'unmetathesized' underscores the finding that listeners are more apt to infer the order of sounds when the information provided in the signal is insufficient.

Attested cases of metathesis strongly support this conclusion. To my knowledge, the output of metathesis consistently conforms to an attested structure in the language; it does not result in the creation of a novel sequence, in other words, where /xy/ is realized as [yx] even though [yx] is otherwise unattested in the language. The direction of metathesis is thus constrained by the phonological system of the language in question. While this finding may not appear 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 order constitutes a licit structure in the language. Interestingly, metathesis is then different from phonological processes such as segment deletion since deletion can result in the creation of otherwise illicit sound sequences (see, e.g. Walker 1984 on schwa deletion in Canadian French). The reason for this difference may relate to metathesis as a processing-based phenomenon and so strongly influenced by possible elements of a language and their patterns of usage. Deletion, on the other hand, is driven by both processing and articulatory considerations and articulation mechanisms may be less influenced by what constitutes a possible structure of the language. I leave this issue open for future consideration.

The claim that a speaker/hearer is biased to parse a string of sounds in a manner consistent with attested patterns in the language makes strong predictions concerning what makes a preferred metathesis output. When only a single order of a 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 an intervocalic consonant/glottal combination as [VhCV]. Thus, if metathesis occurs, the preferred output will be [VhCV], as is the case in Pawnee and Basaa, shown in (3, 4). Conversely, with only [VChV] as the attested order, the

prediction is that a temporally ambiguous intervocalic consonant/glottal combination will be parsed as [VChV], as seen in Hungarian and Cebuano metathesis.

This approach also makes clear predictions regarding the preferred output 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 language, we predict that when both orders of a pair of sounds are attested in a language, the listener will be biased toward the most robust order, that is, the order 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 is with regards to that sequence. Evidence for this claim comes from metathesis in, among other languages, Balangao, Cebuano, Modern Hebrew, Kuvi, and Mutsun, as presented just below.[20]

Recall from (1) that in Balangao metathesis, the expected ordering of a laryngeal [ʔ, h] before a nasal or oral plosive is reversed, thus yielding a plosive, laryngeal output (Shetler 1976), e.g. /pʌhɨd-ɨn/ [pʌdhɨn] *[pʌhdɨn] 'allow, accept', /CV(Red)-ʔɨnɨm/ [ʔɨnʔɨm] *[ʔɨʔnɨm] 'six each'. While laryngeals are not strictly excluded from coda position, the general tendency is for them to occur prevocalically, e.g. [heet], [manhamal], [lehet], [qaho], [bʌtʔong]. Preconsonantal laryngeals are highly restricted occurring only: at a morpheme boundary, e.g. /manoʔ-na/ [namoʔna] 'chicken, his'; as a geminate, 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 laryngeal remains in preconsonantal position. As predicted, the shift observed in the Cebu City dialect is consistent with observed patterns in the language. In Wolff's (1972) lexicon of approximately 7,500 words, preconsonantal [ʔ] occurs in only 8 lexical items, [h] occurs in none. While the glottal stop is also rare postconsonantally, the glottal fricative, on the other hand, occurs in 132 forms. Based on these findings, the shift of the laryngeal from preconsonantal to postconsonantal position is consistent with the most robust laryngeal/consonant pattern in the language.

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 (17a) (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). However, when the stem-initial consonant is a coronal sibilant (c, s, z, ʃ), the /t/ of the prefix occurs to its right, as in (b) (Bat-El 1988, 1989).

[20] 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 due 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.

While the sequence [t] + [strident] occurs in the language, Bat-El (1988, p.c.) reports that it is less common than the opposite order; it is restricted to tautomorphemic forms such as [hi+tsis] 'he fermented' and non verbal forms like [tʃuva] 'reply'.

(17) Modern Hebrew

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'

Consider next metathesis in the Dravidian language, Kuvi (Israel 1979). In this case metathesis results in a change in the prosodic structure of words, as shown in (18). Vowel deletion, a common process in the language, sets the stage for metathesis; the expected sequence resulting from deletion is [CV:CCV], indicated to the right of the actual surface form. Note that in each case, the second consonant is a sonorant, consistent with the observation that all word-initial clusters in the language have a sonorant in second position.

(18) Kuvi

Input	*Output*	*Expected order*	*Gloss*
ḍori-ka	ḍroka	*[ḍorka]	'ropes'
minu-ka	mn̩ika	*[mniṇka]	’fish’
penu-ka	pn̩eka	*[peṇka]	’lice’

The change in prosodic structure by reordering is driven by a dispreference for word-initial superheavy syllables. In Israel's lexicon of approximately 3,100 words, the number of words containing an initial heavy is 699 while only 194 have an initial superheavy syllable. Of this last group, 164 of the forms have medial homorganic clusters, while only 30 are non homorganic. If we exclude homorganic clusters from our comparison count, given that homorganicity is not a condition on metathesis, words with initial heavy syllables occur more than six times as frequently as do those with superheavy syllables. This finding is consistent with the proposal that the output of metathesis conforms to the most common ordering of elements in the language, defined here in terms of prosodic structure.

Finally, anecdotal evidence for the influence of native language patterns on metathesis comes from a change currently underway in Columbus, Ohio, regarding the name of a new Mexican restaurant, Chipotle. The final two consonants are pronounced in either order, i.e. Chipotle or Chipolte. An examination of the frequencies of 'tl' and 'lt'

in the online MRC Psycholinguistic database of English reveals that tautosyllabic 'tl', the original form, occurs in 67 forms while the innovative 'lt' sequence occurs in 356 words.

In the examples just presented, the output of metathesis not only corresponds to the more frequent order of a combination of sounds, it arguably also has more salient acoustic/auditory cues than the opposite order. This 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. This is supported by Makashay's (2001) study of English clusters. He found that the spoken and written word frequencies of intervocalic clusters hypothesized to have better acoustic/auditory cues (indicated by ><) are generally higher than the opposite orders, as shown in Figure 2. The only case in which this is reversed is with [ks, >sk<]. Based on phonetic cues alone, the sequence VskV is predicted to be better acoustically, although [ks] occurs in more words.[21]

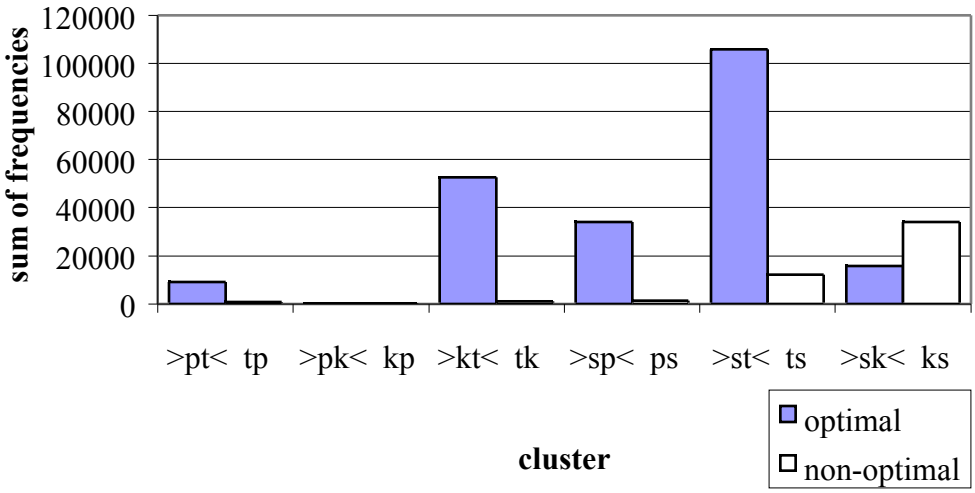

Figure 2. Sum of spoken and written frequencies of *VCCV* English words in the COBUILD 16.6 million written word corpus and in the COBUILD 1.3 million spoken word corpus in CELEX (Makashay 2001).

It is important to point out that improved acoustic/auditory cues in the output is not a trait of all cases of metathesis. Recall from the discussion above that either order of a given sound combination can occur as the output of metathesis in some language. Maintaining the view that metathesis serves to enhance the phonetic cues to the identification of sounds is thus problematic given such patterns (Blevins & Garrett 1998; cf. Hume 1998, 2001; Steriade 2001). As I show just below, in Mutsun metathesis, for example, a stop consonant occurs in a position where the cues to its place and manner identification are arguably less salient, i.e. preconsonantally as opposed to prevocalically. While such cases are less common than those in which the acoustics of the output appear

[21] The observation that the sequence [sk] in some varieties of English is produced as [ks] in others is consistent with the observation that the latter order occurs at a higher rate.

improved, such 'non-optimized' cases are nonetheless attested. This observation receives a straightforward explanation given the view of metathesis developed in this paper.

Metathesis in the Costanoan language Mutsun, as shown in (19), involves the commonly occurring nominal thematic plural suffix, which has two alternants: [-mak] and [-kma] (Okrand 1977).

(19) Mutsun

ru:k	ru:k-mak	'string'
hu:s	hu:s-mak	'nose'
wimmah	wimmah-mak	'wing'
kahhay	kahhay-mak	'head louse'
ʔinnis	ʔinnis-mak	'son'
rukka	rukka-kma	'house'
to:ṭe	to:ṭe-kma	'deer, meat'
čiri	čiri-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].

(20)

ʔurkan	ʔurkan-tak	'mortar'
lo:t	lo:t-tak	'mud'
ṭarah	ṭarah-tak	'sky'
pappel	pappel-tak	'paper'
pire	pire-tka	'world, land'
rukka	rukka-tka	'house'
si:	si:-tka	'water'
pa:rani	pa:rani-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 (19) and (20), it will be noticed that a further change is involved in the nominal thematic suffix. Not only do the variants differ with regards to whether they end in an open or closed syllable, the linear ordering of the consonants also changes: in the allomorph [-kma], [k] precedes [m], while in [-mak], [m] precedes [k]. If we follow the pattern of the locative [Ctak, Vtka], we would expect the nominal thematic suffixes to be [Cmak, *Vmka]. Instead, we find [Cmak, Vkma], consistent with the observed patterns of the language. According to Callaghan (p.c.), there is no general constraint against clusters consisting of nasals plus non-homorganic obstruents, e.g. ʔamši 'so that', namti 'to hear', janpu 'to praise oneself',

riṇta-n 'to get skinny', although some are more common than others. For example, the frequency of [ms] clusters may be due to the -s- infix, which indicates duration or plurality. Clusters of [mk], on the other hand, are rare. Some forms were recorded by Felipe Arroyo de la Cuesta (1815-1860), e.g. omkon 'maggot', hemkon 'to set (sun)', though according to Callaghan's investigations, none with this cluster were judged acceptable by John Harrington's informant, Dona Ascensión Solorsano de Cervantes. This suggests that either the cluster [mk] was rare in the dialect of Harrington's consultant, or it did not occur at all. Either case is consistent with the view that the direction of change in metathesis is influenced by native sound patterns, particularly given that there are no restrictions on sequences of intervocalic [km].

Mutsun labial/velar metathesis is of interest since it provides a case opposite to what we would expect from a strictly phonetic cue-based approach. That is, changing the order does not seem to significantly improve the overall acoustic/auditory cues of the sounds involved. Recall from section 2.2. 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 we take into account sound patterns of each language. In Sidamo, for example, sequences of Vstop,nasalV are non-occurring, while in Mutsun they are common. Conversely, sequences of Vnasal, stopV are robust in Sidamo, while restricted in Mutsun. This strongly suggests that improving the overall psychoacoustic (i.e. universal) cues of a sequence is not the only factor driving metathesis. Conforming to the patterns of usage of a given language can be equally important, a view consistent with earlier proposals of, among others, Grammont (1933), Ultan (1978) and Hock (1985).

4. METATHESIS OBSERVATIONS REVISITED: EXPLANATIONS

As outlined above, 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, we are able to provide straightforward answers to the observations raised at the beginning of this paper, repeated in (21).

(21) 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 cross-linguistically as the result of metathesis, while for other combinations, one order appears just as frequently as the other.

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 in metathesis, the acoustic/auditory cues to the identification of a sound sequence are frequently improved. For example, as we have seen it is common to find metatheses where 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. Less common are cases in which the reverse obtains. 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, it will be recalled that the most important predictor of metathesis is ambiguity; without it, metathesis is unlikely to occur. We have also seen that the phonetic cues to the identification of the input sounds can play a key role in contributing to this ambiguity. This may involve diminished perceptual salience due to similarity between the sounds, or the masking of perceptual cues. Temporal ambiguity can also result from lack of clarity concerning the onset or offset of sounds due to 'stretched out' cues. As outlined in section 3.1, each of these scenarios provides a favorable context for metathesis. Given this, what kind of sound combination resists metathesis? Clearly, the answer must be those with robust perceptual cues since there is sufficient information concerning the identity of the sounds and their order. As a result, sounds with strong cues are more stable, less subject to confusion regarding their order, and less likely to metathesize. Conversely, inputs with poorer cues are more confusable and more likely to undergo metathesis. By taking into account the nature of the input, it is then clear that one reason why many metatheses involve an improvement in perceptual salience is because the most likely candidate 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 order of sounds 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 (21) 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 ambiguous, and less likely to undergo metathesis. This then suggests that the reason why 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 the ambiguous speech signal is parsed (cf. Hume 1998, Steriade 2001).

This view of metathesis also provides a straightforward explanation for our second observation: for some sound combinations, one order is favored cross-linguistically as the result of metathesis, while for others, one order appears just as frequently as the output of metathesis as the other. The first type is exemplified by cases involving plosives/fricatives. As we have seen, the stop typically metathesizes to a cue-richer context, resulting in a perceptually optimized sequence. Metatheses involving these same kinds of sounds but where the stop shifts from an arguably cue-richer to a cue-poorer context are clearly less frequent. The reason for the infrequency of these cases should be clear: sounds occurring in a cue-richer context will tend to provide sufficient information to allow the sounds and their ordering to be identified. Thus, the reason why one order is favored in such sequences is because, all else being equal, only one order of the sounds generally displays ambiguity. For other types of sound combinations, ambiguity may arise regardless of the order in which the sounds occur, due to the nature of the sounds, and/or the context in which the they occur. Common examples include sounds sharing the same manner and/or place features, or sounds with phonetic cues of long duration, as seen above.

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 we take into account two important factors: ambiguity in the signal and the influence of native phonology on speech processing. Recall that this influence is strongest when information specifying a sound or sound sequence is ambiguous. We then correctly predict greater variability in the direction of metathesis in those cases where ambiguity arises regardless of the order of the sounds, as discussed just above. 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 ambiguous speech signal.

5. CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH

In this paper, I have focused on one aspect of the study of metathesis: the factors that enable us to predict its likelihood. As I hope to 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 ambiguity in the signal concerning a combination of sounds; and second, the order of sounds opposite to that which occurs in the input must be attested in the language. Ambiguity in the signal sets the stage for metathesis; a speaker/hearer's knowledge of the sound system and its patterns of usage influence how the signal is

processed and thus, the order into which the sounds are parsed. The greater the ambiguity, the more the speaker/hearer must rely on native language knowledge to infer the temporal ordering of the sounds.

Observed patterns of metathesis point to metathesis as processing-based. Support for this view comes from the observation that the output of metathesis always conforms to an existing pattern in the language. This then sets it apart from articulatorily-driven phenomena such as segment deletion by which otherwise illicit structures can be created. Additional evidence for the processing-based nature of metathesis comes from the findings of Mielke & Hume (2001a) concerning the influence of word recognition on cross-linguistic patterns of metathesis. Their findings reveal that: a. ordering reversals are dispreferred at the beginning of a word or root, and b. metathesis, particularly synchronic, 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, Halle 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. These naturally include those bearing directly on the claims made in this paper, as well as those extending beyond the topics raised here. For example, in section 3.1 I speculated that ambiguity in a visual signal could also result in misparsing the order of sounds. If correct, this may provide further insight into the interplay between language sound patterns and the general mechanisms involved in cognitive processing (see Hume & Johnson 2001 for related discussion). Clearly, experimental work is needed to test the validity of this hypothesis. Additional facts concerning metathesis are also ripe for further investigation. These include the observation that while many cases of consonant/vowel metathesis have acquired morphological status in the respective language, to my knowledge no cases of consonant/consonant metathesis have. Another is that, again to my knowledge, no cases of vowel/vowel metathesis are attested.[22] I suspect that upon closer scrutiny the account developed in this paper will also be relevant to our understanding of this observation. For example, we may suppose that the nature of a signal including (especially) non-adjacent vowels does not result in the necessary ambiguity for metathesis to occur.

Aspects of this study also bear on areas of current interest in phonological theory and merit further consideration. One relates to the impact of external factors on language sound systems. Assumed in this work is the view that an individual's cognitive symbolic representation of language is influenced by many factors, including phonetics, social conditioning, and processing constraints (see Hume & Johnson 2001a). The result is an integrated phonological representation constrained by existing sound patterns in the language, as we have seen in this study. While extra-linguistic factors are external to formal descriptions of language, the extent to which they provide insight into the nature

[22] Chomsky & Halle (1968) claim that Kasem has V/V metathesis though Phelps (1975, 1979) convincingly shows that this is not a case of metathesis.

of these descriptions advances our understanding of both formal and cognitive aspects of language systems.

Consider, in this regard, the relevance of the present study to our understanding of the nature of Optimality theoretic constraints. Potential output forms in OT are evaluated on the basis of a hierarchy of two types of violable constraints: faithfulness and markedness (see e.g. Prince & Smolensky, 1993; McCarthy & Prince, 1993; McCarthy & Prince, 1995). As McCarthy (2002:13) points out: "Faithfulness constraints require identity between the input and the output candidate under evaluation...markedness constraints evaluate the form of the output candidate, favoring certain structural configurations." Included in the set of faithfulness constraints is LINEARITY, given in (22) (McCarthy, 2000; McCarthy & Prince, 1999), which penalizes the reversal of precedence relations among segments in a string (S). As such, forms displaying metathesis incur a violation of LINEARITY.

(22) **Linearity**: "No Metathesis" (McCarthy & Prince, 1999)
S_1 is consistent with the precedence structure of S_2, and vice versa.

The subordination of LINEARITY to a relevant markedness constraints forces a change in segment ordering. Thus, like all faithfulness constraints, LINEARITY may be violated as a means of satisfying a higher ranked markedness constraint.

This formal approach accords well with the results of the present study in that the output of metathesis can be predicted by attested patterns of the language, formulated in terms of markedness constraints (see, e.g. McCarthy 2000; Hume 2001). However, this study raises two issues regarding the nature of these constraints. The first concerns their quality of absoluteness: a structure is either allowed or disallowed. Constraint absoluteness becomes an issue when we attempt to describe patterns of metathesis in which the input sequence is not an illicit structure of the language. Recall that in Kuvi, for example, a change in prosodic structure by reordering is driven by a *dispreference* for word-initial superheavy syllables. Initial superheavy syllables are not ruled out entirely, they are simply less frequent than non-superheavy syllables. Consequently, ranking Linearity below a markedness constraint penalizing word-initial superheavy syllables does not correctly reflect the language's sound patterns. Alternative formal devices may provide a solution to this problem. For example, an enriched inventory of constraints may include weighted constraints, reflecting the observed frequency of sound patterns, or 'soft' constraints which identify certain structures as merely dispreferred rather than ruled out absolutely. A second issue relates to the typical formulation of markedness constraints in negative terms: *X (X is prohibited). While positive constraints such as Onset (an onset is required) have been proposed, they are rare. It may be the case, however, that constraints motivating changes in segment ordering are best characterized in positive terms. In this way, metathesis in Kuvi would be driven by a constraint which encodes a *preference* rather than a *dispreference* for a certain prosodic structure. Positive constraints reflect the observation that metathesis is driven by the *presence* of sound patterns in the language, not their *absence*. The formal description of metathesis may

thus be enriched by our knowledge of the impact of extra-linguistic factors on language sound systems.

APPENDIX:
ADDITIONAL METATHESIS DATA

(23) ***Amharic*** (Abraham 1968; Dawkins 1969)
In words with initial 'ri', the vowel is optionally transposed.

irda	~	rida	'help!'
irkus	~	rikus	'defiled'

(24) ***Ayacucho Quechua*** (Parker 1969)
Parker notes that there are a large number of stems that have freely alternating shapes. Metathesis is one of the ways in which the stems vary.

čaʎwa	~	čawʎa	'fish'
tapsi-	~	taspi-	'to shake'
ʎapča-	~	ʎačpa-	'to feel'
warma	~	wamra	'boy, girl'

(25) ***Bedouin Arabic*** (Al-Mozainy 1981; Al-Mozainy et al. 1985; Hume 1998).
The CVCCVC verbal pattern exemplified by the forms on the left is modified just in case a guttural consonant would follow a low vowel in preconsonantal position. In such cases, the guttural metathesizes with the preceding low vowel, thus surfacing in prevocalic position.

yašṛab	'he drinks'	yḥakum	*yaḥkum	'he rules'
taktib	'you write'	tʕarif	*taʕrif	'she knows'
nasbaḥ	'we swim'	nxaṭuf	*naxṭuf	'we snatch'

(26) ***Cebuano*** (Bunye & Yap 1971; Wolff 1972)
Metathesis occurs when two consonants are adjacent as the result of vowel loss.

a. In Cebu City dialect, the sequences /ʔC/ and /hC/ become [Cʔ] and [Ch] in affixed forms.

/káʔun/	'eat'	+	-a	→	kanʔa	'eat it'
/luhúd/	'kneel'	+	-an	→	ludhan	'kneel on'

b. These metatheses are similar to that observed in related languages Hiliganyon (Wolfenden 1971) and Tagalog (Blake 1925; Schachter, & Otanes 1972).
Bunye & Yap (1971):

inom	'drink'	+	/-on/	→	imnon	'drink something'
tanom	'plant'	+	/-an/	→	tamnan	'plant somewhere'
sulod	'inside'	+	/-on/	→	sudlon	'go inside something'

Wolff (1972):

ngálan	[ŋálan]	'name'	+	-an	→	nganlan	[ŋánlan]	'be named'
sulud	[sulúd]	'enter'	+	-un	→	sudlun	[súdlun]	'enter it'
inum	[ʔinúm]	'drink'	+	-a	→	imna	[ʔimna]	'drink it'
putus	[putús]	'wrap'	+	-un	→	pustun	[pústun]	'wrap it'

(27) ***Chawchila*** (Newman 1944, Stonham 1990)

a. Metathesis occurs in the intensive possessor suffix which displays two alternants, [-ilin] and [-inl-]. The VCVC alternant occurs word-finally while the VCC variant is realized before a vowel-initial suffix.

Intensive possessor suffix

tihṭilin	'one with many head lice'
paṭṭilin	'body-louse'
cawaːʔan paṭṭinl-i	' [he] shouted at the one with many body-lice'

b. Metathesis is also observed in the consequent adjunctive suffix which shows the alternants [-hal'iy'] and [-hay'l-]. The former form occurs finally in a phrase, or when preceding a word beginning with a consonant. The latter allomorph occurs when followed by a vowel-initial suffix, with deletion of the interconsonantal vowel of the morpheme.

Adjunctive suffix

xaya:hal'iy'	'place, put'
t'int'inhal'iy'	'stop repeatedly'
ʔamaʔ ʔam'ak' yɔʔ ta:winhal'iy' wo: ʔuy'ay	'and at dawn they fell asleep again'
ʔamaʔ yɔwmixhal'iy' ṭew yɔw'ke: ʔay yuk'law	'and the one who was taken home, returned to the grave'
xamithay'la maxk'a	'fetch the scythe'
wayax'an ʔamʔan xɔṭ'ɔy yuk'luwša:hay'law	'they are digging the ground in the cemetery'

(28) ***Cherokee*** **(**Foley 1980)

In the derivation of second singular forms, metathesis of a glide and a glottal fricative is observed.

	Counterfactive		*Cislocative*		
	yi-hi-nega	[hyinega]	wi-hi-nega	[hwinega]	'you'
cf.	yi-ji-nega	[yijinega]	wi-ji-nega	[wijinega]	'I'
	yi-ga-nega	[yiganega]	wi-ga-nega	[wiganega]	'he'
	yi-sdi-nega	[yisdinega]	wi-sdi-nega	[wisdinega]	'you'

(29) ***DEg*** (Crouch 1994; Hume 1997a)
Class 1 Dɛg nouns form the plural by addition of the suffix /-rɪ/, /-re/ or /-ri/ according to vowel harmony. When /r/ follows /m/ or /w/, metathesis occurs.

[nɔm]	[nɔrəmɪ]	'scorpion'
[dem]	[derəmi]	'house'
[nam]	[narəmɪ]	'type of tree'
[dom]	[dorəmi]	'sleep'
[bam]	[barəmɪ]	'hard part of fruit'

Some Dɛg verbs also form the plural by the addition of the suffix /-rɪ/. The final vowel is dropped before the suffix and the metathesis applies after vowel deletion if the second consonant of the CVCV verb is /m/ or /w/.

[sɪwɛ]	[sɪrəwɪ]	'to die'
[lawɛ]	[larəwɪ]	'to catch'
[umɛ]	[urəmi]	'to clench fist'
[samɛ]	[sarəmi]	'to wash'

(30) ***Estonian*** (Kiparsky 1967)
Southern Estonian shows a metathesis of Ch to hC, as shown in the following examples borrowed from Finnish.

Finnish	*Southern Estonian*	*Gloss*
jáuhan	jahvan	'I grind'
kárhu	kahr	'bear'
vánha	vahn	'old'

(31) ***Fur*** (Jakobi 1990; Mielke & Hume 2001)
When a consonantal person marker (/j-/ '2nd sg.', /k-/ '1st pl.', /b-/ '2nd pl.', etc.) is prefixed to a consonant initial stem, the stem initial consonant is either deleted or metathesizes with the following vowel, as shown in (a). In case metathesis with the following vowel results in the /ml/ cluster, those segments are metathesized, as illustrated in (b). The consonant sequence /lm/ may optionally undergo assimilation becoming [mm].

a. CV metathesis

verb root:	with C prefix:	
ba	C-ab	'drink'
bu	C-um	'tire'
lem	C-elm	'lick'
leiN	C-aliN	'wake up'

b. CV and CC metathesis:

bul	*C-uml	C-ulm	~	C-umm	'find'
bel	*C-aml	C-alm	~	C-amm	'speak'

(32) ***Georgian*** (Butskhrikidze & van de Weijer 2001; Hewitt 1995):
The thematic suffix –av reduces to –v in the masdar (verbal noun). This reduction results in the /v/ being adjacent to the sonorants, leading to metathesis. [23]

	k'l + av	k'vla	'you kill them'
	xn + av	xvna	'you plough them'
	jr + av	jvra	'you set them in motion'
cf.	rva	*vra	'eight'
	tvramet'i		'eighteen'

(33) ***Gidole*** **(**Black 1974)

a. An obstruent + lateral in related languages is realized as a lateral + obstruent in Gidole.

	Gidole Forms		*Forms in related languages*
	ɗilk	'elbow'	ɗiklá (Konso)
cf.	ɗiklét		
	malk	'pot handle'	maklá (Konso)
	silp	'metal'	siplá (Konso), sibíila (Galla)
	hols-	'to laugh'	xosal- (Konso)
			kobl-, kofl-, or kolf- (Borana Galla)
			qosl- (Somali)
	ɗílha	'charcoal'	ɗúHúl (Somali)

b. A velar stop + nasal in related languages is realized as a nasal + stop in Gidole.

Gidole Forms		*Forms in related languages*	
taŋk	'honey'	takmá (Konso)	
		taxma (Mashile)	
		dámma (Borana Galla)	
suŋk-	'to fall, topple'	sukm- (Konso)	'to roll'

c. A stop + h in related languages is realized as h + stop in Gidole.

Gidole Form		*Forms in related languages*
piht-tó	'left'	bídiH (Somali)

[23] Metathesis involves the fricative /v/ which patterns as a sonorant in this context (see Butskhrikidze & van de Weijer 2001).

(34) ***(Classical) Greek*** (Kiparsky 1967)

a. A PIE tautomorphemic coronal and velar stop sequence underwent metathesis in Greek.

PIE		*Greek*	
*titko:	>	[tikto:]	'beget'
*d^hg^hom-	>	[k^ht^ho:n]	'earth'
*tkey-	>	[ktizdo:]	'found'

b. Nasals, liquids and the glide 'w' metathesize with a following segment 'y'.
The glide 'w' metathesizes with 'y' regardless of what the preceding vowel is.
*dawyo > *daywo > daîo [dayyo] 'kindle'
*ewrewya > *ewreywa > eure ̂ia [ewreyya] 'wide (f.)'

Nasals and liquids metathesize with 'y' only after 'a' and 'o'.
*morya > moîra 'lot'
*phanyo > phaîno 'show'

(35) ***Hanunoo*** (Conklin 1953; Mielke & Hume 2001)

When a glottal stop would otherwise occur in preconsonantal position as the result of vowel syncope, the glottal stop and following consonant metathesize.

?usa	'one'	kas?a	'once'
?upat	'four'	kap?at	'four times'
?unum	'six'	kan?um	'six times'

C/V metathesis is also observed in numerals.

duwa	'two'	tigudwa	'two apiece'
tulu	'three'	tigutlu	'three apiece'
lima	'five'	tigilma	'five apiece'

(36) ***Harari*** (Leslau 1963; Semiloff-Zelasko 1973)

a. hr → rh
agäbäri gehri → agäbäri gerhi 'shepherd'
fuddi fohri → fuddi forhi 'worms of small children'

b. fh → hf
bufhaň → buhfaň 'bladder'

(37) ***Kota*** (Emeneau 1967, 1970; Semiloff-Zelasko 1973)

VC + y → VyC, where 'y' is the past tense marker for one class of verbs
ku:p + y → ku:yp 'blow with breath'
a:k + y → a:yk 'construct'
u:t + y → u:yt 'fix into ground by pressure'
taḷ + y → tayḷ 'push'

(38) ***Kui*** (Winfield 1928, Hume 1998)
In the second conjugation of verbs, the present participle and infinitive is typically formed by the addition of the suffixes /-pi/ and /-pa/, respectively. However, just in case the stem ends in a velar stop, the suffix-initial labial stop occurs to the left of the stem-final consonant. A similar situation holds in the fourth conjugation, although in this instance the stem-final consonant involved in metathesis is [g], while the prefixal consonant surfaces as [b].

Verb Stem	*Future*	*Past Participle*	*Present*	*Infinitive*	
Second Conjugation					
ah-	ahi	ahte	ahpi	ahpa	'to hold'
gas-	gasi	gaste	gaspi	gaspa	'to hang oneself'
mil-	mili	milte	milpi	milpa	'to turn over'
sap-	sapi	sapte	sappi	sappa	[no gloss given]
uṭ-	uṭi	uṭte	uṭpi	uṭpa	'to give to drink'
bluk-	bluki	blukte	blupki	blupka	'to break down'
kok-	koki	kokte	kopki	kopka	'to sit down'
mlik-	mliki	mlikte	mlipki	mlipka	'to turn over'
po:k-	po:ki	po:kte	po:pki	po:pka	'to announce'
lek-	leki	lekte	lepki	lepka	'to break'
ḍik-	ḍiki	ḍikte	ḍipki	ḍiksa	'to light a fire'
kak-	kakki	kakte	kapki	kaksa	'to laugh'
Fourth Conjugation					
sol-	soli	soṭe	solbi	solba	'to enter'
paṇ-	pai	paṭe	paṇbi	paṇba	'to obtain'
nog-	nogi	nogde	nobgi	nobga	'to wash'
geg-	gegi	gegde	gebgi	gebga	'to associate with'
ag-	agi	agde	abgi	abga	'to be fitting'

(39) ***Kuvi*** (Israel 1979) See (18) for examples of consonant/vowel metathesis. The pattern here is similar to that observed in Kui.

/gok-pi-n-esi/	gop-ki-n-esis	'caught continuously-he'
/mek-pi-t-u/	mep-ki-t-u	'plucked-they'
/kak-pi a-/	kap-ki a-	'to laugh at each other'
/nik-pi ki/	nip-ki ki-	'to cause to stand'
/ok-pi ki/	op ki ki-	'cause to carry'
/tuk-p-esi/	tup-k-esi	'let him weigh'
/huk-p-esi/	hup-k-esi	'let him remove it'

(40) ***Mandaic*** (Macuch 1965; Malone 1971, 1985)

a. 'h' and 'ʔ' metathesize with a preceding consonant.
   yarhá > yahrá 'mouth'
   mišhá > mihšá (> miššá) 'oil'
   tirʔá > tiʔrá (> trá) 'door'

b. Metathesis is observed in words containing two or more liquids.
   šalwāra ~ šarwāla 'trousers' cf. Persian šalwār
   raškal ~ laškar no gloss given cf. Persian laškœr

(41) ***Oromo*** (Lloret-Romanyach 1988)

An ejective alveolar stop and alveolar nasal metathesize.
fit' + na 'finish + we' fint'a → finɗa 'we finish'
lit' + na 'enter + we' lint'a → linɗa 'we enter'

(42) ***Rendille***

a. Pharyngeal/C metathesis

Deletion occurs in both verbs and nouns with the addition of a vowel-initial suffix (Heine 1976, 1978; Hume 1998; Oomen 1981; Sim 1981; Zaborski 1986). When the pharyngeal fricative /ħ/ would occur in preconsonantal position as the result of vowel deletion, metathesis applies and the fricative surfaces in prevocalic position, as in (i). In sequences in which the pharyngeal follows a consonant, no metathesis occurs, as in (ii).

i.	baħab	babħ-o	*baħbo	'armpit, sing./plur.'
	saħab	sabħ-o	*saħbo	'clap of hand, sing./plur.'
	aħam	amħ-a	*aħma	'eat!, sing./plur.'
	yaħar	yarħ-a	*yaħra	'cough!, sing./plur.'
ii.	jilaħ	jilħ-o		'charcoal, sing./plur.'
	umaħ-te	umħ-e		'you/she begin(s), I/he begin(s)'
	nabaħ	nabħ-o		'ear, sing./plur.'

b. Obstruent, Nasal/Liquid metathesis

When obstruent and nasal consonants would occur before a liquid as the result of vowel deletion, as in (c) and (d), the obstruent/nasal and the liquid metathesize and the obstruent/nasal consonants surface in prevocalic position (Heine 1976, Oomen 1981, Sim 1981).

c.	ugar	urgo	*ugro	'skinbag'
	ɟafar	ɟarfo	*ɟafro	'cloth'
	abar	arbo	*abro	'mother'

d.	*'you(sg)/she'*	*'we'*	*'I/he'*		
	udurte	udurre	urde	*udre	'sleep'
	agarte	agarre	arge	*agre	'see'
	ħamarte	ħamarre	ħarme	*ħamre	'shiver'

(43) ***Zoque*** (Wonderly 1951; see Sagey 1986 for related discussion)
When /y/ precedes a bilabial, velar, or glottal consonant, metathesis occurs.

y-pata	pyata	'his mat'
y-buro	byuro	'his burro'
y-faha	fyaha	'his belt'
y-mula	myula	'his mule'
y-wakas	wyakas	'his cow'
y-kama	kyama	'his cornfield'
y-ʔaci	ʔyaci	'his older brother'
y-hayah	hyayah	'her husband'
y-huyu	hyuyu	'he bought it'

After vowels:

poy 'to run' + -pa	popya	'he runs'
kuy 'seven' + -mʌy	kumyʌy	'a week hence'
cay 'vine' + -kʌsi	cakyʌsi	'on the vine'
takay 'bitter' + -ʔah-	takaʔyahu	'it becomes bitter'
poy 'to run' + -waʔa	powyaʔa	'he already ran'

After nasals:

Ny- + puht- 'to go out'	mbyuhtu	'you went out'
Ny- + burlacʌhk 'to scoff'	mbyurlacʌhku	'you scoffed'
Ny- + wiht- 'to walk'	nwyihtu	'you walked'
Ny- + ken- 'to look'	ŋgyenu	'you looked'
Ny- + gustacʌhk 'to enjoy'	ŋgyustacʌhku	'you enjoyed yourself'

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