and social–indexical texts through the iconic or presupposing indexing of contextual particulars and regularities (types), of which the latter are systematically anchored on phonetic and other pragmatic (i.e., contextual) extensions, thus forming the basis of the relationship between phonetics and pragmatics.

See also: Bloomfield, Leonard (1887–1949); Carnap, Rudolf (1891–1970); Class Language; Context, Communicative; Conversation Analysis; Deixis and Anaphora: Pragmatic Approaches; Discourse Markers; Distinctive Features; Gender and Language; Genre and Genre Analysis; Gestures: Pragmatic Aspects; Honorifics; Identity and Language; Jakobson, Roman (1896–1982); Kant, Immanuel (1724–1804); Markedness; Maxims and Flouting; Metapragmatics; Peirce, Charles Sanders (1839–1914); Performative Clauses; Phoneme; Phonetics: Overview; Phonology: Overview; Phonology–Phonetics Interface; Politeness; Power and Pragmatics; Pragmatic Acts; Pragmatic Presupposition; Pragmatics and Semantics; Pragmatics: Optimality Theory; Pragmatics: Overview; Register: Overview; Saussure, Ferdinand (-Mongin) de (1857–1913); Semiosis; Semiotics: History; Silence; Silence; Speech Acts.

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Phonetics of Harmony Systems

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Introduction

Harmony involves a non-local spreading of some feature or combination of features over some domain larger than a single segment. The following example from Finnish illustrates back/front vowel harmony. The inessive suffix has two realizations. The variant containing a front vowel (-ssæ) occurs after roots consisting of front vowels, e.g., kylæssæ 'in the village', whereas the allomorph containing a back vowel (-ssɑ) appears after roots with back vowels, e.g., tɑlossɑ 'in the house'.

Harmony processes abound cross-linguistically and may be classified according to the types of features being propagated and whether vowels or consonants are targeted. The Chumash language provides an example of consonant harmony (Beeler, 1970). Chumash has two coronal fricatives, an apical /s/ and a laminal /ʃ/, which may not occur in the same word. This restriction triggers a right-to-left harmony process when a suffix containing a coronal fricative is added to a word containing a different coronal fricative, e.g., saxtun 'to pay' vs. ʃaxtun-ʃ 'to be paid', uʃla 'with the hand' vs. ulsa-siq 'to press firmly by hand'.

Up until recently, studies of harmony were strictly phonological in nature, relying on impressionistic observations rather than instrumental investigation. While this approach yielded many insights into the nature of harmony processes, it also left many questions that proved unanswerable without phonetic data: What are the precise physical and acoustic properties that spread in harmony processes? To what extent is harmony motivated by phonetic considerations such as the desire to minimize articulatory difficulty and enhance perceptual salience? Are segments that appear to be transparent to harmony truly phonetically unaffected by the spreading feature? Do phonetic differences underlie the dual behavior of apparent harmonically neutral segments?

Recent advancements in instrumentation techniques and increased accessibility of speech analysis software have made possible the phonetic research necessary to tackle some of these unresolved issues. This article will discuss some of the phonetic studies that have enhanced our understanding of many aspects of harmony systems. For purposes of the present work, the research on the phonetics of harmony will be divided into two broad categories according to the types of segments affected by harmony. The first section considers vowel harmony, focusing on four types of vowel harmony that have been subject to phonetic research: front/back harmony, rounding harmony, ATR harmony, and height harmony. In the second section we discuss phonetic aspects of harmony processes affecting consonants, including nasal harmony and various types of long-distance consonant harmony.

Vowel Harmony

Different phonetically based explanations for vowel harmony have been proposed in the literature. Suomi (1983) offers a perceptual account of vowel harmony focusing on front/back harmony of the type found in Finnish. He suggests that harmony reflects an attempt to minimize the need to perceive differences in the frequency of the second formant, the primary acoustic correlate of backness, in syllables after the first. Drawing on results from perceptual experiments suggesting greater perceptibility of the first formant (Flanagan, 1955), the acoustic correlate of height, relative to the second formant, Suomi argues that vowel harmony reduces the burden of perceiving the perceptually less salient contrasts in backness.

Ohala (1994) proposes a slightly different explanation for the development of vowel harmony, suggesting that it is a "fossilized remnant of an earlier phonetic process involving vowel-to-vowel assimilation" (p. 491). Coarticulation effects between noncontiguous vowels are well documented in the phonetic literature (Öhman, 1966). Ohala suggests that vowel harmony systems arise when these coarticulation effects, which normally are factored out of the signal by the listener, are misparsed by the listener as being independent of the vowel triggering the coarticulation. This misapprehension leads the listener to infer that the speaker was producing a different target vowel than the speaker actually intended to utter. The listener then introduces into her own speech this new vowel, setting off a sound change to be adopted by other speakers.

Front/back Vowel Harmony

An important question raised by vowel harmony is whether the coarticulatory effects driving harmony actually pass over segments intervening between the target and trigger without affecting them. The apparent transparency of certain segments to harmony can be clearly seen in the neutral vowels described in many vowel harmony systems. Thus, for example, although most Finnish suffixes containing a vowel have two variants, one with a front vowel and the other with a back vowel, there are two vowels /i, e/ which are not paired with corresponding back vowels. These neutral vowels can occur in the same word with either front or back vowels as words containing the translative suffix -ksi show, e.g., kɑtoksi 'roof (translative)' vs. kylvyksi 'bath (translative)'. Furthermore, the neutral vowels can occur in roots containing either front or back vowels, e.g., hihɑ 'sleeve' vs. ikæ 'age', pesæ 'nest' vs. pensɑs 'bush'.

The dual behavior of neutral vowels raises the question of whether a neutral vowel is pronounced the same in all contexts. Specifically, one might ask whether the neutral vowels, which are widely regarded as front vowels, also have two variants, one back and the other front, parallel to other vowels. Investigation of the articulatory properties of neutral vowels potentially has important implications for the treatment of assimilatory processes in phonological theory. If the neutral vowels were phonetically front vowels even when the surrounding vowels are back, this would prove that harmony is truly a long distance phenomenon and can thus only be handled by a theory allowing for non-local spreading of a feature.

Phonetic data, both acoustic and articulatory, have recently been used to investigate the possibility that neutral vowels in front/back vowel harmony systems have both front and back variants. A key advantage of phonetic research on vowel harmony over impressionistic study is its potential ability to differentiate between categorical phonological effects of harmony and the normal coarticulation effects found in languages lacking true phonological harmony (Öhman, 1966). One recent study focuses on Finnish neutral vowels using acoustic data while another body of research investigates articulatory aspects of the Hungarian neutral vowels, which are also /i, e/.

Gordon (1999) compares the realization of the Finnish neutral vowels in front and back vowel words by inferring tongue position from the location of the first two formants. He finds an asymmetric effect that mirrors the left-to-right vowel harmony found in Finnish: the place of the neutral vowel is influenced by the frontness/backness of a preceding vowel but not a following vowel. Following a back vowel, the neutral vowels are noticeably backer as reflected in a lowering of the second formant (F2). The backing of the neutral vowels is observed between back vowels, e.g., ukithɑn 'grandfathers (emphatic)', and when preceded by a back vowel, e.g., tɑpit 'plugs', but not when only followed by a back vowel, e.g., iho 'skin'. However, the effect of vowels in adjacent syllables on the neutral vowels is relatively small, with an approximately 100 Hz difference in F2 as a function of surrounding vowel context averaged over two speakers. Gordon concludes that while vowels in neighboring syllables exert an effect on the relative backness of the neutral vowels, this effect is more consistent with phonetic coarticulation as opposed to a categorical difference in backness.

Gafos and Benus (2003) and Benus *et al.* (forthcoming) investigate neutral vowels in Hungarian using ultrasound and electromagnetic midsaggital articulometry (EMMA), two techniques that provide a direct measure of tongue position. They find that the neutral vowels are articulated with a more posterior tongue dorsum position (by an average of .67 millimeters in their EMMA data) in back vowel contexts relative to front vowel environments. However, although these differences are statistically reliable, their relatively small magnitude leaves open the possibility that the differences are due to normal coarticulation between vowels of the type found in languages lacking vowel harmony. In order to tease apart coarticulation from true harmony effects, Gafos and Benus compare neutral vowels differing in their subcategorization for front and back vowel suffixes. For example, the word viːz 'water' takes the front vowel variant of the dative suffix -nɔk/-nek, i.e., viːz-nek, while the word hiːd 'bridge' takes the back vowel allomorph, i.e., hiːdnɔk. Interestingly, they find that in unsuffixed roots containing neutral vowels but taking back vowel suffixes (e.g., hiːd), there is tendency for the tongue dorsum to be slightly retracted during the neutral vowel relative to the vowel in unsuffixed roots containing neutral vowels taking front vowel suffixes (e.g., viːz). They regard their results, however, as suggestive but nevertheless tentative pending the collection of more data.

Gafos and Benus and Benus *et al.*'s work builds on earlier work by Gafos exploring the articulatory basis of harmony systems. Drawing on both articulatory phonetic data and typological observations about harmony, Gafos hypothesizes that spreading in harmony systems is local rather than long-distance (see also Ní Chiosáin and Padgett, 1997 for a similar view). Under his view, segments that superficially appear to be transparent in the harmony system are actually articulated differently depending on the harmonic environment. Thus, the neutral vowels /i, e/ are claimed to be backer in back vowel environments than in front vowel environments, but crucially the effect of this articulatory backing is not substantial enough to be perceptible. He finds support for this view from Boyce's (1988) phonetic study of coarticulation and rounding harmony in Turkish, whereby high vowels agree in rounding with the preceding vowel in a word (see Rounding Harmony, below). In an electromyographic study of muscle activity, Boyce finds that the Orbicularis Oris muscle, which is responsible for lip rounding, remains contracted during a non-labial consonant intervening between two rounded vowels for Turkish speakers. This is consistent with Gafos' view that harmony is a local spreading process in which no segments transparently allow a propagating feature to spread through them while being unaffected themselves.

ATR Harmony

Hess (1992) is another study that uses phonetic data to test claims about the phonological properties of harmony. Her study focuses on ATR vowel harmony in Akan, a Kwa language of Ghana. In Akan, vowels other than the low vowel /a/ come in pairs differing in tongue root position. The advanced tongue root (+ATR) vowels /i̘ e̘, u̘, o̘/ are associated with an expanded pharyngeal cavity relative to their retracted tongue root (−ATR) counterparts /i̙, e̙, u̙, o̙/. This expansion of the pharyngeal space associated with the +ATR vowels is achieved primarily by advancing the posterior portion of the tongue (and also by adopting a lowered larynx position relative to that associated with −ATR vowels). Hess uses phonetic data to test two competing analyses of vowel harmony. According to one analysis, that adopted by Dolphyne (1988), vowel harmony is a categorical process whereby a −ATR vowel becomes +ATR when the vowel in the immediately following syllable is +ATR. For example, the −ATR vowel in the second syllable of the isolation form fré̙ 'call' turns into a +ATR vowel when followed by a +ATR vowel in the sentence fré̘ kò̘fí. The competing analysis (Clements, 1981) treats vowel harmony in Akan as a gradient assimilation in vowel height, whereby vowels are raised when followed by a +ATR vowel. In this account, raising gradiently propagates over all vowels preceding the trigger vowel, such that raising is greatest in the vowel immediately preceding the trigger and gradually decreases in magnitude the farther the target vowel is from the trigger.

As a starting point in her study, Hess identifies the most reliable correlates of the feature ATR. She explores several potential indicators of ATR, including formant frequency, formant bandwidth, vowel duration, and the relative amplitude of the fundamental and the second harmonic. Hess finds the bandwidth of the first formant to be the most robust correlate of the ATR feature: +ATR vowels have narrower bandwidth values than their −ATR counterparts. (She also finds that +ATR vowels have lower first formant frequency values, but this difference is consistent not only with a difference in tongue root advancement but also a difference in height of the tongue body.) Applying first formant bandwidth as a diagnostic of ATR, Hess then examines vowels preceding a +ATR trigger of vowel harmony in order to test whether harmony involves spreading of height or ATR features and whether it propagates leftward across multiple vowels or is limited to the vowel immediately preceding the trigger vowel. As predicted by Dolphyne, Hess finds that only the immediately preceding vowel is affected by harmony. Furthermore, although the lowering of the first formant frequency in the target vowel is consistent with the height-based analysis of Akan harmony, the decrease in the bandwidth of the first formant is more consistent with ATR harmony than height harmony.

Most of the existing phonetic data on harmony comes from languages where harmony is a firmly entrenched phonological process. However, Przezdziecki's (2000) phonetic study of ATR harmony in Yoruba provides some insight into the development of harmony systems. In this study, he tests Ohala's hypothesis that harmony arises from simple coarticulation effects against data from three dialects of Yoruba differing in the productivity of their ATR harmony systems. In the Akure dialect, ATR vowel harmony is a productive process that creates alternations in the third person singular pronominal prefixes. Before a +ATR vowel, which include /i̘ e̘, u̘, o̘/, the prefix is realized as a +ATR mid back rounded vowel, e.g., ò̘ kú̘ 's/he died', ò̘ r'u̘lé 's/he saw the house', whereas the prefix surfaces as a −ATR vowel before a −ATR vowel /i̙, e̙, u̙, o̙/ e.g., ò̙ lo̙ 's/he went', o̙ r'ù̙gbá 's/he saw the calabash'. The Moba dialect also has prefixal ATR vowel harmony, but the high vowels do not participate in the alternations either as triggers or as targets of harmony. Finally, Standard Yoruba lacks prefixal alternations entirely, though it has static co-occurrence restrictions on ATR within words. Przezdziecki explores the hypothesis that the fully productive alternations affecting the high vowels in the Akure dialect will also be observed as smaller coarticulation effects for the high vowels in the other two dialects. Taking the first formant frequency as the primary correlate of ATR harmony in Yoruba, he measures the first formant for the high, mid, and low vowels in two contexts, before a +ATR mid vowel and before a −ATR mid vowel, in the three dialects. As expected, for the Akure speakers, both the high and mid vowels differ markedly in their first formant values between the +ATR and −ATR contexts: vowels in the −ATR context have much higher F1 values than vowels in the +ATR context. Low vowels do not reliably differ in F1 between the two environments. In the other two dialects where harmony does not target high vowels, the high vowels show F1 differences going in the same direction as the Akure data (higher F1 values before −ATR vowels), but the magnitude of these differences is much smaller than in Akure. These results are consistent with the view that phonological harmony arises as a phonetic coarticulation effect that becomes sufficiently large to develop into a categorical alternation.

Height Harmony

Phonetic data has also been used to test claims about the existence of vowel harmony in a particular language. Kockaert's (1997) acoustic study attempts to experimentally verify the system of height harmony reported for siSwati (Swati). According to Kockaert, siSwati mid vowels are reported by several researchers to have two realizations in the penultimate syllable, a relatively high allophone /e, o/ when the final vowel is one of the high vowels /i, u/, and a lowered allophone /ɛ ɔ/, when the following vowel is non-high. Contra these reports of harmony, Kockaert finds that first formant values, the formant correlated with vowel height, fail to support the hypothesized variation in vowel height in the penultimate syllable.

Rounding Harmony

Kaun (1995) pursues a perceptually driven account of vowel harmony involving rounding. As a starting point in her investigation, she observes a number of recurring cross-linguistic patterns found in rounding harmony systems. First, she finds that rounding harmony is most favored among high vowel targets. We thus find languages like Turkish, in which only high vowels alternate in rounding as a function of the rounding in the preceding vowel. For example, the 1st person possessive suffix has four variants -ɪm/ -ʏm/ -ʊm/ -ɨm, where the choice of allomorph is conditioned by the frontness/backness and rounding of the root vowels: ipɪm 'my rope', kɨzɨm 'my girl', sytʏm 'my milk', buzʊm 'my ice'. The non-high vowel dative suffix, on the other hand, has only two allomorphs –ɛ/-ɑ which differ in frontness and not rounding: ipɛ 'rope (dative)', sytɛ 'milk (dative)', kɨzɑ 'girl (dative)', buzɑ 'ice (dative)'. Conversely, the typology indicates that rounding harmony is favored when the triggering vowel is non-high. Thus, there are languages in which rounding harmony is unrestricted (e.g., many varieties of Kirgiz [Karghiz]): high vowels and non-high vowels trigger rounding harmony in both high and non-high vowels. There are also languages in which rounding harmony is triggered in high vowels by both high and non-high vowels (e.g., Turkish), and languages in which rounding harmony only occurs if both the trigger and target are both non-high (e.g., Tungusic languages). We do not find any languages, however, in which only high vowels but not non-high vowels trigger harmony in both high and non-high vowels. Kaun also finds that rounding harmony is more likely when the trigger and target vowels agree in height, i.e., either both are high vowels or both are non-high vowels. Thus, in Kachin Khakass, both the trigger and target must be high vowels. Finally, rounding harmony is more prevalently triggered by front vowels. Thus, in Kazakh, rounding harmony in high suffixal vowels is triggered by both front and back vowels, e.g., kœl-dʏ 'lake (accusative)', kʊl-dʊ 'servant (accusative)'. For non-high suffixal vowels, however, rounding harmony is only triggered by front vowels, e.g., kœl-dœ 'lake (locative)', kʊl-dɑ 'servant (locative)'.

Kaun attempts to explain these typological asymmetries in perceptual terms. Following Suomi's account of front/back vowel harmony, Kaun suggests that rounding harmony reflects an attempt to reduce the burden of perceiving subtle contrasts in rounding. By extending a feature over several vowels, in this case rounding, the listener will be better able to perceive that feature and also will not have to attend to the rounding feature once it is correctly identified the first time. Rounding, like frontness/backness, primarily affects the second formant, which as we saw earlier, is perceptually less salient than the first formant.

Kaun draws on Linker's (1982) articulatory study of lip rounding and Terbeek's (1977) perceptual study of rounded vowels to explain the typological asymmetries in rounding harmony based on backness and vowel height. Linker's work shows that rounded vowels can be differentiated in their lip positions (expressed in terms of lip opening and protrusion) and their concomitant degree of rounding. Among the set of rounded vowels, she finds that high rounded vowels are characteristically more rounded than non-high rounded vowels and that back rounded vowels are more rounded than their front counterparts. Terbeek's study indicates a perceptual correlate of these articulatory differences in rounding: high rounded vowels are perceived as more rounded than non-high rounded vowels and back rounded vowels are perceived as more rounded than front rounded vowels. Kaun suggests that the lesser perceptibility of non-high and front rounded vowels makes them more likely to spread their rounding features to other vowels in order to enhance identification of rounding. Kaun attributes the bias for rounding in high vowels to the synergistic relationship between lip rounding and the higher jaw position associated with high vowels. Rounded vowels are associated with increased lip protrusion which is achieved in large part by decreasing the vertical opening between the lips; the decreased vertical opening is aided by a higher jaw position. The final cross-linguistic tendency in rounding harmony, the requirement in many languages that trigger and target agree in height, is attributed by Kaun to a preference for uniform articulatory gestures associated with a given phonological feature. High and non-high vowels achieve their rounding through different articulatory strategies: non-high vowels rely more on lip protrusion than high vowels, for which rounding is associated with both an approximation of the lips and protrusion.

Consonant Harmony

Nasal Harmony

Researchers have also offered phonetic accounts of harmony systems involving the spreading of nasality to both consonants and vowels. Boersma (2003) suggests a dichotomy in nasal harmony systems. One type of nasal harmony, he suggests, has an articulatory basis, while the other type of nasal harmony is perceptually driven. The articulatory nasal harmony entails spreading of nasality from a nasal consonant rightward until spreading is blocked by a segment that is incompatible with nasality. For example, in Malay, nasality spreads rightward through the glide in mãj̃ãn 'stalk' but is blocked by the oral plosive in mãkan 'eat'. Crucially, because the spreading nasality is attributed to a single velum opening gesture, nasality fails to skip over segments whose identity would be altered too much by nasality. This explains the asymmetric behavior of oral plosives, which block nasal spreading, and glottal stop, which does not. An oral plosive would become a nasal if the velum were lowered during its production. Glottal stop, on the other hand, can be produced with an open velum, since the closure for the glottal stop is lower in the oral tract than the velum and thus does not allow for nasal airflow. Consonants for which the acoustic effect of nasality is intermediate in strength, e.g., liquids, may or may not block nasal harmony depending on the language. In fact, Cohn's (1993) study of airflow in Sundanese suggests a distinction between sounds that completely inhibit nasal spreading, such as stops, and those that are partially nasalized due to interpolation in nasal air flow between a preceding phonologically nasalized sound and a following phonologically oral sound. Cohn argues that these transitional segments, which include glides and laterals in Sundanese, are phonologically unspecified for the nasal feature, unlike true blockers of nasal spreading, which are phonologically marked as [-nasal].

In contrast to languages in which nasal harmony is sensitive to articulatory compatibility, in languages possessing auditory nasal harmony, there is no strict requirement that nasality be produced by a single velum opening gesture. For this reason, nasal harmony of the auditory type is not blocked by oral plosives. Although the oral plosive cannot be articulated with an open velum, it still can allow spreading of nasality through it to an adjacent segment compatible with the nasal feature. Auditory nasal harmony thus reflects an attempt to expand the perceptual scope of nasality, even if this entails producing multiple velum opening gestures.

Palatal Harmony

Recent work by Nevins and Vaux (2004) has investigated the phonetic properties of transparent segments in the consonant harmony system of the Turkic language Karaim. In Karaim, the feature of backness/frontness spreads within phonological words, as in Finnish and Hungarian, but unlike Finnish and Hungarian, it is consonants rather than vowels that agree in backness. Most consonants in Karaim occur in pairs characterized by the same primary constriction but differing in whether they are associated with secondary palatalization. If the first consonant of the root has a palatalized secondary articulation, palatalization spreads rightward to other consonants in the word, including consonants in the root and suffixal consonants. If the first consonant of the root lacks secondary palatalization, other consonants in the word also are non-palatalized. Palatal harmony leads to suffixal alternations. For example, the ablative suffix has two variants: -dɑn and d^{j}ɑn^{j}, the first of which occurs after roots containing non-palatalized consonants, e.g., suvdɑn 'water (ablative)', the second of which is used with roots containing palatalized consonants, e.g., k^{hj}un^{j}d^{j}ɑn^{j} 'day (ablative)'. Crucially, descriptions of palatal harmony in primary sources suggest that it is a property only of consonants and not of vowels, meaning that back vowels remain back even if surrounded by palatalized consonants. In order to test this prediction, Nevins and Vaux conduct a spectrographic comparison between back vowels surrounded by palatalized consonants and back vowels surrounded by non-palatalized consonants. Taking the second formant as the primary correlate of backness in vowels, they find no consistent difference in backness between back vowels in the two contexts, suggesting that front/back consonant harmony mirrors front/back vowel harmony in being a non-local process. They do find, however, that vowels, which occur in contexts associated with phonetic shortening, are potentially fronter when adjacent to palatalized consonants. They attribute this effect to coarticulation rather than participation of vowels in the harmony system: phonetically shorter vowels have less time to reach their canonical back target positions.

Other Long-Distance Consonant Harmony Effects

Consonant harmony encompasses many other assorted types of long distance assimilation processes, whose phonetic underpinnings may not be uniform. Drawing a parallel to his account of vowel harmony, Gafos argues that consonant harmony systems also involve local assimilatory spreading propagating over relatively large domains. His cross-linguistic typology of consonant harmony indicates that many cases of consonant harmony entail spreading of coronal gestures involving the tongue tip and/or blade, e.g., the Chumash case discussed in the Introduction. Because the part of the tongue involved in coronal harmony can be manipulated largely independently of the tongue body, which is the relevant articulator for vowels, coronal gestures associated with consonants may persist through an intervening vowel without noticeably affecting the vowel.

Not all functional explanations for consonant harmony are purely phonetic in nature, however, although they all rely on a basic notion of phonetic similarity mediated by phonological features. Hansson (2001a, 2001b) and Walker (2003) discuss consonant harmony systems of various types (e.g., nasality, voicing, stricture, dorsal features, secondary articulations) that may not be best explained in terms of local spreading of a feature. Hansson and Walker argue that speech planning factors might account for certain consonant harmony effects which are truly long distance.

Building on work by Bakovic (2000) on vowel harmony, Hansson (2001a) observes a strong tendency for consonant harmony either to involve assimilation of an affix to a stem or to involve anticipatory assimilation of a stem to a suffix. Crucially, consonant harmony systems in which a stem assimilates to a prefix appear to be absent.

Hansson finds parallels to this asymmetry in both child language acquisition and also speech error data. Hansson reports results from Vihman (1978) showing a strong bias toward anticipatory consonant harmony in child language. Furthermore, speech errors also display a strong anticipatory effect (Schwartz *et al.*, 1994, Dell *et al.*, 1997), suggesting that errors result from the articulatory influence of a planned consonant on the production of an earlier consonant (Dell *et al.*, 1997). Hansson suggests that consonant harmony stems from the same speech planning mechanisms underlying the anticipatory bias in child language and adult speech errors.

Hansson also offers a speech planning explanation for another interesting typological observation he makes about consonant harmony. He finds that coronal harmony systems of the Chumash type involving an alternation between anterior and posterior fricatives follow two patterns. In some languages, bidirectional alternations are observed; thus /ʃ/ can become /s/ and /s/ can become /ʃ/ under appropriate triggering contexts. In other languages, coronal harmony is asymmetric, involving a change from /s/ to /ʃ/. Almost completely absent are languages that asymmetrically change /ʃ/ to /s/ but not *vice versa*. Hansson points out that this asymmetry has an analog in speech error data from Shattuck-Hufnagel and Klatt (1979) showing that alveolars such as /s, t/ tend to be replaced by palatals such as /ʃ, tʃ/, respectively, much more often than *vice versa*. This parallel in the directionality of harmony in speech error data offers support for the view that at least certain types of consonant harmony systems are driven by speech planning considerations.

Walker (2003) offers direct experimental evidence that consonant harmony is motivated by speech planning mechanisms. A survey of long distance nasal harmony over intervening vowels (Rose and Walker, 2003, Walker, 2003) indicates that harmony in many languages is subject to a requirement that the target and trigger are homorganic. For example, in Ganda (Katamba and Hyman, 1991), roots of the shape CV(V)C may not contain a nasal stop and a homorganic oral voiced stop or approximant. For example, roots like nónà 'fetch, go for', gùgá 'curry favor with' occur, but roots like *gùŋá or *nódà do not. Roots may, however, contain heterorganic consonants differing in nasality, e.g., bónèká 'become visible'. Walker also observes that in certain languages, e.g., Kikongo [Kituba] (Ao, 1991), voiceless stops are transparent to harmony, neither undergoing it nor blocking it.

Walker sets out to explore the potential psycholinguistic basis for the sensitivity of nasal harmony to homorganicity and voicing using a speech error inducing technique in which listeners are asked to read pairs of monosyllabic words differing in the initial consonant (e.g., *pat*, *mass*) after being primed with other pairs of words with reversed initial consonants (e.g., *mad*, *pack*). In keeping with the typological observations about nasal harmony, Walker finds that more errors (e.g., *mat*, *pass*; *mat*, *mass*; *pat*, *pass*) occur when the two consonants are homorganic and when they disagree in voicing. On the basis of these results, Walker concludes that consonant harmony has a functional basis in terms of on-line speech production considerations.

Conclusions

In summary, phonetic research has shed light on a number of issues relevant to the study of harmony systems. Evidence suggests that many types of harmony systems have a phonetic basis as natural coarticulation effects that eventually develop into categorical phonological alternations and static constraints on word and/or morpheme structure. The desire to increase the perceptual salience of certain features may also play a role in harmony systems. Harmony processes that may not be driven strictly by phonetic factors may be attributed to on-line speech production mechanisms that also underlie speech errors found in natural and experimental settings. Phonetic data also provide insights into the proper phonological treatment of harmony by exploring issues such as the phonetic realization of neutral segments, the acoustic correlates of harmony, and the local versus non-local nature of assimilation.

See also: Harmony.

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Phonetics, Articulatory

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'Articulatory phonetics' is the name commonly applied to traditional phonetic theory and taxonomy, as opposed to 'acoustic phonetics,' 'aerodynamic phonetics,' 'instrumental phonetics,' and so on. Strictly speaking, articulation is only one (though a very important one) of several components of the production of speech. In phonetic theory, speech sounds, which are identified auditorily, are mapped against articulations of the speech mechanism.

In what follows, a model of the speech mechanism that underlies articulatory phonetic taxonomy is first outlined, followed by a description of the actual classification of sounds and some concluding remarks. The phonetic symbols used throughout are those of the International Phonetic Association (IPA) as