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Edited by

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CHAPTER FIFTEEN

SYLLABLE MARKEDNESS AND MISPERCEPTION: IT'S A TWO-WAY STREET

Iris Berent, Tracy Lennertz and Paul Smolensky

1 *Introduction*

A key argument for the postulation of the syllable as a constituent is presented by universal phonological preferences that specifically target the syllable as their domain. For example, syllables like *blif* are universally preferred to *lbif*. Not only are *lbif*-type syllables less frequent across languages, but their presence in any given language implies the presence of syllables such as *blif* (Greenberg 1978, Berent et al. 2007). Several linguistic accounts attribute such typological regularities to universal markedness constraints that are active in the linguistic competence of all speakers (Prince and Smolensky 2004, Smolensky and Legendre 2006) and potentially shape linguistic performance as well (Davidson et al. 2006). On an alternative explanation, the cross-linguistic preference for *blif*- type syllables reflects only extra-linguistic factors governing the transmission of language over time. Unmarked syllables like *blif* are typologically frequent because they are easier to perceive and produce (Ohala 1992, Kawasaki-Fukumori 1992), and consequently, their transmission across speakers is more stable (Blevins 2004, 2006). On this view, the typology of syllables, while providing clues concerning language transmission, is irrelevant to the study of linguistic competence, in general, and the grammatical theory of syllable structure, in particular.

The disagreement between these two accounts centers on two key issues. The first concerns the ontological status of markedness restrictions: are markedness constraints mentally represented in the brains and minds of individual speakers, or are they mere psychologically irrelevant descriptions, relics of language change and its nonlinguistic determinants—historic facts, the statistical structure of linguistic experience and the properties of nonlinguistic mechanisms governing perception and articulation? If markedness did play a role in the grammar, then a second question arises. It is well known that the ease of perception and articulation of linguistic objects correlates with their grammatical well-formedness, and such correlation may well indicate causation. The debate concerns the direction of the causal link between performance and competence: are performance difficulties the cause of grammatical markedness or its consequence?

The research described in this chapter addresses both issues by examining the universal restrictions on the structure of onset clusters. We begin by showing that the typological preference for *blif*-type syllables is synchronically active and it extends even to syllables that are unattested in one's language: marked syllables are systematically misperceived relative to less marked syllables. We next describe two novel experiments demonstrating that the misperception of marked syllables reflects preferences that are internal to the faculty of language. Such preferences are not explained by the properties of the lexicon nor are they byproducts of domain-general mechanisms of perception and articulation. The results reported in this chapter suggest that universal markedness restrictions are synchronically active in the grammars of all speakers, and are causally linked to perceptibility. But contrary to the proposal of evolutionary phonology, perceptibility can be a consequence of grammatical markedness, not necessarily its cause.

2 *Sonority Restrictions on Onset Clusters*

Before we can experimentally examine speakers' grammatical preferences regarding onset structure, we must briefly discuss some of the formal accounts of such preferences and their empirical support. The typological preference for syllables such as *blif* over *lbif* has been attributed to universal restrictions on sonority (s)—an abstract phonological property that correlates with intensity (Clements 1990, Parker 2002, Wright 2004). The least sonorous consonants are obstruents ($s = 1$), followed by nasals ($s = 2$), liquids ($s = 3$) and glides ($s = 4$). Accordingly, the obstruent-liquid combination in *blif* manifests a sonority rise of two steps: the sonority difference, Δs, is 2. By contrast, *lbif* manifests a fall in sonority: a negative sonority difference $\Delta s = -2$. The specific preference for *blif* over *lbif* may thus reflect broad markedness restrictions that disfavor onsets with smaller sonority differences—disfavoring, for example, $\Delta s = -2$ to $\Delta s = 2$ (e.g. Clements 1990, Smolensky 2006).

Sonority sequencing restrictions have been invoked in explaining various grammatical phenomena (syllable structure: Vennemann 1972, Hooper 1976, Steriade 1982, Selkirk 1984, Prince and Smolensky 2004, Smolensky 2006; syllable contact: Gouskova 2001, 2004; stress assignment: de Lacy 2007; reduplication: Pinker and Birdsong 1979, Steriade 1982, 1988, Morelli 1999, Parker 2002 and repair: Hooper 1976). The sonority of consonants also correlates with their production accuracy in first- (Ohala 1999, Pater 2004, Barlow 2005) and second-language acquisition (Broselow and Finer 1991, Broselow et al. 1998, Broselow and Xu 2004), developmental phonological disorders (e.g. Gierut 1999, Barlow 2001), aphasia (e.g. Romani and Calabrese 1998, Stenneken et al. 2005), speech errors (Stemberger and Treiman 1986), word games (Treiman 1984, Treiman and Danis 1988, Fowler et al. 1993, Treiman et al. 2002) and reading tasks (Levitt et al. 1991, Alonzo and Taft 2002).

Although these results strongly suggest that speakers possess preferences regarding the sequencing of onset consonants, they leave open some questions regarding the scope of such restrictions and their nature. Most existing evidence for sonority preferences concern preferences for unmarked onsets that are attested in one's language. Such preferences could be due to the familiarity with these particular onsets, rather than a broad preference for any onset with a large sonority difference. Although there is evidence that speakers' preferences might extend to syllables that are unattested in their language (Pertz and Bever 1975, Broselow and Finer 1991, Moreton 2002, Zuraw 2007), the small number of items used in these studies makes it difficult to determine whether the observed preferences concern sonority difference or some other grammatical properties of the clusters (Eckman and Iverson 1993, Davidson 2000, 2006a, b, Davidson et al. 2006, Zuraw 2007). Even if it were unequivocally shown that people prefer onsets with larger sonority differences, questions would still remain regarding the source of this preference: whether it reflects grammatical markedness, or performance pressures that favor the perception and production of unmarked syllables over marked onsets.

The following research examines both questions. Section 3 shows that English speakers broadly favor unmarked onsets to marked ones even when all onsets are unattested in their language. Section 4 explores the source of those preferences.

3 *Are Speakers Sensitive to the Markedness of Onsets that are Unattested in their Language?*

If all universal markedness constraints are synchronically active, and if onsets with smaller sonority differences are universally more marked, then speakers should favor onsets with larger sonority differences to those with smaller differences. Crucially, such preferences should be present even if all onset types are unattested in one's language. A series of experiments (Berent et al. 2007) evaluated this prediction with English speakers. English systematically allows only onsets with a difference of at least 2 (*s*-initial onsets are systematic exceptions in English as well as other languages, for discussions, see Selkirk 1982, Wright 2004). Of interest is whether English speakers extend their preference to unattested onsets. To address this question, we compared three types of onsets with obstruent-sonorant combinations: onsets with small sonority rises (mostly obstruent-nasal sequences, e.g., *bnif*, $\Delta s = 1$), more marked onsets of level sonority (e.g., *bdif*, $\Delta s = 0$) and highly marked onsets of falling sonority (sonorant-obstruent combinations, e.g., *lbif*, $\Delta s = -2$).

Speakers' preferences were inferred from the effect of markedness on perception. Previous research has shown that people tend to misperceive marked onsets that are unattested in their language (Massaro and Cohen 1983, Hallé et al. 1998, Dupoux et al. 1999, 2001). For example, English speakers misperceive the unattested onset *tla* as *tela*—separating the illicit consonant sequence by a schwa (Pitt 1998). (Here and below, epenthetic schwa is orthographically written as 'e'.) These results suggest that marked onsets tend to be repaired epenthetically in perception. Of interest is whether the rate of epenthetic misperception depends on sonority difference. If speakers are sensitive to the markedness of onsets that are unattested in their language, and if marked onsets with smaller sonority differences trigger epenthetic repair at a greater rate, then as the markedness of monosyllables increases, people should be more likely to misperceive them as disyllabic.

To examine these predictions, we investigated the perception of onsets with small sonority rises, sonority plateaus and falls. These onsets were incorporated into monosyllabic words, matched for the structure of their rhyme (e.g., *bnif, bdif, lbif*), and compared to disyllabic items which differed from their monosyllabic counterparts only on the presence of a schwa between the two initial consonants (e.g., *benif, bedif, lebif*). All items were recorded naturally by a native speaker of Russian (a language in which all relevant types of onsets are attested).

The perception of these items was investigated using several tasks (for a full description of the results, see Berent et al. 2007). Here, we focus on findings from a syllable count task. In this task, participants are presented with a single auditory item and asked to determine whether it includes one syllable or two. If the onset-cluster markedness of monosyllabic items leads them to be misperceived epenthetically, then as the markedness of the monosyllabic item increases, people should be more likely to perceive it as disyllabic. The results (see Figure 1, solid lines) are consistent with this prediction. On most trials, participants considered unmarked onsets with rising sonority monosyllabic (62% of the responses), but they were reliably less likely to do so for onsets of level sonority (28% of the responses) and even less so for sonority falls (19% of the responses). In fact, monosyllabic items with sonority plateaus and falls were reliably misperceived as disyllabic. The misperception of such onsets by English speakers is not due to stimulus artifacts, as Russian speakers, tested with the same materials and procedure, perceived these items as monosyllabic (see Figure 1, dotted lines). These results suggest that the misperception of marked onsets reflects a preference triggered, in part, by linguistic experience.

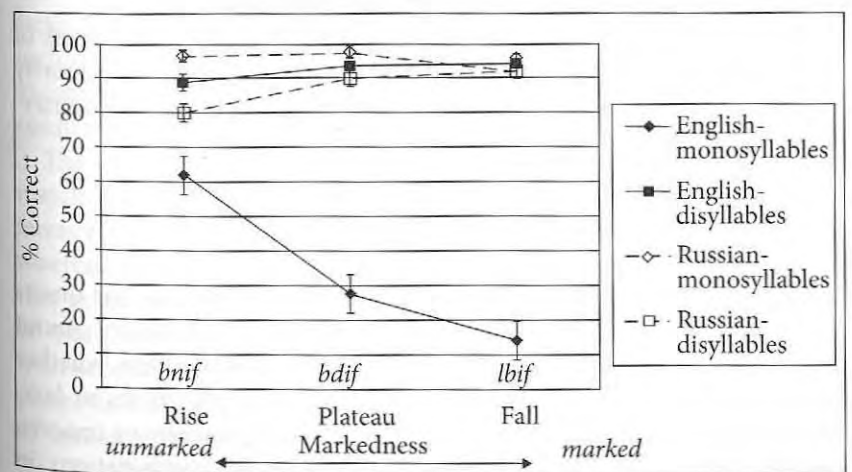

Figure 1 Mean response accuracy of English and Russian speakers as a function of the markedness of onsets and the number of syllables. Error bars represent confidence intervals constructed for the difference between the means. Data from Berent et al. (2007, Experiments 1–2)

Interestingly, however, the markedness of onset clusters also affected responses to their disyllabic counterparts. English speakers were more accurate responding to disyllabic items whose counterpart is marked (e.g., to *lebif*, counterpart of *lbif*) compared to those with an unmarked counterpart (e.g., to *benif*; a similar trend was also found with Russian participants). Additional analyses showed that the difficulties with *benif*-type items are not due to the phonetic length of the vowel. Instead, these difficulties appear to reflect a competition from the monosyllabic counterpart. Because participants in this task must make a forced choice as to whether the item has one syllable or two, their responses to disyllabic items are affected by the markedness of their monosyllabic counterparts: unmarked monosyllabic counterparts tempt participants to incorrectly choose the monosyllabic form, whereas disyllabic forms with marked counterparts are spared from such competition, and are consequently more likely to elicit correct disyllabic responses. Put differently, speakers' top-down grammatical dispreference shifts their interpretation of bottom-up phonetic evidence (Massaro and Cohen 1983). Specifically, the dispreference for sonority falls shifts the interpretation of the phonetic evidence for the schwa away from a monosyllabic response. Accordingly, a schwa is more likely to elicit a disyllabic response when it is flanked by a sonorant-obstruent compared to an obstruent-sonortant sequence.

These results suggest that people are sensitive to the markedness of onsets that are unattested in their language: onsets with small sonority differences tend to be misperceived, whereas their disyllabic counterparts tend to elicit more accurate responses.

4 *Nature of Preferences and their Source*

The performance of English speakers implies a preference for onsets with larger sonority differences. However, this result alone cannot determine the source of this preference. We first examine whether the observed preferences are due to grammatical restrictions or lexical analogies. Next, we investigate whether such preferences concern sonority difference, in general, or obstruent-sonorant combinations, in particular. The final section examines whether markedness is a cause or consequence of misperception.

4.1 *Lexical vs. Nonlexical Preferences*

One alternative explanation attributes the preference of large sonority differences not to an active grammatical component but to their analogical similarity to the English lexicon; some such mechanism would be required by a theory denying the psychological status of markedness constraints, placing the entire burden on the lexicon for carrying the residue of systematic language change. Although onsets such as *bn, bd,* and *lb* are all unattested in English, they nonetheless differ on their similarity to attested onsets. English onsets typically begin with an obstruent (as in *bn* and *bd*), rather than a sonorant (as in *lb*), and the second position of the onset is far more likely to include a sonorant (e.g., nasal) than by a stop. The *bn>bd>lb* preference could thus reflect the co-occurrence of such segments in the English lexicon, rather than their sonority difference.

Previous research evaluated and rejected this possibility by demonstrating that the preference for onsets with large sonority differences is inexplicable by various statistical properties of the English lexicon (phoneme probability, biphone probability, neighbor count and neighbor frequency, Berent et al. 2007; see also Albright 2007). Stronger evidence against the lexical account is presented by the replication of the English results with Korean speakers—whose language arguably lacks onset clusters altogether. These experiments (Berent et al. 2008) included the same materials and tasks used with English speakers, except for the addition of onsets with large sonority rises and their counterparts (e.g., *blif, belif*).

The results from the syllable count task (see Figure 2) closely match the findings observed with English speakers: as sonority difference decreased, monosyllabic items were perceived less accurately, whereas their disyllabic counterparts were more likely to elicit correct responses. Additional analyses suggested that the misperception of marked monosyllabic items is not likely to be due to proficiency with second languages, most notably English, nor is it due to various phonetic and phonological properties of Korean (the phonetic release of initial stop-consonants, their voicing, the distribution of [l] and [r] allophones, the experience with Korean words beginning with consonant-glide sequences, and the occurrence of CC sequences across Korean syllables). The finding that Korean speakers possess preferences regarding onset structure—preferences that mirror the

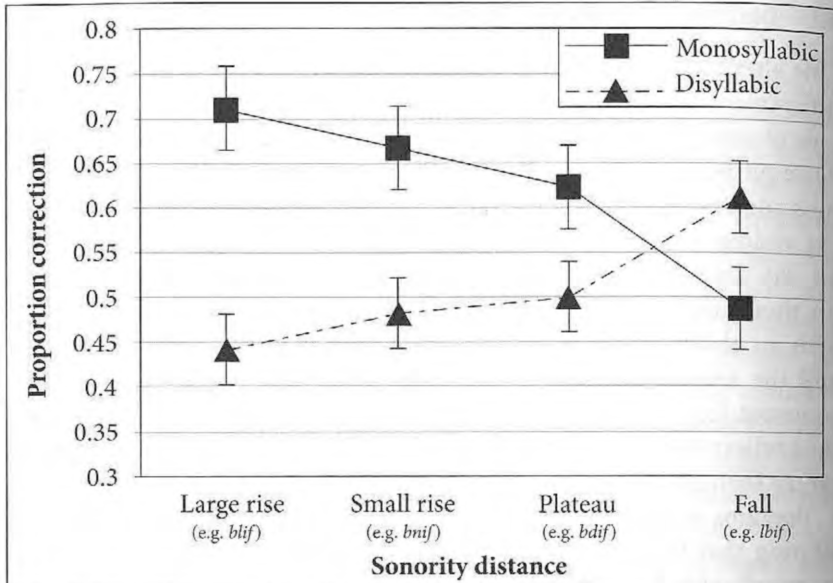

Figure 2 Mean response accuracy of Korean speakers as a function of the markedness of onsets and number of syllables. Solid line with squares is the monosyllabic condition while dotted line with triangles is the disyllabic condition. Error bars represent confidence intervals constructed for the difference between the means. Data from Berent et al. (2008, Experiment 1)

typological distribution of these onsets and converge with the preferences of English speakers—imply preferences that are broad and nonlexical in nature.

4.2 *The Scope of the Restrictions on Onset Structure: Sonority Difference or Obstruent-Sonorant Sequencing?*

Although English speakers' preference for onsets with large sonority difference is not based on the statistical properties of English words, it may not concern sonority difference specifically. Because the preference for large sonority differences were tested only with onsets comprising obstruent-sonorant combinations, it is impossible to determine whether it reflects a broad preference for a large sonority difference, in general, or a narrow preference for obstruent-sonorant sequences—sequences that also resemble the type of onsets attested in English.

To gauge the scope of these preferences, it is desirable to determine whether they are specific to comparisons involving obstruent-initial items. Here, we report two experiments that extend the investigation of sonority preferences to nasal-initial onsets. Our experiments compare two types of nasal-initial onsets. One onset type (e.g., *mlif*) manifested a sonority rise, a second type (e.g., *mdif*) manifested a fall in sonority. (Note that English has no nasal-liquid or nasal-obstruent onsets.) Each such onset was generated by a procedure of incremental splicing along the lines described in Dupoux et al. (1999).[1] We first had a native English speaker naturally produce the disyllabic counterparts (e.g., *melif* and *medif*), and selected pairs that were matched for length. We next continuously extracted the epenthetic vowel in five steady increments. This, in turn, yielded a continuum of six equal steps, ranging from the original disyllabic form to an onset cluster, in which the schwa was fully removed. Sonority rises and falls were each represented by three pairs of items, prepared in the same fashion.

These materials were presented to English speakers in an identity judgment task (AX). In each trial, participants were presented with two auditory stimuli and asked to quickly indicate whether they are identical. The experiment included an equal proportion of identity and nonidentity trials, which were further balanced for the number of marked and unmarked onsets, the phonetic length of the schwa, and order of presentation. Our interest concerns responses to nonidentity trials. Nonidentity trials paired each of the steps (the target) with one of the endpoints, which served as an anchor. In Experiment 1, the anchor corresponded to the disyllabic endpoint (step 6); in Experiment 2, we used the monosyllabic endpoint (step 1). This design systematically varied the phonetic distance between the anchor and the target (see Table 1), ranging from a distance of 1 (comparing either steps 6 and 5, in Experiment 1, or steps 1 and 2, in Experiment 2) to a distance of 5 (comparing steps 1 and 6).

Consider first the comparison of the target to the disyllabic anchor (in Experiment 1). Generally speaking, we expect the perceived distance

[1] For each member of the pair, we created a continuum of six stimuli by incrementally removing the schwa at the zero crossings. The excision of the medial vowel proceeded from the center of the schwa outwards, guided by the pitch period cycles. Stimulus one contained only the onset cluster, removing all pitch periods associated with the vowel and consonant transitions. Stimulus two contained one pitch period at each end of the schwa (a total of two pitch periods); each subsequent stimulus from 3 to 5 had two additional periods (one at each end); stimulus six was the original disyllabic form. Within each pair, the mean length of the schwa in stimulus 6 was 68ms for both rises and falls, and it contained an average of 13.5 pitch period cycles (range of 12–15 cycles).

Table 1 The structure of nonidentity trials in Experiments 1–2

	Experiment 1		Experiment 2	
Distance	Anchor	Target	Anchor	Target
1	6	5	1	2
2	6	4	1	3
3	6	3	1	4
4	6	2	1	5
5	6	1	1	6

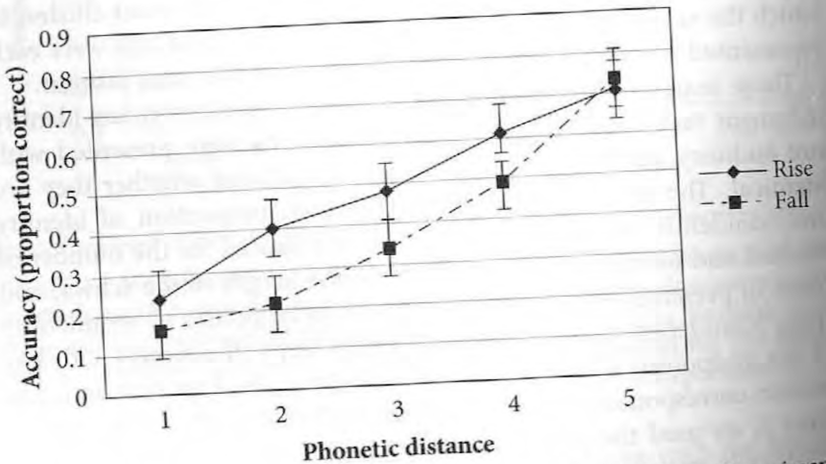

Figure 3 Mean response accuracy to sonority rises and falls in Experiment 1 as a function of phonetic distance. Error bars represent confidence intervals constructed for the difference between the means

between the target and anchor to increase with phonetic distance, resulting in better discrimination. Of interest is whether the perceived distance is also affected by the sonority profile of the onset. If people possess broad preferences concerning sonority difference, then the markedness of nasal-initial onsets of falling sonority should increase their epenthetic misperception compared to onsets of rising sonority. Thus, at any phonetic distance, perceptual distance should be smaller for sonority falls relative to rises, resulting in a reduction in response accuracy.

The results (of twelve English speakers, see Figure 3) are consistent with this prediction. As the distance between the two items increased,

discrimination improved. However, discrimination was overall better with the less marked onsets of rising sonority compared to sonority falls. These conclusions are supported by a 2 (onset type: sonority rises vs. falls) × 5 (distance) ANOVA. The significant main effect of distance F(4, 44)=40.34), MSE=.025, p<.0002) reflected an increase in identification accuracy with phonetic distance, and the marginally significant effect of onset type, F(1, 44)=3.78, MSE=.078, p<.08, indicated that sonority rises produced higher accuracy than falls. However, the effect of onset type was modulated by phonetic distance, resulting in a significant interaction, F(4, 44)=3.10, MSE=.013, p<.03. A series of tests for the simple main effect of onset type indicated that onsets of rising sonority produced reliably higher accuracy than sonority falls at distance 2, F(1, 11)=8.72, MSE=.025, p<.02, and at distance 3, F(1, 11)=5.56, MSE=.02, p<.04. No other effects were significant. This pattern suggests that the perceived distance between targets and anchors depends on both their phonetic distance and their sonority profile. Marked onsets tend to be misperceived epenthetically, and consequently, they produce lower accuracy than sonority rises. However, because phonetic distance improves accuracy, marked targets are protected at large phonetic distances (e.g., for distance 4–5). Another factor that might contribute to discrimination is the phonetic evidence for the schwa: targets with a substantial schwa might be protected from misperception. This factor might explain the lack of a sonority-difference effect at distance 1. Recall that distance 1 comprised of the disyllabic anchor and a nearly-disyllabic target of step 5. The strong phonetic evidence for the schwa might have protected *md*-type targets from misperception, rending their discrimination as good as their *ml*-type counterparts.

These results suggest that the perceptual advantage of onsets of rising sonority previously observed with obstruents generalizes to nasal-initial onsets. Markedness triggers the misperception of sonority falls, and consequently, it decreases their perceived distance from their counterpart items in a manner akin to the acoustic effect of phonetic distance.

4.3 *Markedness and Misperception: Chickens and Eggs*

Why are marked onsets misperceived? One possibility is that misperception reflects a phonological process (see Figure 4). Although we currently do not outline a formal model, our proposal attributes

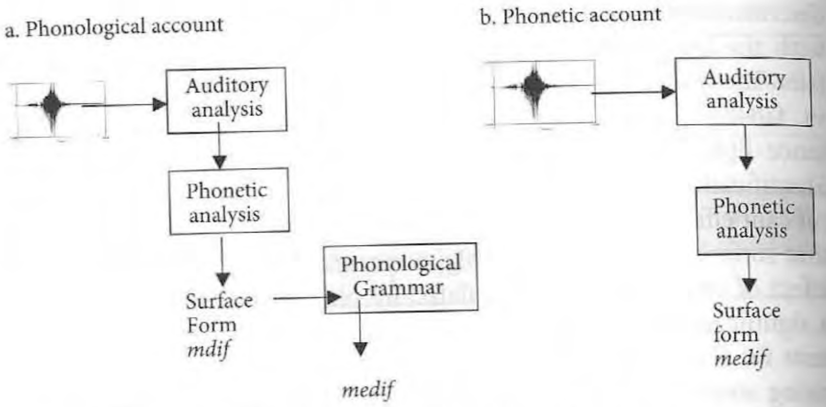

Figure 4 Phonetic vs. phonological explanations for the misperception of unattested onsets

misperception to the ranking of the relevant markedness constraints above faithfulness constraints, a state that prevents the faithful encoding of marked onsets. In this view, the misperception of marked onsets does not necessarily affect the initial extraction of phonetic form from the auditory input. In fact, this account is perfectly consistent with the possibility that the initial phonetic encoding of marked onsets is precise—as precise as that of unmarked onsets. Misperception occurs at a subsequent grammatical process that actively alters the (faithful) surface form to abide by markedness restrictions. Misperception is thus a consequence of markedness.

On an alternative phonetic explanation, onsets like *mdif* are misperceived because their acoustic properties are similar to those of their counterparts, *medif*, more so than for *mlif* vs. *melif*. Misperception occurs at an initial stage of phonetic analysis due to a passive failure to extract the phonetic form from the available acoustic information. The phonetic fragility of sonority falls results in their instability during language change and their infrequency in the typology. Markedness is thus a consequence of misperception.

Although perceptibility failures might well constrain language transmission and explain certain aspects of the typology (Blevins 2004, 2006) it is unclear that they can subsume the effects of grammatical markedness. There are several cases in which phonological restrictions can be dissociated from their functional motivations: some functionally motivated processes are unattested, whereas other attested processes are functionally unmotivated (see de Lacy 2006, de Lacy and

Kingston 2006). Here we present experimental evidence of such dissociations. We first review additional results with nasal-initial onsets, demonstrating that marked onsets are not invariably misperceived. In fact, when attention to phonetic detail is encouraged, people can represent marked onsets accurately—as accurately as they represent less marked onsets. We next show that the misperception of marked onsets and their aversion occurs even when people do not process auditory clusters. These findings will suggest that markedness is not solely a consequence of performance pressures but is potentially their cause.

4.3.1 *Marked Onsets are not Invariably Misperceived*

If the misperception of marked onsets were due to an inability to extract their phonetic form from the acoustic information, then one would expect marked onsets to be always misperceived relative to less marked onsets. In contrast, if misperception is an active phonological process that modifies the surface form, and if that surface form is accurate and accessible, then conditions encouraging its inspection should yield accurate performance with marked onsets.

One set of findings consistent with this prediction is presented by an experiment that follows up on the investigation of nasal onsets described in section 4.2. As in the previous experiment, participants engaged in an AX discrimination of a continuum of nasal-initial targets and a fixed anchor, but the fixed anchor was now set to the monosyllabic endpoint (step 1; see Table 1). Unlike the disyllabic anchors used in the previous experiment, the monosyllabic anchors are at risk of epenthetic misperception, as are the monosyllabic targets. But because anchors are frequently repeated (they are paired with every target in the nonidentity trials), people are more likely to store their surface phonetic form (other results indeed show that people store indexical phonetic information after a brief exposure, e.g., Goldinger 1998). Of interest is whether the surface phonetic form of such anchors is precise.

Given onsets of rising sonority, we expect the representation of both the target and anchor to be faithful, and consequently, monosyllabic targets (e.g., in step 2) should be difficult to discriminate from the anchor (step 1). Our interest concerns the perception of onsets of falling sonority. If epenthetic misperception is due to phonetic failure that occurs already at the initial stage of phonetic encoding, then the representation of marked targets and anchors should be effectively identical (in both cases *mdif* → *medif*), and their discrimination should be difficult. In contrast, if misperception is due to an active repair of an accurate phonetic form, and if this form is accessible, then the perceived distance between anchors and target of falling sonority will increase: unlike the anchors, monosyllabic targets will undergo repair, so their representation will differ from the faithful phonetic encoding of the anchor. This account thus predicts a paradoxical reversal in the effect of markedness on performance: marked onsets of falling sonority should produce higher accuracy compared to less marked onsets with sonority rises.

The results (from twelve native English speakers, see Figure 5) agree with this latter prediction. As in the previous experiment, response accuracy increased with phonetic distance, but onsets of falling sonority now produced reliably higher accuracy relative to onsets of rising sonority, especially when the phonetic distance was short. These conclusions were supported by a 2 (onset type: rises vs. falls) × 5 (distance) ANOVA. The reliable main effect of phonetic distance, $F(4, 44)=20.04$, $MSE=.03$. $p<.0002$, reflected an increase in performance accuracy with phonetic distance, and the effect of onset type, $F(1, 11)=4.21$, $MSE=.052$

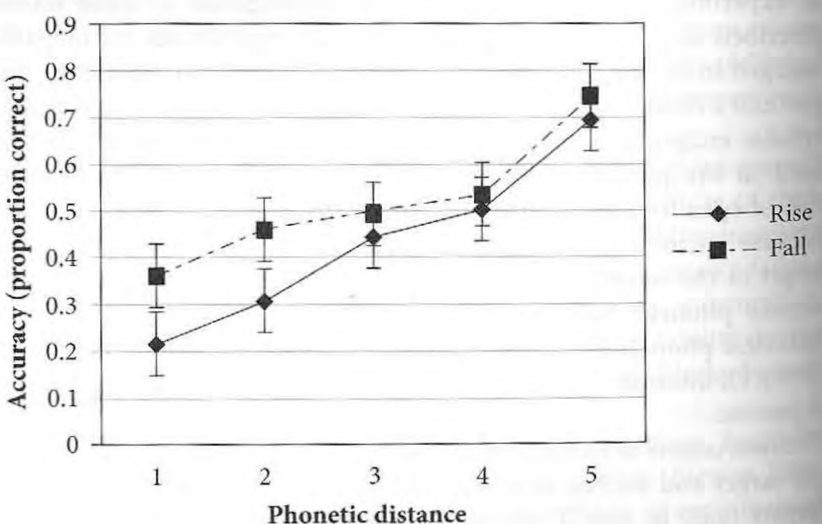

Figure 5 Mean response accuracy to sonority rises and falls in Experiment 2 as a function of phonetic distance. Error bars represent confidence intervals constructed for the difference between the means

$p<.07$, suggested that sonority falls produced higher accuracy than rises. A test of the simple main effect of onset type showed that sonority falls yielded more accurate responses than rises at distance one, $F(1, 11)=7.00$, $MSE=.018$ $p<.03$, and marginally so at distance two, $F(1, 11)=4.08$, $MSE=.035$ $p<.07$. No other effects were significant.

The better discrimination of onsets of falling sonority suggests that the representation of the marked monosyllabic anchor was more faithful than the target. Had participants misperceived anchors of falling sonority, then their representation should have been identical to the (epenthesized) target, and the disadvantage of marked onsets (demonstrated in Experiment 1) should have persisted. The misperception of the marked anchor should have also increased its similarity to disyllabic targets (e.g., to step 6, in distance 5). Unlike these targets (protected from misperception by the strong phonetic cues for the schwa), the monosyllabic anchor would have been repaired, resulting in a paradoxical *decrease* in perceived distance as phonetic distance increases. But our results do not support either prediction. As phonetic distance increased, accuracy improved, suggesting an increase in perceived distance, and sonority falls produced higher accuracy than rises. These results suggest that the repetition of highly marked anchors of falling sonority allowed participants to extract a faithful phonetic representation, thereby increasing the perceived distance with (repaired) targets. Our findings demonstrate that onsets of falling sonority are not invariably misperceived.

Note that these results do not specifically demonstrate that the representation of marked onsets is as precise as that of unmarked onsets, but this interpretation is certainly consistent with these results, and it is directly supported by additional experiments examining the perception of obstruent-sonorant combinations (Berent et al. 2007, Experiments 5–6). These experiments gauged the representation of onset clusters with sonority plateaus and falls by examining their potential to elicit identity priming. Identity priming reflects the change (typically facilitation) in the identification of a target (e.g., *lbif*) when it is preceded by an identical prime (e.g., *lbif-lbif*) relative to a nonidentical control prime (e.g., *lebif-lbif*). We expect that if people misperceive the prime (e.g., *lbif* → *lebif*) then its potential to prime an identical target (e.g., *lbif*) should be diminished relative to a less marked prime (e.g., *bdif-bdif*), and the results indeed supported this conclusion. However, when participants were encouraged to attend to the phonetic properties of the prime (by manipulating the constitution of distractor trials), the ability of sonority falls to prime the target was restored, and did not differ from that of sonority rises. These results show that, not only can people represent onsets of falling sonority accurately, but that the representation of marked onsets is as precise as less marked onsets. These observations are inconsistent with the proposal that the misperception of marked onsets is due to an inability to encode their surface phonetic form.

4.3.2 *The Dispreference of Marked Onsets is not Limited to the Perception of Auditory Onsets*

The hypothesis that markedness reflects performance difficulties in perception and production assumes that such difficulties are the sole reason for the misperception of marked onsets. So far, we have argued against this possibility by showing that marked onsets are not necessarily harder to perceive from the acoustic input. These results, however, do not necessarily show that the misperception is due to the phonological grammar. A modified version of the phonetic account, depicted in Figure 4b might maintain that repair still occurs at the phonetic stage, rather than a phonological analysis. To explain people's ability to perceive marked onsets accurately under certain conditions, this modified account asserts that people also maintain a precise, lower-level representation of the input, which allows them to circumvent the effects of repair. Regardless of whether that precise representation of the input is phonetic (on the phonological account) or echoic (on the modified phonetic version), the results clearly show that people can accurately represent the surface form of marked onsets that they typically misclassify as disyllabic. Nonetheless, it might be interesting to dissociate these two explanations by examining the circumstances triggering repair. If the aversion to marked structures and their repair reflects difficulties in phonetic analysis, then they should occur only when participants experience difficulties in the extraction of phonetic form from the auditory signal. In contrast, the phonological account allows for the possibility that the effects of markedness and repair might persist even when no perceptual difficulties are expected. This latter prediction is supported by several demonstrations.

One line of evidence comes from cases in which aversion to marked onset clusters affects the processing of forms that do not in fact have clusters. Recall that English and Korean speakers both exhibit difficulties in the perception of the disyllabic counterparts of unmarked onsets. For example, *benif*, counterpart of *bnif*, produced significantly fewer disyllabic responses relative to *lebif* (counterpart of *lbif*). As discussed earlier, the better performance with *lebif* reflects a top-down bias against *lbif*. Because such aversion to marked onset clusters emerges even when people do not process these acoustic forms, it cannot be attributed to difficulties in extraction of the phonetic properties of marked onsets.

In fact, the difficulties in discriminating marked onsets and their epenthetic counterparts emerge even when acoustic processing is altogether eliminated—when the input is printed (Berent and Lennertz 2010). In these experiments, participants engage in an identity judgment (AX task) of two printed words, presented at an onset asynchrony of 2.5 seconds—an interval that promotes the coding of the items in phonological working memory. The materials and procedure are otherwise identical to the ones previously used with auditory clusters (Berent et al. 2007; the only other difference is the addition of accuracy feedback). The results show that participants take longer to distinguish marked onsets from their epenthetic counterparts (e.g., *lbif* vs. *lebif*) relative to unmarked onsets (e.g., *bnif* vs. *benif)* just as they do with auditory materials. Clearly, the misperception of marked onsets is not confined to auditory stimuli. These results suggest that misperception can be a symptom of markedness, not invariably its cause.

5 *Conclusions*

The research described in this chapter gauged the role of universal markedness preferences and their interaction with the perceptual system. To this end, we examined whether English speakers are sensitive to the sonority distance of onset cluster types that are unattested in their language. The results suggest that the perception of unattested onsets varies as a function of their markedness: unattested onsets with smaller sonority differences are systematically misperceived compared to unattested onsets with larger differences. These misperceptions are inexplicable by various non-grammatical sources. Specifically, the perceptual advantage of onsets with large sonority rises is unlikely due to lexical analogies, as the perceptual advantage of large rises remained after controlling for several statistical properties of English, it extended to nasal-initial onsets, and it obtained even among speakers of Korean despite the absence of onset clusters from their language. The misperception of marked onsets is also not due to an inability to encode their phonetic form. We showed that onsets of falling sonority can be encoded accurately when their phonetic form becomes more salient (through repeated presentations) or relevant to task demands. In fact, the dispreference for onsets with small sonority differences is observed even when people do not process their phonetic form at all—when they process their disyllabic counterparts, and with printed materials. These results suggest that the systematic misperception of onsets with small sonority differences is not due to a passive failure to encode their surface form, but rather to an active grammatical process that converts a faithful surface form to a less marked representation. These results further suggest that speakers possess markedness restrictions concerning the sonority difference of onsets that are unattested in their language, and that such restrictions shape the perception of marked onsets.

Our findings are consistent with the hypothesis that markedness restrictions are not mere relics of language change, language frequency and the properties of the mechanisms of perception and articulation. Rather, markedness restrictions are active in the brains of individual speakers. These conclusions do not preclude the role of performance factors in shaping markedness preferences—such factors, along with historical considerations might be necessary to explain why most typological generalizations are only statistical tendencies, rather than absolute statements (Berent 2009). Nonetheless, markedness is not invariably the consequence of misperception: it can also be its cause.

One question that is not directly addressed by our results concerns the precise domain of the restriction: whether the restrictions on the structure of words' onsets appeal to the left edges of syllables or words. Steriade (1999) suggests that the preference for forms such as *blif* reflects linear restrictions on consonant sequencing, motivated by knowledge concerning the perceptibility of consonant combinations at the word's edge. The preference for *blif* thus refers to knowledge about words, not syllables per se. Because our results invariably concern monosyllabic words, we cannot pinpoint the precise domain of the relevant knowledge. Nonetheless, our findings call into question the assertion that sequencing preferences invariably reflect knowledge of perceptibility. Specifically, the possibility that (mis)perception is shaped, in part, by markedness, suggests that the imperceptibility of certain linear sequences might, in fact, be the consequence of markedness, not necessarily its cause. The precise relationship between the grammar and perception awaits further research, but there is every reason to believe it is not unidirectional.

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