Lateral phonotactics in Australian languages∗

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1. Introduction

Australian languages have large inventories of sonorant laterals; there are generally at least two, and often up to four, laterals in a language. These laterals are subject to fairly strict phonotactic restrictions: they rarely appear word-initially, and almost never appear postconsonantally. The distribution of laterals in Australian languages is in fact implicational, such that a language allowing word-initial laterals will always allow postvocalic laterals, and one allowing postconsonantal laterals will always allow word-initial laterals as well. Examples of languages demonstrating these implicational restrictions on lateral distribution are given in (1).

(1) a. Panyjima Dench (1991)
   Laterals:  | | | λ Word-initial: * | | | | * | | | | λ Postconsonantal: * | | | | * | | | | λ

   Laterals:  | | λ Word-initial:  | | λ Postconsonantal: * | | * | | λ

This paper will discuss possible explanations of these restrictions. Recent work on phonotactics has offered two types of analyses of this sort of pattern. An analysis based on positional sonority restrictions (e.g. Gouskova 2002, 2003; Smith 2002) would attribute lateral distribution to the sonority of laterals. A Licensing by Cue analysis (e.g. Jun

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1995; Kochetov 1999; Steriade 1997, 1999) would attribute this distribution instead to the interaction of lateral acoustics with contextual acoustics. Section two provides an analysis of lateral phonotactics in Australian languages based on positional sonority restrictions, and shows that such an analysis can capture the phonotactic patterns in these languages. Section three discusses Licensing by Cue, and presents the results of an acoustic experiment which shows that the acoustic properties of Australian laterals do not provide evidence that lateral phonotactics can be described by such an analysis.

2. A sonority-based account

An account of lateral phonotactics must describe their appearance (and lack thereof) both word-initially and also postconsonantally. This section will present first Smith’s (2002) positional augmentation analysis of the word-initial restrictions, and then a syllable-contact account of the postconsonantal restrictions following Gouskova (2002, 2003).

2.1. Word-initial restrictions

As described above, Australian languages like Panyjima don’t allow laterals to appear word-initially. This restriction is discussed by Smith (2002), who argues that word-initial onsets are preferentially of low sonority, as the acoustic properties of low-sonority segments maximize the perceptual salience of a word beginning and facilitate word recognition. She encodes this tendency in the sonority-based [*ONSET/X]/σ₁ constraint hierarchy in (2) and (3).

\[
(2) \quad [*ONSET/X]/σ₁ \quad \text{The onset of the initial syllable in a word must have sonority less than that of X.}
\]

\[
(3) \quad [*ONS/Glide]/σ₁ \gg [*ONS/R]/σ₁ \gg [*ONS/L]/σ₁ \gg [*ONS/N]/σ₁ \gg [*ONS/Stop]/σ₁
\]

Ranking IDENT[F]\(^1\) below [*ONSET/Lateral]/σ₁ forces low-sonority nasals and stops to appear faithfully in word-initial position, but bans initial high-sonority glides, rhotics, and (crucially) laterals, as shown in (4).

\[
(4) \quad \begin{array}{ccc}
/lana/ & [*ONSET/Lateral]/σ₁ \quad \text{IDENT[F]} \\
\hline
\text{lana} & *! & \\
\text{tana} & \ast & \\
\end{array}
\]

Using this sonority-based hierarchy to prevent initial laterals correctly predicts that higher-sonority segments like rhotics will be banned in languages lacking initial laterals. This

\(^{1}\) As this is a phonotactic effect, alternations provide no evidence about which faithfulness constraint bans initial laterals; I use IDENT[F], which penalizes feature changes, here, but MAX or DEP would work as well.
prediction is borne out in Australian languages; Panyjima is typical in banning its full inventory of both laterals and rhotics in intial position.\(^2\)

(5) Panyjima Dench (1991) Liquids: \( r \ R \ l \ n \ \lambda \) Word-initial: \( *r *r *l *l *\lambda \)

**2.2. Postconsonantal restrictions**

Most Australian languages (e.g. Panyjima, Anindilyakwa) also prevent laterals from appearing postconsonantally. As Australian languages tend to have quite simple syllable shapes, without complex margins, this means that laterals cannot appear as the second member of a medial coda-onset cluster. Evidence that this is a syllable contact effect, rather than simply a restriction on sequences of phonemes, is found in languages like Gooniyandi (McGregor 1990). Here, CL clusters are possible when they are word-initial (tautosyllabic), but not medial (heterosyllabic): \( p l a n . p i . r a \) ‘on one’s back’, but \( *k a p . l a \). Laterals are therefore only banned as the second member of a coda-onset cluster, rather than in all postconsonantal positions.

In order to formalize this syllable contact restriction, we must define sonority values for laterals and other segments. Parker (2002) found that the sonority values given in (6) (where values are shown for those segments which occur in Australian languages) correlate with segments’ acoustic intensity.\(^3\)

\[
\begin{array}{|c|c|}
\hline
\text{w} j & 11 \\
\text{r} & 10 \\
\text{l} l \ l \ \lambda & 9 \\
\text{r} & 8 \\
\text{m} n n n p \eta & 6 \\
\text{p} t t t c k & 1 \\
\hline
\end{array}
\]

Syllable contact restrictions based on these sonority values can be expressed using Gouskova’s (2002, 2003) \(*D I S T A N C E \ X\) constraint hierarchy.\(^4\) This enforces syllable contact restrictions by preferentially licensing coda-onset clusters with steeply falling sonority contours. Constraints of the form in (7) are in the fixed ranking in (8), where a relatively high-ranked constraint like \(*D I S T A N C E +3\) assigns violations to clusters like \( m . l \), where the sonority of the onset \( l \) is three degrees above the sonority of the preceding coda \( m \). Such a cluster with a steep rise in sonority is worse than a cluster like \( l . m \), where the sonority of the coda is greater than that of the onset.

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\(^2\) Factorial typology predicts that glides should occasionally fail to follow the general sonority-based phonotactic patterns that other consonants do, because glides also have vocalic ([V -Place]) features (Clements 1991). Formally, this means that the ranking \( D E N T [V - \text{Place}] \gg \text{sonority restrictions} \gg D E N T [F] \) is possible. Throughout Australian languages, it is common for glides to surface word-initially and postconsonantally.

\(^3\) Relevant earlier work on numerical sonority values includes Clements (1990), Selkirk (1984), and Steriade (1982).

\(^4\) The \(*D I S T A N C E \ X\) hierarchy is formally developed through relational alignment of the \(*O N S E T / X\) and \(*\mu / X\) hierarchies, which prefer low-sonority onsets and high-sonority codas, respectively. This produces a syllable-contact hierarchy which may also be characterized in terms of numeric sonority contours.
(7) *DISTANCE X The sonority difference between consonants in a heterosyllabic cluster may not be X.

(8) steep rise flat steep fall
... *DIST +3 ≫ *DIST +2 ≫ *DIST +1 ≫ *DIST 0 ≫ *DIST -1 ≫ *DIST -2 ≫ *DIST -3...
e.g. *m.l *l.c *l.m

The *DISTANCE X constraints relevant to possible clusters in Australian languages are given in (9). Ranking *DISTANCE -2 ≫ IDENT[F] ≫ *DISTANCE -5 correctly predicts a lack of lateral-final clusters; this ranking can be determined based on the inventory of clusters in Australian languages, as will be described below.

(9) *DIST +8 ≫ *DIST +3 ≫ *DIST +1 ≫ *DIST 0 ≫ *DIST -1 ≫ *DIST -2 ≫ IDENT[F] ≫ *DIST -5
e.g. *p.l *m.l *r.l *l.l *r.l *w.l ✓ n.t

First, we know that IDENT[F] must outrank *DISTANCE -5. This is because, of the possible clusters in Panyjima (whose cluster inventory is typical of Australian languages), the worst cluster which is allowed to surface – i.e. the cluster with the smallest sonority drop – is a nasal followed by a stop, as in kan.ta ‘leave it!’ The nasal has a sonority value of 6, and the stop has a sonority value of 1; the slope is therefore -5, so in order for this cluster to surface faithfully, IDENT[F] must outrank *DISTANCE -5.

(10) /kanta/ IDENT[F] *DISTANCE -5
   ↓ kana *!
   kal.ta *

The inventory of Panyjima clusters further demonstrates that *DISTANCE -4 must outrank IDENT[F], because clusters with a sonority drop of -4 (e.g. r.y) never surface faithfully.

(11) /tarña/ *DISTANCE -4 IDENT[F] *DISTANCE -5
   ↓ tar nya *!
   tar.ka *

Given the ranking *DISTANCE -4 ≫ IDENT[F] ≫ *DISTANCE -5, and the rest of the *DISTANCE hierarchy, the absence of lateral-final clusters is predicted as shown in (9). The best possible lateral-final cluster – i.e. the one with the maximal sonority drop – would be composed of a glide followed by a lateral. This would violate *DISTANCE -2, which outranks *DISTANCE -4 and therefore outranks IDENT[F]. This and all other lateral-final clusters (which would have even less optimal sonority contours) are therefore banned.

   ↓ taw la *!
   taw.ta *
2.3. **On the implicational distribution of laterals**

I have shown that the common word-initial and postconsonantal bans on laterals in Australian languages can be explained in terms of laterals’ relatively high sonority, as these phonotactic positions prefer to host low-sonority segments. The restrictions are formally encoded in sonority-based constraint hierarchies targeting initial and postconsonantal onsets; the rankings of these constraints necessary to predict the restrictions on laterals also correctly predict other phonotactic patterns found in these languages.

As noted earlier, lateral phonotactics are implicational: if laterals are licensed word-initially in a language, they also appear postvocically; if they are licensed postconsonantally, they will be licensed word-initially as well. This section has shown that the lateral restrictions in these two positions can be captured using the \( \ast \text{DISTANCE}_X \) and \( \ast \text{ONSET}/X/\sigma_1 \) constraint hierarchies. The use of independent constraints, however, does not inherently capture the implicational nature of the restrictions. Factorial typology predicts that a language should be able to ban laterals word-initially but allow them to surface postconsonantally; this pattern is never attested in Australian languages. Given the crosslinguistic tendencies to impose sonority-based restrictions word-initially and postconsonantally, however, as well as the tendency towards phonological consistency within Australian languages, this accidental implicational relationship is nevertheless expected, as follows.

Only a small set of languages bans initial high-sonority segments: the Iglesias dialect of Campidanian Sardinian (Bolognesi 1998) and Mbabaram (Dixon 1991) ban initial rhotics, and Mongolian (Poppe 1970), Kuman (Lynch 1983), and most Australian languages (Hamilton 1996) ban all initial liquids. While such high-sonority segments are perceptually marked in word-initial position, most of the world’s languages allow them. This means that there is a strong tendency for \( \ast \text{ONSET}/\text{Lateral}/\sigma_1 \) to be relatively low-ranked. In contrast, syllable-contact restrictions against coda-onset clusters without sharp sonority drops are prevalent (see Gouskova (2003) and references cited therein); this indicates that \( \ast \text{DISTANCE}_X \) constraints (which tend to prevent lateral-final clusters) tend to be relatively high-ranked cross-linguistically.

A likely functional motivation for these tendencies arises in the competing pressures to which word-initial position is subject. Initial segments are preferentially of low sonority in order to facilitate identification of word boundaries. However, in order to facilitate rapid word recognition, it is also important to maximize the number of segmental contrasts realized in initial position; this pressure is expressed by positional faithfulness constraints; see e.g. Beckman 1998. The cross-linguistic desirability of low-sonority initial segments is likely often sacrificed in order to maximize initial contrasts. No similar competing pressures are relevant in medial clusters, and thus syllable-contact restrictions may apply more freely across languages.

Given these tendencies, it is not surprising to find that \( \ast \text{DISTANCE}_X \) constraints apply more frequently across Australian languages than do \( \ast \text{ONSET}/X/\sigma_1 \) constraints. The fact that these languages go beyond a mere tendency and are deeply consistent in allowing \( \ast \text{ONSET}/X/\sigma_1 \) constraints to be active (i.e. high-ranked) only if those \( \ast \text{DISTANCE}_X \) constraints which ban postconsonantal laterals are highly-ranked as well is also unsurpris-
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Given that the phonological systems of Australian languages tend to be quite consistent (Hamilton (1996), Dixon (2002)). Lateral restrictions are only one of many phonological patterns which are common across Australian languages. While individual languages vary in where laterals may appear, they adhere to a basic pattern where laterals are dispreferred word-initially, and even more strongly dispreferred postconsonantly.

3. Experimental evidence against a Licensing by Cue analysis

Another type of explanation which is commonly used to explain phonotactic patterns is Licensing by Cue (LBC); this would explain lateral phonotactics in terms of the interaction of lateral acoustics and contextual acoustics (Steriade 1997, 1999).

An example of a LBC analysis is that given by Steriade (1999) for the distribution of retroflex segments. This analysis is based on two observations. First, crosslinguistic surveys show that retroflexion is implicationally licensed: if a language allows retroflexion word-initially, it is also allowed postvocally; if it is allowed postconsonantally, it is allowed word-initially. Second, the primary acoustic difference between retroflexes and very similar apico-alveolar segments is found in their anticipatory F3 and F4 transitions (Steriade 1999; Stevens and Blumstein 1975); the fact that the segments contrast primarily at their left edges makes them acoustically left-anchored. LBC claims that the presence of asymmetric acoustic cues to segmental identity determine the possible phonotactics of those segments. In the case of retroflexes, the acoustics of the left-edge context of the segments determine the degree to which the left-edge acoustic cues are perceptible. The anticipatory transitions are easy to hear postvocally, somewhat masked word-initially, and largely obscured postconsonantally; retroflexes are therefore implicationally licensed across these contexts.

As was observed above, laterals have the same implicational distribution, across the same contexts, that retroflexes do. This begs the question of whether laterals, like retroflexes, are acoustically left-anchored; if so, their acoustics could provide a straightforward explanation for their phonotactics. As will be shown below, however, acoustic experiments showed no evidence of left anchoring in Australian laterals.

3.1. Methods

Tokens for acoustic analysis were taken from three Australian languages where lateral manner of articulation has an implicational distribution.5

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(13) a. Ngandi (Arnhem Land; Heath 1978)
Lateral: 1ʃ Word-initial: 1ʃ *ʃ Postconsonantal: ʃ *

b. Jingulu (Mindi; Pensalfini 1997)
Lateral: 1ʃ ń Word-initial: 1ʃ *ń Postconsonantal: *ʃ *ń *λ

c. Warlpiri (Pama-Nyungan; Nash 1986)
Lateral: 1ʃ ń Word-initial: 1ʃ *ń *λ Postconsonantal: *ʃ *ń *λ

The data in (13) shows that retroflex and palatal laterals are sometimes subject to independent restrictions, e.g. acoustically-based LBC restrictions, in particular phonotactic positions. These restrictions against particular laterals are not the subject of the current investigation, which is instead concerned with patterns of licensing lateral manner. If any laterals may surface in a phonotactic position, this is evidence that lateral manner is licensed in that position.

The overall spectral intensity of vowel-lateral transitions in these languages was examined for evidence of left-anchored acoustic asymmetry. This measure was identified as a likely locus of asymmetry because laterals are known to be less intense than vowels, due to both the relatively closed oral configuration during a lateral and also the acoustic zero which results from a lateral’s supralingual cavity. Vowel-to-lateral transitions are therefore characterized by a decrease in intensity. Stevens claims that English laterals display abrupt, dramatic increases in formant amplitudes during transitions into following vowels, while transitions from preceding vowels into laterals show much shallower and more gradual changes in formant amplitude. While formant transitions are the locus of asymmetry in retroflexes, and Stevens does note asymmetrically long F2 transitions in English laterals (1998: 550), impressionistic examination of representative spectrograms such as that in figure 1 suggests that this is not the case for Australian laterals, and so this measure was not examined.

Figure 1. [ala], from Jingulu kalara

The experiment used tokens of laterals which were pronounced by a single speaker of each language in the context a_a; the number of tokens of each lateral is shown in (14).
The edges of laterals and flanking vowels were identified by hand. The spectral amplitude of each token was measured (using Praat (Boersma and Weenink 1992)) at the midpoints of the glottal pulses which occur at the midpoint of each flanking vowel; the midpoint of each lateral; and, for each token, the last three pulses in the pre-lateral vowel, the first and last three pulses in the lateral, and the last three pulses in the post-lateral vowel. Amplitude measurements in each token were normalized to reference amplitude values, taken at the midpoints of the flanking vowels in that token. Amplitudes in the preceding vowel and before the midpoint of the lateral were normalized using the amplitude of the midpoint of the preceding vowel, and similarly measures taken after the midpoint of the lateral and in the following vowel were normalized using the amplitude of the midpoint of the following vowel. The amplitude of the lateral midpoint was compared to the amplitudes of the midpoints of both the preceding and following vowel, to evaluate relative coarticulation. For more discussion of the experimental procedure and results, see Flack 2005.

If laterals are in fact left anchored, they may have either of two acoustic properties. It may be the case that the whole of a vowel which precedes a lateral would be less intense than a vowel which follows a lateral, as a result of increased anticipatory coarticulation with the lateral. It may also be the case that local coarticulation could be observed, and that the transition from a preceding vowel into a lateral would be less intense than the transition from a lateral into a following vowel, also as a result of anticipatory coarticulation rendering the preceding transition more lateral-like than the following transition. The acoustic study conducted here showed no evidence confirming either of these predictions.

3.2. Results

Data examined in this experiment failed to find evidence that vowels preceding laterals are more coarticulated with laterals than are vowels following laterals. Figure 2 shows the difference in intensity between laterals and the midpoints of flanking vowels. The height of the bars represents the extent to which the vowel is louder than a lateral; a shorter bar represents more acoustic similarity and thus more coarticulation.
Figure 2. Flanking vowel coarticulation with laterals, measured as difference between the normalized intensity of laterals and preceding/following vowels; low values indicate high coarticulation. Data is averaged across Ngandi, Jingulu, and Warlpiri laterals at each place of articulation, with 95% CI.

If preceding vowels were more coarticulated with laterals than following vowels, the light bars would be shorter at each place of articulation; this is generally not the case. The only laterals in which this pattern begins to emerge are the retroflexes, but this is likely because retroflex segments are left-anchored for articulatory reasons unrelated to laterality. If anything, following vowels are generally more similar to apico-alveolar and palatal laterals, indicating that there may be a weak tendency for lateral articulation to continue into following vowels. This will be further discussed in section 3.3.

Transitions between laterals and flanking vowels were also examined for asymmetries in spectral intensity; the crucial question in this investigation was whether the end of a pre-lateral vowel showed acoustic characteristics of laterality. These results are shown in figure 3, where three charts represent changes in intensity during vowel-to-lateral and lateral-to-vowel transitions at each place of articulation. The x-axis in each chart represents intensity measurement points across time; measurements were taken at the final three glottal pulses preceding a lateral and the first three pulses of the lateral itself, as well as at the last three glottal pulses of the lateral and the first three pulses in the following vowel. Dotted vertical lines represent the edges of the laterals. The y-axis represents the normalized intensities found at these points. The heavy horizontal lines at 0 dB represent the normalized intensity of the flanking vowels, to which intensities at other positions were compared; lateral intensity is consistently lower than that of the flanking vowels, as expected.
If laterals induced anticipatory coarticulation in the end of preceding vowels, such that vowel-to-lateral transitions were acoustically similar to laterals, we would expect the intensity at the end of the preceding vowels to be lower than that at the midpoint of the vowels, and similar to that of a lateral – that is, the first three measurements in each graph should be below 0 dB. This is never reliably the case; these final measurements in the preceding vowels are quite close to 0 dB, and there is a consistent sharp drop in intensity at the beginning of the lateral, rather than preceding this edge.

In both measurements, therefore, there is no evidence that laterals are acoustically left-anchored. This means that there is no support for the claim that Licensing by Cue can explain lateral phonotactics in terms of their acoustic properties.

3.3. Discussion

Lateral acoustics do not support a Licensing by Cue analysis of their phonotactics. As lateral licensing depends on the segmental context at their left edge, Licensing by Cue predicts that there should be information about laterals available in preceding vowels. The previous section demonstrated that this was not the case. Given the acoustic properties of laterals, Licensing by Cue may in fact predict that laterals are right-anchored, and thus that...
lateral licensing should be dependent on right-edge contexts. The reasons for this are as follows.

Figure 2 showed a tendency for vowels following laterals to be more coarticulated with laterals than are the vowels preceding laterals. This indicates that acoustic characteristics of laterality may be found primarily in following vowels. This acoustic asymmetry would render laterals right-anchored, rather than left-anchored.

Another pattern suggestive of right-anchoring appears in figure 3. At each place of articulation, there is a brief, burst-like amplitude peak which rises above the mid-vowel amplitude, immediately following a lateral release. Blumstein and Stevens (1979, 1980; Stevens and Blumstein 1978) have shown that this sort of abrupt acoustic event attracts the attention of the auditory system and plays a crucial role in segment identification. The reliable presence of such bursts following laterals suggests that identification of laterals may be aided by these bursts, and this is therefore another indication that more information about laterals is available at the right, rather than the left, edge of a lateral.

If anything, laterals seem to be acoustically right-anchored. Phonotactically, however, their distribution can be described in terms of their left-edge context. This mismatch in acoustic and phonotactic properties challenges the strongest formulation of the Licensing by Cue hypothesis, which is that asymmetrical segmental acoustics will determine segments’ phonotactic distributions, and that edge-sensitive phonotactics necessarily result from asymmetrical acoustics. Neither of these claims is supported by the acoustics of Australian laterals. The evidence discussed here suggests instead that Licensing by Cue should instead make the weaker claim that asymmetrical segmental acoustics may determine phonotactics, as is the case for retroflex segments. Other factors, however, may also be important in determining patterns of phonotactic licensing, as is sonority in the case of Australian laterals discussed here.

4. Conclusion

In Australian languages, the left-edge environment of a phonotactic position determines whether laterals may occur there. Similar phonotactic patterns have been explained both by reference to asymmetrical segmental acoustics and also using optimality-theoretic positional sonority restrictions. Acoustic experiments have shown that there is no evidence of explanatory left-anchoring in lateral acoustics, and further that there may be evidence of right-anchoring, which is unexpected given the phonotactic patterns of laterals. An analysis based on positional sonority restrictions, on the other hand, both accurately describes lateral phonotactics and also correctly predicts other phonotactic patterns which occur in these languages. As the sonority-based analysis is the best way to characterize this pattern, Licensing by Cue must be formulated in such a way that it does not universally demand a causal relationship between asymmetrical acoustics and phonotactic licensing. Instead, it must allow other theoretical means of determining patterns of phonotactics.
References


Leeding, Velma Joan. 1989. Anindilyakwa phonology and morphology. Doctoral Disser-
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