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Prosody and melody in vowel disorder[1]

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The paper explores the syllabic and segmental dimensions of phonological vowel disorder. The independence of the two dimensions is illustrated by the case study of an English-speaking child presenting with an impairment which can be shown to have a specifically syllabic basis. His production of adult long vowels displays three main patterns of deviance – shortening, bisyllabification and the hardening of a target off-glide to a stop. Viewed phonemically, these patterns appear as unconnected substitutions and distortions. Viewed syllabically, however, they can be traced to a single underlying deficit, namely a failure to secure the complex nuclear structure necessary for the coding of vowel length contrasts.

1. Introduction

One problem with attempting to specify the nature of disorders affecting the phonology of vowels lies in the notion VOWEL itself. VOWEL is a lay term which is ambiguous in so far as it can refer either to a sound's syllabic position or to its phonetic quality. In the first sense, it describes a sound which occupies the nuclear portion of a syllable. In the second, it describes the quality of a sound produced with open approximation of the articulators. The notion has no unique embodiment in modern non-linear constructions of phonological representation, in which the syllabic and qualitative dimensions are kept formally distinct. From a non-linear perspective, a 'vowel' disorder could in principle target one of these dimensions to the exclusion of the other.

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Here we discuss the case study of an English-speaking child who was initially diagnosed as presenting with a vowel impairment. The disorder, we will argue, has a specifically syllabic basis. His production of adult long vowels displays three main patterns of deviance – shortening (as in *wɪd* ⟨weed⟩), bisyllabification (as in *tɔyə* ⟨tyre⟩ (*y* = IPA *j*)) and, most strikingly, hardening. Under the last of these, the second portion of a target long vowel/diphthong is hardened to a labial or palatal stop, as in *kab* ⟨cow⟩, *yɪb* ⟨you⟩, *sɪɟ* ⟨see⟩.

Described in traditional phonemic terms, shortening, bisyllabification and hardening might give the impression of being an arbitrary collection of unconnected substitutions and distortions. Viewed in relation to syllable structure, however, they can be shown to stem from the same underlying deficit, namely a failure to secure the complex nuclear structure necessary for the coding of vowel length contrasts. The deficit might have been expected to produce across-the-board vowel shortening, including monophthongisation of the sort reported in certain other studies of developing phonology (see for example Bleile 1989, Davis & MacNeilage 1990) and disordered phonology (Pollock & Keiser 1990, Reynolds 1990, Gibbon, Shockey & Reid 1992). However, the generalization of this effect throughout the child's phonology is apparently forestalled by some pressure to retain the overall quantity of target forms. Glide hardening, we will argue, represents a response to the conflict between quantitative imperatives and the nuclear deficit.

Before introducing the case study in section 3, we set the scene in section 2 by considering what we see as the main issues in the specification of vowel disorder. Section 4 clarifies our position on what constitutes phonological as opposed to phonetic disorder. In section 5, we provide arguments supporting the assumption that the deficit presented in the case study is authentically phonological in nature. Section 6 summarizes the main conclusions.

2. Syllabic universals and vowel disorder

2.1 *Phonological* '*deviance*'

Children with developmental phonological disorder have difficulty in producing well-formed output despite typically having normal language comprehension and no obvious neurological or physical impairment. Assessment and remediation of such cases have tended to focus almost exclusively on consonant production. However, increasing evidence suggests that vowel acquisition in this group is more problematic than has previously been recognized. Pollock & Keiser (1990), for example, report latent mean error levels of 24% in the vowel productions of a group of phonologically disordered children diagnosed as having moderate or severe consonant disorder. In addition, there is a growing body of case studies describing systems with gross vowel errors (see especially Hargrove 1982, Reynolds

1990, Stoel-Gammon & Herrington 1990, Gibbon et al. 1992, Penney, Fee & Dowdle 1994).

The analysis of consonant production in developmental disorder has traditionally been concerned with making the clinically useful distinction between delayed and deviant output. DELAY describes the perseverance of forms which are more typically associated with earlier stages of acquisition and which are presumed to resolve themselves along the same paths as in normal development. Deviant phenomena, often identified as priority targets for therapy (see for example Ingram 1992), consist in idiosyncratic forms which rarely if ever figure in normative data. The substantial body of data on normal consonant acquisition allows us to apply this differentiation to corresponding disordered data with some degree of confidence.

A certain amount of information on normal vowel acquisition also exists (see especially the quantitative studies of English in Bond, Petrosino & Dean 1982, Davis & MacNeilage 1990, Otomo & Stoel-Gammon 1992 and the relevant contributions to Irwin & Wong 1983). However, the database in this case is considerably more limited than that available for consonantal acquisition. In the absence of a full set of developmental guidelines that would allow us confidently to categorise vowel disorders along the lines of delay versus deviance, we explore here the value of using cross-linguistic phonological universals as a benchmark.

Research has largely vindicated Jakobson's (1971) claim that explicit parallels can be drawn between the universal preferences exhibited by primary phonological systems and the sorts of phenomena that occur in language impairment and the early stages of language acquisition. The congruities are particularly clear in the realm of syllable structure. Broadly speaking, syllabic configurations that are cross-linguistically disfavoured tend to be suppressed in secondary systems – emergent or disordered approximations of primary grammars. Perhaps the best known examples involve implicational universals governing the syllabification of consonants. For example, some languages allow consonants to occur both as singletons and in clusters; others eschew clusters altogether; but there are no languages in which consonants only ever appear in clusters. Some languages accommodate both vowel-final and consonant-final words; in others, all words end in vowels; but there are no languages in which all words end in consonants. These cross-linguistic distributions are matched by a high incidence of consonant deletion and consonant-supporting vowel epenthesis in language acquisition and impairment. Together, these patterns confirm the unmarked status of, among other things, simplex onsets, open syllables and vowel-final words.[2]

[2] This is not to deny that there can be circumstances under which a marked option is selected in order to satisfy constraints that are orthogonal to the syllabic typology under discussion here. For example, minimal weight requirements may force a syllable to be closed in certain contexts, a point we return to in section 5.2.

The facts of consonant syllabification relate specifically to the constituency of onsets and codas, but they suggest a general preference for non-branching structure which might be predicted to extend to the syllabification of vowels. Some languages possess a contrast between short and long vowels, expressed syllabically as a distinction between non-branching and branching nuclei (as in English ⟨bid⟩ versus ⟨bead⟩). Languages lacking such a contrast can reasonably be treated as disallowing branching nuclei. However, there is no evidence to support the postulation of grammars in which nuclei are always required to branch. If Jakobsonian syllabic universals are of general validity, we should expect vowel length contrasts to come under pressure to restructure in language acquisition and disorder. This matter has been largely ignored in the relevant literature, but the expectation appears to be borne out by the available evidence, some of which we discuss here.

Delimiting the syllabic resources available to languages forms part of a wider theoretical programme which seeks to define the notion POSSIBLE PRIMARY SYSTEM. This involves identifying (i) a set of universal principles which determine the absolute structural bounds beyond which primary systems are unable to stray and (ii) a putatively small set of (typically binary) choices governing the respects in which systems are free to vary. Most choices are evidently weighted, as revealed in the unequal way in which alternatives are distributed across languages. For example, many languages decline the option of allowing syllable onsets to branch (and thus to contain consonant clusters); hence the implicational universal whereby all languages possess forms with simplex onsets, while only a subset also permit more marked forms with complex onsets.

According to an essentially Jakobsonian line of thinking, the totality of unmarked phonological alternatives defines the initial state in language acquisition. Normal linguistic development proceeds via the switching of options in cases where the target system shows the marked alternative. Any holdup in this resetting process will result in a secondary system that is parochially deviant – one which belongs to the set of universally possible primary systems but is inappropriate in relation to the ambient model. It is a moot point whether impaired development can ever produce a grammar that is universally deviant in the sense that it generates phonological structures which are unattested in the world's primary languages.

In the case study to be presented below, the child's system shows itself to be parochially deviant with respect to the organisation of nuclear structure. The disorder, we will argue, consists in a failure to consolidate the branching constituent setting necessary for the full acquisition of English vowel length contrasts. The perseverance of unmarked non-branching structure results in a nuclear subsystem that is well-formed in many languages but is inappropriate for languages such as English.

2.2 *The melodic and prosodic dimensions of vowel disorder*

The ambiguity of the term VOWEL can probably be traced to the fact that particular aspects of the two dimensions to which it refers, syllable structure and phonetic quality, overlap to some extent. Nuclei are preferentially occupied by sounds produced with open approximation of the articulators (VOCOIDS, to use Pike's (1943) term). Nevertheless, the less than perfect fit between the two dimensions is confirmed by the fact that nuclei can be inhabited by non-vocoids, such as syllabic nasals or laterals, and that vocoids can also occupy non-nuclear positions (where they are traditionally referred to as glides). One lesson to be drawn from the present case study is that it pays to keep the syllabic and qualitative interpretations quite distinct. (This will not prevent us from continuing to use VOWEL as a convenient descriptive term wherever the context disambiguates it.)

The ambiguity inherent in the notion VOWEL touches on a fundamental design property of phonological form. It is now widely accepted in the theoretical literature that phonological representations combine two quite distinct organizational subsystems, PROSODY and MELODY. Prosodic structure (roughly equivalent to Jakobson's (1971) FRAMEWORK) comprises a hierarchy of domains which define relations between segments within phonological strings. The terminal nodes of this hierarchy are skeletal syllabic positions, which are gathered into syllabic constituents (onsets, nuclei and rhymes).[3] At this level, representations code such relations as a segment's syllabic affiliation, its contribution (if any) to syllable quantity and its phonotactic adjacency to neighbouring segments. Syllabic constituents themselves are grouped into larger domains, including the foot and the prosodic word. Relations defined at these levels are implicated in such matters as metrical structure (responsible for word stress, amongst other things), vowel syncope and the scope of long-distance harmonic assimilation.

Melody (Jakobson's (1971) CONTENT) codes those characteristics of a segment's make-up that are manifested as phonetic quality, including such properties as labiality, palatality, occlusion, friction and voicing. These categories are assumed to be deployed on separate autosegmental tiers, in recognition of the fact that each is independently accessible by phonological processes. (The use of the term MELODY acknowledges the similarity between tonal and non-tonal categories in this respect (Halle & Vergnaud 1980).).

The independence of melody and prosody is underscored by the fact that they are evidently connected in a non-linear fashion. As a result, a single piece of melody can be associated simultaneously to more than one position in prosody; and a single position can be linked to more than one piece of

[3] Under a competing view, the skeletal level is composed of morae which are directly dominated by syllable nodes (Hyman 1985, Hayes 1989). In the following discussion, no issues of substance hinge on this difference.

melody. In this representational scheme of things, there is no autonomous object corresponding directly to the lay term VOWEL. The nearest we get to a formal implementation of the traditional notion is the union of two independent objects – (i) a package of melodic properties defining a vocoid, linked to (ii) one or more prosodic positions contained within a syllabic nucleus. The independence of the two objects is confirmed by the fact that elsewhere the same type of vocalic melody can occupy a non-nuclear position.

The use of the notion VOWEL, along with the complementary notion CONSONANT, is firmly rooted in the phonemic tradition. Phonemics, it should be borne in mind, was originally conceived as an explicit set of guidelines for efficient alphabetic transcription (a particularly useful resource that we have only mild qualms about exploiting below). One important moral to be drawn from research in both theoretical and applied phonology is that it is misguided to seek to extend the phoneme's use beyond this domain. In particular, the concept has proved to be singularly unsuited to the pursuit of what has come to be acknowledged as the central goal of phonological theory – to construct a formal model of the knowledge that allows native speakers to produce and recognize speech sounds. There is no place in such a model for anything directly corresponding to the phoneme – at least as understood in its traditional sense as a minimal unit of contrast. For example, using the separate phonemic symbols *i* and *y* to transcribe the two occurrences of palatality at the beginning of the form ⟨yeast⟩ should not blind us to the fact that we are dealing with one and the same melodic object, albeit one that happens to occupy different prosodic positions.

Much of the terminology traditionally used to describe phonological impairment is similar to VOWEL in betraying its phonemic origins. Terms such as ADDITION, OMISSION, SUBSTITUTION and DISTORTION refer primarily to the alphabetic transcription of disordered data. Useful as they may be, they should not be allowed to mislead us into assuming that phonological impairment affects phoneme-sized units in the language faculty.

Although phonemicism continues to pervade much work on phonological disorder and acquisition, the recent literature bears increasing witness to the advantages of jettisoning it in favour of non-linearity. (On the application of non-linear theory to the study of acquisition, see, for example, Menn 1983, Spencer 1986, Stemberger & Stoel-Gammon 1991, Bernardt 1992a, Stemberger 1993, Menn & Stoel-Gammon 1995 and Bernardt & Stemberger 1998; on the same approach to disorder, see, for example, Chiat 1989, Chin & Dinnsen 1991, Bernhardt 1992b and Leonard 1995.)

To the limited extent that the use of the ambiguous notion VOWEL allows us to formulate explicit hypotheses about the nature of phonological impairment, it makes no particular predictions about whether disorders so designated will target either the qualitative or the syllabic dimensions of segments. If anything, it encourages us to expect a uniform impairment type

that affects both dimensions simultaneously. Although non-linear theory does not rule out such composite disorders in principle, the formally established independence of melody and prosody explicitly predicts the occurrence of impairments which target one dimension to the exclusion of the other. This seems to tally with the empirical record. Broadly speaking, patterns traditionally referred to as additions and omissions can be shown to have a primarily prosodic basis, while those described as substitutions and distortions are primarily melodic in nature. Some reported cases of 'vowel' impairment evidently fall into the melodic category; that is, they specifically target vowel quality (examples of which we discuss presently). The case study to be discussed below, we will argue, exhibits the other error type predicted to affect vowels, one in which the prosodic subsystem is the primary site of disturbance (admittedly with melodic side-effects).

2.3 *Vocalic melody*

The model of melodic representation which we employ in our case-study analysis incorporates the following design properties: (i) all phonological distinctions are privatively expressed in terms of monovalent elements; (ii) a single set of elements codes resonance contrasts in nuclear positions ('vowels') and non-nuclear positions ('consonants'); and (iii) each element is phonetically interpretable in isolation from other elements. We assume the traditional tricorn set of resonance elements, symbolized here as [A], [I] and [U] (Anderson & Jones 1974, Schane 1984, Kaye, Lowenstamm & Vergnaud 1985, van der Hulst 1989, and the references in Harris (1994: ch. 3)). Individually, these define the corner vocalic values in (1)a; the two-element combinations in (1)b define mid vowels.[4]

(1) (a) [A] *a* (b) [A, I] *e*
[I] *i* [A, U] *o*
[U] *u*

One manner category will figure in the analysis below, the stop element [?]. This inheres in non-continuant sounds, manifesting itself as an abrupt and sustained drop in overall amplitude (see Harris 1990, Kaye, Lowenstamm & Vergnaud 1990, Harris & Lindsey 1995). When [?] appears in isolation, this effect is achieved by a glottal stop. Otherwise, as illustrated in (2), the location of the stop gesture is determined by whatever place element [?] is combined with.

(2) Labial stop [U, ?]
Palatal stop [I, ?]

There is plenty of evidence to support the conclusion that the same place categories inhere in vowels and consonants (see, for example, Smith 1988 and

[4] Other dimensions of vocalic contrast (such as tense versus lax and peripheral versus central) require additional representational machinery. See fn. 5.

Clements 1991). Among other things, this explains the assimilatory interactions that are frequently observed between the two types of position. For example, palatalization of a consonant before a front vowel can be directly represented as the spreading of a single category from a nucleus into a preceding onset. Since it is [I] that defines the class of front vowels, we conclude that [I] must also be present in palatal and palatalized consonants. By the same token, [U] is contained in both round vowels and labial consonants.

The classification of vowel space in terms of the elements [A], [I] and [U] is similar to one incorporating orthodox features such as [±high], [±low], [±back] and [±round] to the extent that both approaches are founded on the 'naturalness' principle – the assumption that melodic categories stand in a non-arbitrary relation to their auditory, acoustic and articulatory correlates. However, a theory based on elements can be argued to be better equipped to capture the nature of this relation than one based on features. For one thing, the element approach more directly reflects the fundamentally triangular organization of vowel space that is evidenced in phonological universals, speech production and language acquisition. For example, the corner values represented by *a*, *i* and *u* are by far the most common categories encountered in the vowel systems of the world; indeed in many languages they are the only vowels (Maddieson 1984). This universal preference is evidently related to the finding that the corners of vowel space defined by these three points constitute 'quantal' areas in speech production – regions which exploit the most robust match between distinctive acoustic structure and possible articulatory gestures (Stevens 1989). The primacy of these points is also demonstrated in the early post-babbling stages of vowel acquisition (see for example Bond et al. 1982).

Within an orthodox feature framework, the tricorn organisation of vowel space is no more than a contingent fact. The intersection of one height feature, [±high] say, with [±back] counterfactually predicts a basic rectangular pattern (expanded to further dimensions by the addition of [±low] and [±round]). Unmarked triangularity can only be derived by the ad hoc expedient of introducing supplementary redundancy rules or constraints, such as one which disables the [±back] contrast in low vowels.

In an element-based model, on the other hand, the triangular patterning of vowel space follows as a necessary consequence of there being three basic elements. Moreover, the unmarked status of *a*, *i* and *u* is directly reflected in the fact that, since they consist of only one element each, they are representationally simpler than mid vowels, which contain at least two elements each. Any process that pushes mid vowels towards the corners of vowel space is thus straightforwardly expressible as element simplification. This effect is widely attested in the raising and lowering of mid vowels that occur in primary grammars. In many languages – Portuguese, Catalan and Bulgarian, for example – the maximal system of vowel contrasts is restricted

to positions bearing main word stress; elsewhere we find contracted sets consisting of corner values and schwa. (Reduction to schwa represents the ultimate in simplification – the suppression of all elemental content; see for example Schane 1984 and Harris & Lindsey 1995.)

The primacy of corner vowels and the marked status of mid vowels are further supported by the fact that similar reduction effects are observable in the early stages of vowel acquisition. Levelt's (1994) study of normal Dutch-acquiring children amply illustrates the prevalence of processes which, in element terms, constitute melodic simplifications. Mid vowels display widely attested lowering and raising effects (see (3a) and (3b)); they are also subject to the less commonly reported process of diphthongisation (3c).[5]

(3) (a) [A, I] > [A] [A, U] > [A]

Adult	Child		Adult	Child	
χɛk	*hak*	'silly'	*bom*	*bam*	'tree'

(b) [A, I] > [I] [A, U] > [U]

Adult	Child		Adult	Child	
zɛs	*zɪs*	'six'	*pɔp*	*pup*	'doll'

(c) [A, U] > [A][U]

Adult	Child	
kokə	*kawkə*	'cook'

Representationally, each of these processes produces melodic simplification: a two-element compound, defining an adult mid vowel, is dissolved in one way or another. In the case of lowering (3a) and raising (3b), the result is a straightforward reduction to one element. Viewed in articulatory terms, diphthongisation of *o* to *aw* (3c) presents itself as an increase in complexity: a single basic gesture gives way to a movement between two gestures. However, unlike the mid-vowel articulation, the manoeuvres involved in the production of the diphthong execute universally favoured corner qualities, in this case *a* and *i*. This change to unmarked structure is captured elementally as a decrease in the complexity of a melodic expression: a two-element compound is unpacked into a linear sequence of single elements.[6]

Processes which shift vowels in the opposite direction to mid-vowel raising and lowering can only be expressed as an increase in melodic complexity. High-vowel lowering, for example, involves the addition of [A]. In primary

[5] In element theory, the tense-lax distinction evident in (3) is expressed in terms of different dependency relations within the segment. In tense vowels (*i*, *e*, *u*, *o*), [I] or [U] acts as the head of the melodic unit, while any other element acts as a dependent. Lax vowels (*ɪ*, *ɛ*, *ʊ*, *ɔ*) lack a head element. For example, *e* is [I, A] (head underlined), while *ɛ* is [I, A]. For discussion and references, see Harris (1994: 105 ff.).

[6] A good case can be made for saying that the reduction in representational complexity accompanying the diphthongization of mid vowels to *aw* and *ay* goes hand in hand with a decrease in acoustic complexity. The signal characteristics of mid vowels can be viewed as amalgamation of simpler spectral patterns associated with the corner vowels (Harris & Lindsey 1995).

grammars, this type of shift almost always occurs under the assimilatory influence of a neighbouring non-high vowel (as in the height harmony systems of many Bantu languages; see, for example, Goldsmith 1985). Context-free lowering of high vowels is extremely rare and runs counter to the general patterns reported for early vowel acquisition.[7]

Element theory thus provides a direct formal correlation between relative markedness and degree of melodic complexity in vowels: the outputs of processes which move a system towards an unmarked state are simpler than those with more marked directionality. No such correlation is possible in orthodox feature theory, in which any vowel shift, regardless of directionality, has to be expressed as the substitution of one set of feature values by another. For example, an unmarked rule of mid-vowel raising is formally no simpler than a marked rule of high-vowel lowering.

The unmarked status of simplification processes in normal acquisition suggests that the occurrence of similar effects in developmental vowel impairment should be considered indicative of delay. This would be the case in the examples of mid-vowel lowering and diphthongisation in (4), reported in the disordered output of RC, one of the children included in the Central Scottish Vowel Project (Watson, Bates, Sinclair & Hewlett 1994).

(4) (a) [A, I] > [A]

tade	teddy
sal	shell
padlz	pedals

(b) [A, I] > [A][I]

nayst	nest
ayg	egg
ðaym	them

Further exemplification of the favoured status of corner vowel qualities in developmental disorder is provided by Reynolds (1990) and Stoel-Gammon & Harrington (1990). In contrast, processes which increase melodic complexity by introducing elementary material that has no correspondent in the relevant adult target forms are more likely to be deviant in relation to age norms. Context-free lowering of high vowels, involving the addition of [A], would fall into this category. Reynolds (1990: 123) provides examples (such as *ɛp* ⟨leaf⟩, *tsɔː* ⟨shoe⟩) which he himself describes as idiosyncratic.

2.4 *Prosody*

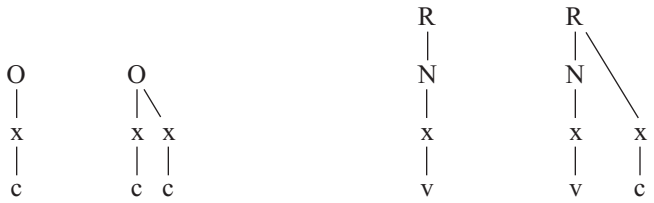
One major source of cross-linguistic diversity in the realm of prosody is the availability of choice in the structure of syllabic constituents. With regard to the syllabification of consonants, the options bear primarily on the shape of onsets and rhymes. The occurrence of consonant clusters in a language is

[7] Perhaps the best known example of non-assimilatory lowering of high vowels is provided by Yawelmani Yokuts (Newman 1944). However, even here the effect is not context-free, being restricted to long vowels.

most likely to reflect the selection of either complex onsets or complex (closed) rhymes or both. In English, for example, two consonants within a cluster may be co-occupants of a complex onset (as in the *tr* of ⟨try, petrol⟩); or they may straddle a syllable boundary, in which case the first closes a complex rhyme while the second occurs in an onset (as in the *nt* of ⟨winter⟩).[8]

Expressed arboreally, the relative complexity of a syllabic constituent is represented in terms of whether or not it branches. For onsets and rhymes, this gives rise to the following distinction between non-branching and branching alternatives (**v** and **c** abbreviate melodic content):

(5) (a) Onset (b) Rhyme



There are good reasons for considering branching syllabic constituents to be universally left-dominant; that is, the position on the left is the head of the constituent, while that on the right is a dependent. In the case of rhymes, the nucleus may be deemed the head on the assumption that it is the only position that is obligatorily present in a syllable. In the case of onsets, the dominance of the lefthand position is reflected in the fact that its ability to support segmental contrasts is significantly greater than that of its sister on the right. (In English, virtually any obstruent in the system can occupy the first onset position, while the second is restricted to a liquid or glide.[9]) The left dominance of syllabic constituents is consistent with one aspect of the analysis to be developed below: when truncation affects a complex onset or nucleus, it is the dependent position that typically gives way.

Underlying the distribution of onset and rhyme types across the world's languages is a set of well-known implicational universals. The availability of a branching constituent in a particular language automatically implies the availability of a non-branching counterpart, but not necessarily vice versa. In

[8] For fully referenced summaries of the recent theoretical literature on syllable structure, see Kenstowicz (1994: ch. 6) and Harris (1994: ch. 2).

[9] Two types of consonant cluster appear to contradict the universal left dominance of syllabic constituents – word-initial clusters beginning with *s* (as in ⟨sting⟩) and word-final clusters (as in ⟨best⟩). On the basis of their general sonority-sequencing profiles, both configurations exhibit right dominance. This would be anomalous if, as according to one standard assumption, *s*C clusters constituted branching onsets and final clusters constituted branching codas. However, there are very good reasons for rejecting these assumptions in favour of the view that both types of cluster form heterosyllabic sequences of coda plus onset (see Harris 1994: ch. 2) for discussion and references). This is not a point that we need take up here, however, since it has little bearing on the case study to be analysed below.

other words, while all languages have forms with non-branching onsets, only some languages also have forms with branching onsets; the parallel relation holds of rhymes. This indicates that absence of branching structure is the default state for both types of constituent:[10]

(6)	Branching	Default	Marked
	Onsets	[NO]	YES
	Rhymes	[NO]	YES

The notation in (6) suggests a standard Chomskyan approach under which language acquisition proceeds on the basis of parameter-setting. While this will set the tone for what follows, there is little in the detail of our case study analysis that clashes with an alternative view according to which development consists in the reranking of violable constraints (see Bernhardt & Stemberger 1998 for a comprehensive Optimalist presentation of this model). This otherwise far-reaching disagreement is not an issue here, largely because the phonological constraints crucially invoked in our analysis are not in conflict with one another.

The marked status of branching onsets and rhymes is confirmed by the facts of language acquisition. Consonant cluster simplification in early phonological development reflects a failure to adopt the branching constituent structure of an adult target (see Bernhardt & Stemberger 1998 for a recent review and discussion of the relevant evidence). This is consistent with the assumption that the negative alternatives in (6) help define the initial state in language acquisition.

The manner in which consonant clusters are simplified in child output bears witness to the crucial role played by syllable structure in phonological representation. Typically two options are available for dealing with a two-consonant onset cluster. In one case, traditionally described as omission, one of the consonants is dropped – in an obstruent-resonant sequence, normally the resonant, as in *pey* ⟨play⟩. The preference for preserving the first position is consistent with the assumption that this is the head of the constituent. As a less common alternative, the cluster may be broken up by the intrusion of a vowel with no adult correspondent (as in *pəley*). Both effects, it is reasonable to assume, stem from a mismatch between the child's prosodic resources and the melodic material that is present in the relevant adult forms. In the absence of marked branching syllabic structure, the child's onset template makes provision for only one segment. In the event of two target

[10] Additional provision has to be made for an implicational relation that holds between the branching options available to onsets and rhymes: languages with complex onsets typically also have closed syllables, and the latter are usually acquired before the former. Moreover, since the choices presented in (6) are prosodic in nature, they make no predictions about the relative markedness of the specific clusters that can occur in complex constituents. The fact that certain onset clusters are acquired earlier than others, for example, is a melodic matter.

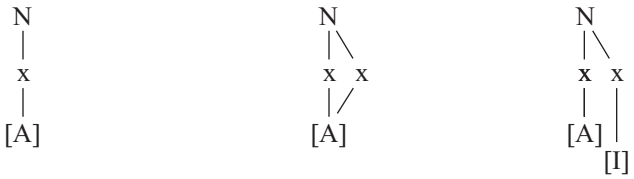
segments vying for a single onset berth, as in (7b), the one that fails to link to a syllabic position receives no phonetic interpretation – in this instance, the liquid occupying the dependent position in the adult form.

(7) (a) Adult *pley* play (b) Child *pey* (c) Child *pəley*

The alternative solution, depicted in (7c), is the creation of an extra independent onset supported by its own nucleus. In this case, both consonants find prosodic accommodation, albeit at the expense of forcing the appearance of a nucleus with no source in adult input.[11]

Length contrasts in vowels, it is now generally agreed, are represented in the same constituent-based terms as the syllabification of consonants in onsets and rhymes. On the basis of the different contributions they make to syllable weight, we are justified in concluding that a short vowel occupies one nuclear position, while a long monophthong or diphthong takes up two. In other words, short in this context implies non-branching nuclear structure, as in (8a), while long implies branching structure, as in (8b) and (8c).

(8) (a) *a* (b) *aː* (c) *ay*



In terms of their constituent status, short vowels are the nuclear counterpart of simplex onset consonants, while long vowels are equivalent to onset clusters. Moreover, complex nuclei may be considered left-headed in the same way as other syllabic constituents. For example, as in branching onsets, the first position is distributionally better endowed than the second. In English, virtually any vocalic quality can appear in the first nuclear slot (although the details vary from dialect to dialect). Where the second slot is qualitatively distinct from the first, as in a diphthong, it can only support an off-glide.

[11] This solution implies that bi-positional onsets are more marked than bisyllabic words. This seems a reasonable conclusion, given that CVCV words appear comparatively early in normal phonological acquisition (more on this in fn. 23).

The implicational universals governing the distribution of branching structure in onsets and rhymes across the world's languages extend to nuclei, indicating that length contrasts in vowels are marked. This raises the question, barely touched on in the relevant literature, of whether a preference for non-branching nuclei is also manifested in phonological acquisition and impairment. If such a parallel does indeed exist, we should expect it to consist in a disruption of vowel length contrasts. As Bernhardt & Stemberger point out (1998: 409 ff.), if nuclei are affected in the same fashion as onsets (see (7)), we would predict diphthongs to be restructured as in (9b) and (9c).

(9) (a) (b) (c)

Straightforward truncation of the right-hand position of the adult branching nucleus in (9a) would result in a short monophthong, as in (9b) – the counterpart of cluster reduction in onsets. Given the left-headedness of branching constituents, it is the first portion of a target diphthong that would be expected to survive shortening. The equivalent of consonant-supporting vowel epenthesis would be the split-nucleus alternative in (9c). Here the second slot of a target branching nucleus is salvaged through assignment to the nucleus of an independent syllable. In this case, an adult long diphthong would in effect be rendered as a sequence of two short vowels. Corresponding developments affecting target long monophthongs (10a) would be expected to produce the outcomes in (10b) (short monophthong) and (10c) (two identical vowels in hiatus).

(10) (a) (b) (c)

A version of the split-nucleus pattern in (9c)/(10c) is well established in some dialects of English, where it represents the 'broken' development of original long vowels, particularly before historical *r* and *l* (as in *fi:yə*(*r*) ⟨fear⟩, *fi:yəl* ⟨feel⟩).[12] Significantly, it has also been noted in early child

[12] See McCarthy (1993) for a recent analysis of this phenomenon in New England.

approximations of dialects which do not display the broken variants (Smith 1973: 130).

There is some indication that the alternative treatments of target long vowels in (9b)/(10b) and (9c)/(10c) also occur in developmental disorder. Published evidence potentially relating to shortening is not always easy to interpret, since the relevant vowel disorders are often described as phonemic substitutions, and not all phonemic transcription systems record vowel length. Bernhardt & Stemberger (1998: 410) make the same point about descriptions of normal development. Cases of diphthong reduction (see, for example, Gibbon et al. 1992, Pollock & Keiser 1990, Reynolds 1990) present prima facie evidence of shortening, but before drawing any such conclusion it would be necessary to exclude the possibility of compensatory lengthening in the output monophthong. The generalized laxing of English tense vowels, reported in some studies of developmental disorder (see Stoel-Gammon & Herrington 1990 for references), almost certainly also implies concomitant shortening. We discuss some unambiguous examples of shortening below.

As to the bisyllabification pattern in (9c)/(10c), Reynolds (1990: 131) reports a particularly clear case, with forms such as *pɪyəd* ⟨peas⟩, *ʃɛwə* ⟨shoe⟩, *bayəd* ⟨boys⟩, *layət* ⟨light⟩ and *awət* ⟨out⟩. Examples such as these conform to the normal broken development just mentioned in that they contain a medial glide. This, it is reasonable to assume, represents an onset that splits independent nuclei. The quality of the onset either extends that of the preceding nucleus (palatal in *ɪyə*) or retains some portion of that present in the adult target (as in the labial of *ʃɛwə* ⟨shoe⟩). (The use of a transcription such as *ɪy* in such cases is thus a segmentalized way of alphabeticizing the simultaneous association of a single melodic unit ([I] in this instance) to a nucleus and a following onset.)

The intrusion of a *y* or *w* glide in the split-nucleus development reflects the suitability of palatal and labial vocoids as onset occupants. It is instructive to consider what happens when neither quality is available in the first position of an input nucleus – that is, when this portion contains an open vowel (as in *aː*, *aw* or *ay*, for example). Bisyllabification might be expected to be blocked under these conditions, and this is indeed what we find in the study of disorder to be presented below. (It is also what occurs in those varieties of primary English which otherwise show the broken pattern described above.) However, we have encountered the case of a phonologically impaired child in which the split-nucleus strategy does appear to have been adopted in precisely this context.

DB, aged 4;1 at the time he was recorded as part of the Queen Margaret College Cluster Acquisition Database project (Hardcastle, Fletcher, Gibbon & Scobbie 1997), displays thorough-going monophthongization of Scottish English *ay*, which has long and short reflexes in the adult system. His production of the long reflex is characterized by a suite of variably present phonetic effects which are typically activated roughly midway through the

vowel; these include an abrupt change in phonation, especially to creaky voice, an abrupt change in pitch, and an interval of significantly reduced overall amplitude (for a detailed instrumental analysis, see Scobbie & Harris, in prep.). Most frequently, the extent of amplitude reduction is such as to indicate the presence of an intervening glottal stop (*aʔa*). A good case can be made for treating the medial period of laryngeal activity as the consonantal reflex of an onset separating two short vowels – in other words, an example of the split-nucleus pattern in (9c).

Unlike simple truncation in (9b)/(10b), bisyllabification in (9c)/(10c) preserves the overall bi-positional quantity of an input branching nucleus, albeit redistributed over two nuclei. There is, in principle, another means of retaining prosodic weight in the absence of branching nuclear structure – vowel shortening accompanied by conversion of the second position to a non-nuclear position (VV > VC). Provided the non-nuclear position in question bears weight (as in a closed VC rhyme, for example), it will compensate for the loss of the nuclear slot. Several reported cases of vowel disorder appear to fit this pattern. SD, one of the children studied by the Central Scottish Vowel Project (Watson et al. 1994), shows a tendency to render target diphthongs as a short vowel followed by a nasal stop, for example *taŋz* ⟨ties⟩, *amz* ⟨eyes⟩, *hans* ⟨house⟩, *klans* ⟨clouds⟩, *ban* ⟨boy⟩. A similar pattern is recorded by Gibbon et al. (1992). A more dramatic version of this strategy, we will argue, is observable in the case study to which we now turn.

3. Nuclear disorder: a case study

3.1 *PS*

PS was referred by his speech-language clinician to the Central Scottish Vowel Project at 4;11 years, on the grounds of unusual vowel production. He had a history of recurrent otitis media; audiometric testing at 4;10 years revealed a conductive hearing loss (30–40 dB) in the left ear. At 5 years his receptive language ability was judged to be at a stage of 7+ years and his expressive language skills at 6+ years. Although PS lived in the north of Ireland (Belfast) until he was three and has subsequently been resident in Scotland (Edinburgh), his main target system appears to be essentially of the standard type historically associated with the south of England (henceforth simply the 'southern' system). This is the dialect of the family home (although his father is from the north of England (Nottingham) and his mother from Belfast) and is also used by his sister (four years his elder) and his neighbouring maternal grandparents.

The data to be discussed here were collected during eight sessions when PS was aged between 4;11 and 6;7 years and have previously been reported in Bates, Hewlett, Kaighin, Sinclair, Sweet & Watson (1993) and Bates & Watson (1995). The bulk of examples are drawn from two audio-recorded

corpora: one comprises 493 vowel tokens elicited during three presentations of a single-word picture naming task at 4;11, 5;5 and 6;2 years; the other (exploiting PS's precocious reading ability) consists of 317 read tokens gathered at 5;7 and 6;7 years. Additional examples were collected from extensive recorded samples of spontaneous speech. The productions were transcribed phonetically both at the time of data collection and afterwards from audio-recordings (Sony TCD D3 DAT with ECM S220 microphone). A final relatively narrow transcription was agreed on by four transcribers, using the consensus procedure described by Shriberg, Kwiatkowski & Hoffman (1984).

In an effort to minimize potential dialect bias in our presentation of the case-study data, we employ a transcriptional system widely used in the general phonological literature, rather than one more closely associated with descriptions of particular standardized varieties of English. The transcriptions depart from the IPA only in the following details: *y* symbolizes a palatal glide, *æ* a fully front open vowel, and *a* a non-front open vowel of any degree of backness. (Unlike in some transcriptions of text-book English, *æ* does not here imply a raised value; nor does *a* imply length, which is explicitly marked below in the normal way by *ː*.)

3.2 *Shortening, glide hardening and bisyllabification*

We start by considering PS's subsystem of short stressed vowels. Here he shows a five-way contrast in place of the standard six-term inventory. As illustrated by the forms in (11), the distinction between adult short *ɪ* and *ʊ* is collapsed under *ɪ* in PS's output.

(11)	lick	*lɪk*	book	*bɪk*
	red	*wɛd*	mug	*mʌg*
	jam	*dæm*	socks	*sɒks*

It would probably be wide of the mark to view the merger as a straightforward substitution of *ʊ* by *ɪ*. All of the adult systems to which PS has had prolonged exposure have relatively fronted variants of high round vowels, both short and long. Representationally, this quality comprises not only [U] (contributing labiality) but also [I] (palatality). PS's *ʊ*/*ɪ* merger thus consists in a failure to sustain [U] in this combination; the *ɪ* in a word such as ⟨book⟩ manifests the residual target [I].[13]

[13] Fronting of high round vowels is well established in Scotland and the north of Ireland and is increasing prevalent in the southern system. One result of this development is that vowels broadly transcribed as '*u*' in these systems do not occupy the canonically high back corner of vowel space. This does not necessarily imply an absence of truly high back round quality in these systems. In classic chain-shift fashion, that niche can come to be filled by vowels from other historical sources (for example, by the CAUGHT class in southern systems – see Bates 1995).

The most noteworthy characteristics of PS's vocalic phonology occur in his version of the adult long subsystem, comprising both diphthongs and long monophthongs. Although adult-like long vowels occasionally appear in his data (more so in the later recording sessions), his output systematically diverges in a number of ways from the presumed target. Three main developments are in evidence here. One is shortening, exemplified by the following forms which have long vowels in the presumed target:

(12)	(a)	weed	*wɪd*	beak	*bɪk*
	(b)	height	*hɔd*	tube	*tɪb*
		spade	*spɪd*	groan	*gwɪn*
	(c)	class	*kwæs*	grass	*gwæs*
		branch	*bwæns*	banana	*bənænə*

As the forms in (12b) illustrate, shortening goes hand in hand with monophthongization. The words with short low front *æ* in (12c) are included here on the grounds that they have long broad *aː* in the southern system.[14]

A second development in the long subsystem, and perhaps the most striking feature of PS's phonology, is a process of hardening. In its most general form, this results in an adult up-gliding vowel being rendered as a short vowel followed by an oral stop. The hardened offset retains the basic place property of the target, producing labial *b* for *w* and palatal *ʄ* for *y*, as in forms such as *kab* ⟨cow⟩ and *sɪʄ* ⟨see⟩.

Hardening of the labial up-gliding series is illustrated by the following forms:

(13)	*uw* = *ɪb*		*əw* = *əb*		*aw* = *ab*	
	to	*tɪb*	know	*nəb*	cow	*kab*
	you	*yɪb*	so	*səb*	now	*nab*
	do	*dɪb*	toe	*təb*		

Note the absence of rounding in the vocalic portion of *uw* = *ɪb*, an effect that is consistent with the merger of *ʊ* and *ɪ* in the short subsystem (see (11)). (Lack of rounding in the corresponding portion of the vowel in ⟨know, so⟩, etc. is unremarkable, given the *əw* value of this diphthong in the southern system.)

[14] Of the other dialects to which PS has been exposed, northern Irish English also shows a long vowel in at least some of the words in (12c) (albeit one that is phonologically conditioned rather than distinctive as in the southern system). A corresponding short vowel can occur in some of the relevant varieties of Scottish English. The father's geographical background in the north of England (where shortness is the basic pattern) is an unlikely source of the short vowel in (12c), since his dialect is basically southern in type. We cannot rule out the possibility that PS's short vowel here reflects a system-internal development. Whatever its source, the favouring of shortness over southern length is consistent with what we will try to show is the overall design of PS's vowel system.

The effects of hardening on the adult palatal up-gliding series are exemplified in (14).

(14) (a) *iy* = *ɪʃ* *ey* = *ɛʃ*

we	*wɪʃ*	they	*ðɛʃ*
see	*sɪʃ*	bay	*bɛʃ*
he	*hɪʃ*	day	*dɛʃ*

(b) *ay* = *aʃ* *ɔy* = *ɔʃ*

eye	*aʃ*	boy	*bɔʃ*
sky	*skaʃ*		

Where the short vowel before the hardened reflex is front, as in the examples in (14a), the whole VC sequence is fully palatal. The basic palatal identity of the stop is confirmed by the fact that it is retained even after a back vowel (14b). This gives rise to a transitional palatal glide between the vocalic and consonantal phases; narrowly transcribed, a form such as ⟨eye⟩ is thus $a^{y}ʃ$.

The detailed effects of hardening in PS's output can be witnessed in Figure 1, which shows a speech waveform and wideband spectrogram of the

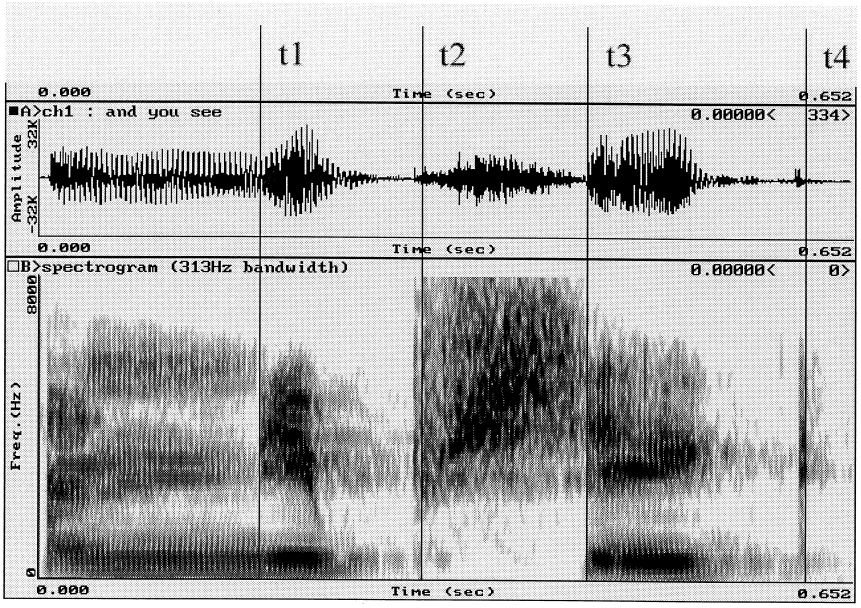


Figure 1

Speech pressure waveform and wideband spectrogram of the phrase <and you see> uttered by PS. The interval between t1 and t2 corresponds to the vowel in the adult form of <you>; the interval between t3 and t4 corresponds to the vowel in the adult form of<see>.

utterance ⟨and you see⟩. The interval between time t1 and t2, which corresponds to the long-vowel portion of the adult form of ⟨you⟩, consists of two clearly distinct phases. The first is characterized by well defined formant structure, indicative of a vocoid. The second shows a steep fall in the second formant and a significant drop in overall amplitude followed by an abrupt noise burst, which together signal a labial plosive. A similar pattern of decreased amplitude and noise release is observable in the latter phase of the interval between t3 and t4, corresponding to the vocalic portion of adult ⟨see⟩. In this case, the convergence of F2 and F3 in the transition from the first phase is consistent with the production of a dorsal stop.

A variable degree of constriction also appears in PS's rendition of adult glides in syllable-onset position (in ⟨you⟩ and ⟨we⟩, for example). (There is some evidence of this in the slight amplitude drop that occurs immediately before t1 in Figure 1.) This effect, also attested in some primary languages (see for example Maddieson & Emmorey 1985), offers a clue as to the possible syllabic basis of hardening that we will follow up in our analysis below.

A third pattern in PS's system is evident in his rendition of adult in-gliding vowels (mostly originating from historical VV*r*; the relevant southern target system is non-rhotic). As illustrated in (15a) and (15b), these are frequently treated as bisyllabic:

(15)	(a)	hire	*hɔyə*	tire	*tɔyə*
		cure	*kɕɪwə*	flour	*fʁawə*
	(b)	here	*hɪɟə*	disappear	*dɪsəpɪɟə*
	(c)	idea	*æydɪɟə*	fewer	*fɕɪwə*

The independent nuclei in such forms are separated by an onset that is filled by a glide (as in (15a)) or its hardened counterpart (as in (15b)). The bisyllabicity of the relevant sequence makes it prosodically identical to the structure encountered in PS's version of adult heterosyllabic sequences of long vowel followed by schwa (see (15c)).

For reasons to be expanded on presently, we consider it significant that shortening in PS's output only occurs preconsonantally, as suggested by the forms in (12). Glide hardening is also possible in this context, as in *mɪɟt* ⟨meat⟩, *sɪbt* ⟨shoot⟩ (more extensive exemplification below). Also taking into account the occasional appearance of adult-like long tokens, we are thus faced with the fact that PS's production diverges from the adult target in a variable fashion. This observation will hardly come as a surprise to anyone familiar with the nature of speech data reflecting disorder. An important general point that should be borne in mind in this connection is that variability does not necessarily imply a lack of systematicity (something that can also be said of sociolinguistic variability in adult speech). The manner in which PS's phonology deviates from the adult long-vowel subsystem may not

be fully invariant, but it is not at all random. This point is acknowledged in the very use of the terms SHORTENING, HARDENING and BISYLLABIFICATION as labels for observed regularities. Moreover, as we will see below, these processes are not fully interchangeable in PS's output but are sensitive to significantly different sets of regular phonological conditions.

4. Demarcating phonological impairment

4.1 *Disorders of phonological representation*

The analysis of PS's disorder to be presented below is couched in terms of the notation of non-linear phonological theory. If this were nothing more than an exercise in the use of formalism for formalism's sake, it would provide at best a retranscription of the data we are trying to explain (albeit one that might be more revealing of phonetic detail than broad alphabetic-phonemic writing). However, there are two respects in which the notation has much more significance than this.

First, its explanatory potential derives from the fact that it formally expresses a theory of phonological structure, and in particular the sub-theories of melody and prosody outlined in Section 2. In this respect, it aids the formulation of quite explicit hypotheses about the nature of phonological knowledge and the manner in which it can be impaired.

Secondly, the notation reflects a commitment to the view that PS's disorder is indeed phonological. We consider it worthwhile to detail the reasons for reaching this conclusion – the purpose of this section. It would hardly be necessary to make this point, were it not for fact that the formalisms of phonological theory are sometimes misleadingly employed in the literature as a means of describing impairments that are in all probability not phonological at all.

In principle, the aetiology of a disorder that can be described in general phonetic terms can be traced either to the phonological module of the language faculty or to the language-external domains of motor programming or auditory perception. The dichotomy is often spoken of in terms of a distinction between phonological and phonetic disorder. Unfortunately the waters are frequently muddied in this matter by a lack of clarity in the use of the term PHONETIC. It is not always made explicit whether the label is intended to identify one of the grammar-external devices or some grammar-internal level of representation that is distinct from the phonological.

According to one widespread view, the phonological wing of the grammar houses two distinct levels of representation – one underlying (SYSTEMATIC PHONEMIC in Chomsky & Halle's (1968) terms), the other surface (or SYSTEMATIC PHONETIC). The two levels are claimed to fulfil different functions: the underlying level codes lexical contrasts, while the surface serves as input to the articulatory and auditory-perceptual facilities. The levels also differ in

type in that a surface form is assumed to be more concrete than its underlier. In orthodox feature theory, this is reflected in the arrangement whereby the surface level contains feature values that are underlyingly absent; these are redundant values the only purpose of which is to prepare representations for submission to articulation and auditory perception.

Within this overall approach, the phonetic interpretation of a phonological form must be assumed to be performed both within the grammar and outside it. The grammatical stage in this process involves the conversion of relatively abstract underlying forms into more concrete surface forms (for example by filling in redundant feature values). The extra-grammatical stage involves the mapping of phonological output onto articulation or auditory perception. Here lies the source of the potential ambiguity of the term PHONETIC: does it refer to the first or the second of these stages?

The assumption that phonological form contains two distinct levels of representation constitutes a research hypothesis which, however implicit, not only has to be tested against the empirical record but also has to be weighed up in relation to any simpler alternatives that might be available. The usual course of action in such comparisons is to accept the more complex hypothesis only once simpler competitors have been conclusively proved inadequate. In this case, the obvious simpler alternative, which might reasonably be deemed the null hypothesis, is that phonological form consists of but one type of representation – in other words, it is MONOSTRATAL (see Scobbie, Coleman & Bird (1996) for a fully referenced discussion of this notion). However, explicit arguments refuting monostratalism are rarely offered in work based on a two-level conception of phonological derivation. In what follows, we will encounter no compelling reasons for giving up the simpler alternative.

Within the simpler model, a single type of phonological representation not only codes lexical contrasts but also serves as input to articulation and auditory perception. There is no need to conceive of one function as taking on a more abstract or concrete guise than the other. The monostratal conception of phonology can be straightforwardly implemented within the theory of melody outlined in section 2.3 (see Harris & Lindsey 1995 for discussion and references). Any representation composed of elements can immediately be submitted to articulation and auditory perception; its realization is not contingent on its being able to summon anything akin to additional, redundant melodic information. Under this view, phonetic interpretation is not a function of grammar but is the exclusive preserve of the articulatory and auditory-perceptual facilities.

In a monostratal model, there is only one potential site of truly phonological disturbance – phonological representation itself. If the term PHONETIC is to be used in a distinct sense from PHONOLOGICAL in this general context, it can only refer to a site outside the grammar, specifically to the auditory-perceptual and/or articulatory devices. It cannot identify some

grammar-internal half-way house. It may well turn out that things really are more complex than allowed for under this view, but this has not yet been demonstrated. As it stands, however, the monostratal model makes explicit claims about the location of disorder that are more obviously testable than those typically associated with multistratal models.

4.2 *Phonological versus linguistic phonetic disorder*

That is not to say that monostratalism altogether eliminates the degree to which a model of phonological disorder is underdetermined by the data against which it is to be tested, although it certainly does narrow it. Certain problems common to all theorizing on this subject remain. One concerns the familiar mismatch between perception and production that is attested both in developmental disorder and in early normal acquisition. PS is quite typical in this respect: for example, he is able to discriminate auditorily between adult VV and VC stimuli, even though hardening potentially neutralizes this distinction in his output. It would be simplistic to assume that any individual case of disorder exhibiting such a mismatch necessarily reflects a situation in which phonological representations are fully target-like but their phonetic interpretation becomes garbled in translation into articulation. Given the manifestly asymmetric manner in which the lexicon is accessed in production and perception, an alternative possibility is that the discrepancy is due to an impairment in phonological output representations. (Whether the accessing asymmetry is modelled in terms of distinct input and output lexicons or in terms of distinct retrieval routes to a single lexicon is not germane to the point in hand; see Leonard 1992, Macken 1992 and Menn & Mattei 1992 for reviews of the competing positions.) In any event, an ability to discriminate auditorily between target forms is in itself no guarantee that a child is employing the same perceptual strategies as the adult.[15]

The task of delineating the site of a phonetically specifiable disorder is further complicated by the possibility that part of the information stored in the articulatory and auditory-perceptual modules is reserved for the execution of linguistic knowledge. (This cannot be taken for granted, however. On one view, the auditory processing of speech input does not involve specialized neural mechanisms; see Delgutte 1997 for discussion of the relevant literature.) In what follows, we will use the term LINGUISTIC PHONETIC to refer specifically to this type of information – knowledge that is external to but nevertheless targeted on grammar. A linguistic phonetic impairment might be difficult to distinguish from one that has a grammar-internal basis in phonology. Nevertheless, in seeking to decide this matter in individual cases, we may let ourselves be guided by the putatively distinct

[15] Indeed in the case of PS there is evidence that he relies on perceptual strategies which in some respects differ from those of his normally developing peers (see Watson 1997).

nature of grammar-internal and grammar-external knowledge. Phonological information is represented in terms of the categorical distinctions which code lexical contrasts and define phonological well-formedness. Articulatory and auditory-perceptual knowledge, on the other hand, is framed in terms of the continuously varying motoric and neural mechanisms activated in speech. It would be a caricature of this non-phonological knowledge to assume that it is expressed in terms of the same gross categories as those appropriate for grammar. The currency of phonology is convertible in the interfacing modules, but it is not in itself valid in those realms.

The significance of this point to the study of phonetically describable disorders is that a grammar-internal impairment is predicted in principle to involve the substitution of one set of phonologically definable categories by another. In the case of grammar-external impairment, in contrast, a particular phonological category set is predicted to be articulated or perceived in a way which deviates from ambient targets without its categorical integrity being necessarily jeopardized. The validity of this distinction has been demonstrated in detailed studies of disorders affecting voice onset time in plosives.

Two main types of VOT deficit have been identified in aphasia (see Blumstein & Baum 1987 for a summary and discussion of the relevant literature). In one (typically associated with Wernicke's, conduction and transcortical motor aphasias), a categorical VOT contrast is maintained, but the categories are unpredictably misallocated to individual words or word-tokens. In the other type (more typically associated with Broca's and global aphasias), the VOT contrast is collapsed, with productions tending to converge on the region appropriate for voiceless unaspirated plosives (with zero or short-lag VOT values). Under a standard two-level view of phonology, the first type is classified as phonemic, the second as grammar-internal phonetic (see for example Blumstein, Cooper, Goodglass, Statlender & Gottlieb 1980). In fact, the first type is strictly speaking not phonological at all, since it leaves the representational basis of the VOT contrast intact. It is instead lexical in scope: a phonologically correct distinction is incorrectly distributed across the lexicon. This is quite different from the second type, in which the collapse of the VOT distinction initially suggests either a phonologically sited merger or some grammar-external disturbance in motor control. Two considerations support the phonological alternative. Significantly, VOT merger in aphasia looks quite unlike the sort of VOT disorder which is uncontroversially attributable to motor impairment. Non-aphasic dysarthric production is reported to exhibit shorter lead and longer lag VOT values than in normal speech; nevertheless, there is typically little or no overlap of VOT categories (see, for example, Gandour & Dardarnanda 1984). The conclusion that aphasic VOT merger is indeed grammar-internal is bolstered by the fact that it results in a pattern identical to that found in primary systems which lack laryngeal contrasts in plosives (see Harris 1998).

In sum, the distinction between the Wernicke's and Broca's patterns of VOT disorder can be adequately accommodated within a monostratal model – the former is lexical, the latter phonological.

Extrapolating from the VOT example into the area of vowel disorder leads us to postulate the following distinction. A truly phonological vowel impairment is definable as one in which the prosodic structure or melodic content of syllable nuclei submitted by the secondary grammar to the articulatory or auditory-perceptual facilities diverges from that associated with the primary grammar. A deficit of this type is predicted to take the form of a substitution of one set of prosodic or melodic categories by another, potentially resulting in the neutralization of vocalic distinctions under some unmarked value. Moreover, any contextual conditioning evident in such a pattern would itself be definable in terms of phonological or other grammatical categories (such as stress or morphosyntactic domain).

In contrast, a disorder affecting grammar-external knowledge that is dedicated to the production of vowel contrasts is defined as one in which the vocalic structures outputted by the grammar are intact but are wrongly articulated. A dysfunction of this type is predicted to result in qualities or durations which are distorted but which do not necessarily destroy phonological distinctions. (The distortion may be such as to render the relevant distinctions indiscriminable by untrained listeners, giving rise to a falsely reported merger (see Scobbie, Gibbon, Hardcastle & Fletcher (in press) for recent discussion of his phenomenon).) Moreover, such a deficit should be insensitive to any kind of specifically phonological conditioning. For example, in one pattern of vowel distortion that is reported to be prevalent in deaf speech, the phonetic space within which vocalic contrasts are realized is greatly compressed compared to that employed by normal-hearing speakers (Angelocci, Kopp & Holbrook 1964, Monsen 1976, Dagenais & Critz-Crosby 1992). (According to Monsen, the contraction of phonetic space is primarily reflected in a relative immobility of the second formant.) While the compression produces considerable phonetic overlap among the vocalic categories, there is little evidence of full-scale merger.

Against this background, we will present evidence which supports the conclusion that PS's vowel disorder is specifically phonological in nature.

4.3 *PS's disorder is phonological*

In considering the possibility that PS's disorder is located outside the grammar, our attention is naturally directed towards the process of glide hardening. We might speculate that PS experiences some difficulty in executing the fine-tuned tongue and lower mandible manoeuvres necessary to sustain an approximant gesture that is close enough to deliver high vocalic quality but not so close as to cause friction. Or we might appeal to some

notion of tense articulatory set. Either way, the articulatory closure effected by hardening would be attributed to target overshoot.

Any suggestion that hardening might be symptomatic of some global deficit in motor programming can be discounted straight away. Given a purely mechanical basis, the effect would be expected to manifest itself in vocalizations which do not draw directly on phonological knowledge. However, PS has no difficulty in producing quasi-iconic utterances which involve simultaneous lip rounding and high back tongue bunching ('*woooo!*') and which he is able to sustain for time intervals much longer than anything normally associated with vowel production proper. Thus if hardening did reflect some extra-grammatical impairment, it would have to be isolated in the area of linguistic phonetic knowledge.

However, two important considerations tilt the balance of evidence in favour of a phonological explanation of hardening. First, the regularity needs to be evaluated in conjunction with shortening and bisyllabification. These processes conspire to produce output that is commensurate with what we will try to show is a parochially deviant system. In other words, the combined effect of the processes is consistent with the conclusion that they replace one possible primary phonological grammar by another. It would be somewhat far-fetched to suggest that this substitution could be accidentally achieved by some grammar-external deficit.

Furthermore, the regularities of PS's disorder can be shown to be sensitive to contextual effects which have no obvious articulatory dimensions but are straightforwardly defined in phonological terms. As we will see presently, there is one site in which hardening occurs to the total exclusion of shortening – adult long vowels in absolute word-final position. The absence of shortening in this context is attributable to an independent constraint on the minimum size of the English word. It is quite implausible that the constraint has a basis in articulation, particularly in view of the fact that it is active in some languages but not others. On the other hand, it has a very obvious phonological definition, one that invokes prosodic constituency.

We develop these points in the next section.

5. The prosodic dimensions of PS's vowel disorder

5.1 *The syllabic basis of shortening and hardening*

The effects of hardening in PS's system receive straightforward expression in the element-based model of melodic form outlined in section 2.3. In general, a hardening or fortition process consists in the addition of the stop element [?] to a segment, such as a fricative or glide, which otherwise lacks it. A vocalic glide contains a single resonance element – [U] in the case of *w*, [I] in the case of *y*. The fusion of either of these elements with [?] produces a

homorganic oral stop; as shown in (2a) [U,?] defines *b*, while [I,?] defines *ɟ*.[16] In PS's case, this yields an outcome such as *ab* for adult *aw*, as in *kab* ⟨cow⟩:

(16) (a) Adult *aw* (b) PS *ab*

One question that arises at this point is whether PS's output forms containing the hardened representation in (16b) are independently stored (as would be assumed under a dual-lexicon account) or are derived from input forms containing adult-like representations of the type in (16a) (again see Menn & Mattei 1992 versus Macken 1992). Although we happen to prefer the first of these alternatives, it should be stressed that this issue is a derivational matter and is thus quite independent of the representational question of how hardening is expressed melodically.

The correspondence between (16a) and (16b) illustrates how the segmental effects of hardening follow directly from the inherent design properties of element theory. Note that there is no call for supplementary patch-up rules such as would be required in a feature-based treatment of the same facts. (In conventional feature terms, glide hardening has to be expressed as the rewriting of no fewer than three specifications (more if vowels and consonants are represented in terms of different place categories): [+continuant] → [−continuant], [−consonantal] → [+consonantal] and [+sonorant] → [−sonorant].)[17]

Of course, specifying the melodic effects of hardening does not in itself explain why the process occurs in the first place. In particular, why should the glide portion of a target vowel acquire an extra element that is more usually associated with a consonant? The reason, we contend, is rooted in the syllabic contexts the sounds in question occupy: while the adult glide resides in a nucleus, PS's corresponding stop appears in a non-nuclear position.

[16] For a referenced discussion of how other place categories in stops are characterized in terms of elements, see Harris (1994: 118 ff.).

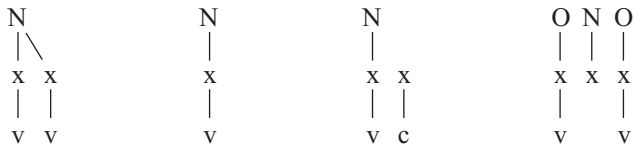
[17] No features or elements are required for identifying the context in which hardening occurs, since this is specified in prosodic rather than melodic terms (see below). In orthodox feature theory, [±consonantal] defines the stricture characteristics of a sound (not its syllabic affiliation, as might be suggested by the lay term CONSONANT) and is thus implicated in the melodic specification of glide hardening.

Whether this position forms the coda portion of a closed rhyme or an onset is a question we can set on one side here.[18] Of more immediate relevance is the fact that oral closure is the most favoured manner state for sounds occurring in non-nuclear positions. Glide hardening produces conformity with this unmarked state of affairs.

The most direct way of accounting for this resyllabification effect is to assume that PS's nuclear template is simply not big enough to accommodate the adult glide. This we interpret as a failure to establish the marked branching setting necessary for the representation of vowel-length contrasts. In the absence of branching structure, a nucleus only makes provision for the first portion of an adult long vowel (the head). If the second portion is to receive phonetic interpretation, it must be accommodated in some other type of constituent. This account is consistent with the fact that PS's system also exhibits shortening of adult long vowels. Here the lack of a second nuclear slot is not compensated for by the reassignment of the adult glide to a non-nuclear position. As a result, the glide has no corresponding realization in PS's output.

Under this account, shortening and hardening may thus be viewed as different responses to the same fundamental prosodic deficit. As anticipated by the discussion in section 2.4, they represent two of the possible outcomes predicted to occur whenever syllabic restructuring is forced by an absence of branching nuclear structure. The alternatives are repeated in (17). Simple truncation of the right-hand position of a branching nucleus (17a) produces vowel shortening, as in (17b).

(17)



Preservation of the second slot can be achieved by reassigning it to a non-

[18] Under one widely held view, a form such as *sɨ* ⟨see⟩ would be deemed to end in a closed VC rhyme. This analysis is at odds with a significant body of facts which show that a word-final consonant behaves more like a word-medial onset than a coda (see Harris (1994: 66 ff.) for a fully referenced summary of the evidence). This is consistent with a more ancient tradition, associated with various eastern syllabic writing systems, which treats a word-final consonant as the onset of a syllable with a silent nucleus. For our immediate purposes, we may sidestep this theoretical disagreement, since the two approaches converge on the main point being made here: the hardening site is a non-nuclear position.

nuclear position, as in (17c), where the melodic content falls under the influence of hardening in PS's system.

Further confirmation of the essentially syllabic nature of PS's vowel disorder comes from the observation that he also employs the split-nucleus alternative in (17d), illustrated by forms such as *tɔyə* ⟨tire⟩ and *fʁawə* ⟨flour⟩ in (15). Here the second slot of a primary branching nucleus is salvaged by assigning it to the nucleus of an independent syllable. Nuclear split here is strongly reminiscent of the breaking that occurs in some primary types of English, although it is not particularly well-established in any of the dialects to which PS has had prolonged exposure. A significant difference is that the initial vowel in such sequences is long in the relevant primary systems but short in PS's case, in keeping with his nuclear branch deficit.

As noted in section 2.4, the bisyllabification of originally tautosyllabic vocoids extends to historical (V)V*l* sequences in some primary types of English, as in *fi:yəl* ⟨feel⟩, etc. This development is potentially bound up with vocalization of post-vocalic *l* to *w*, a process that is attested to some extent in PS's linguistic environment and appears to be quite general in the early stages of normal phonological acquisition. (The *w* reflex can be treated as the residual [U] element that inheres in dark laterals (Harris 1994: 220).) Vocalization potentially swells the set of words containing labial up-gliding vowels. Both bisyllabification and some analogue of *l*-vocalization show up in PS's system.

In one pattern involving the lateral, hardening affects original V*l* forms no less than V*w*, as the following examples demonstrate:[19]

(18)	(a)	bull	*bɪb*	(b)	school	*skɪb*
		milk	*mɪbk*		wheel	*wɪb*
		pencil	*pɛnsɪb*			
		tell	*tɛb*			
		belt	*bɛbt*			

In primary dialects, *l*-vocalization has not necessarily resulted in a merger of historical V*l*-V: contrasts.[20] In PS's case, however, the neutralization of the

[19] A word about the apparently heterogeneous voicing of the final obstruent clusters in the examples *mɪbk* ⟨milk⟩ and *bɛbt* ⟨belt⟩ in (18). When PS's hardened segments appear in absolute word-final position (as in *yɪb* ⟨you⟩, *sɪβ* ⟨see⟩), voicing is typically sustained throughout the VC sequence. This can be seen in Figure 1, where a voice bar is evident during the closure phases immediately preceding t2 and t4. When followed by a voiceless obstruent, however, the stopped reflex is characterized by rapid decrescendo voicing. Further examples appear below.

[20] In London English, for example, the original contrast between *u:* and *ul* is maintained as a vowel-quality distinction (compare *təw* ⟨two⟩ with *tow* ⟨tool⟩). Lowland Scots, in contrast, does bear the marks of merger in this case (exemplified by *ku:* 'cow' and *pu:* 'pull').

standard vowel-length contrast before *b* in the forms in (18) (compare adult short (18a) with long (18b)) shows vocalization to have produced potentially diphthongal inputs to hardening which are, as far as we can tell, indistinguishable from original *Vw*.

The other relevant pattern affecting laterals, which typically co-occurs with hardening, is bisyllabification, exemplified in the following renditions of adult *Vl* forms:

(19)	seal	*sɪɟʊ*	eel	*ɪɟəb*
	wheels	*wɪɟɪbz*	field	*fɪɟʊt*
	bale	*bɛɟəb*	bell	*bɛɟʊ*
	tail	*tɛɟʊ*	tile	*tɔɟʊ*

The bisyllabicity evident in such forms further confirms that nuclear split is available to PS as a means of dealing with the nuclear branch deficit. The validity of this conclusion is not diluted by whatever doubts there might be about whether bisyllabification before an original lateral is a development that is internal to PS's system or is triggered by primary input.

5.2 *Prosodic minimality*

There is yet another piece of evidence which confirms the prosodic basis of PS's vowel disorder: the variation between hardening and shortening is not entirely free. Under one set of conditions that can only be specified in prosodic terms, hardening occurs to the total exclusion of shortening. As we will now see, shortening is blocked if it presents a threat to the minimal size of the English phonological word.

Before a word-final consonant, both hardening and shortening are in evidence in PS's system. In the case of hardening, this results in VCC] sequences, both in the adult palatal (20a) and labial (20b) series:

(20)	(a)	meat	*mɪɟt*	Keith	*kɪɟf*
		sheet	*sɪɟt*	teeth	*tɪɟf*
		neat	*nɪɟt*	seep	*sɪɟp*
		wheat	*wɪɟt*	leaf	*wɪɟf*
		sweets	*swɪɟts*	leave	*wɪɟf*
		bees	*bɪɟz*	five	*faɟv*

(b)	shoot	*sɪbt*	boat	*bapt*	out	*apt*
	rude	*wɪbd*	coat	*kəbt*	loud	*wabt*
	food	*fɪbt*	goat	*gəbt*	crowd	*kwapt*
	Luke	*wɪbk*	bone	*bəbn*	house	*haps*
	bruise	*bwɪbz*	cone	*kəbn*	mouse	*maps*
	lose	*wɪbs*				
	smooth	*smɪbf*				
	roof	*wɪbf*				
	move	*mɪbf*				
	groove	*gwɪbf*				

Shortening of adult long vowels also occurs freely before a word-final consonant. (21) expands on the exemplification already provided in (12).[21]

(21)	(a)	weed	*wɪd*	white	*wɔd*	grown	*gwɪn*
		beef	*bɪf*	height	*hɔd*		
		spade	*spɪd*	sight	*sɔt*		
	(b)	beak	*bɪk*	tube	*tɪb*		
		week	*wɪk*	boob	*bɪb*		
		meek	*mɪk*	soup	*sɪb*		
		seek	*sɪg*	robe	*rəb*		

As suggested by the examples in (21b), shortening is particularly favoured if the final consonant of the target is already of the same manner and general labial or dorsal place as the hardened reflex of the glide. For example, the labial stop of *tɪb* ⟨tube⟩ not only corresponds to the final consonant of the adult form but also coincides with the output of hardening. A related effect is observable in sequences which consist of a labial up-glider followed by a coronal nasal in the adult grammar. In PS's rendition of adult forms

[21] Many of the forms in (21) (and in (22) below) also have short vowels in Scottish English, conditioned by the following consonant in accordance with a regularity known as Aitken's Law (Aitken 1981, Lass 1974). However, the Scottish pattern does not disturb the basic tense-lax contrast, with the result that shortened *bid* ⟨bead⟩, for instance, remains distinct from *bɪd* ⟨bid⟩. The fact that shortening in PS's case does potentially produce neutralization (under the lax series, as in *bɪk* ⟨beak⟩) suggests that this is an independent development which is internal to his system.

It is interesting to speculate that PS's vowel-length deficit might at least in part be a response to conflicting primary input data emanating from the typologically distinct grammars that are represented in his linguistic environment. He is confronted on the one hand by the southern system, in which vowel length is lexically distinctive, and on the other by Scottish English, in which length is largely determined by phonological context. One effect of this is that many words will be presented to him in long- and short-vowelled variants. In the absence of any conclusive evidence bearing on this possible explanation, it must remain a matter of conjecture.

featuring this structure, we find shortening accompanied by a transfer of the labiality onto the nasal:[22]

(22)

throne	*fwɪm*	brown	*bam*
sown	*sɪm*	crown	*kəwam*
loan	*lɪm*	bounce	*bams*
bone	*bəm*		

Significantly, the preconsonantal site is the only one in which shortening is permitted in PS's system. The process never affects a word-final stressed vowel. In this particular context, PS's grammar apparently responds to some imperative to preserve the overall quantity of an adult final long vowel. In the absence of branching structure, the second portion of the long vowel cannot be accommodated within the nucleus in PS's output and must instead be assigned to a following non-nuclear position, where it falls prey to hardening – the result illustrated in forms such as *tɪb* ⟨two⟩ and *wɪʃ* ⟨we⟩ (see (13) and (14)). The explanation for this contextually determined ban on shortening appears to lie in a constraint which places a lower limit on the size of the phonological word in English. The fact that adult VV] forms are the only ones to resist shortening reflects the fact that this is precisely the context where the process would place the quantitative minimum in jeopardy.

Consider the following well-known facts about words containing a single stressed vowel in English. They are required to end either in a long vowel (⟨see, cow⟩, etc.) or in at least one consonant, in which case the preceding vowel can be either long (⟨bead, shout⟩, etc.) or short (⟨bid, bit⟩, etc.). There are no words ending in a short stressed vowel (**bɪ*, **sɛ*, etc.). These facts follow from the assumption that, as in many other languages, the phonological word in English must consist minimally of a bimoraic foot – a metrical unit containing two weight-bearing positions (see McCarthy & Prince 1986). (Only rhymal positions contribute to the calculation of weight.)

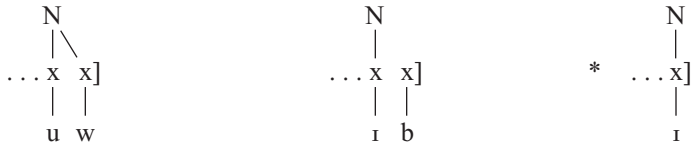
[22] Representationally, this effect consists in the labial element [U], cut adrift from the nucleus through truncation of the second position, docking onto the following non-nuclear position:

The syllabic repositioning of labiality has also been observed in normal development (Smith 1973: 16).

The bimoraic minimum is satisfied in words that end in VV] or VC]. In VV] words (⟨see, cow⟩, etc.), the two weight-bearing positions are housed within a final branching nucleus. In VC] words (⟨bit, back⟩, etc.), weight is distributed over a nucleus (V) and a following non-nuclear constituent (C).[23] The requirement is also met in (V)VCV] words (⟨city, treaty⟩, etc.), with each nucleus contributing at least one mora's worth of weight. The ungrammaticality of forms such as **bɪ* or **sɛ* is due to the fact that, in containing a final single-position nucleus, they fall below the bimoraic threshold.

The failure of PS's nuclear branch deficit to produce across-the-board shortening finds explanation in the assumption that prosodic minimality is respected in his grammar no less than in the adult's. This accounts for why shortening can be found in PS's version of adult VC] but not VV] words. In the absence of branching nuclei, one way in which PS's system can retain the bimoraicity of VV] forms is to render them as VC]. In other words, while hardening is an option in this context (see (23b)), shortening is not. Simple nuclear truncation of VV] to V] would allow a word to slip below the bimoraic minimum (see 23c).

(23) (a) Adult *duw* do (b) PS *dɪb* (c) **dɪ*



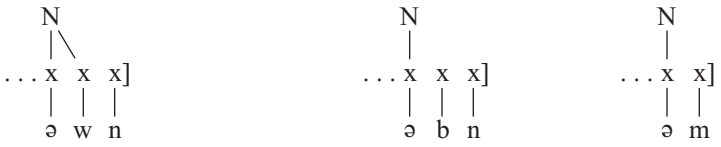
Bisyllabification is also an option in this context (as in *tɛɟʊ* ⟨tail⟩), since it preserves two weight-bearing positions, albeit split between separate syllables.

[23] According to one of the two approaches outlined in fn. 18, final VC] is defined as a bimoraic rhyme. The other treats the C as the onset of syllable containing a silent nucleus. Under the latter approach, it is the silent nucleus that constitutes the second mora of a final VC] sequence. A form such as ⟨pit⟩ (CVCØ) is binuclear and hence bimoraic in just the same was as, say, ⟨pity⟩ (CVCV). The disagreement between the two approaches does not undermine the main point in hand – the fact that the English word is subject to a bimoraic minimum.

The second approach allows us to maintain that feet universally contain two nuclear positions; that is, there are no 'degenerate' mono-nuclear feet. This is turn avoids a potential anomaly whereby non-branching structure would have to be deemed unmarked in all syllabic constituents but marked in feet. In the case of PS, this would have made it difficult to explain why branching feet but not branching nuclei are firmly established in his system.

In contrast, shortening in the VVC] context does not threaten prosodic minimality, because the final consonant already satisfies the bimoraic minimum irrespectively of whether a long or short vowel precedes. In this context, PS's system thus has options for either hardening (24b) or simple shortening (24c).

(24) (a) Adult *bəwn* bone (b) PS *bəbn* (c) PS *bəm*



The inhibition of vowel shortening by prosodic minimality would also be expected to feature in normal phonological development, although not necessarily with the specific hardening effects witnessed in PS's system. This is explicitly confirmed by Bernhardt & Stemberger (1998: 449–450), who report the case of an English-acquiring child who optionally produces adult VV] words as V*ʔ*], for example *nɤʔ* ⟨no⟩, *miʔ* ⟨me⟩.

6. Conclusion

PS's version of the adult subsystem of long vowels is characterized by three main developments – shortening, bisyllabification and glide hardening. Each of these has clear analogues in developments affecting primary systems, for example in linguistic change and inter-language borrowing.

For instance, shortening occurred in the evolution of Latin, which had a vowel length contrast, into daughter languages such as Italian and Spanish, which do not. In Sesotho (Bantu, southern Africa), which lacks a vowel length distinction, English loan words containing diphthongs are subject to nuclear split (as in *biya* 'beer'). The hardening of original VV to VC is attested in certain dialects of Romansch (as in *fayra* > *fɛgra* 'market'; Lutta 1923, Kaisse 1992). All three of these examples reflect a situation in which the earlier or donor language possesses branching nuclei but the later or recipient language does not.

The same type of syllabic mismatch, we have argued, is responsible for the appearance of similar processes in PS's output. Far from being accidental, the co-occurrence of these effects within the same system thus stems from a single fundamental deficit – a failure to secure the branching structure necessary for the acquisition of nuclear length contrasts in English. The entrenchment of non-branching nuclear structure reflects the perseverance of an unmarked alternative which would make for a well-formed primary subsystem but happens not to coincide with what is required for English.

Besides offering insights into the syllabic dimensions of vowel disorder, the case study provides external confirmation of the independence of the prosodic and melodic facets of phonological representation.

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