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Context-Conditioned Error Patterns in Disordered Systems

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This chapter reviews and expands the literature on consonant-vowel (CV) interactions in developing sound systems (normal and disordered) and explores the usefulness of current phonetic models (Davis and MacNeilage, 1995; Kent and Bauer, 1985; MacNeilage and Davis, 1990b; Studdert-Kennedy and Goodell, 1995) in accounting for and predicting the occurrence of these phenomena. The phonetic models provide a biological perspective insofar as the immature pronunciations of the normally developing child are viewed as systematic reflections of organic constraints imposed by the child's developing phonetic systems, both perceptual and motor.[1]

In the clinical setting, context conditioning manifests itself most frequently as consonantal speech errors, which only occur in specific vocalic contexts, although recent research has also uncovered evidence of vowel errors conditioned by consonantal context (Bates and Watson, 1995; Reynolds, 1990). Such interdependencies accord well with current phonetically orientated models of speech acquisition and have important implications for clinical practice.

In espousing this approach, we do not intend to overlook the benefits of an analysis in terms of recent developments in phonological theory. This is an approach robustly argued in Harris, Watson, and Bates (1999), and taken up in Chapter 6. Rather, we consider the extent to which current phonetic models of speech acquisition contribute to an understanding of disordered child speech. Research into early speech production has traditionally concentrated on the order of acquisition of individual segments, especially consonants, carrying with it the assumption that vowels and consonants are under independent control. This view is strongly attacked in phonetically oriented research into acquisition and adult sound systems. We will discuss this view in the following text.

The Biological Framework

A phonetically orientated framework for linguistic description does not disregard the importance of phonological patterning, but does seek an explanation for many of these patterns from functional principles of perception and production. In this section, we will briefly describe prelinguistic[2] and adult phonetic systems, before considering the transition between the two, which corresponds to acquisition.

The prelinguistic infant generates a number of vocalization types. At approximately 7 months, the child produces canonical babble (such as [baba], [dada]). MacNeilage and Davis (1990b) suggest that the consonant in such sequences is reflective of a resting position of the velum and tongue at syllable onset, and that the identity of the vowel is the product of the extent of a simple down-up jaw movement. The execution of repeated cycles of jaw opening and closing, which MacNeilage and Davis call *frames,* therefore unavoidably results in vocalizations corresponding somewhat to CV syllables.

This view holds that the unit of speech production defined by children's holistic, and, as yet, undifferentiated groupings of articulatory gestures, corresponds to the syllable or word, not the phoneme. This is supported by evidence presented by Hodge (1989); MacNeilage and Davis (1990a); Nittrouer, Studdert-Kennedy, and McGowan (1989); Studdert-Kennedy (1987, 1991a, 1991b); Studdert-Kennedy and Goodell (1995); and Wode (1994), cited by Piske (1995); and MacNeilage and Davis (1995), cited by MacNeilage (1998). As the child expands its repertoire to include a number of distinct CV forms, there appears to be strong restrictions on the co-occurrence of the "C" and the "V" within these syllable-like units.

In accordance with their "Frames, then Content Hypothesis," MacNeilage and Davis (1990b, 1995) describe the co-occurrence of both alveolar consonants and the palatal glide [j] with front vowels as *fronted* frames, and the co-occurrence of velars and back vowels as *backed* frames. Both patterns reflect the infant's restricted tongue physiology, kinematic potential and control. At the earliest stages, the tongue is thought to be pre-positioned in the horizontal plane prior to syllable onset, and is not actively moved at all during the syllable.

Thus, the association of labials and central vowels, described as pure frames, is essentially characterized by jaw movement with a neutral tongue position. Already by 9 or 10 months, some characteristics of the language spoken to the child are reflected in the relative frequency of fronted, backed, and neutral frames (de Boysson-Bardies, Sagart, Halle, and Durand 1986; de Boysson-Bardies, Vihman, Roug-Hellichius, et al., 1992).

Adult speech, on the other hand, is not similarly constrained in its inventory of syllables. This is evident from the rich possibilities for the co-occurrence of consonants and vowels. In adult language, segments are seen as crucial aspects of language (Studdert-Kennedy and Goodell, 1995), but are not taken to be the basic units of speech because they only exist as subparts of syllables and as combinations of gestures. Current gestural models of adult speech production characterize sounds indirectly as synchronized articulatory gestures, or functional groupings of gestures. The many coarticulatory effects in adult speech are a natural consequence of the literal coproduction of gestures and represent varying degrees of spatial/temporal overlap (Browman and Goldstein, 1986; 1989; Recasens, 1991). The unique contribution of the biological framework is most evident when we try to explore how the child accomplishes the transition from simple frames to the complexity of gestural scores.[3]

At first, very young children moving beyond the simplest mandibular frames produce sets of gestures in a largely synchronous manner (Kent, 1992). With the development of finer motor control and with practice, children gradually master the relative phasing of gestures, enabling more adultlike patterns of spatiotemporal overlap. This leads to a greater inventory of possible gestural routines and a greater segmental inventory (Studdert-Kennedy and Goodell, 1995).

To flesh out this characterization using the terms of the frame/content model, the child begins to reanalyze holistic fronted or backed frames as *content* corresponding to lip, tongue, velar and laryngeal gestures superimposed on top of the very simplest (mandibular) *frames*. In addition to the frame motion, undergoing refinement to allow for consonant clusters, onsetless syllables, and closed syllables, gesture patterns for the oral and laryngeal articulators are gradually refined.[4] Eventual mastery of the relative phasing of gestures produces adultlike patterns of spatiotemporal overlap in which children accomplish mature gestural patterns corresponding to segmental categories perceived on-line.

We emphasize that the path from the undifferentiated holistic syllable frame to segmentlike organization is not a simple or deterministic one. Characterizing it in detail is a major goal for current and future research in this framework. There is a great deal of intersubject variation but, in general, it seems that during acquisition children rely on syllables as organizational units. Simple syllables appear as components of a suite of relatively fixed gestural routines called *prosodic schemata* (Waterson, 1971), *word patterns* (Macken, 1979), *templates* (Menn, 1983), or *vocal motor schemes* (McCune and Vihman, 1987). Such a templatic inventory might define and limit the infant's repertoire in the early stages of lexical expansion, and the inventory itself might undergo change (Piske, 1997). Radical variation in the interrelationships of gestures is also readily observable within the word (Ferguson and Farwell, 1975).

The emergence of intergestural coordination has been examined most closely in studies of anticipatory coarticulation in vowel-vowel and consonant-vowel sequences. Interpreting this research is problematic for the reasons summarized in Kühnert and Nolan's (1999) review. Coarticulation is not a unitary phenomenon. Not all cases are alike, and they cannot be expected to develop in the same way (Repp, 1986). Thus, conflicting developmental patterns described in the literature may be attributed to intersubject variability as well as a lack of methodological agreement.

With respect to anticipatory coarticulation from vowel to consonantal onset, however, the large, well-controlled studies of Nittrouer, Studdert-Kennedy, and colleagues provide convincing evidence (Goodell and Studdert-Kennedy, 1993; Nittrouer, 1993; Nittrouer, Studdert-Kennedy, and Neely, 1996). Though they note the problem of intersubject variability, it seems clear that some children around the ages of 2 to 3 years have a great deal more intrasyllabic coproduction of consonants and vowels than older children and adults. This pattern is also maintained when looking at data averaged within these age groups. Within-syllable coarticulation (largely dependent on the control of tongue movements) may continue to mature until at least the age of 7 years (Nittrouer, Studdert-Kennedy, and McGowan, 1989; Nittrouer, 1993). These studies show, furthermore, how the organization of gestures within syllables matures at a different rate, depending upon the articulator in question and the particular sequence of segments involved.

A comparison of coarticulation in children's and adult's productions of fricative/vowel sequences *sea-she, Sue-shoe, sa-sha,* (/si-ʃi/, /su-ʃu/, /sɑ-ʃɑ/) found that only adult fricatives preceding the /u/ vowel showed modification due to anticipatory lip rounding. Children's tokens, however, showed a higher degree of tongue body fronting or backing during the fricative portion, depending on the identity of the following vowel (such as fronting for /i/ and backing for /a/ and /u/), indicating greater overlap between the consonant and vowel lingual gestures. It would, therefore, appear that within syllables, young children find it more difficult to segregate or differentiate sequences sharing the same primary articulator (in this case the tongue), than sequences involving different articulators (in this case, the tongue and lips).

This difficulty in dealing with homorganicity in an adultlike way was also revealed in a study of two children (RS and AE) with phonological disorder, who reduced initial /s/ clusters to a fricative (Scobbie, Gibbon, Hardcastle, and Fletcher, 1997). Both children found the homorganic cluster /st/ more difficult to master than /sk/ or /sp/. First, one of the subjects (RS) reduced only /st/, but not /sp/ or /sk/, a pattern which was apparent to the normal listener. Second, although both children appeared, at a later date, to be producing all three clusters correctly, instrumental phonetic analysis showed that the stop in /st/ clusters was still not adult-like. It was heavily spirantized and overly short, both in absolute terms and as a proportion of the cluster duration. Catts and Kamhi (1984) report a similar pattern of reduction whereby /st/ appeared as a fricative, while /sp/ and /sk/ appeared as stops.

These observations about gestural differentiation can be interpreted as evidence for Davis and MacNeilage's "frames, then content" hypothesis and may account for the occurrence of some context-conditioned error patterns as noted in point 1 of the following list. Many of the complex articulations required by adult languages (such as to produce nonhomorganic consonant clusters and closed syllables) do not have obvious cognates with the articulatory gestalts found in the earliest babbling routines (although future research might uncover such connections). These may, however, be explained within the wider biological framework as detailed in points 2 to 4. In each case, the context of the child's error pattern is seen to be crucial.

1. The immature gestural gestalt governing a single articulator in basic syllabic frames might exert a strong repressive influence on the process of differentiation of the gestalt into a coordinated sequence of anatomically proximal, yet independent, gestures (MacNeilage and Davis, 1990b).
2. Children might have difficulty mastering some mature speech patterns, simply due to the complexity of the gestural coordination demanded (Kent, 1984; Waters, 1995).
3. Immature perceptual skills and ongoing immaturity of speech motor skills may be involved in the appearance of developmental speech errors (Nittrouer and Studdert-Kennedy, 1987; Watson 1997).[5] "A child's phonology is grounded in both perceptual and motoric constraints" (Nittrouer, Studdert-Kennedy, and McGowan, 1989, 131).
4. Early motoric or perceptual constraints may become fossilized into simplification strategies, continuing to be manifested even once the speech production or perceptual difficulties are overcome (Hewlett, 1995).

Given this empirical evidence, it is important, when approaching the simplifications or phonological avoidance strategies (Menn, 1983) observed for young normally developing and phonologically disordered (PD) children, to expand analyses beyond the consideration of individual segments in isolation. To illustrate, phenomena, such as alveolar backing, should not be considered without taking into account the vocalic context of the consonant, since alveolars might behave quite differently in the context of front and back vowels.

Clinical Implications

Evidence of context-conditioned error patterns in disordered systems has important implications for clinical diagnosis and management. It highlights the need for the clinician to assess a child's pronunciation beyond the production of individual sounds or classes of sounds to potentially problematic CV sequences. Failure to test a child's production of sounds in a variety of phonetic environments could result in the false impression that the child is unable to pronounce the target when, in fact, they are able to do so in a specific context or set of contexts.

Conversely, correct pronunciation in one or a few contexts might give the impression that the child has no difficulty with a given sound, although they might not be able to produce it in the full range of phonetic and phonotactic settings. Unless the clinician systematically tests for context conditioning, it might be falsely concluded that any variability noted in the child's system is random. Given the typically small number of test items in most tests and the difficulty in selecting appropriate vocabulary (such as familiar and imageable words), it is hardly surprising that the vowel context is not evenly distributed for every consonant or cluster. For example, in the Phonological Assessment of Child Speech test (Grunwell, 1985), only one probe item for word-initial /k/ has a highfront vowel context, while two are before a highback vowel, one before a mid vowel, and six before a low vowel. Evaluation of the child's progress is also likely to vary depending upon the relative frequency of the operative contexts in the words selected for production practice (Camerata and Gandour, 1984).

In addition to providing a more accurate diagnosis, identification of the operative contexts of a given error pattern or patterns narrows the focus of treatment. This minimizes time potentially wasted practising production in contexts which are unproblematic for the child (Leonard, Devescovi, and Ossella, 1987). It has also been suggested that children who do not pronounce target sounds in any contexts, or who show genuine variability (as opposed to context-conditioned variability), might be helped to achieve more accurate productions by targeting the sounds initially in maximally facilitatory contexts, and gradually progressing to more difficult contexts (Gierut, 1990; Grundy and Harding, 1995; Lancaster and Pope, 1989). In Chapter 7, Gibbon and Mackenzie Beck discuss how clinicians might utilize context to facilitate accurate vowel production.

Awareness of potential context conditioning can also assist in the prioritization of remediation targets. In the case of consonant disorders, this is generally done on the basis of whether or not the error pattern reflects delayed or deviant development, with higher priority being afforded to more atypical features. Classification of errors as either delayed or deviant has often been based on how frequent they occur in the literature or how frequent they occur in the clinician's own personal experience. This explains why clinicians tend to regard *all* vowel errors as reflecting disordered development (Reynolds, 1990). However, where vowel error patterns are phonetically principled in accordance with biological models of acquisition, these may be classified as representing delayed development. For example, while alveolar backing across all contexts is rightly regarded as more unusual, and hence more deviant, than velar fronting, alveolar backing occurring only in the context of back vowels may be seen to constitute delayed, as opposed to disordered, development.

Context-Conditioned Patterns in Normally Developing Systems

The discussion in the "Biological Framework" section of this chapter might suggest that there is an unmarked (universal) pattern for the prelexical babbling child of strong contextual conditioning of the "C" and "V" in a simple syllable.[6] In fact, the relative frequency of fronted, backed, and neutral frames in babbling can be influenced by the ambient language and the transition from babbling to early phonology is not an abrupt one (de Boysson-Bardies, Sagart, Halle, and Durand, 1986; de Boysson-Bardies and Vihman, 1991; de Boysson-Bardies, Vihman, Roug-Hellichius, et al., 1992; Davis, MacNeilage, Gildersleeve-Neumann, and Teixeira, 1999; Vihman, Ferguson, and Elbert, 1986). It is therefore reasonable to expect some cross-linguistic variation even in the earliest recorded data, leading to differences in the apparent segmental constitution of even very highly constrained output.

Our review in this section of context-conditioned errors in normal development appears to show that variation in the set of basic frames is possible, even within a single language.

Davis and MacNeilage (1990) report, in a single case study investigating vowel acquisition (age 1 year, 2 months to 1 year, 8 months) that, almost without exception, highfront vowels occurred in the context of alveolars while highback vowels occurred in velar contexts. Midcentral and lowcentral vowels tended to co-occur with labial consonants. In a later longitudinal study of babbling and first word production by six infants, Davis and MacNeilage (1995) note a similar pattern of CV interactions (Figure 5-1).

Fudge (1969), however, reports CV patterning in his son's early system of a slightly different type (Figure 5-2). In this case, target labials and velars were realized as alveolars in the context of a following front vowel, while target alveolars were realized as labials preceding back rounded vowels, and as velars preceding back unrounded vowels (Table 5-1).[7]

If these examples indicate that more than one pattern of simple frames is available, then a simple deterministic interpretation of the biological framework is not possible. We think, however, that intersubject variation may arise at the point at which children attempt to individuate gestures, but are not yet able to recombine them so as to increase the variety of their output patterns. It is clear that more gesturally oriented research on the earliest output of normally developing children is required.

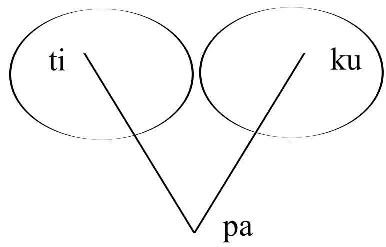

Figure 5-1 Triangular representation of the vowel space with indication of which consonantal places co-occur with different vowel regions in the "frames, then content" hypothesis.

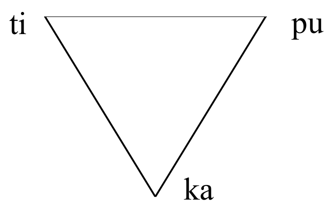

Figure 5-2 Triangular representation of the vowel space showing another possible pattern of consonant-vowel co-occurrence within different vowel regions.

Table 5-1 Fudge Junior (English, 1 year, 4 months)

Alveolar + front vowels			*Labials + back rounded vowels*			*Velars + unrounded vowels*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
drink	drɪnk	ti	ball	bɔl	bo	cake	kɛik	kʌk
again	əgein	dɛn	book	bʊk	bo	truck	trʌk	kʌk
			dog	dɒg	bo bo	garden	gɑdɛn	gʌŋ
						doggie	dɒgi	gʌgɯ

Key: CP = child's pronunciation

Results from children with larger vocabularies, whose outputs are more varied and indicate more clearly a degree of gestural sophistication, are easier to interpret. Consider the major study of Dutch children undertaken by Levelt (1994). Her interest in CV interaction arises from her hypothesis that the purportedly long-distance consonant-to-consonant relationships across an intervening vowel termed *consonant harmony* are in fact *local* CV interactions. In her data, harmony was shown to be heavily influenced by the intervening vowel.

> Examination of the vowels that intervened between the consonants that were thought to be involved in the phenomenon revealed that these actually had the same articulator feature as the harmonised consonant—or as the apparent trigger consonant, for that matter. Numerous data containing consonants that were clearly affected by the adjacent vowel strengthened the hypothesis that Consonant Harmony can better be viewed as Vowel~Consonant Harmony (Levelt, 1994, 70).[8]

Several authors report systems in which only the occurrence of labial consonants is restricted. In a case study of his son J, Braine (1974) notes a general preference for alveolar consonants up until age 1 year, 9 months (Table 5-2). Between 1 year, 9 months and 2 years, Child J started to produce words with labials in initial position preceding low vowels (*mama, ball, bird*), but continued to realize target labials as alveolars where they preceded highfront vowels.

Stoel-Gammon (1983) describes the system of Child D who, at 1 year, 2 months, produced both labials and alveolars in initial position (*bottle* /bɔdl/ [bɑbu]; *bubble* /bʌbəl/ [bʌbu]; *daddy* /dɑedi/ [dædæ]; *light* /lɑit/ [dɑɪ]). She reports a similar restriction on the occurrence of target labials, although in Child D's case the conditioning context was extended to include all front vowels and diphthongs with a front vowel offglide (*baby* /bebi/ [didi]). Child D continued to realize target labials as alveolars in this context until age 1 year, 5 months, when words containing a labial stop-front vowel sequence were produced correctly.

Table 5-2 J (English, 1 year, 9 months to 2 years)

	Alveolar + highfront vowels	
Word	*Target*	*CP*
pee	pi	di
bee	bi	di
big	bɪg	diʔ
baby	bɛibi	didi
milk	mɪlk	niʔ niʔ

Ferguson and Farwell (1975) and Leonard, Newhoff, and Mesalam (1980) also observe an alternation between [b] and [d] in the early productions of their subjects. Both authors attribute this pattern to lexical variation, noting the coexistence of variant pronunciations of the same word (such as [baba] and [daɪdaɪ] for *bye-bye*). However, in each of the examples they cite, the labial target is pronounced as alveolar when followed by a front vowel or diphthong with a front vowel offglide indicating, in these cases also, that the variant pronunciation is context-conditioned although lexically variable. MacNeilage (1998) attributes the lexical variation in cases such as these to difficulty in the relative phasing of gestures. This typically results in the child producing the requisite articulatory components for a given sequence, which are gesturally scored in an incorrect way (such as *pen* /pɛn/ pronounced variably as [dɛ^{dn}], [hɪn], [mbo]) (Ferguson and Farwell, 1975). This is a good example of where the description of the child's variation in terms of indissoluble, segment-sized units fails to capture the child's success in producing appropriate gestures, albeit in inappropriate sequence and combination.

To summarize, the most common pattern to emerge from the literature on normal phonological development in English is the association of *place* of articulation in consonants and vowels. This pattern is namely alveolar consonants with front vowels, labials with round vowels, and velars with back vowels. In some cases, the distribution of either alveolars and labials or alveolars and velars is complementary, such that labials are pronounced as alveolar in the context of front vowels and alveolars are pronounced as velars and labials or just labials in the context of back vowels.

In gestural terms, each of the error patterns described above can be explained in relation to what Kent and Murray (1982) have termed the *compatibility factor*. Alveolar consonants and front vowels are both characterized by a relatively raised and fronted tongue body, while velar consonants and back vowels both involve constriction at the back of the tongue. Labials are compatible with back rounded vowels insofar as they share their specification for labiality. The co-occurrence of labials and mid or low central vowels noted by Davis and MacNeilage (1990) can also be attributed to greater articulatory compatibility between consonant and vowel gestures, in this case, with respect to jaw position since this may be lower at closure for labial than for lingual consonants (Sussman, MacNeilage, and Hanson, 1973, cited in MacNeilage, 1998).

In the normally developing child, CV interactions seem to phase out in the second year in most cases, as gestural reorganization takes hold. Tyler and Langsdale, in their cross-sectional and longitudinal study of nine children aged 18 months, 21 months, and 24 months, conclude that "CV interactions may hold for only the earliest period of lexical acquisition and with differing strengths in individual phonological systems" (Tyler and Langsdale, 1996, 159).

Consonant-Vowel Interactions in Developmental Phonological Disorder

Agreement between consonants and vowels regarding place of articulation also features predominantly in studies reporting context conditioning in PD children. However, here the effects are not confined to word initial stop consonants, but can apply across different manner classes. This can also include sounds in different word positions, reflecting the more advanced age of the children in question and, consequently, the greater overall maturity of their systems. The literature on disordered development also contains examples of error patterns not documented for normally developing children, principally involving variation in vowel quality as a function of consonantal context.

Vowel Conditioning of Consonant Error Patterns

Wolfe and Blocker (1990) report a constraint on labial consonants in the system of Child H, age 4 years, 7 months. Child H realized both labial stops (voiced and voiceless) and labiodental fricatives as [d] preceding front vowels and as [b] preceding back vowels. The bilabial nasal stop /m/ was produced as [n] in front vowel contexts. The constraint not only applied to consonants in word initial position but also in syllable-initial, word-medial position: *doorbell* [dodɛl], *baby* [dɛdi].

In the system of Child NE described by Williams and Dinnsen (1987), alveolars and velars appeared in complementary distribution depending upon the front/back specification of the following vowel. Labials were produced correctly in both environments (Table 5-3).

Table 5-3 NE (USA, 4 years, 6 months)

Consonant-front vowels *Alveolars maintained* *Velars → Alveolars*			*Consonant-back vowels* *Alveolars → Velars* *Velars maintained*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*
deer	diɚ	diʊ	soup	sup	kuʔ
leg	lɛg	dɛ	girl	gɝl	gʊ
cage	kɛiʤ	tɛ	goat	gout	goʔ, go
swim	swɪm	di			
Labials unrestricted					
peach	peʧ	piʔ	blow	blou	bo
big	bɪg	bɪ			
page	pɛiʤ	buʔ			

Camerata and Gandour (1984) report a similar case of complementary distribution between alveolars and velars, but one conditioned by vowel height rather than frontness/backness (Table 5-4). In this case, high vowels condition alveolars whereas mid and low vowels condition velars. Labials are unrestricted. Note that Child GG reduced diphthongs to their first element and pronounced /ɛ/ as [ɑ], as shown in examples marked with * and ** in Table 5-4.

At first glance this appears to be a dissimilatory process in that velar consonants share the same height specification as high vowels, while alveolar consonants pattern with mid and low vowels (Chomsky and Halle, 1968). Notwithstanding this, Camerata and Gandour (1984) argue that this error pattern can be considered phonetically motivated insofar as it shows agreement between consonants and vowels in terms of acoustic properties, which in traditional feature terms were described as [+diffuse] (Jakobson and Halle, 1971). Diffuse sounds (that is, alveolars, labials, and high vowels) are characterized by a higher concentration of energy in a noncentral region of the spectrum, and nondiffuse sounds (that is, palatals, velars, and nonhigh vowels) by higher energy bands in a central spectral region. Diffuse sounds also have a lesser overall degree of energy than nondiffuse sounds. In contrast to previous cases described, this pattern appears to represent a perceptual as opposed to articulatory constraint on production.

Table 5-4 GG (USA, 2 years, 10 months to 3 years, 7 months)

			Consonant-high vowels					
Alveolars maintained			*Velars → Alveolars*			*Labials unrestricted*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
tea	ti	di	key	ki	di	bee	bi	bi
			kick	kɪk	di	boot	but	bu
two	tu	du	cook	kʊk	du	book	but	bu
						boat	bot	bo
			Consonant-mid and low vowels					
Alveolars → Velars			*Velars maintained*			*Labials unrestricted*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
duck	dʌk	gə	cup	kʌp	gə	bus	bʌs	bə
*toe	tou	go	*goat	gout	go	bath	bath	bɑe
*tie	taɪ	gæ	*kite	kait	gæ	pan	paen	bɑeng
dog	dɒg	gɑ	*clown	klaun	gæŋ	boat	bot	bo
**train	trɛin	gæŋ	car	kɑ	gɑ	ball	bɑl	bɑ

A similar constraint on the occurrence of velars is reported by Leonard, Devescovi, and Ossella (1986) for Child E (age 3 years) (Table 5-5). Note that in this system, the distribution of labials, although not conditioned by vowel context, was not unrestricted. Child E produced a labial consonant word-initially (even in words with no initial target consonant at all) if there was a labial in medial or final position of the same word, or if a labial occurred at any position in the following word. Word-initial plosives and fricatives were replaced by a labial stop and liquids and glides by the labiovelar approximant [w] (such as *tummy* /tʌmi/ [bibi]; *jump* /ʤʌmp/ [bɛ, bʌ]; *give* /gɪv/ [bɪm]; *up* /ʌp/ [wʌ]). In words where labials did not appear, vocalic context did, however, condition the occurrence of alveolars and velars. In word-initial position, velars occurred preceding mid and low back vowels and in diphthongs with an /u/ offglide, while alveolars occurred elsewhere.

Grunwell (1981) describes a case, Child S, where the distribution of labials across three different manner classes, stops, fricatives, and approximants is conditioned by the front/back specification of the following vocalic context (Table 5-6). Target labial stops and labiodental fricatives were produced as alveolar stops and dental fricatives respectively in the context of a following front vowels. The fact that alveolar and palatal fricatives and approximants were also realized as dental fricatives in this context might suggest an earlier general preference for the dental place of articulation, which is beginning to resolve. From the biological perspective, this patterning accords with the notion of increasing refinement and differentiation of anatomically proximal gestures.

Table 5-5 E (USA, 3 years)

		Consonant-high vowels			
Alveolars/Palatals maintained			*Velars → Alveolars*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*
sit	sɪt	di	geese	gis	di
duck	dʌk	dɛ	cake	keik	dei
shoe	ʃu	du			
		Consonant-mid and low vowels, diphthongs with an /u/ offglide			
Alveolars → Velars			*Velars maintained*		
doll	dal	gɔ			
down	dəun	gəʊ			
no	nəu	go			
nose	nəuz	go			

Table 5-6 S (English, 6 years, 3 months)

Consonant-front vowels *Labial stops → Alveolar stops*		
Word	*Target*	*CP*
bee	bi	di
peg	pɛg	tɛk
men	mɛn	dɛə
Labiodental fricatives → Dental fricatives		
feet	fit	θɪ
thread	θrɛᵈ	θɛᵊ
Alveolar/Palatal fricatives → Dental fricatives		
sea	si	θɪ
ship	ʃip	θɪʔ
Labiovelar/Alveolar approximant → Dental fricatives		
wind	wɪnd	ði
leg	lɛg	ðɛk

Table 5-7 SC (Scottish, 7 years, 2 months)

Front vowels *Velars maintained*			*Back rounded vowels* *Velars → Aveolars*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*
key	ki	ki	school	skul	stoɭ
grape	grep	grep	comb	comb	tom
curly	cʌrle	kɛle	goat	got	dot
car	car	kar	coffee	cɔfi	tɔfi

In the system described by Hezelwood (1998) the occurrence of alveolar consonants is constrained. Child JP (age 4 years, 2 months) realized all target alveolars as labials in the context of a following rounded vowel: *toy* /tɔi/ [pᵂɔɪ]; *do* /du/ [bᵂu]; *sun* (northern English /sʊn/) [pᵂʊn].

The following two cases represent a departure from the typical pattern of front/back vocalic influence in that velars are fronted preceding back rounded vowels but appear as velar before front vowels (Table 5-7). In the first case reported by Bates and Watson (1995) Child SC's sound system was characterized by widespread variability with the exception of this particular context-sensitive error pattern.

In a study of consonant cluster acquisition (Scobbie, Gibbon, Hardcastle, and Fletcher 1998; 2000), unpublished data from Child DB shows that his realizations of /st/ and /sk/ are partly context-sensitive (Table 5-8). Though the materials of the study provide only partial data, it appears that Child DB's pervasive velar fronting does not occur in the context of /i/.

One hypothesis about this data is that Child DB is maintaining a covert phonetic distinction between /st/ and /sk/, which is only observable in transcription before /i/. The reason this vowel context reveals a difference between /st/ and /sk/ is that /i/ exerts a strong palatalizing influence on the gestures realizing the stops, producing a percept for /sk/ which sounds like an acceptably fronted velar and a percept for /st/ which sounds like an acceptably palatalized alveolar.

Bates and Watson (1995) also describe a system in which consonantal manner of articulation appears to be conditioned by vocalic context (Table 5-9). In this case, the labiodental fricatives /f, v/ are produced correctly preceding back rounded vowels, but as [b] in the context of a following lowcentral vowel [a], and as [sw] preceding nonlow front vowels. As in the examples of place agreement, this pattern also lends itself to an account in terms of articulatory compatibility. In the context of [ɑ], which represents maximal jaw opening, it is arguably

Table 5-8 DB (Scottish, 4 years, 1 month)

Consonant-high front vowel /i/ Velar maintained Alveolar maintained			*Consonant-nonhigh front vowels (/e, a/) and /o/ Velar → Alveolar*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*
skier	skiær	kia	kate	ket	det
steer	stiær	tia	skate	sket	det
			sky	skai	da
			sty	staɪ	da
			score	skɔr	doa

Table 5-9 JC (Scottish, 6 years, 2 months)

Front vowels Labiodental fricatives linearised			*Low vowels Labiodental fricatives stopped*			*Back vowels Labiodental fricatives maintained*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
feet	fit	swit	fan	fan	ban	phone	fon	fon
face	fes	swes	van	van	ban	fork	fɔrk	fork

easier to achieve a stop closure characterized by a rapid ballistic movement, than the more precise articulatory positioning required for the fricative. In the context of high- and midfront vowels, which are less antagonistic in terms of jaw position, Child JC was able to produce both a labial and fricative gesture, although not as an integrated sound. The fricative was also produced at the same place of articulation as the vowel. Correct fricative production was arguably facilitated by the back rounded vowel context, which shares the consonant's specification for labiality.

Following Lindsey and Harris (1995), Bates and Watson (1995) describe realization of /f/ as [sw] as a *linearization* of the features frication and labiality, and report a similar example in the case of a child who realized /f/ as a combination of [p] and [s] preceding the diphthong /ai/: *fence* [psains]. Again, this pattern may be interpreted as target overshoot, given the conflicting demands on jaw/lip position for the consonant and vowel gestures. (That is, it is arguably easier to attain a full stop closure in the context of a following [a], than the more precisely specified opening required for the fricative.) With the biological framework, this pattern can also be interpreted as resulting from incorrect phasing of the component gestures (Ferguson and Farwell, 1975).

Consonant Conditioning of Vowel Error Patterns

[ɫ] Conditioning

The most commonly reported CV effect in the literature is the lowering/backing of front vowels in the context of a following velarized lateral [ɫ] (Bates, Hewlett, Kaighin, et al., 1992; Bates and Watson, 1995; Gibbon, Shockey, and Reid, 1992; Pollock and Keiser, 1990; Reynolds, 1990). In their group study, Bates and Watson (1995) found examples of this process in the systems of three children (Table 5-10).

Table 5-10 RC (Scottish, 3 years, 9 months), IP (Scottish, 6 years), SC (Scottish, 7 years, 2 months)

RC ε→[a] preceding /ɫ/			*IP ε→[a] preceding /ɫ/*			*SC ɪ, u, ε→[o,ɔ] preceding /ɫ/*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
nest	nεst	naist	vest	vεst	vest	pencil	pεnsɪl	pεnsoɫ
egg-cup	εgkʌp	aig kʌp	neck	nεk	nek	school	skul	stoɭ
melting	meltiŋ	maɫtɪŋ	yellow	jεlo	jawo	spell	spεl	spoɫᵊ
shell	ʃel	saɫ	wellie boots	wεle buts	wawe bʉts	melting	meltiŋ	moɫtɪŋ
						girl	gɪrl	gɔɫ

With Children RC and IP, the lateral context influenced the production of a single vowel only, while in the case of Child SC there was evidence of at least three vowels being affected. Children RC and IP both had difficulty with the midlow front vowel /ɛ/. Child RC typically realized /ɛ/ as [ai]. However, in the context of [ɫ], he produced it as [a]. Child IP raised /ɛ/ to [e] in the context of velars and alveolars, and lowered it to [a] in the context of /l/, itself pronounced as [w]. These patterns also represent a natural assimilatory effect given the greater articulatory and acoustic compatibility of mid- and lowback vowels with [ɫ] or [w], rather than front vowels, high vowels, and diphthongs.

[ɹ] Conditioning

Bates and Watson (1995) also report examples of /ɹ/-conditioning. Two of their Scottish subjects, Children SC and DN, fronted, raised, or fronted and raised the midlow back vowel /ʌ/ to [ɛ], [e] or [ɪ] preceding /ɹ/ (which was itself unrealized).[9] A third subject, Child DP, realized /ʌ/ as [o] in this context (Table 5-11).

It can be argued that these error patterns represent a coalescence, or synthesis, of the vowel and consonantal properties (expressed as [+vocalic] and [+coronal] in traditional feature terms), rather than simple /ɹ/ deletion on account of the change in vowel quality. In the first two cases, the relatively raised and forward tongue position characteristic of the consonant is anticipated during the vowel gesture. In the final example, the substitution of [o] for /ʌ ɹ/, the rounded vowel might also reflect recognition of the lip-rounding quality that is associated with [ɹ] or, in the case of *purple* and *worm,* assimilation to the place of articulation of the final consonants, respectively [p] and [m]. Once again, this pattern can be explained in terms of immaturity in differentiating articulatorily compatible gestures.

Table 5-11 SC (Scottish, 7 years, 2 months), DN (Scottish, 6 years, 2 months), DP (Scottish, 5 years, 5 months)

SC			*DN*			*DP*		
ʌ→e, ɛ preceding [ɹ]			*ʌ→e, ɛ, ɪ preceding [ɹ]*			*ʌ→o preceding [ɹ]*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
purple	pʌrpʌl	pepʊl^{ə}	purple	pʌrpʌl	pe^{ə}pəɫ	turn	tʌrn	don
turn	tʌrn	ten	turn	tʌrn	te^{ə}n	purple	pʌrpʌl	bobo
worm	wʌrm	wɛm	worm	wʌrm	wɛ^{ə}m	worm	wʌrm	wom
curly	kʌrle	kɛli	curly	kʌrle	kɪle			
turtle	tʌrtʌl	tɛtoɭ						

Nasal Conditioning

A further pattern of CV influence noted by Reynolds (1990) is the lowering of high- and midhigh vowels preceding a nasal consonant. Reynolds suggests that this pattern may be perceptually motivated as children acquiring speech might misconstrue the tendency for nasalized vowels to sound more open. Evidence that nasalized high vowels are characterized by lower second formant frequencies than their nonnasalized counterparts is provided by Wright (1986), cited in Johnson (1997). Johnson (1997) also reports the tendency for certain vowel contrasts to be collapsed in nasal contexts in some dialects of American English.

In the children P and B reported by Reynolds (1990), vowel length associated with /iː/ is preserved in the substituted diphthong, while in his Child E, it is attached to the nasal (Table 5-12). Realization of /ɪ/ as [ɛə] and /ɑʊ/ as [ɛə] in Child P suggests that the pattern has extended to include all vowels preceding nasals irrespective of their high/low or long/short specification.

Vowel Devoicing

Further unpublished data from Child DB (described earlier in "Vowel Conditioning of Consonant Error Patterns") provides an example of a rather different type of context conditioning (Scobbie, Gibbon, Hardcastle, and Fletcher, 2000), which is gradient and variable. In this case, Child DB sometimes devoices vowels when they appear in closed syllables with a particular tendency for the devoicing of /i/. Table 5-13 indicates the number of tokens in which the vowel was totally voiceless (out of six attempts) for a range of words.

A phonetic explanation for this pattern given by Scobbie, Gibbon, Hardcastle, and Fletcher (2000), in keeping with the biological framework, follows from the fact that (for aerodynamic and articulatory reasons) voice onset time

Table 5-12 P (English, 4 years, 8 months), E (English, 4 years, 9 months), BL (English, 6 years, 6 months)

P *ɪ, ɪ, ɛi, au→[ɛ] preceding /n/*			*E* *ɪ→[ɛ]; ɪ→[ɒ]* *ɛi, au→[an] preceding /n/*			*B* *i→[eɪ, ɛɪ] preceding /m, n/* *ɛɪ→[eɪ, ɛɪ] preceding /n/*		
Word	*Target*	*CP*	*Word*	*Target*	*CP*	*Word*	*Target*	*CP*
queen	kwin	gɛə	queen	kwin	kwɛnː	ice-cream	aisʁcrim	aɪˀgeɪ
green	grin	gɛə	green	grin	gwɛnː	queen	kwin	keɪə
ring	rɪŋ	wɛə	drinking	drɪŋiŋ	ʔɒkɪ	green	grin	gɛɪ
train	trɛin	tsɛə	train	trɛin	twanː	aeroplane	ɛərəplɛin	ɛləpeɪ
crown	krəun	kɛə	crown	krəun	kwanː	train	trɛin	tɛɪ

Table 5-13 DB (Scottish, 4 years,1 month)

	/6	*Mean VOT*	*Vowel*	*Target*	/6	*Mean VOT*	*Vowel*		/6	*Mean VOT*	*Vowel*
kate	0	43ms	71ms	pot	0	36ms	46ms	peak	5	38ms	38ms
gate	2	36ms	92ms	"Bot"	0	28ms	48ms	beak	4	6ms	50ms
skate	0	38ms	92ms	spot	0	32ms	64ms	speak	2	37ms	52ms

(VOT) tends to have a greater duration before high vowels than before low ones; that high vowels tend to be of less duration than low vowels; and that vowels in closed syllables tend to be of less duration than vowels in open syllables. In Child DB's case, VOT reflects vowel height to an extreme degree. (Note, however, that VOT is not a cue for the target voicing status of the initial consonant.) Scobbie and colleagues (2000) report that Child DB's mean VOT (in open syllables) before /i/ is 52 ms, appreciably longer than VOT before /o/ or /ai/ (30 ms and 22 ms, respectively). In closed syllables, vowels are so short that the VOT might therefore completely occupy the time available for the vowel (see Table 5-13, which gives the mean duration of VOT and of the voiced portion of the vowel in those cases where the vowel is not devoiced). Because the /i/ vowel is particularly short, and because it conditions the longest VOT, these factors combine to maximize the likelihood of devoicing.

Discussion

Nature of Error Patterns

The most common context-conditioned error pattern reported in studies of young normally developing children is the co-occurrence of alveolar stops and front vowels, velar stops and back vowels, and labial stops and back rounded vowels. The fact that this pattern has been observed in both the early and later stages of babbling and in early word production supports the idea that during early word acquisition children initially utilize and exploit articulatory routines already within their production capacities (MacNeilage, 1998; Piske, 1995). Where it occurs in meaningful speech, it might be understood as an assimilation by the consonant to the place of articulation of the vowel.

This error pattern is also the most common vowel-to-consonant effect reported for PD children, although in this clinical case it is not confined to stops but may extend to different manner classes (that is, nasals, fricatives, approximants). The literature on normal development also reports a relatively higher proportion of constraints on labials compared with other consonants, whereas in the case of PD children, it would appear that alveolar and velar consonants are more likely to be constrained than labial consonants. This difference between the two groups of children might be attributed to the younger age of the normally developing children and to the fact that children tend to master the spatiotemporal coordination of discrete articulators (that is, tongue and lips) earlier than the phasing of gestures involving the same articulator (such as, front and back of tongue) (Nittrouer, Studdert-Kennedy, and McGowan, 1989).

In the majority of cases, it can be argued that these error patterns reflect difficulty in the timing and coordination of adjacent articulatory gestures. There are two main factors supporting this argument. First, the sequences in question involve consonants and vowels, which are characterized by diverging or antagonistic gestures, and which involve anatomically proximal articulations (such as velars characterized by back of tongue constriction followed by front vowels characterized by front of tongue constriction). Context conditioning results in greater articulatory compatibility between segments (such as /k/ → [t] /_i).

Second, without exception, the directionality of the contextual influence observed is from right to left, that is, the target segment undergoes a quality change as a function of following context. Based on evidence from normal adult speech, right to left or anticipatory effects are believed to be timing effects reflective of articulatory preprogramming. This is in contrast to left to right or carry-over effects which are thought to be largely mechano-inertial in nature (Gay, 1977), and therefore less likely to be under independent control.

The higher incidence of context-conditioned vowel errors reported in the case of the PD children, to some extent, reflects the recent increase in attention given to disordered vowel production, and in particular the group studies which have targeted this population (Bates and Watson, 1995; Reynolds, 1990). However, it can also arguably be attributed to the greater maturity and therefore more extensive segmental repertoire of the older PD children. These children have already acquired the later appearing and articulatorily more complex liquids /l/ and /r/ which, according to the literature, are the consonants most likely to condition vowel errors.[10] The consonant-conditioned vowel errors, although representing difficulties at a different stage of development (that is, beyond constraints imposed by a frames and content model), still accord with the biological framework in that they can be explained in terms of articulatory compatibility.

The majority of the context-sensitive vowel error patterns noted in this chapter involve the midvowel series (that is, /ɪ, ɛ, ʌ, ʊ/). These vowels also appear to be the most susceptible to coarticulatory effects in normal speech (Bates, 1995; Stevens and House, 1963). Within the gestural framework, degree of coarticulation is considered to be dependent on both degree of articulatory compatibility and on degree of mechanical constraint imposed on the tongue body during production (Recasens, 1984; 1991). The peripheral vowels, that is, /i, ɑ, a, u, o, ɔ/, characterized by more extreme articulations and longer inherent durations, are arguably subject to greater constraints on tongue body activity. Therefore, they show less overall compatibility with context than the mid vowels. In other words, midvowels plus consonant-midvowel sequences are more problematic because the CV gestures are more similar (that is, there is less articulatory distance between them) than is the case between consonant-peripheral vowel sequences. A similar comparison can presumably also be made between sententially stressed versus unstressed vowels (Bates, 1995). In the latter case, the vowel gestures arguably involve a greater degree of constraint on the tongue body than the consonant gestures (that is, they are characterized by more extreme articulatory configurations). In the case of the consonant plus mid vowel sequences, it could be hypothesized that the consonant gestures are more highly constrained than the midvowel gestures, thus accounting for the vowel assimilation to the consonantal place of articulation.

Phonological versus Biological Perspectives

In an earlier review of clinical CV interaction, Bernhardt and Stemberger (1998, 548) used a constraint-based phonological perspective to account for their data, and concluded that CV interactions, while not common, give rise to provocative issues for acquisition theory. For example, it must account for the fact that CV interactions are possible, but infrequent. This is a typical problem for phonological theories of symbolic representations, configurations, and constraints, which define the possible but not the probable. For those phonological theories, which also incorporate theories of markedness, the problem is that clinical phenomena are by definition marked, and so it is unclear to what extent phonological theory should explain them.

The biological framework is rather different in emphasis. Being phonetic, it attempts to cover both the very earliest structures used in babbling (which are language-specific in terms of the relative distribution of nonneutral frames) and also mature gestural systems. It also needs to provide an account of the transition between the two, drawing mainly on phonetic development in speech-motor abilities, physiology, and perception.

Aspects of linguistic development, such as phonological and morphological categorization, might be partly the result of phonetic developments in the biological framework. Thus, phonological disorders are predicted to result, in some cases, from problems in reanalyzing holistic productions into their gestural components and in relating subtle adult patterns of language-specific coarticulation to the undifferentiated and well-rehearsed infantile patterns. The apparent neutralization of contrast in the clinical cases is possible, but infrequent, because relatively few children extract the wrong lessons from CV interaction from the babbling stage and make the wrong connections between infant CV interaction and adult coarticulation.

Another problematic issue is that vowels typically influence consonantal errors, although the reverse is possible, if infrequent. A phonological theory does not easily represent this asymmetry without extra machinery being created for the purpose. Furthermore, phonological theory does not provide a nonstipulative account of why it is *place* that is involved, in the large part, in CV interactions.[11] The biological framework, on the other hand, can draw on the central concept of the frame on which content is imposed. This can account for the dominance of vowels in the majority of cases, and for the fact that it is place that is accommodated.

Conclusion

The patterns of CV interaction in disordered systems we reviewed demand explanation from theories of acquisition. It is necessary for such theories to account for the difference between the clinical cases and the much younger normally developing child. While further work needs to be done to make a really convincing case for the claim that phonological disorder will not be understood without reference to the biological framework of language, we feel this framework is useful for determining research themes and has great explanatory potential.

Endnotes

1. A phonetic system combines language-specific (and universal) "knowledge" (that is, stored schemata for patterns of behavior) which relate physical phenomena (both in perception and production) to abstract linguistic concepts, such as lexically contrastive features, sociolinguistically relevant variables, prosodic structures, and so on. A phonetic system defines the appropriate articulatory and acoustic targets for phonological features whatever prosodic, lexical, morphological, pragmatic, or other relevant context they appear in, for all the speaker's dialectal variants. Such a system also specifies the appropriate degrees of spatial and temporal coarticulation.
2. Given the language-specific perceptual knowledge of the infant (Jusczyk, 1997), and the apparent continuity between babble and early phonology in production (Vihman, 1996; Vihman and Velleman, in press) "pre"linguistic is an inaccurate term, but will serve our purposes here.
3. A gestural score, like an orchestral one, is a coordinated representation of a number of quasi-independent sequences, one for each articulator (or instrument).
4. We do not wish to imply that each of these physiological regions is equivalent to a single articulator. Note, though, that the tongue may act

as a single unit initially, only gradually developing independent control of the tongue/tip blade (Gibbon, 1998; 1999).

5. Nittrouer and Studdert-Kennedy (1987) compared child and adult perceptual judgements of fricatives. They found that in contrast to the adults, the children relied to a greater extent on information contained in the transitional portion of the syllable between the fricative and vowel than in the steady-state portion of the fricative itself. These results suggest that children's perceptual organization is less segmental than that of adults.
6. The extent to which the segment is a valid term in phonological analysis is not explicitly the topic of this chapter. Yet because our focus is primarily larger domain phenomena and because of our phonetic perspective, we should make it clear that segmental treatment of the phenomena discussed is, in part, to ensure it is relevant to current clinical practice. It should be clear, however, that the segment alone is not sufficient to capture the range of behaviors observed in normal acquisition or in the clinical population. Our data are mostly transcriptional, and therefore reflect the listener's segmentally oriented interpretation of the child's output. In most CV sequences which we discuss, either the C or the V sound is correct, while the other segment is in error. So while a nonsegmental perspective will, perhaps, be essential to a proper understanding of the underlying processes responsible for speech errors, the segment remains a highly popular means of expressing the impression a speech error induces in the child's interlocutors.
7. It is important to note that the conditioning is dependent on the child's surface realization of the vowel and not the underlying target, hence the apparently different treatment of /d/ in *dog* and *doggie* depending on realization of target /ɒ/ as [o] or [ʌ].
8. Labials are conditioned by round vowels, alveolars by front vowels, and velars are conditioned by back vowels (Levelt, 1994, 60). In addition to front unrounded vowels, Dutch has front rounded vowels, which might pattern with alveolars or labials, and the higher back rounded vowels condition both labials and velars. We are not in a position to do more than call for further data in order to enable future cross-linguistic work on C~V interaction; in particular in languages with front rounded or back unrounded vowels or both (such as Turkish).
9. The reader is reminded that Scottish English is a rhotic accent system.
10. In emerging or disordered systems acquiring a rhotic accent, the "r" itself may not be pronounced. The change in vowel quality represents a recognition of the consonant in the target system and therefore an attempt to signal its presence.

11. Bernhardt and Stemberger (1998) and Levelt (1994) exemplify the problems that arise from trying to find a feature system for phonological place which enables the appropriate generalizations to be made regarding which features might spread, the triggers and targets.

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APPENDIX

Summary of Consonant-Vowel Sequences Most Likely to Be Problematic and Likely Facilitatory Contexts for Remediation

A list of stimulus words is presented in Table A5-1. This is intended to form the basis of an assessment procedure designed to identify potential CV interactions, which could be administered in the form of a picture-naming response task. As far as possible, words have been selected that are most likely to be familiar to young children and that are imageable or easily stimulable through verbal prompting.

The phonetic contexts represented in the word list have been selected on the basis of the articulatory and acoustic regularities evident from the review of published reports. An attempt has also been made to target each consonant-vowel or vowel-consonant sequence at least four times, allowing for detection of inconsistency of production (following Pollock and Keiser, 1990). In general, it is important to establish patterns of variability, whether this is progressive or nonprogressive, or whether their system is static (Grunwell, 1981). Where this has proved difficult due to the relatively limited frequency of occurrence of the sequence in English words (such as /k/ + /ɛ/ sequences), it is advisable to supplement the data set either with nonsense words or repetitions of the real words that are available.

Contexts for vowel-to-consonant effects are listed separately from those designed to detect consonant-to-vowel effects. To give a more complete picture of the child's production capabilities and to ensure an accurate diagnosis of context conditioning, each of the three principal consonantal place categories are represented for each effect. For example, while it is only velars and labials that are subject to incorrect realization in front vowel contexts, alveolar consonant-front vowel sequences have also been included. It is useful to include these because they represent the contexts most likely to facilitate correct pronunciation of the target. To assist orientation, target sounds which are vulnerable to a given error process occur in the shaded sections of the word list.

A similar procedure has been adopted in the case of vowels errors. Where a vowel probe has been omitted, this indicates that no appropriate lexical items were found to illustrate that particular sequence. It is also noted that dental and palatal consonants and, in the case of vowel-to-consonant effects, liquids and glides are not represented. This reflects their apparently low incidence of involvement in context-sensitive error patterns.

The word list is designed to accommodate the nonregional or Southern British Standard accent system. However, given the potential of vowel raising, fronting, or both in Scottish English, vowel-/ɹ/ sequences have been included in the section on consonant-to-vowel effects. The question of how far error patterns vary across different accent systems and the design of a word list to encompass regional accent variations are important areas for future study.

Since all reported error patterns are conditioned by following context, examples of the target sound are restricted to syllable-initial position (CV or VC). In cases where suitable syllable-initial, word-initial words are limited, the list has been supplemented with examples of the target consonant occurring in syllable-initial, word-medial position. Target vowels occur in syllable-initial position without exception. Similarly, since there is no evidence in the literature to suggest an effect of lexical stress, no attempt has been made to systematically vary stressed and unstressed syllables. Given that the purpose of the word list is to identify CV interactions rather than vowel harmony or consonant harmony effects, the majority of words are also monosyllabic. However, a range of syllabic structures (that is, CV, CVC, CVCV) is included because children's performance may deteriorate with an increase in linguistic complexity and therefore processing load.

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