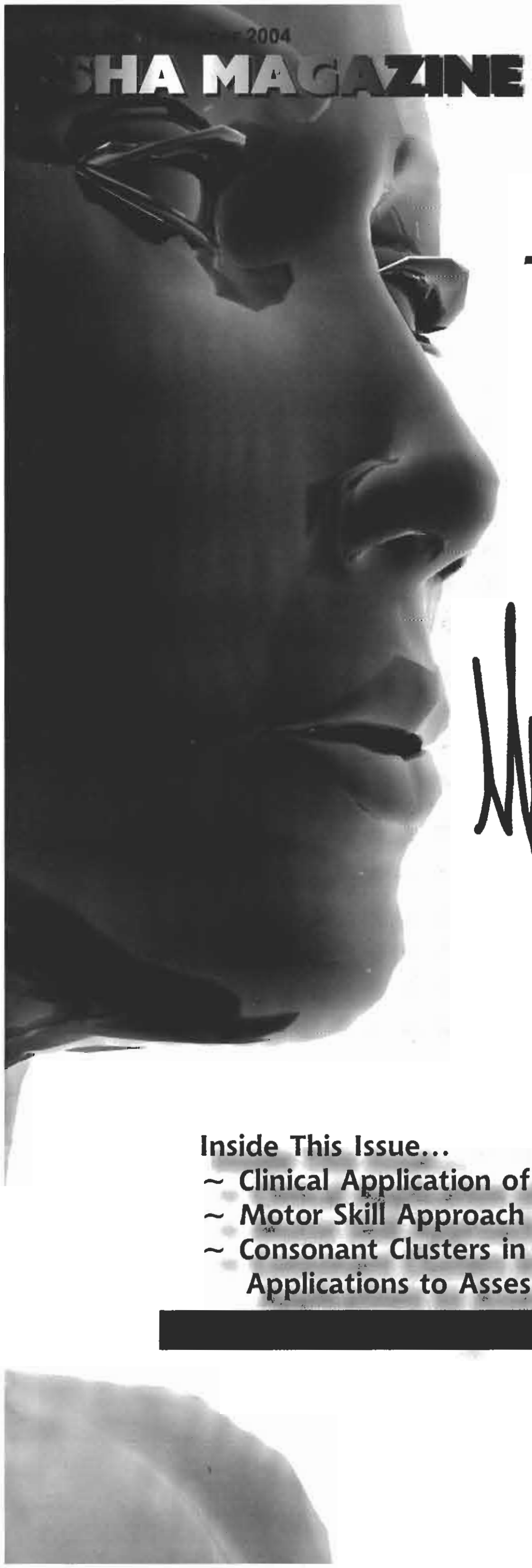
2004

SHA MAGAZINE



Focus On Phonology
Teaching Targets & Tasks

Inside This Issue...

~ Clinical Application of Phonological Complexity
~ Motor Skill Approach to Speech Sound Disorders
~ Consonant Clusters in Phonological Acquisition: Applications to Assessment & Treatment

CSHA
CALIFORNIA SPEECH-LANGUAGE-HEARING ASSOCIATION

Consonant Clusters in Phonological Acquisition: Applications to Assessment and Treatment

Jessica Barlow
School of Speech-Language, and Hearing Sciences
San Diego State University, San Diego

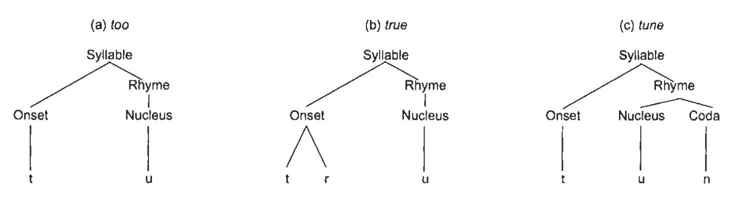
Consonant clusters are notoriously problematic for children, and very often play a large role in the unintelligibility of children with phonological disorders. Very often children's errors on clusters may be difficult to interpret, which leads to difficulty in making informed judgments about developing an appropriate treatment program. The purpose of this review is to provide an in-depth discussion of the nature of children's errors on clusters, the variation that may occur in their production patterns, as well as the treatment recommendations that have resulted from treatment efficacy research for children with phonological disorders.

What is a Cluster?

We begin our review with a definition of consonant clusters. The present review focuses on initial clusters only, though clusters do occur in medial and final contexts as well. Generally speaking, a consonant cluster is a sequence of consonants; however, clusters are best described in terms of their subsyllabic structure.

Syllables are divided into subsyllabic constituents known as the onset and the rhyme, the latter of which further divides into the nucleus and coda. An example of a simple consonant-vowel (CV) syllable is shown in Figure 1a (for the word "too"). The onset and rhyme constituents contain a single segment each. This is generally viewed as the simplest, most common syllable type of the world's languages (Blevins, 1995), and is, not surprisingly, the first syllable shape to emerge in phonological acquisition (Demuth, 1996).

Figure 1. Subsyllabic structure for the words (a) "too" [tu], (b) "true" [tru], and (c) "tune" [tun].



Syllable Complexity

Syllables become more complex when the onset constituent branches, forming a consonant cluster, as shown in Figure 1b (for the word "true"), or when the rhyme branches further into the nucleus and coda (Figure 1c), resulting in a CVC syllable. For the present purposes, we focus on the onset structure only.

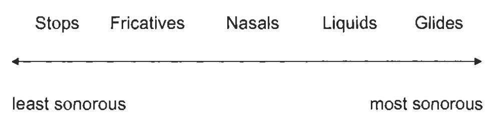
Children often simplify the onset clusters, showing a general preference for simple CV syllables. Most often the simplification occurs in the form of reduction, though patterns of coalescence and epenthesis also occur. With reduction, the child preserves one of the two segments of the target cluster, as in "true" → [tu], or "play" → [pe] (Smit, 1993). Coalescence occurs when the resulting segment is a fusion of the two segments of the target cluster (Chin & Dinnsen, 1992), as in "swan" → [fan] (where the fricative properties of the /s/, and the labial properties of the /w/, are retained). Epenthesis typically involves the insertion of schwa[ə] between the two elements of the cluster, thus breaking the illicit cluster into two separate syllables, as such: "plane" → [pəlen] (Smit, 1993).

Returning to syllable complexity, it is important to note that the relationship between branching versus nonbranching onsets is implicational in nature. That is, if a sound system allows a branching onset, it also necessarily allows a simple onset. Thus, the occurrence of /tr-/ in a sound system implies the occurrence of singletons /t/ and /r/ as well. In fact, the occurrence of a cluster also implies the occurrence of many other singleton types, most notably affricates (Gierut & Champion, 2001). Implicational relationships such as these are important to consider in the selection of treatment targets. Much treatment efficacy research has shown that treatment on clusters enhances the production of singletons, even when those singletons are not directly targeted in treatment (e.g., Barlow, 2003; Elbert & McReynolds, 1975; Gallagher & Shriner, 1975; Gierut & Champion, 2001). For example, in Gierut and Champion's (2001) study, one child (Subject 3) added singletons /g θ ð ʃ z ʧ l/ to his inventory following treatment on the /spl/ cluster only. In fact, all seven children of their study added an average of five singleton sounds to their repertoires following treatment on one cluster. This example also illustrates that clusters can be targeted in treatment prior to mastery of the singletons that make up the target cluster. Thus, it is not necessary to first teach mastery of a singleton sound prior to targeting it in a cluster. More importantly, greater system-wide gains occur when the more complex (branching onset) structure is targeted first.

Cluster Complexity

Some clusters are more complex than other clusters. Across sound systems, the organization of consonants within a syllable is restricted by a universal principle of sonority sequencing (Clements, 1990). Generally speaking, this principle requires that syllables gradually increase in sonority towards the nucleus of the syllable and then fall or remain level in sonority after the nucleus (refer to the universal sonority scale shown in Figure 2). According to this principle, the individual segments within an onset constituent must differ such that the first segment is less sonorous than the second segment. Thus, /tr-/ is an acceptable onset (as in "tree" [tri]), while /rt-/ is not (*[rti]). (It should be noted that certain clusters in English violate sonority sequencing; these clusters will be discussed in the next section.)

Figure 2. Sonority hierarchy (adapted from Selkirk, 1984)



Sonority sequencing also determines the relative complexity of individual clusters. Those clusters whose individual segments are relatively close together on the sonority hierarchy are more complex (and notably less common) cross-linguistically (Selkirk, 1982), and tend to emerge later in acquisition (see, e.g., Gierut, 1999), as compared to those clusters whose segments are farther apart on the hierarchy. For example, referring back to Figure 2, a cluster such as /tw-/ is made up of a stop (which is on the least sonorous end of the scale) followed by a glide (on the most sonorous end of the scale). This cluster is considered less complex as compared to, for example, /fr-/, which includes two segments, a fricative followed by a liquid, that are relatively close together on the sonority scale.

***Consonant Clusters** continued on page 11*

Consonant Clusters continued from page 10

Put another way, a sound system will not allow fricative + liquid clusters unless stop + liquid or stop + glide sequences are also allowed.

This has important implications for treatment of children with phonological disorders. Speech-language pathologists can capitalize on this relationship and effect greater system-wide change on clusters by targeting clusters with a smaller sonority distance (e.g., /fr-/) in order to enhance production of clusters with a greater sonority distance (e.g., /tw-/). This prediction has been supported experimentally in a variety treatment efficacy studies on children with phonological disorders (Anderson, 2002; Barlow, 2003; Elbert, Dinnsen, & Powell, 1984; Gierut, 1999; Gierut & Champion, 2001). For example, in Gierut's (1999) study, Subject 5 learned the following onset clusters after treatment on only /fr-/: /tw-, kw-, pl-, kl-, tr-, bl-, _l-, dr-, sw-, fl-/.

Because sonority sequencing is a universal property of sound systems, it also governs sound production in children's sound systems as well. In fact, the most commonly occurring reduction pattern observed in phonological acquisition can be described in terms of sonority (see Pater & Barlow, 2003). Specifically, children usually reduce clusters by preserving the least sonorous segment of the target cluster, as in "tree" →[ti] and "twin" →[tIn] (where /t/ is less sonorous than both /r/ and /w/). Of course, such systematicity in error patterns is not always so obvious. We consider next some asymmetries in children's productions of consonant clusters.

Asymmetries in Cluster Production

It is very often the case that more than one production pattern may occur in a given child's speech. In the preceding sections, three types of cluster production patterns were mentioned, each involving cluster simplification: reduction, coalescence, and epenthesis. Of course, a fourth production pattern is preservation, where consonant clusters surface in the child's productions. In such cases, the child may produce clusters target-appropriately, or may exhibit substitution patterns that affect the individual segments that make up the cluster, or both (Barlow, 1997).

While variation in a given child's production of consonant clusters may appear random or asymmetrical on the surface, very often one can find systematicity with respect to the child's different patterns of production. In such cases, the variation may be attributed to interacting error patterns within the child's grammar, or to structural differences between the clusters in question. We consider each type of variation in turn.

Interacting Errors

Interacting errors may cause asymmetries in a child's productions of consonant clusters in a variety of ways. In some cases, segmental error patterns of stopping or fronting will add to the decreased accuracy in a child's production of target clusters (e.g., "flag" →[pæg], "grow" →[doʊ]) (Barlow, 1997). In other cases, interacting errors may be responsible for different reduction patterns, whereby the child retains the least sonorous segment for some target clusters, but retains the most sonorous segment in other cases (e.g., Pater & Barlow, 2003). In still other cases, the influence of a substitution pattern on a child's production of clusters may obscure the true difficulty that the child has in acquiring the sound system.

Consider John (aged 3;9), discussed in Barlow (2001a), who shows variability in his productions of clusters. As illustrated in (1), John preserves some clusters (albeit with gliding on the liquids), while others are reduced to a singleton:

(1) John's productions of clusters (Barlow, 2001a, 2001b)

a. Clusters are preserved

[bwɪ]	"bridge"	[kwaʊn]	"clown"
[twen]	"train"	[dwɑr]	"drive"
[kweə]	"crayon"		

b. Clusters reduce to a singleton

[wæʔ]	"flag"	[lɛ]	"sled"
[nets]	"snake"	[dod]	"stove"

While this pattern may appear simply as inconsistency in the child's grammar, a careful examination of the data reveals that reduction only occurs when the target cluster includes a fricative (1b), while the cluster is preserved otherwise (1a). Thus, John does produce some clusters, though with segmental errors on the liquids. The only clusters that are reduced are those that include fricatives. Therefore, John would not require treatment on clusters, necessarily, given that branching onsets are allowed by his sound system. Instead, he requires training on fricatives, so that they too can be produced, as singletons or in clusters. Of course, training on fricatives could occur in a fricative + liquid cluster context, thereby maximizing generalization of fricatives to various contexts. However, training sessions should focus on the articulatory characteristics of the fricatives, rather than the branching onset structure associated with consonant clusters.

Thus, the cluster errors that John exhibited are systematic, despite their superficial inconsistency. As demonstrated, such in-depth examination of a child's errors on clusters is critical for the selection of treatment targets. Now let us consider yet another type of asymmetry that occurs in cluster acquisition, this time related to structural differences.

Structural Differences

Certain consonant clusters are notorious for their asymmetrical patterning in languages of the world, and are furthermore reflected in phonological acquisition. The most obvious of such clusters are the /s/ + stop clusters (such as /sp-/, /st-/, /skw-/). Generally speaking, these clusters are unusual in that they violate the principles of sonority sequencing discussed above. While onset clusters should rise in sonority, /s/ + stop clusters fall in sonority (that is, /s/ is more sonorous than /p/ in an /sp-/ cluster).

The unusual patterning of these clusters is likewise reflected in children's speech. Children learn /s/ clusters independently of other "true" clusters (those that satisfy sonority sequencing): While some children learn /s/ clusters first, other children learn them last (see Barlow, 2001c for discussion). As a class, the /s/ clusters appear to be organized differently in children's sound systems.

Consider the data in (2) from KR, discussed in (Barlow, 2001c), who, at the age of 3;11 has mastered all /s/ + consonant clusters to the exclusion of any other clusters.

(2) KR's productions of clusters (Barlow, 2001c: 305)

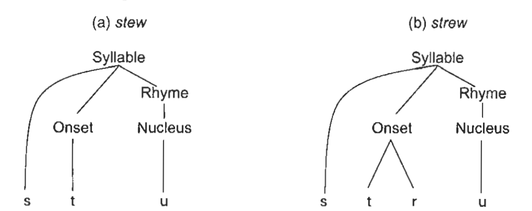
a. /s/ clusters

[swɪm]	"swim"	[slipin]	"sleeping"
[sno]	"snow"	[stovi]	"stove (dimin.)"
[skar]	"sky"	[stawi]	"starry"
[speɪ]	"spray"	[stɔ]	"straw"

b. True clusters

[dɪn]	"twin"	[kin]	"queen"
[per]	"pray'	[fowin]	"throwing"
[bo]	"blow"	[gaɪm]	"climb"
[dʕv]	"glove"	[faɪ]	"fly"

Figure 3. Subsyllabic structure of the words (a) "stew" [stu] and (b) "strew" [stru]



As is evident in the data in (2), KR produces all /s/ clusters intact, though three-element clusters are reduced to two-element /s/ + stop clusters (e.g., "spray" →[speɪ]). The true clusters (those that conform to sonority sequencing) are all reduced to the less sonorous segment (e.g., "queen" →[kin]). These production patterns seem strange, given the absence of certain true clusters, such as /tw-/, which are presumably easier to produce given the greater sonority distance between the two segments (not to mention the fact that stops are easier to produce than

Consonant Clusters continued on page 12

Consonant Clusters continued from page 11

fricatives). Why does /sw-/ occur, but /tw-/ does not?

This asymmetry is difficult to explain, unless we consider that /s/ clusters are structurally different from other true clusters. Given the unusual patterning of /s/ clusters cross-linguistically, it is generally assumed that the /s/ is outside the onset constituent, as shown in Figure 3a, and is viewed as an "adjunct" to the syllable (Clements, 1990). This structural characterization of /s/ clusters also nicely accounts for the three-element /s/ clusters (depicted in Figure 3b), which all consist of an adjunct /s/ followed by an allowable branching onset cluster: /tr-/ is a possible branching onset, /str-/ is a possible three-element cluster; /kw-/ is a possible branching onset, /skw-/ is a possible three-element cluster. Thus, the three-element cluster in Figure 3b represents the combined structures from Figure 1b and Figure 3a.

Returning to KR, the asymmetry observed in his productions is now easier to explain. Though he has not yet learned branching onset structure (Figure 1b), he has mastered the adjunct structure depicted in Figure 3a. Furthermore, the absence of three-element clusters is simply due to the fact that he has not mastered the branching onset structure of Figure 1b.

It should be noted that treatment research also supports the differing structural representations for true versus adjunct clusters. That is, training on /s/ clusters generally does not cause improvements on true branching onsets, nor does training on branching onsets cause change on /s/ clusters (see, e.g., Gierut, 1999). Therefore, it may be necessary to target these clusters independently of one another in treatment, as generalization between the two types is not expected. Alternatively, treatment on three-element clusters does show change on both cluster types, given that the three-element clusters include both adjunct and branching onset structures (Figure 3b). For example, consider again Subject 3 from Gierut and Champion's (2001) study, discussed in the preceding section. Following training on /spl-/, this child learned two-element adjunct and branching onset clusters /pl-, dr-, fl-, sm-, sn-, sp-, st-/, in addition to those singletons mentioned earlier. Six of the 7 other children in Gierut and Champion's study also added from one to nine untreated clusters to their sound systems. The extent to which change occurred seemed to depend on the children's pretreatment inventories. Specifically, the greatest change occurred following treatment on a three-element cluster if the second consonant of the target cluster was present in the child's inventory, according to Gierut and Champion. In the case of Subject 3 in their study, his pretreatment inventory included [p], and treatment on /spl-/ led to widespread change across clusters and cluster types.

Returning to our case study of KR, treatment should focus on the branching onset structure. Of course, no treatment is required on the /s/ clusters, since he has already mastered them. There is the added prediction that, following treatment on branching onsets, KR would be expected to also master the three-element clusters, given that adjunct clusters are already allowed in his system. If, however, treatment were to target a three-element cluster, the second segment of the cluster should already be present in his sound system. As [p, t, k] are already present in his inventory, any three-element cluster would be appropriate, as long as the branching onset structure of the target cluster were the focus of treatment.

Conclusions and Future Directions

To summarize, consonant clusters pose a challenge for developing systems because they are structurally complex to different degrees. The way in which children deal with these complex clusters varies, though this variation is usually systematic in nature. Additionally, other error patterns occurring in a child's sound system may influence the way in which the clusters are produced, sometimes leading to variation in cluster production patterns. Other times, variation in production may be attributed to the nature of the structural differences between true clusters and adjunct /s/ clusters.

In terms of treatment, children with phonological disorders who simplify clusters will require intervention that focuses on introducing the new syllable structure such as that in Figure 1b and/or Figure 3a. Targets should be chosen that take into consideration those points addressed in the previous sections. First, it is not necessary for the child to master a sound as a singleton prior to targeting it in a cluster. Therefore, a cluster such as /fr-/ may be targeted, even if the child lacks /f/ or /r/ in his singleton repertoire. In fact, treatment on clusters is expected to cause improvements on singletons throughout the child's sound system. Second, cluster targets should be chosen with maximum generalization to other cluster types in mind. Thus, true clusters with a small sonority distance are ideal targets. For those children who show errors on both true clusters and adjunct /s/ clusters, the best treatment targets may be the three-element clusters.

The majority of research on clusters has focused on syllable-initial clusters (true and adjunct), hence the focus of this review. Less is generally known about acquisition of heterosyllabic clusters (e.g., /-nd-/ in "window") or coda clusters (e.g., /-lk/ in "milk") (though see Kirk & Demuth, 2003; Ohala, 1998), let alone treatment programs for such clusters that are most effective in causing system-wide change. It is hoped that future research will consider these structures as well, so that the findings may be incorporated into treatment practice.

Important to any treatment program is the goal of maximizing change within the least amount of time (Gierut, 1998, 2001). Thus, it is important to monitor the child's entire sound system even when treatment may be focusing on clusters only. It has been illustrated throughout this review that treatment on certain structures may result in change on other structures as well. In fact, in some cases, the greatest changes may occur on structures that were not directly targeted in treatment (see Barlow, 2003; Gierut, 2001). Keeping these facts in mind while planning and conducting treatment will help speech-language pathologists ensure that they are providing the most efficacious treatment programs to their clients. ◆

References

Anderson, R. T. (2002). Onset clusters and the sonority sequencing principle in Spanish: A treatment efficacy study. In F. Windsor & M. L. Kelly & N. Hewitt (Eds.), Investigations in clinical phonetics and linguistics (pp. 213-224). Mahwah, NJ: Erlbaum.

Barlow, J. A. (1997). A constraint-based account of syllable onsets: Evidence from developing systems. Unpublished doctoral dissertation, Indiana University, Bloomington, IN.

Barlow, J. A. (2001a). Case study: Optimality theory and the assessment and treatment of phonological disorders. Language, Speech, and Hearing Services in Schools, 32, 242-256.

Barlow, J. A. (2001b). Prologue: Recent advances in phonological theory and treatment. Language, Speech, and Hearing Services in Schools, 32, 225-228.

Barlow, J. A. (2001c). The structure of /s/-sequences: Evidence from a disordered system. Journal of Child Language, 28, 291-324.

Barlow, J. A. (2003). Phonological change and the representation of consonant clusters in Spanish: A case study. San Diego State University.

Blevins, J. (1995). The syllable in phonological theory. In J. A. Goldsmith (Ed.), The handbook of phonological theory (pp. 206-244). Oxford: Blackwell.

Chin, S. B., & Dinnsen, D. A. (1992). Consonant clusters in disordered speech: Constraints and correspondence patterns. Journal of Child Language, 19, 259-285.

Clements, G. N. (1990). The role of the sonority cycle in core syllabification. In J. Kingston & M. E. Beckman (Eds.), Papers in laboratory phonology I: Between the grammar and physics of speech (pp. 283-333). New York: Cambridge University Press.

Demuth, K. (1996). Alignment, stress and parsing in early phonological words. In B. Bernhardt & J. Gilbert & D. Ingram (Eds.), Proceedings of the UBC International Conference on Phonological Acquisition (pp. 113-125). Somerville, MA: Cascadilla Press.

Elbert, M., & McReynolds, L. V. (1975). Transfer of /r/ across contexts. Journal of Speech and Hearing Disorders, 40, 380-387.

Elbert, M. F., Dinnsen, D. A., & Powell, T. W. (1984). On the prediction of phonologic generalization learning patterns. Journal of Speech and Hearing Disorders, 49, 309-317.

Gallagher, R., & Shriner, T. (1975). Contextual variables related to inconsistent /s/ and /z/ production in the spontaneous speech of children.

Consonant Clusters continued on page 13

Consonant Clusters continued from page 12

Journal of Speech and Hearing Research, 18, 623-633.

Gierut, J. A. (1998). Treatment efficacy: Functional phonological disorders in children. Journal of Speech, Language, and Hearing Research, 41, S85-S100.

Gierut, J. A. (1999). Syllable onsets: Clusters and adjuncts in acquisition. Journal of Speech, Language, and Hearing Research, 42, 708-726.

Gierut, J. A. (2001). Complexity in phonological treatment: Clinical factors. Language, Speech, and Hearing Services in Schools, 32, 229-241.

Gierut, J. A., & Champion, A. H. (2001). Syllable onsets II: Three-element clusters in phonological treatment. Journal of Speech, Language, and Hearing Research, 44, 886-904.

Kirk, C., & Demuth, K. (2003). Coda/onset asymmetries in the acquisition of clusters. Boston University Conference on Language Development, 27, 437-448.

Ohala, D. K. (1998). Medial cluster reduction in early child speech. In E. V. Clark (Ed.), Proceedings from the Annual Child Language Research Forum (pp. 111-120). Stanford: Center Study for the Language and Information.

Pater, J., & Barlow, J. A. (2003). Constraint conflict in cluster reduction. Journal of Child Language, 30, 487-526.

Selkirk, E. (1984). On the major class features and syllable theory. In M. Aronoff & R. T. Oehrle (Eds.), Language sound structure: Studies in phonology presented to Morris Halle by his teacher and students (pp. 107-136). Cambridge, MA: MIT Press.

Selkirk, E. O. (1982). The syllable. In H. van der Hulst & N. Smith (Eds.), The structure of phonological representations (Vol. 2, pp. 337-383). Dordrecht, Netherlands: Foris.

Smit, A. B. (1993). Phonologic error distributions in the Iowa-Nebraska Articulation Norms Project: Word-initial consonant clusters. Journal of Speech and Hearing Research, 36, 931-947.

Acknowledgments: Aspects of this research were supported by grants from the National Institutes of Health (DC01694, DC05754). *- Address for correspondence: Jessica Barlow, School of Speech, Language, and Hearing Sciences, San Diego State University, San Diego, CA 92182-1518 - Email: jbarlow@mail.sdsu.edu*