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Learning and the Representation of Complex Onsets

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1.0 Introduction

Children's acquisition of onset consonant clusters has received considerable attention in the developmental literature. It has long been observed that children exhibit errors in cluster production, reducing complex sequences of segments to simple onsets. This pattern of cluster simplification is mirrored by children who are normally developing and by those presenting with phonological delays. The archival interest has been to document the order of emergence, common substitution patterns, and acoustic phonetic characteristics of clusters in acquisition. Recently, however, the focus has shifted to the experimental manipulation of learning and the corresponding representation of clusters by children. The purpose of this paper is to continue the examination of learning as a reflection of the representation of clusters by documenting the longitudinal course of phonological change in a child who was taught a 3-element onset cluster.

1.1 Learning patterns in cluster acquisition

Experimental manipulations of children's learning have relied primarily on the population of children exhibiting functional phonological delays. These children are performing within normal limits in all linguistic and nonlinguistic domains, with exception of the sound system. Because the children are highly unintelligible, they warrant direct clinical treatment to induce sound change, with the treatment structured as a single-subject experiment (McReynolds & Kearns, 1983). Different children receive different manipulations of the independent variable, with the dependent measure being change in production accuracy. The potential result is differential learning associated with the different experimental conditions.

In single-subject experiments of cluster acquisition, issues of markedness have been of central concern (Elbert, Dinnsen, & Powell, 1984; Powell & Elbert, 1984). One key question is whether the markedness of clusters differentially impacts children's learning in treatment. In this regard, recent experiments have appealed to markedness relationships that derive from the Sonority Sequencing Principle (SSP). The SSP states that onsets maximally rise in sonority to the nucleus, and codas fall (or remain level) in sonority to the coda (Clements, 1990). Vowels are considered the most sonorous segments and, at the opposite end of the continuum, voiceless stops are least sonorous (Selkirk, 1982). By assigning numerical values to the sound classes along this sonority hierarchy, it is possible to compute the sonority difference between sequences of segments that are allowed in onset position. These sonority differences translate to implicational relationships (Davis, 1992): If a language allows clusters of small sonority difference in onset position, it will also allow those with greater differences, but not vice versa. In other words, the smaller the sonority difference, the more marked the cluster. A well-defined exception to this involves the adjunct sequences /sp, st, sk/, whereby a more sonorous fricative precedes a less sonorous stop when in fact it should be just the reverse. Consequently, the markedness status of adjuncts is unclear.

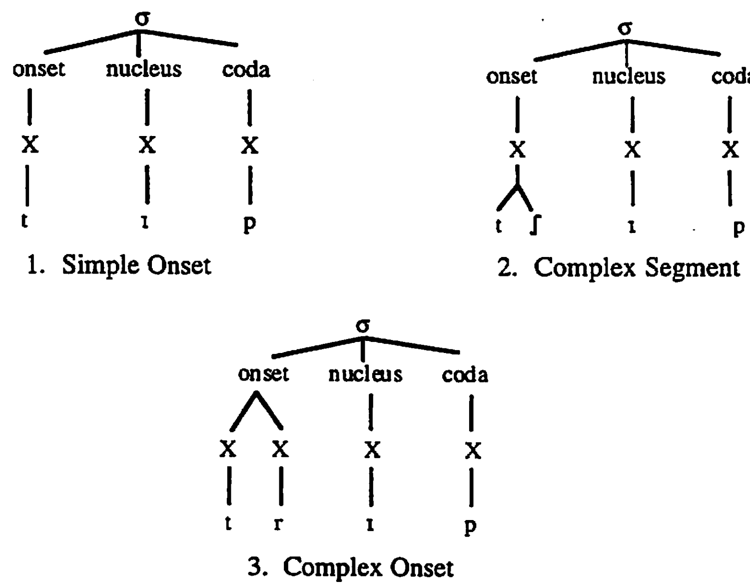
Given the robustness of the SSP for fully-developed linguistic systems, a relevant question for acquisition was whether manipulation of children's learning would be in compliance with the SSP, and whether learning may be revealing of the markedness of adjuncts. In general, experimental findings supported children's conformity to the SSP, but differential patterns of learning emerged (Gierut, 1999). Specifically, treatment of true clusters resulted in gradient phonological change, such that unmarked clusters were acquired with greater accuracy than marked clusters. Moreover, the presence of marked clusters implied all other unmarked sonority values, as predicted by the SSP. In comparison, treatment of adjunct sequences resulted in gaps in children's learning, with marked clusters occurring in the absence of unmarked clusters. Gaps in learning by sonority difference are not in accord with the SSP. These differential patterns of learning were interpreted as reflecting differences in the markedness of clusters, with adjunct sequences being unmarked.

1.2 Representational change in cluster acquisition

Complementary studies have explored how representational structure may change as children progress from the use of simple segments to complex onsets. Two independent, but parallel investigations offered a proposal based on potential relationships between affricates and clusters. One study appealed to longitudinal evidence regarding the acquisition of American English by children who were normally developing and others who were phonologically delayed (Barlow, 1997; Barlow & Dinnsen, 1998); a second cross-sectional study documented the acquisition of German and of Spanish by children who were normally developing (Lleó & Prinz, 1997). Both studies converged to identify a three-step course of representational change, depicted in Figure 1. The acquisition path begins with simple segments with nonbranching onsets occupying a single timing slot, as in Step 1. Children next advance to Step 2 by using complex segments also with single timing slot, as in production of affricates. Finally, in Step 3, complex onsets with more than one timing slot are allowed, as in use of true clusters.

In the present study, the proposed representational course was integrated with experimental learning data to address the following question: If adjuncts are unmarked, how might they be represented relative to other true clusters in acquisition?

Figure 1. Representational expansion of onsets in acquisition.



2.0 Subject and methods

The child who participated was a female (C.A. 4;2) who exhibited a functional phonological delay. She performed within normal limits on standardized assessments of nonverbal intelligence, receptive vocabulary, receptive and expressive language, oral-motor skills, and hearing. In comparison, her consonantal inventory was severely impoverished, with performance below the 1st percentile on the *Goldman-Fristoe Test of Articulation*. An in-depth sample of the phonemic repertoire was elicited through picture-naming and was audiorecorded. The naming task evaluated all target sounds and sound sequences in all relevant contexts in a variety of lexical items. Analyses of these data indicated that the only sounds used contrastively by this child were /m n p b t d w j h/. Targets /r ð/ were restricted in distribution, occurring only in postvocalic positions. Additionally, the child never produced or used ambient or non-ambient clusters in onset position.

Treatment targeted production of the 3-element sequence /skw/. In reference to the singleton inventory, while the child had productive knowledge of C3 of the sequence (i.e., /w/), she did not produce C1 or C2 (i.e., /s/ or /k/, respectively). Prior to treatment, the child consistently substituted [t] for the targeted sequence.

Treatment itself consisted of two phases: imitation and spontaneous production of 16 nonwords. Nonwords were phonotactically permissible sequences, with /skw/ presented in the onset position. Nonword stimuli were balanced in phonetic composition, canonical structure, and syntactic category. Nonwords were introduced in stories, and production practice followed to preestablished time/performance-based criteria (cf. Gierut, 1992). In the first phase of treatment, the child was to repeat a verbal model of the nonword items; whereas in the second phase, the child independently produced these same forms. In both phases, feedback regarding the accuracy of /skw/ was provided, with corrective modeling for errored outputs. Given our concern with learning as revealing of the representation of clusters, an important aspect of the treatment program was the way in which feedback and modeling were delivered. Consider that this child could have produced any of the individual segments in error, in addition to any aspects of the /skw/ sequence. Consequently, the models that were provided during treatment took 1 of 3 forms, presented equally and randomly by blocks of trials: (1) complete feedback whereby /skw/ was presented as a unified sequence (e.g., the nonword [skwɪni]), (2) partial feedback emphasizing the adjunct (e.g., [*sk*] pause [wɪni]), and (3) partial feedback emphasizing the true cluster (e.g., [s] pause [*kw*ɪni]). Use of varied feedbacks thus provided equal input and practice on the 3-element unit, adjunct, and true cluster portions of the treated target.

The child's performance during treatment of nonwords was most variable during the imitation phase. During initial sessions, only singletons were produced, as might be expected. Shortly thereafter, the child began sequencing two consecutive consonants, although these were errored relative to the treated cluster /skw/. Interestingly, affricates were often members of these 2-element outputs, as in use of [sč] or [čw] in onset position. The child eventually came to produce three consecutive consonants, but these were either in the wrong sequence (e.g., [ksw]), or consisted of the wrong elements (e.g., [kkw]) relative to the treated cluster. During the spontaneous phase of treatment, the 3-element target was produced correctly in terms of segmental structure and sequencing, but brief pauses were often inserted between each consonant.

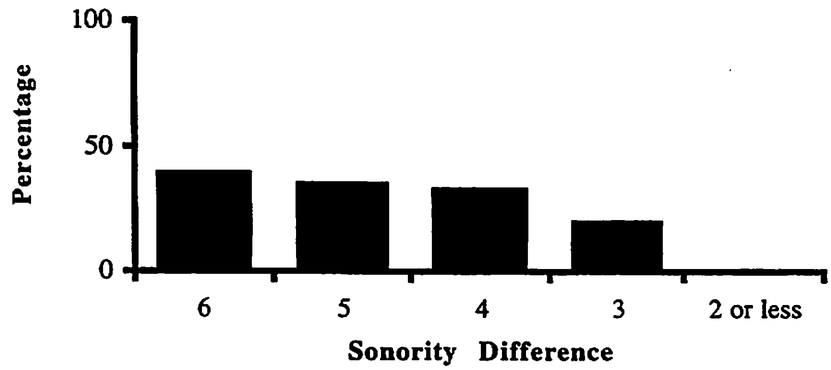
Following the completion of treatment, an in-depth sampling of the child's phonological system was again obtained. Posttreatment data were used in evaluation of learning, with the relevant comparison being the child's pretreatment performance on the same measure. The child's use of ambient clusters (true and adjuncts), elaboration of the singleton inventory, and overgeneralizations are each considered relative to the question of the representation of onset clusters in acquisition.

3.0 Results and discussion

Figure 2 displays the mean percentage accuracy of clusters plotted by sonority difference. Posttreatment, this child used ambient clusters of the sonority values 6 (i.e., /tw/), 5 (i.e., /pr, tr/), 4 (i.e., /br, dr, bl/), and 3 (i.e., /fr/). Unmarked sonority values were acquired with greater accuracy than more marked values, resulting in a gradient pattern of learning. This gradient pattern follows from prior experimental manipulations of the SSP, and is wholly consistent with treatment of true clusters. Of further relevance is the fact that sC sequences (of sonority difference 2) were never produced or used by the child.

The child's primary focus must have been on /kw/ portion of the /skw/ sequence in treatment, such that the 3-element input was parsed as a true cluster and not as an adjunct.

Figure 2. Posttreatment accuracy of target clusters by sonority difference.



Six new untreated phonemes were added to the child's singleton repertoire posttreatment: /f θ č ǰ l r/. Of these, affricates emerged first and with the greatest accuracy in production. The spontaneous emergence of affricates following from the treatment of clusters is precisely what is predicted from the proposed representational course of cluster acquisition. That is, branching segments (in the form of affricates) should be prerequisite to branching onsets (in the form of clusters).

This apparent change in representational structure associating affricates and clusters was confirmed by the child's overextension of affricates to other phonological categories. As below in (1) and (2), affricates were accurately produced for target affricates, but also overgeneralized to target clusters, both true and adjunct sequences. Importantly, the reverse was never obtained, whereby clusters overgeneralized to affricates. This is consistent with the presumed unidirectional relationship between affricates and clusters in elaboration of representational structure.

(1) Affricates = Affricates

[ǰ ɛ l ɪ]	'jelly'	[č ɪ p]	'chip'
[ǰ ʌ m p]	'jump'	[č i d]	'cheese'
[eɪ n ǰ o l]	'angel'	[p ɪ n č i n]	'pinching'
[b æ ǰ]	'badge'	[w ɔ č]	'watch'
[k eɪ ǰ]	'cage'	[r ɛ č]	'catch'

(2) Affricates = Clusters (true and adjunct)

[č i]	'tree'	[č eɪ ɾ]	'skate'
[ǰ oʊ]	'grow'	[č ɔ·r p]	'scarf'
[č oʊ n]	'throne'	[č u ə l]	'school'
[č ɔ]	'crawl'	[č ɑ p]	'stop'
[č ɛ l v]	'twelve'	[č oʊ b]	'stove'
[ǰ ʌ v]	'glove'	[č ɔ r]	'star'
[ǰ ʌ m]	'drum'	[č æ m p]	'stamp'

Quantitative evaluations of overgeneralization provide further evidence of the relationship between affricates and clusters. Figure 3 displays the percentage accuracy of true clusters relative to the overgeneralization of affricates. As expected, when the accuracy of true clusters increased, the overgeneralization of affricates declined. This implies that true clusters were initially represented by this child as branching segments (i.e., affricates). Then, the representation was elaborated so that true clusters became structurally distinct from affricates in the form of complex branching onsets.

A different pattern emerged with regard to adjuncts because these were never acquired, and overgeneralization of affricates persisted over time, as in Figure 4. This hints that the child never altered the structure of adjuncts from branching segments to branching onsets. Apparently, the representational changes that took place for true clusters versus adjuncts differed, with adjuncts lagging behind in structural complexity. Yet, if adjuncts are unmarked as experimental learning data has demonstrated, then representational changes in adjuncts should have taken place *before* corresponding changes in true clusters, but they did not.

This presents an unusual paradox which motivates alternative proposals about the representation of complex onsets and markedness. On the one hand, the present data are consistent with the proposal that the representation of clusters arises from affricates in development. The findings also reaffirm that the representation of true clusters and adjuncts must be fundamentally different. True clusters are represented as branching onsets, whereas adjunct sequences may remain as branching segments. Drawing upon the differential learning of true versus adjunct sequences in prior experiments, a further possibility is that these different representational structures may, in fact, be governed by different markedness relationships. Branching onsets will be governed by the SSP, and associated with gradient learning patterns. Branching segments will be governed by a unique implicational relationship between adjuncts and affricates, with corresponding gaps in learning. The specific markedness relationship can be stated as the occurrence of adjuncts implies affricates, but not vice versa. To experimentally evaluate this proposal will require treatment of affricates relative to adjuncts, and affricates relative to true clusters for children who present with no true clusters, no adjuncts, and no affricates in the pretreatment repertoire. The results of such studies may reveal that proposed differences in representational structure, along with corresponding differences in markedness relationships may be key factors in accounting for children's differential learning of true clusters versus adjunct sequences.

Figure 3. Percentage accuracy of true clusters relative to overgeneralization of affricates.

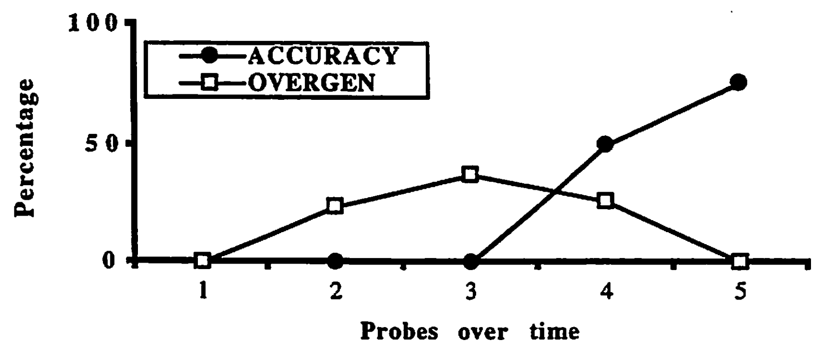
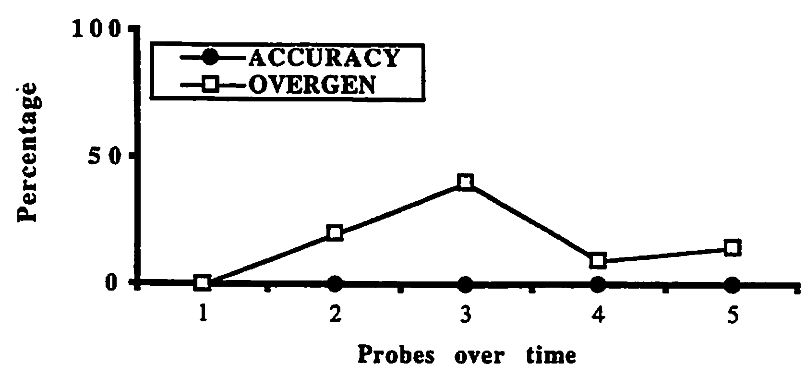


Figure 4. Percentage accuracy of adjuncts relative to overgeneralization of affricates.



Endnotes

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