

Cyclicity in the acquisition of phonemic distinctions[☆]

Judith A. Gierut

Department of Speech and Hearing Sciences, Indiana University, Bloomington, IN 47405, USA

Received July 1993

Abstract

Symmetric, asymmetric, and recurring patterns in the acquisition of phonemic distinctions by children with phonological delay are examined. In an attempt to reconcile observed regularities and dichotomies in phonemic structure, a cyclic principle of acquisition is advanced. The principle involves specifically Laryngeal–Supralaryngeal Cyclicity whereby distinctions are added to an inventory in alternation of these two domains. Laryngeal–Supralaryngeal Cyclicity is demonstrated from both cross-sectional and longitudinal perspectives, and the structure of emerging phonemic systems is shown to be derivative of the principle. The Cyclicity principle has further consequences for theories of acquisition and of language generally.

1. Introduction

A striking property of fully developed phonological systems is their symmetry. For the most part, phonologies are symmetrical in inventory composition, distribution, and contrastiveness of segments (Maddieson, 1984). Such symmetries have been observed within and across languages, and these patternings have been brought to bear as evidence for claims about the underlying nature of grammars (Anderson, 1981) and the universal properties of language (Greenberg, 1978).

Coexistent with symmetries of phonological systems are also asymmetries. Despite an overall pattern and balance in sound systems, there are gaps or ‘holes in the pattern’ (Anderson, 1981: 498). These asymmetric relationships among sounds are precisely what capture our attention and warrant explanation, for how is it possi-

[☆] This research was supported in part by grants from the National Institutes of Health (DC 00433, DC 01694, DC 00076) to Indiana University. Steve Chin and Dan Dinnsen provided helpful comments throughout this project. Elizabeth Connell Anttonen, Mi-Hui Cho, Mary Hughes, Michele Morrisette, and Holly Storkel provided assistance with data analysis and management. Portions of this paper were presented at the 1992 Boston University Conference on Language Development.

ble that a linguistic system is simultaneously symmetric and asymmetric? Moreover, why should it be that these seemingly contradictory patterns come about? It is this examination of asymmetries that typically reflects back on the symmetries, providing greater insight into the patterned relationships among sounds and aiding in the refinement of linguistic theory.

To illustrate, markedness relations are one kind of pattern that has been observed across languages. One particular markedness relationship associated with the voice distinction states that if a language has voiced obstruents, it will also have voiceless obstruents. Gamkrelidze (1975) observed gaps in this voice relationship that appeared to vary with place of articulation. In particular, he noted that if a language maintained three places of articulation, labial, coronal, and dorsal, and had a voice distinction within the stop series, and further had a gap in the basic stop inventory, then either /g/ or /p/ would be absent from the system. These observed gaps in the stop series had the effect of further qualifying the markedness of voicing by place of articulation. That is, within the voiced stop series, labial place emerged as unmarked, but within the voiceless series, dorsal place is unmarked. In this way then, the asymmetric patterning of voicing in stops by place of articulation served to refine the general voiced–voiceless relationship.

In a similar vein, the prevalence and role of coronal segments in language have received considerable attention. It has long been noted that segments produced at the coronal (as opposed to labial or dorsal) place of articulation are more frequently occurring in languages of the world (Maddieson, 1984). Furthermore, coronal segments undergo a variety of phonological processes more often than segments of other places of articulation (Kiparsky, 1985). Recently, the uniqueness of coronal place has been reconsidered within the nonlinear frameworks of feature geometry and underspecification theories (Paradis and Prunet, 1991b). Coronal has been reinterpreted as the default place of articulation, being predictable and therefore requiring no featural specification in the underlying representation. This reevaluation has served to advance these theoretical models, as well as facilitate our understanding of the peculiar structure and representation of coronal segments in language.

The interplay between symmetry and asymmetry in phonological systems also has been evidenced in developing systems. As with fully developed languages, the emerging sound systems of young children are highly symmetric (Locke, 1983). This is the case both for the segmental and the featural composition of such systems (Dinnsen, 1992; Dinnsen et al., 1990; Ferguson, 1977; Ingram, 1990b). It is further true cross-linguistically for children who are acquiring language normally (Bortolini and Leonard, 1990; Ingram, 1988a; Locke, 1983; Pye et al., 1987), as well as for children with unusual or atypical sound systems including, for example, those with functional (nonorganic) phonological delays (Ingram, 1989; Leonard, 1992). But, with the occurrence of such symmetries also comes asymmetries in development. One key difference, however, between the symmetric–asymmetric relationships of fully developed and developing linguistic systems is the static versus dynamic status of these inventories. For development, symmetry and asymmetry in the sound system can be observed both cross-sectionally and longitudinally. Further, these relationships generally change with time. Development thus provides a unique opportu-

nity to examine the structure of phonological systems for purposes of both acquisition theory and a theory of language.

To demonstrate more specifically, Ingram (1990a, 1992a) reported that for normally developing children, a place distinction in word-initial stops emerges prior to a voice distinction in this series. For instance, a developing inventory may include at an early point in time the initial consonants /b d/, and at a later point in time, the consonants /b p d s/ (e.g. Ferguson and Farwell, 1975). Notice, on the one hand, that this sample inventory is symmetric, marking both labial and coronal places. But on the other hand, there is an asymmetry in the place of articulation that the voice distinction emerges, and in the relationship between voice and place. To extend this observation further, Ingram reported that for phonologically delayed children, a voice distinction emerges prior to a place distinction in the word-initial stop series. This is precisely the reverse of that observed for normal development. Consequently, another asymmetry becomes apparent, that is the relationship between normal and delayed phonological systems. Why should normally developing children exhibit a pattern of acquisition whereby place emerges in advance of voice, but delayed children evidence voice prior to place? Ingram characterized the reverse orders of emergence of voice and place as a potential defining property of normal as opposed to delayed language development. An articulatory account of the asymmetry was offered, such that children with phonological delays were hypothesized to have difficulty achieving fine supralaryngeal control, and consequently focus on expansion of the phonological system first through laryngeal control. Thus, by tracing longitudinally the emergence of contrasts in developing systems, the asymmetric properties of these systems contributed to a possible characterization of the course of phonological acquisition, the defining properties of developing systems, and the identification of potential subsystems within development. Moreover, the articulatory account was drawn in part from current perspectives on the geometric structure of phonological representations for fully developed primary languages (Paradis and Prunet, 1991b).

The purpose of this paper is to examine further the relationship between voice and place in developing sound systems. The motivation comes from observed symmetric, asymmetric, and recurring patterns in the structure of phonemic inventories of children with phonological delay (Gierut et al., 1994). In part, these patterns resemble and extend those described by Ingram (1990a, 1992a). However, in contrast to the previous work, a cyclic principle of phonological acquisition is advanced in the attempt to reconcile regularities and dichotomies in phonemic structure. The principle is demonstrated from both cross-sectional and longitudinal perspectives, thus encompassing static and dynamic aspects of developing systems. The structure of emerging phonemic inventories is shown to be derivative of cyclicity in phonological acquisition. The cyclic principle has the further advantage of characterizing normal and delayed phonological development in a unified way which, in turn, has consequences for a general theory of acquisition. The principle also provides a substantive means of evaluating the structure of phonological representations from the theoretical perspective of feature geometry.

2. Asymmetries in developing phonemic inventories

In a recent cross-sectional study, Gierut et al. (1994) presented a typological characterization of phonemic structure based on evidence from 30 children with phonological delays. Children were between the ages 3 years, 4 months and 5 years, 7 months and were normally developing in all respects with exception of their phonologies, which were characterized primarily by restricted consonantal inventories. Also, because children were part of a larger project on the learnability of sound systems, they received experimentally controlled and manipulated clinical treatment that was designed to induce changes in the sound system. Consequently, longitudinal phonological and learning data were available for each child.

Methodologically, the phonemic inventory of each child was determined from extended speech samples following principles of standard generative analysis (for details see Gierut et al., 1994). For purposes of establishing the inventory, underlying representations were presumed to be constituted by systematic phonemes. The phonemic inventory was further confirmed on the basis of two additional criteria: contrastiveness and consistency (cf. Cook, 1988). Contrastiveness required the occurrence of a minimum of two sets of minimal pairs before observed consonants were taken to be phonemic. Consistency required that these same consonants function contrastively over two consecutive sampling sessions.

From these data, five distinct types of consonantal phonemic inventories were identified based on the kinds of segments that were contrastive within and across children's systems. The five types, shown in Fig. 1, were further differentiated on the basis of both common and minimal (or nonredundant) featural distinctions. Inventory types were independent of each other, but appeared to be related hierarchically in terms of featural complexity. The inventory types ranged from the most primitive systems (i.e. Type I exhibited by 2 children), which included only nasal and obstruent stop consonants, to the most complex systems (i.e. Type IV evidenced by 6 children), which included all manner categories: nasals, stops, fricatives, affricates, and liquids. Of most relevance to the present discussion are the intervening types, Type II, IIIA, and IIIB.

More specifically, Type II inventories included only nasal, stop, and fricative phonemes. Eight of the 30 children displayed inventories with this composition of segments. Within the obstruents, all 8 children marked a voice distinction in stops, but place of articulation was free to vary. That is, there was no single featural description that could capture the place characteristics of stops for all of the inventories classified as Type II. Place then could not be distinguished by a common and requisite feature or feature set. Within the fricatives, there was also no common voice or place distinction, with considerable individual variation observed across children's systems.

Type III inventories were remarkable in that they seemed to take one of two forms, thought to be equivalent in complexity. Type IIIA systems, characteristic of 6 children's inventories, included only nasal, stop, fricative, and affricate phonemes. As in the simpler Type II systems, there was an obligatory voice distinction observed in stops, along with a further place distinction. Thus, all 6 children marked mini-

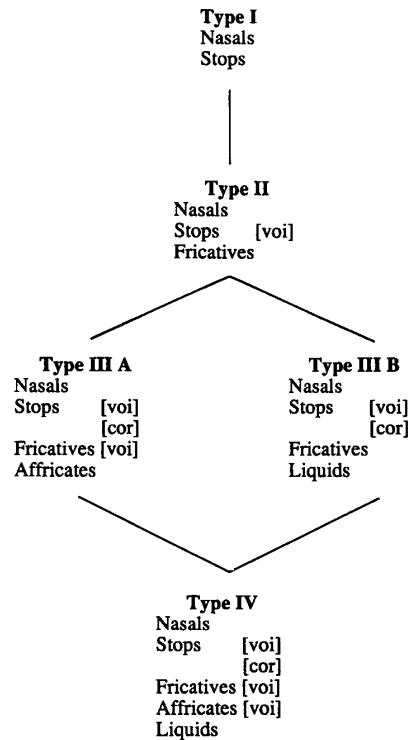


Fig. 1. A cross-sectional typology of phonemic inventories of children with phonological delays (Gierut et al., 1994).

mally voice and place in stops in exactly the same way. For fricatives, a voice (but no common place) distinction was maintained across the children's systems. For affricates, there was no necessary or common voice or place contrast observed.

In comparison, Type IIIB systems admitted a liquid phoneme, along with nasals, stops, and fricatives of simpler types. There were 8 children evidencing a phonemic system of this kind. Like the Type II and IIIA systems, these children maintained an obligatory voice distinction within stops, but a voicing distinction within fricatives was not a necessary property. Also, all Type IIIB systems marked a common place distinction within stops, but not within fricatives.

Importantly, each of the 30 phonemic inventories were classified as one and only one of these five types. The typology uniquely captured common distinctions maintained across the 30 systems and, at the same time, allowed for individual differences in the specific phonemic composition of each inventory. Because of the implicational nature of the typology, the cross-sectional characterization of phonemic inventories also provided a testable framework for tracing the longitudinal course of

acquisition by a given child. Moreover, three inventory types, II, IIIA, and IIIB, highlighted potential asymmetric patterns to be expected and accounted for in the emergence of phonemic structure. Four such asymmetries warrant further discussion.

First, there was an asymmetry in the order of acquisition of voice and place within the obstruent series. Voice distinctions always emerged first, in advance of place distinctions. This finding confirmed the tendency noted by Ingram (1990a, 1992a) for phonologically delayed children with regard to word-initial stops, and extended it more broadly across the obstruent series independent of word position. Second, the introduction of a voice distinction repeated or copied itself across the obstruent series, but not uniformly. Voice was first implemented in the stops (Type II inventories). Then, this contrast was extended to fricatives, but only subsequent to and not simultaneous with the acquisition of fricatives (Type IIIA inventories). Finally, it was exemplified in the affricates, again only following the emergence of this manner class (Type IV inventories). In each case, a new manner was introduced first and remained without a corresponding voice distinction. (A similar delayed pattern of copying across the obstruent series could also be projected for place.) Third, there was an asymmetry in the occurrence of affricates versus liquids. Some children's inventories included affricates and fricatives to the exclusion of liquids (Type IIIA systems). In contrast, other inventories included liquids and fricatives to the exclusion of affricates (Type IIIB systems). Fourth, there was an interaction between these asymmetries which had a further (asymmetric) impact on phonemic composition. That is, the occurrence of an affricate in the system (associated with Type IIIA inventories) required an obligatory voice distinction in both the stop and fricative series. There was no such necessary implication with the occurrence of liquids in the system (Type IIIB systems).

Thus, it seems that the observed asymmetries involving voice and its repetitive transfer across the obstruent series, and the occurrence of affricates as opposed to liquids may be in some way related. One account that has been offered is that the introduction of liquids as opposed to affricates in a phonemic system is a parameter to be set by an individual child (Gierut et al., 1994: 14–15). Given the setting of this parameter, the emergence of voice (and subsequently, place) would follow automatically. The fact that voice distinctions are introduced repeatedly and in sequence across the obstruent series was taken simply as an independent and general mechanism of change in development, whereby new categories are formed from existing categories (e.g. Carey, 1985; Gierut, 1992; MacWhinney, 1985; Slobin, 1971).

While a parameterization account may be plausible, it is lacking in several important respects associated particularly with the nature of the target, its trigger, and the operation. First, the parameter itself is not well-motivated. Why should the target involve specifically affricates versus liquids, as opposed to any other manner classes? There is no independent or a priori phonological or phonetic evidence to support this dichotomy in the structure of developing inventories (Gierut et al., 1994: 12). Also, it is unclear what conditions trigger the setting of this parameter, since both options (affricates versus liquids) emerge out of a phonemic system that includes fricatives and stops (i.e. Type II inventories). Lastly, with regard to the operation, it appears that the child must do one of two very different things. For the

setting of an affricate, the child must establish further the properties of air flow (cf. Rice, 1992), differentiating fricatives from affricates (e.g., [\pm continuant]) and/or stops from affricates (e.g., [\pm delayed release]). Here, simplex segments must also be distinguished from contour segments (Lombardi, 1990). Additionally, a new voice distinction must be added to fricatives under this setting. In contrast, for the setting of the liquid, the child must elaborate further the properties of sonorant voice, distinguishing sonorant consonants that are nasal from those that are nonnasal. It appears then that the operation is not general, but rather specific to each alternative setting. Taken together, these limitations suggest that parameterization may be an inadequate account of observed asymmetries in the development of phonemic inventories and thus motivate an alternative hypothesis.

3. The principle of Laryngeal–Supralaryngeal Cyclicity

The question then remains: Is there a means of reconciling the symmetries and asymmetries of phonological development such that the addition of affricates versus liquids to an inventory is wholly integrated with the emergence of voice distinctions in the obstruent series? Moreover, can these relationships be joined in a unified way with the recurring and sequential transfer of voice in obstruents? In part, noted deficiencies in the parameterization account provide insight to this question. Specifically, closer inspection of the operation itself reveals that, to achieve either parameter setting, a child must necessarily add a new supralaryngeal distinction to the phonemic repertoire. However, the extension of voice to the fricative series (i.e. a laryngeal distinction) appears optional, being implemented in the case of affricates, but not in the case of liquids. These observations suggest that supralaryngeal and laryngeal distinctions may underlie the emergence of phonemic inventories, and that these distinctions may be added in alternation as supported by the repetitive extension of voice distinctions across obstruents. This gives rise to a potential principle of phonological acquisition as formulated below.

Laryngeal–Supralaryngeal Cyclicity:

Laryngeal and supralaryngeal properties of a phonological system will be elaborated in continuous cycle, with expansion of the inventory first in one domain of the representation and then the other, but not with change occurring in both domains simultaneously.¹

Notice that the two primary domains of inventory expansion involve laryngeal properties, associated with voice distinctions, and supralaryngeal properties, associ-

¹ The Structural Complexity Constraint (SCC) as advanced by Rice and Avery (1991) states that increased structure in one domain of the geometric representation predicts reduced structure in another domain of the representation. In contrast to the Laryngeal–Supralaryngeal Cyclicity principle, the SCC constrains the degree of structure expected in the phonological representation and is static in nature. As the SCC is formulated, it does not purport to account for changes in development.

ated with manner and/or place distinctions. Each domain represents one phase of a continuous cycle, with alternations between phases, laryngeal and supralaryngeal. The principle does not specify which domain will initiate the cycle. The principle also does not dictate precisely which laryngeal or supralaryngeal property will be expanded, thereby allowing for the same general property to be realized in different ways by different children. In this way then, the addition of an affricate for Type IIIA systems would not be incompatible or in conflict with the addition of a liquid for Type IIIB systems, as will be demonstrated. Moreover, the cyclic nature of the principle captures the pattern of the repetitive transfer of voice and the sequential relationship between voice and place distinctions. Thus, the apparent symmetries, asymmetries, and repetitions in phonemic development may be united by a single principle of Laryngeal–Supralaryngeal Cyclicity. It is this principle that is predicted to guide the course of phonological acquisition.

Importantly, the falsifiability of Laryngeal–Supralaryngeal Cyclicity can be examined in regard to two well-defined exclusions to its application. As the principle is formulated, it excludes the occurrence of two consecutive phases of the same type. That is, a child should not acquire a voice contrast, followed by another voice contrast. Similarly, a sequence of two consecutive supralaryngeal distinctions would not be predicted to occur. These exclusions may be difficult to establish empirically given the potential indeterminacy of phase completion. To establish the completion of a phase, independent criteria should be invoked, much like in the case of determining the cyclic domain of rule application in lexical phonology (Kiparsky, 1982). For Laryngeal–Supralaryngeal Cyclicity, one possible criterion for completion of a phase may be associated with phonotactic permissibility, such that a phase may be considered complete when sounds occurring in that phase are used in all word positions. Other possible and less stringent conditions may be available; however, all of these remain to be established empirically. Another more readily falsifiable claim is that the co-occurrence of laryngeal and supralaryngeal distinctions in exactly the same phase of a cycle is prohibited. This means that both a voice contrast and a manner/place contrast should not emerge simultaneously in development. It is this principled exclusion that provides the clearest testing ground for refinement or rejection of Laryngeal–Supralaryngeal Cyclicity.

4. Methodological considerations in evaluation of Laryngeal–Supralaryngeal Cyclicity

To test Laryngeal–Supralaryngeal Cyclicity as a viable principle of acquisition, longitudinal data from 15 children were examined (Table 1). The children were a randomly selected subset of the 30 subjects who participated in the earlier cross-sectional investigation (Gierut et al., 1994). As was noted, the children who participated had phonological delays and were enrolled in an experimental clinical treatment program. Consequently, phonological data from two points in time were available for analysis: prior to treatment and 2 weeks posttreatment. The phonemic

Table 1
Phonemic inventories of 15 children obtained at two points in time

Subject	Age (months)	Time span Points 1 and 2 (months:days)	Phonemic inventory	
			Point 1	Point 2
1	41	2:6	m n ŋ pb td kg ʃʒ ʃj l r	m n ŋ pb td kg fv sz š čj l r
3	42	2:11	m n ŋ pb td kg	m n ŋ pb td kg ð z l r
6	44	3:3	m n pb td f	m n pb td kg f θð r
10	49	1:25	m n pb td fv sz l	m n pb td g fv θð sz l
11	50	4:11	m n pb d f š	m n ŋ pb td kg fv sz š čj
12	50	2:22	m n pb td fv s š r	m n ŋ pb td kg fv θð sz š čj l r
15	53	3:2	m n ŋ pb td kg sz š čj l	m n ŋ pb td kg fv θð sz š čj l
18	56	2:0	m n pb td kg fv sz l	m n ŋ pb td kg fv ð sz š čj l
22	58	2:8	m n pb td sz l	m n ŋ pb td Φβ f θð sz l

Table 1 (cont.)

Subject	Age (months)	Time span Points 1 and 2 (months:days)	Phonemic inventory	
			Point 1	Point 2
23	58	1:24	m n ŋ pb td kg fv ʃdz č r	m n ŋ pb td kg fv θ ʃdz čj r
24	60	2:25	m n pb td fv čj	m n ŋ pb td kg fv θ z š čj l r
25	60	2:6	m n ŋ pb td sz ʃ dz	m n ŋ pb td θð sz š dz čj
26	60	1:18	m n ŋ pb td kg fv sz	m n ŋ pb td kg fv θð sz j l
29	65	1:19	m n pb td fv šž čj r	m n ŋ pb td g fv sz šž čj r
30	68	3:5	m n pb td kg fv šž čj	m n ŋ pb td kg fv θ sz šž čj l

systems of the children at each of these two points in time were established using the same methodology involving minimal pairs as in the previous study and as described above. However, because the resulting inventories for each child represented essentially two static points in time, it was also necessary to project a potential sequence of emergence of phonemes in a given inventory between these two points in time. The assumption was that first acquired phonemes would be most stable, being firmly established in the lexicon (cf. Ingram, 1981, 1988a, 1989; Locke, 1983; Pye et al., 1987). First acquired phonemes would be used with greater frequency, accuracy, and consistency, and these phonemes would extend to a number of lexical items and across word positions. In contrast, phonemes added most

5. Implementation of the principle of Laryngeal–Supralaryngeal Cyclicity

The pretreatment phonemic inventory and projected sequence of phonemic acquisition to two weeks posttreatment for each of the 15 children are summarized in Table 3. The data are discussed first in illustration of the Laryngeal–Supralaryngeal Cyclicity principle. Then, general observations about the implementation of this principle are noted. Individual differences in implementation of the principle are also identified.

Table 3
Laryngeal (L) – Supralaryngeal (SL) Cyclicity demonstrated for 15 children

Subject	Phonemic inventory Point 1	Laryngeal–Supralaryngeal Cyclicity					
		SL	L	SL	L	SL	L
1	m n ŋ pb td kg ʃʒ ʈs	ʃ	č	f	v		
3	m n ŋ pb td kg	ð					
		z					
		l					
		r					
6	m n pb td f	k	g	θ	ð	r	
10	m n pb td fv sz l	ð	θ	g			
11	m n pb d f ʃ	k	g	ŋ	t		
		s	v	č	z		
					j		
12	m n pb td fv s ʃ r	k	g	ŋ	č	ð	θ
			z	j		l	
15	m n ŋ pb td kg sz ʃ čj l	f	v	ð	θ		
18	m n pb td kg fv sz l	ŋ	č	ʃ			
		ð					
		j					

Table 3 (cont.)

Subject	Phonemic inventory Point 1	Laryngeal–Supralaryngeal Cyclicity					
		SL	L	SL	L	SL	L
22	m n pb td sz l	ŋ	β				
		Φ	θ				
		f					
		ð					
23	m n ŋ pb td kg fv ʈs ɟz č r		j	θ			
24	m n pb td fv čj	ŋ	g	z			
		k					
		θ					
		ʃ					
		l					
		r					
25	m n ŋ pb td sz ʈs ɟz	j	č	ð	θ		
			ʃ				
26	m n ŋ pb td kg fv sz	ð	j				
		l					
29	m n pb td fv ʃž čj r	ŋ	z				
		g					
		s					
30	m n pb td kg fv ʃž čj	ŋ	z	θ			
		s					
		l					
		čj					

To illustrate generally how the principle of Laryngeal–Supralaryngeal Cyclicity is implemented, the inventory of Child 23 is considered (Tables 2 and 3). At Point 1 in time, this child’s phonemic repertoire included nasals and stops at all places of articulation (labial, coronal, dorsal), with a voicing distinction in the stops; voiced and voiceless labial fricatives /f v/; alveolar and alveopalatal affricates /ʈs ɟz č/; and the liquid /r/. At Point 2 in time, the inventory was expanded to also include /j θ/. Based on the acquisition metric described above, these segments were further hypothesized to have emerged, one after the other, in that order (Table 2). To begin the laryngeal–Supralaryngeal cycle, the occurrence of /j/ marked a laryngeal distinction in contrast to /č/. Prior to the addition of /j/, voicing of nonanterior coronal affricates

was predictable because /ç/ was the only segment of this type. With the inclusion of /ʃ/, voicing became a distinctive property. Next to emerge was /θ/, signaling a supralaryngeal distinction within the continuants that could be interpreted as either the introduction of a new place or a new manner. With /θ/, fricatives that were coronal (i.e. a new place) and nonstrident (i.e. a new manner) were permitted in the system as opposed to previously when the only fricatives of the system were labial and strident /f v/. While the properties of place and manner were distinctive for fricatives at this point, voicing of the newly added coronal fricative was entirely predictable. Thus, for Child 23 there were two new segments added to the phonemic repertoire between Points 1 and 2 in time. The addition of these segments was accomplished in two phases of one cycle: Laryngeal → Supralaryngeal. Only one phoneme was added during each phase, and the onset of the cycle was the laryngeal phase.

Child 6 presented a similar case whereby the implementation of the principle of Laryngeal–Supralaryngeal Cyclicity involved the addition of one segment per phase of the bivalent cycle. However, for this child, many more cycles were completed, and the cycle began in the supralaryngeal phase as induced through minimal pair treatment of /f/ in contrast to /g/ (Gierut, 1992).² Notice that the pretreatment sound system of Child 6 (Table 3) included only labial and coronal nasals and stops (both voiced and voiceless), and the voiceless labial fricative /f/. In the first phase of inventory expansion, Child 6 acquired /k/, marking a supralaryngeal place distinction (i.e. dorsal) within the stop series. Here, a velar was added, but its voicing was predictable given its place. Next to emerge was the treated sound /g/, indicative of a laryngeal distinction within dorsal stops. A supralaryngeal contrast followed with the occurrence of the nonstrident coronal fricative /θ/. /θ/ signaled both new manner and place distinctions within the fricative series because, prior to its inclusion, the only fricative in the child's system was labial and strident /f/. Voicing remained a predictable property for all fricatives. The next phoneme to be acquired was /ð/ during the laryngeal phase of the cycle in contrast to /θ/, thereby making voicing distinctive for coronal fricatives. The final contrast acquired involved supralaryngeal properties with the emergence of /t/, marking a nasal–nonnasal distinction within sonorant consonants. Prior to this, sonorant consonants were predictably nasal. Notice that the implementation of the principle of Laryngeal–Supralaryngeal Cyclicity paralleled

² This child's inventory was asymmetric with regard to laryngeal distinctions in the fricative series, since /f/ was the only fricative used. It might be predicted then that laryngeal would be the next phase of the cycle, with the addition of /v/. There are two possibilities as to why the acquisition cycle began instead with the supralaryngeal phase for this child. On the one hand, perhaps the supralaryngeal phase involving acquisition of /f/ was not completed, thus allowing for the introduction of additional supralaryngeal distinctions. As described with regard to falsifiability of the principle (p. 8), the evidence may come from phonotactics, given that /f/ was restricted in distribution to word-initial position. On the other hand, the expressed purpose of clinical treatment was production of a contrast between /f/ and /g/. The contrastive relationship of these sounds relative to the inventory may have deliberately forced a supralaryngeal distinction. A similar case occurred for Child 11, to be discussed on p. 16. These two cases raise important questions regarding the independent criteria for establishing duration of a phase and the role of treatment relative to the implementation of Laryngeal–Supralaryngeal Cyclicity. These issues remain for empirical study.

that of Child 23 above with one segment added per phase of the cycle. However, Child 6 completed more cycles and, accordingly, added more phonemes to the inventory from pre- to two weeks posttreatment (i.e. 5). For these two children, there was an obvious one-to-one relationship between the number of cycles completed and the number of new phonemes acquired. Children 10 and 15 also displayed a similar positive relationship between cycles completed and phonemic expansion.

The more prevalent pattern for the group was the addition of multiple segments during a given phase of the cycle. This was observed for 11 of the 15 children (Ss 1, 3, 11, 12, 18, 22, 24, 25, 26, 29, 30). To illustrate how multiple phonemes may have emerged simultaneously in a given phase, the phonemic inventory of Child 25 is examined (Tables 2 and 3). At Point 1 in time, the child's system included nasals at all places of articulation, voiced and voiceless labial and coronal stops, coronal fricatives /s z/, and alveolar affricates /ts dz/. At Point 2 in time, the segments /j ç ð š θ/ were also used contrastively. For this child, the acquisition cycle began with the emergence of a supralaryngeal distinction involving place within the affricates. Namely, the nonanterior coronal affricate /j/ was introduced in contrast to its anterior counterpart /dz/. Voicing for the newly acquired nonanterior affricate remained predictable until the next phase of the cycle, whereby a laryngeal distinction was marked with the occurrence of /ç/. Following this, /ð š/ were predicted to emerge simultaneously. As shown in Table 2, these two sounds had identical rankings following application of the heuristics to establish order of phonemic acquisition. Consequently, they were presumed to be acquired during the same phase of the cycle. The occurrence of /ð š/ represented supralaryngeal elaboration of both manner, through the introduction of a stridency distinction between /z ð/, and place, with an anteriority distinction between /s š/. Voicing in each case was again predictable. /θ/ emerged in the final phase of the cycle, characteristic of a laryngeal distinction in contrast to /ð/. Like Child 6 above, this child also added 5 phonemes to the repertoire over time; however, this was accomplished in fewer cycles through the addition of multiple segments in a given phase. Thus, the potential correspondence between number of cycles completed and number of phonemes added to a system was not a necessary condition of the principle.

For the most part, multiple segments were added to children's inventories during one given phase, but not across phases of the cycle (i.e. Ss 1, 3, 18, 24, 25, 26, 29, 30). However, there were 3 children (Ss 11, 12, 22) who exhibited the addition of multiple segments across multiple phases of Laryngeal–Supralaryngeal Cyclicity. Child 11 best illustrates this alternative strategy. At Point 1 in time, this child's inventory included labial and coronal nasals, stops, and fricatives. Within the stops, there was a voicing distinction maintained for labials /p b/, but not coronals /d/. Within the fricatives, there was no voice distinction, with only /f š/ in the system. The onset of Laryngeal–Supralaryngeal Cyclicity began with the acquisition of /k s/ concurrently. This marked the introduction of supralaryngeal distinctions as induced through minimal pair treatment of /g/ in contrast to /f/ and /ç/ in contrast to /s/. Within the stops, the addition of /k/ marked a place distinction between labials and dorsals, but not coronals given the voiceless quality of the newly added segment. Within fricatives, the addition of /s/ also marked distinctions of place, namely labial

versus coronal with a contrast between /f s/ and anterior versus nonanterior with a contrast between /s ʃ/. The next phase of the cycle involved elaboration of laryngeal properties of stops and fricatives given the addition of both /g v/. Voicing was thus distinctive for dorsal stops and for labial fricatives. Next to emerge were supralaryngeal distinctions as signaled by the simultaneous occurrence of both /ŋ ʒ/. /ŋ/ marked a place distinction within nasals, whereas /ʒ/ represented a new manner distinction within obstruents. In the final phase of the cycle, laryngeal contrasts were added given the co-emergence of /t z ʃ/. These newly acquired voice contrasts were extended only to coronal place of articulation, /t d/, /s z/, and /ʃ ʒ/. Further, these voice distinctions were distributed evenly across the obstruent series to stops, fricatives, and affricates. Thus, for Child 11, the application of Laryngeal–Supralaryngeal Cyclicity involved elaboration of the inventory through the addition of multiple phonemes over multiple phases. The end result was the acquisition of 9 new segments completed in 2 cycles.

Taken together, these case examples demonstrate apparent variation across children in the implementation of the principle of Laryngeal–Supralaryngeal Cyclicity. Variation was observed in the number of phonemes added in a given phase and in the number of cycles completed. Some children added one sound per phase of the cycle, whereas others added multiple sounds. Further, if multiple sounds were added, this occurred either during a given phase or across multiple phases. The number of cycles completed by these children ranged from 1 Laryngeal → Supralaryngeal sequence (S 23) to 3 such sequences (S 12). Overall, the minimum inventory expansion involved the acquisition of 2 new phonemes in 1 completed cycle, whereas the maximum expansion involved 9 new phonemes in 3 completed cycles. In addition to such variation, the precise way in which a laryngeal or supralaryngeal distinction was realized was not predictable from the principle and accordingly was free to vary. That is, the exact distinction to emerge or the specific segment to be acquired was left unconstrained by the Cyclicity principle, except with regard to its fundamental character being a laryngeal or a supralaryngeal property. For instance, a supralaryngeal distinction could be manifested by the introduction of a new place contrast only, a new manner contrast only, or both new places and manners relative to the existing sound system. Importantly, the range of variation that was observed was not associated with a child's chronological age or the time span between pre- and two weeks posttreatment inventories (Table 1), as might be predicted by other alternative developmental stage accounts of phonological acquisition (Smit et al., 1990). Because Laryngeal–Supralaryngeal Cyclicity was relatively unconstrained in its formulation, such variation was not only tolerated but expected by the principle.

In summary, the principle of Laryngeal–Supralaryngeal Cyclicity applied without exception to the inventories of 15 children with phonological delays. Despite considerable individual differences among these children, a pattern of acquisition was discernible. Further, the nature of this pattern was delineated, i.e. cyclicity, and the nature of this cyclicity was characterized, i.e. alternations of laryngeal and supralaryngeal expansion. Thus, the principle of Laryngeal–Supralaryngeal Cyclicity defined a possible course of phonological acquisition. Because the principle is underdetermined, individual variation in its implementation was permitted (cf.

Dinnsen, 1992; Mohanan, 1992). Within lawfulness then, there was flexibility. Given this, the principle has the potential to integrate observed asymmetries in the development of phonemic inventories, and to contribute to more general issues associated with acquisition and phonological theories.

6. Implications and research directions

6.1. Adequacy of Laryngeal–Supralaryngeal Cyclicity

Because the aim of this investigation was to examine the structure of phonemic inventories of children with phonological delay and to advance a principle to reconcile noted dichotomies in structure, it is necessary to reconsider these asymmetries in light of the proposed principle of Laryngeal–Supralaryngeal Cyclicity. Recall that four asymmetries were observed as related to the emergence of voice and place distinctions, and the emergence of affricates as opposed to liquids (p. 6). These asymmetries can be accounted for by Laryngeal–Supralaryngeal Cyclicity because they are simple derivatives of the principle.

First, voice distinctions were observed in advance of place distinctions in developing systems. This asymmetry is captured by the principle given the two phases of the cycle, laryngeal and supralaryngeal.

Second, the emergence of a voice distinction was realized first in the stop series. Then, voice was extended in sequence to the fricatives, and finally to the affricates. Consistent with the principle, this is traced in the ordered and parallel sequence: Supralaryngeal distinction involving stops → Laryngeal distinction in stops → Supralaryngeal distinction involving fricatives → Laryngeal distinction in fricatives → Supralaryngeal distinction involving affricates → Laryngeal distinction in affricates.

Third, affricates emerged following fricatives to the exclusion of liquids, and liquids emerged following fricatives to the exclusion of affricates. As was discussed previously (p. 7), the asymmetric acquisition of affricates versus liquids involves marking a more general supralaryngeal distinction in the cycle.

Finally, the emergence of affricates versus liquids and the extension of voice across the obstruent series appeared to be related. That is, affricates occurred concurrent with an obligatory voice distinction in both the stops and the fricatives, whereas the emergence of liquids required no necessary voice distinction. The close association between affricates and voicing is consistent with the sequence depicted above for the repetitive extension of voice across the obstruent series. That is, in order to add an affricate to the system, it seems that a series of at least four prior phases of the cycle must be completed, namely, Supralaryngeal → Laryngeal in stops, Supralaryngeal → Laryngeal in fricatives. This can be further exemplified by the longitudinal expansion of the phonological system of Child 11 of this study (Table 3). In contrast, the lack of association between liquids and voicing is one indication that liquids may be acquired as a supralaryngeal distinction simultaneous with the occurrence of fricatives, as in the emergence of multiple sounds in a given phase.

Here, fewer cycles may need to be completed prior to the addition of liquids, particularly Supralaryngeal → Laryngeal in stops followed by Supralaryngeal in fricatives and affricates. This pattern was also reflected in the longitudinal data set for Child 3, whereby fricatives and liquids emerged simultaneously as supralaryngeal distinctions. With regard to this final asymmetry, notice that both affricates and liquids were considered instances of the supralaryngeal phase, but the introduction of each seemed to require that the sound system undergo different numbers of cycles, with affricates potentially requiring more prior cycles than liquids. Thus, the cyclic nature combined with the laryngeal and supralaryngeal domains of the acquisition principle provide a cohesive account of observed symmetries, asymmetries, and recurrences in developing phonemic systems.

Laryngeal–Supralaryngeal Cyclicity can be extended further as an account of other phonological asymmetries of voice and place that presumably differentiate normal development from phonological delay (Ingram, 1990a, 1992a). Recall that Ingram observed a tendency for children with phonological delays to introduce voice distinctions in advance of place distinctions in the word-initial position of stops. Conversely, children with normally developing phonologies tended to evidence the reverse sequence, with place distinctions acquired before voice contrasts. The order of emergence of voice and place in word-initial stops was interpreted by Ingram as a defining and differentiating characteristic of these two populations. However, if the proposed cyclic course of laryngeal–supralaryngeal acquisition is accepted, then all children (albeit normal or delayed) would show both patterns: voice before place distinctions, and place before voice distinctions. These would be reflected in alternating phases of the cycle, as in Fig. 2. Following Ingram, a normally developing child may initiate the acquisition cycle in the sequence Supralaryngeal → Laryngeal. In the return cycle, this very same ‘normally developing’ child would follow the sequence Laryngeal → Supralaryngeal, presumably a characteristic of phonological delay. Accordingly, normally developing sound systems would exhibit both ‘normal’ and ‘delayed’ properties; the same would be true of delayed phonological systems. This, in fact, was realized in the data of individual subjects as reported by Ingram (1992a: 3). Specifically, some normally developing children did exhibit the supposed pattern of ‘delay’, whereas other delayed children showed the pattern presumed to be ‘normal’. By adopting the principle of Laryngeal–Supralaryngeal Cyclicity, this differentiation between normal and delayed populations is no longer necessary. Such a distinction becomes simply an artifact of the noted asymmetries. Thus, the appeal to Laryngeal–Supralaryngeal Cyclicity in interpreting these data has the further advantage of demonstrating continuity in development by providing a unified perspective on language acquisition for all children, normal or delayed (cf. Dinnsen, 1992; Ingram, 1992b).

6.2. Extensions of cyclicity to other aspects of phonological development

Cyclicity has been reported in connection with other aspects of the study of language, for example, rule application (Chomsky and Halle, 1968; Kiparsky, 1982). For this reason, it may be an underlying component of acquisition with possible

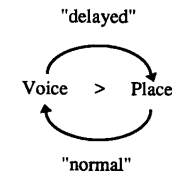


Fig. 2. Laryngeal–Supralaryngeal Cyclicity as an account of observed differences in the order of emergence of voice and place distinctions in the phonologies of normally developing children versus those with phonological delays (Ingram, 1990a, 1992a).

extensions to other domains of language besides the emergence of the consonantal system of English. In particular, the course of vowel acquisition in Hungarian as documented by Fee (1991, 1992) appears to have cyclic properties (although this is not Fee's interpretation). Vowel acquisition in this language was reported to proceed in order with the emergence of a distinction between: (1) /a o/, (2) /a e/, (3) /e i/ simultaneous with /o u/, and (4) /u ü/ simultaneous with /o ö/. This sequence of vowel emergence demonstrates a possible alternation between height (i.e. high versus low) and depth (i.e. front versus back) contrasts. Notice especially that height differences are marked by the emergent vowel distinctions in (1) and (3) above, whereas depth differences are marked by the vowel distinctions in (2) and (4). Given this, the domains of the cycle for vowel acquisition in Hungarian may involve height and depth properties yielding, for example, a possible principle of Height–Depth Cyclicity.

6.3. Implications of Laryngeal–Supralaryngeal Cyclicity for phonological theory

With regard to current phonological theory, Laryngeal–Supralaryngeal Cyclicity may help define the relevant components of a phonological representation and the hierarchical relationship among these. From the perspective of feature geometry in particular, these acquisition data suggest that Laryngeal and Supralaryngeal are relevant properties to be represented as nodes in the grammar (see Iverson, 1989; McCarthy, 1988, for an alternative argument). These nodes appear to be of equal importance, functioning on par with each other in a sisterhood relationship, as in Fig. 3. Further, Supralaryngeal seems to have Place and Manner as its dependents, and these also function as coequals (cf. Clements, 1985, 1987; Davis 1989). This claim is supported by the fact that the supralaryngeal phase was realized in different ways by the children of this study, that is, place distinctions only, manner distinctions only, or both place and manner distinctions. The co-occurrence of both place and manner in a given phase can be taken as further evidence that manner is a constituent of Supralaryngeal and not a branch of the Root node as some have argued (Paradis and Prunet, 1991a: 4, 24).³ With continued research, it should be possible to elabo-

³ It is of course possible that no subordinate structure exists in the geometry (cf. Iverson, 1989, McCarthy 1988).

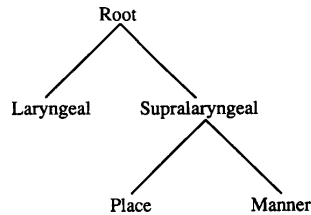


Fig. 3. Organizational structure of feature geometry as supported by the principle of Laryngeal–Supralaryngeal Cyclicity.

rate the details of this geometric representation. Two such extensions come to mind. In particular, the laryngeal phase of the cycle may be more complex and multifaceted than was established here. Cross-linguistic study of the acquisition of languages manifesting laryngeal distinctions in ways other than [±voice] may provide the necessary evidence in this regard. Additionally, cross-linguistic studies of languages that do not maintain laryngeal distinctions may help to elaborate the alternate supralaryngeal phase of the cycle, such that cycles within the laryngeal–supralaryngeal cycle may be identified. For instance, a cyclic relationship between place and manner may emerge to further define the geometric structure. Such studies will also serve to test the universality of the principle.

In conclusion, the principle of Laryngeal–Supralaryngeal Cyclicity holds broad potential as a testable and defining property of phonological acquisition. It advances a plausible and cohesive account of observed symmetries, asymmetries, and recurrences in phonological development. Observed patterns and individual differences in the acquisition of phonemic distinctions may be derivative from this principle. Laryngeal–Supralaryngeal Cyclicity also provides a means of verifying and elaborating the structure of feature geometry by appealing to data from developing sound systems. In this way then, Laryngeal–Supralaryngeal Cyclicity may be found to be an important component of a general model of both language and its acquisition.

References

- Anderson, S., 1981. Why phonology isn't natural. *Linguistic Inquiry* 12, 493–539.
- Bortolini, U. and L.B. Leonard, 1990. The speech of phonologically disordered children acquiring Italian. *Journal of Clinical Linguistics* 5, 1–12.
- Carey, S., 1985. *Conceptual change in childhood*. Cambridge, MA: MIT Press.
- Chomsky, N. and M. Halle, 1968. *The sound pattern of English*. New York: Harper and Row.
- Clements, G.N., 1985. The geometry of phonological features. *Phonology* 2, 225–252.
- Clements, G.N., 1987. Phonological feature representation and the description of intrusive stops. In: A. Bosch, B. Need, E. Schiller (eds.), *Papers from the 23rd regional meeting of the Chicago Linguistic Society, Part 2: Parasession on autosegmental and metrical phonology*, 29–50. Chicago, IL: Chicago Linguistic Society.
- Cook, V.J., 1988. *Chomsky's universal grammar*. New York: Blackwell.

- Davis, S., 1989. The location of the feature [continuant] in feature geometry. *Lingua* 78, 1–22.
- Dinnsen, D.A., 1992. Variation in developing and fully developed phonologies. In: C.A. Ferguson, L. Menn, C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*, 191–210. Timonium, MD: York.
- Dinnsen, D.A., S.B. Chin, M. Elbert and T.W. Powell, 1990. Some constraints on functionally disordered phonologies: Phonetic inventories and phonotactics. *Journal of Speech and Hearing Research* 33, 28–37.
- Fee, E.J., 1991. *Underspecification, parameters and the acquisition of vowels*. Unpublished Ph.D. thesis, University of British Columbia.
- Fee, E.J., 1992. *Vowel acquisition in Hungarian: Evidence for an order of feature acquisition*. Paper presented at the Boston University Conference on Language Development.
- Ferguson, C.A., 1977. *New directions in phonological theory: Language acquisition and universals research*. In: R.W. Cole (ed.), *Current issues in linguistic theory*, 247–299. Bloomington, IN: Indiana University Press.
- Ferguson, C.A. and C.B. Farwell, 1975. Words and sounds in early language acquisition: English initial consonants in the first fifty words. *Language* 51, 419–439.
- Gamkrelidze, T.V., 1975. On the correlation of stops and fricatives in a phonological system. *Lingua* 35, 231–261.
- Gierut, J.A., 1992. The conditions and course of clinically-induced phonological change. *Journal of Speech and Hearing Research* 35, 1049–1063.
- Gierut, J.A., C.L. Simmerman and H.J. Neumann, 1994. *Phonemic structures of delayed phonological systems*. *Journal of Child Language*, to appear.
- Greenberg, J.H. (ed.), 1978. *Universals of human language, Volume 2: Phonology*. Stanford, CA: Stanford University Press.
- Ingram, D., 1981. *Procedures for the phonological analysis of children's language*. Baltimore, MD: University Park.
- Ingram, D., 1988a. The acquisition of word-initial [v]. *Language and Speech* 31, 77–85.
- Ingram, D., 1988b. Jakobson revisited: Some evidence from the acquisition of Polish. *Lingua* 75, 55–82.
- Ingram, D., 1989. *Phonological disability in children* (2nd ed.). San Diego, CA: Singular.
- Ingram, D., 1990a. The acquisition of the feature [voice] in normal and phonologically delayed English children. Paper presented at the American Speech–Language–Hearing Association Convention, Seattle.
- Ingram, D., 1990b. Toward a theory of phonological acquisition. In: J. Miller (ed.), *Research perspectives on language disorders*, 55–72. Boston, MA: College-Hill.
- Ingram, D., 1992a. The categories of phonological delay. Paper presented at Indiana University, Bloomington.
- Ingram, D., 1992b. Early phonological acquisition: A cross-linguistic perspective. In: C.A. Ferguson, L. Menn, C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*, 423–435. Timonium, MD: York.
- Iverson, G.K., 1989. On the category supralaryngeal. *Phonology* 6, 285–303.
- Kiparsky, P., 1982. Lexical morphology and phonology. In: The Linguistic Society of Korea (ed.), *Linguistics in the morning calm*, 1–91. Seoul: Hanshin.
- Kiparsky, P., 1985. Some consequences of lexical phonology. *Phonology* 2, 85–138.
- Leonard, L.B., 1992. Models of phonological development and children with phonological disorders. In: C.A. Ferguson, L. Menn, C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*, 191–210. Timonium, MD: York.
- Leonard, L.B., M. Newhoff and L. Mesalam, 1980. Individual differences in early child phonology. *Applied Psycholinguistics* 1, 7–30.
- Locke, J., 1983. *Phonological acquisition and change*. New York: Academic Press.
- Lombardi, L., 1990. The nonlinear organization of the affricate. *Natural Language and Linguistic Theory* 8, 375–425.
- MacWhinney, B., 1985. Hungarian language acquisition as an exemplification of a general model of grammatical development. In: D.I. Slobin (ed.), *The crosslinguistic study of language acquisition, Vol. 2: Theoretical issues*, 1069–1155. Hillsdale, NJ: Erlbaum.
- Maddieson, I., 1984. *Patterns of sounds*. Cambridge: Cambridge University Press.

- McCarthy, J.J., 1988. Feature geometry and dependency: A review. *Phonetica* 43, 84–108.
- Mohanan, K.P., 1992. Emergence of complexity in phonological development. In: C.A. Ferguson, L. Menn, C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*, 635–662. Timonium, MD: York.
- Paradis, C. and J.F. Prunet, 1991a. Introduction: Asymmetry and visibility in consonant articulations. In: C. Paradis, J.F. Prunet (eds.), *Phonetics and phonology, Vol. 2: The special status of coronals: Internal and external evidence*, 1–28. San Diego, CA: Academic Press.
- Paradis, C. and J.F. Prunet (eds.), 1991b. *Phonetics and phonology, Vol. 2: The special status of coronals: Internal and external evidence*. San Diego, CA: Academic Press.
- Pye, C., D. Ingram and H. List, 1987. A comparison of initial consonant acquisition in English and Quiche. In: K.E. Nelson, A. Van Kleeck (eds.), *Children's Language* 6, 175–190. Hillsdale, NJ: Erlbaum.
- Rice, K.D., 1992. On deriving sonority: A structural account of sonority relationships. *Phonology* 9, 61–99.
- Rice, K.D. and P. Avery, 1991. On the relationship between laterality and coronality. In: C. Paradis, J.F. Prunet (eds.), 1991. *Phonetics and phonology, Vol. 2: The special status of coronals: Internal and external evidence*, 101–124. San Diego, CA: Academic Press.
- Slobin, D.I., 1971. Data for the symposium. In D.I. Slobin (ed.), *The ontogenesis of grammar*, 3–14. New York: Academic Press.
- Smit, A.B., L. Hand, J.J. Freilinger, J.E. Bernthal and A. Bird, 1990. The Iowa articulation norms project and its Nebraska replication. *Journal of Speech and Hearing Disorders* 55, 779–798.
- Stoel-Gammon, C., 1985. Phonetic inventories, 15–24 months: A longitudinal study. *Journal of Speech and Hearing Research* 28, 505–512.
- Stoel-Gammon, C. and J.A. Cooper, 1984. Patterns of early lexical and phonological development. *Journal of Child Language* 11, 247–271.