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On the lawfulness of change in phonetic inventories

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Changes in the phonetic inventories of 34 children (ages 3;4 to 6;8) with functional (nonorganic) speech disorders were analyzed in terms of distinctive feature oppositions. All subjects received conventional minimal pair contrast treatment to induce changes in their phonetic inventories. The changes were found to be governed by the same principles that govern cross-sectional variation before treatment. Sounds were added (or lost) consistent with implicational relationships among feature distinctions as set forth in Dinnsen, Chin, Elbert and Powell (1990).

1. Introduction

It is well-established that linguistic systems can and do change either spontaneously or as a result of some outside force such as clinical intervention. Change is especially important in the linguistic systems of young children with speech disorders, because these systems need to change and generally require clinical intervention to effect the appropriate changes. Also, the type and amount of change that occurs in response to a particular form of treatment is an important measure of the effectiveness of that treatment. Moreover, to the extent that changes in linguistic systems are in any way orderly or principled, speech pathologists may be able to appeal to such

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principles in assessment, the selection of treatment targets, and the projection of learning patterns. Although change is fundamental to linguistic systems and to clinical intervention, many basic questions remain about the nature of change. For example, are there any linguistic principles that would predict the changes that actually occur? Is there a fixed order such that certain changes must occur before certain other changes? Is the course of change in normally developing systems the same as in disordered systems?

Many studies have either directly or indirectly addressed these questions with regard to the development of phonetic inventories, but with mixed results. The principal sources of information for normal development have come from large scale cross-sectional normative studies (e.g., Prather et al. 1975, Smit et al. 1990, Templin 1957; Wellman et al. 1931), diary studies (e.g., Leopold 1947, Menn 1976, Smith 1973), and other longitudinal studies (e.g., Vihman et al. 1986). Developmental norms have established the mean ages at which particular speech sounds are acquired by the majority of children. In general, phonetic inventories increase the number and type of sounds as children get older, although some cases of regression have been noted (see the discussion in Smit et al. 1990). Developmental norms are at least suggestive of a semi-orderly progression in the development of consonant inventories. There are, of course, many limitations in ascribing predictive value to these norms, especially with regard to the course of development for any individual inventory (Edwards and Shriberg 1983, Winitz 1969). In fact, the various diary studies and the small group longitudinal studies have revealed substantial individual differences in the order of acquisition of particular sounds. For example, although normative group studies have identified some sounds to be early developing and others to be later developing, it is not uncommon to find individual inventories that are missing early developing sounds even though they evidence later developing sounds. Additionally, studies that have compared phonetic inventories of normal and disordered subjects have found both similarities and differences (e.g. Crocker 1969, Leonard 1985, Menyuk 1968). Such comparisons tend, however, to be based on cross-sectional and averaged characteristics of groups rather than individual inventories and are moreover only hypothetically related to claims about the longitudinal development of any individual phonetic inventory. The relevance of cross-sectional variation to longitudinal variation needs to be established on the basis of facts from both domains for both groups and individuals. The purpose of this paper will be to establish certain facts about the nature of change by examining both the cross-sectional and longitudinal characteristics of phonetic inventories of young children with functional (nonorganic) speech disor-

ders. The results from an earlier study by Dinnsen et al. (1990) on the individual pretreatment phonetic inventories of 40 misarticulating children (cross-sectional) will be integrated with the results from this follow-up study on the cross-sectional and longitudinal characteristics of the same subjects' inventories following treatment. These facts will also serve as a further test of the principles set forth in the Dinnsen et al. study.

Based largely on the insights of Menyuk (1968) that the essential property of phonetic inventories is not the sounds per se but rather the features that distinguish sounds, Dinnsen et al. (1990) analyzed the pretreatment phonetic inventories of 40 children (ages 3;4 to 6;8) with functional (nonorganic) speech disorders to determine whether certain phonetic distinctions are common across inventories and whether certain phonetic distinctions are implicationally related. The study differed in at least one important respect from earlier studies in that it analyzed the inventories independent of the adult system or the child's substitutions. The analysis resulted in a typological characterization of the phonetic inventories such that an implicational or hierarchical relationship was revealed. The typology reduced the variety of inventories to five characteristically distinct types or levels of complexity.

Briefly, the simplest or most limited inventories were assigned to Level A because they included nonvowels that were limited to nasals, glides, and obstruent stops with no voice or manner distinction among the obstruents. The sonorant consonants were moreover limited to nasals. The next more complex type of inventory was assigned to Level B because it elaborated the Level A inventories solely by the inclusion of a voice distinction among the obstruent stops. The next more complex type of inventory was assigned to Level C because it elaborated Level B solely by the inclusion of a manner of articulation distinction. These inventories were typified by the inclusion of fricatives, affricates, or both, in addition to stops. Inventories of this type could differ, however, in the specific fricatives or affricates that occurred. The next more complex type of inventory was assigned to Level D because it elaborated Level C solely by the inclusion of a liquid consonant, either [l] or [r]. For all less complex inventories, all the sonorant consonants were nasals, but for Level D inventories, it was necessary to introduce a nasal/nonnasal distinction to differentiate between the nasals and either of the liquid consonants. The most complex type of inventory observed for this sample was assigned to Level E because it elaborated the Level D inventories by the inclusion of either a stridency distinction (e.g. [s] and [θ]), a laterality distinction (e.g. [l] and [r]), or both.

The typological characteristics of these various inventories represent impli-

cational relationships among general classes of sounds. This means that the use of any feature from a relatively complex level implied necessarily the use of all crucial feature distinctions (but not necessarily all sounds associated with those distinctions) from less complex levels. For example, any inventory that used a Level C distinction, that is, a manner distinction, also used all necessary features characteristic of Levels A and B, namely the major class features (characteristic of Level A) and voicing (characteristic of Level B). A Level C inventory did not, however, distinguish any sounds solely on the basis of nasality, stridency, or laterality and did not necessarily include all sounds associated with a voice or manner distinction. Likewise, more complex inventories, such as those assigned to Level E, included sounds from each of the less complex but implied levels. Thus, a phonetic inventory using a Level E distinction also employed a nasal/nonnasal distinction among the sonorants and voice and manner distinctions among the obstruents. This hierarchy presumably defines the lawful constitution of any given phonetic inventory, and as such represents an empirical hypothesis about how an individual inventory might be expected to change. The principal prediction would be that phonetic inventories can change only in conformity with one of the five established types. If true, changes that involve the acquisition of certain feature distinctions should imply necessarily the acquisition of certain other feature distinctions. For example, then, a Level C inventory might change by adding a stridency distinction (Level E) if and only if a liquid consonant (nasal/nonnasal distinction of Level D) were also added. Similarly, a Level A inventory might change to a Level C inventory by adding a manner distinction if and only if a voice distinction (Level B) were also acquired. These and other related predictions about the nature of change are evaluated against the facts of change established in the present study.

2. Subjects and methods

Thirty-four of the forty children studied in Dinnsen et al. (1990) with functional speech disorders participated in a treatment study that allowed changes in their individual phonetic inventories to be observed. Prior to treatment, subjects ranged in age from three years four months to six years eight months, produced a minimum of six sounds in error across three manner categories as determined by performance on the *Goldman-Fristoe Test of Articulation* (Goldman and Fristoe 1986), and scored within normal limits on all other tests, including those of hearing sensitivity and receptive vocabulary.

In order to promote some change in the phonological systems of these subjects, clinical treatment was provided. For a detailed description of the treatment, see Elbert et al. (1990, 1991). For each subject, three of the sounds that were produced in error were targeted for treatment. Of the targeted sounds, only those that remained stable (i.e., did not improve) during a baseline period were actually treated. Some of the targeted sounds for some subjects changed spontaneously and thus did not require direct treatment to induce a change. Consequently, all subjects received treatment on one to three sounds, using 3 to 10 exemplars per sound, with the majority requiring 5 or fewer exemplars before generalization occurred. Treatment consisted of conventional minimal-pair contrast training (e.g., Weiner 1981), continuing until a predetermined criterion level was achieved on treatment items. The time period from pre-to posttreatment ranged from 83 days to 409 days with a mean of 204 days. Treatment represented only a fraction of this time, because subjects were paired in a multiple baseline across subjects experimental design. That is, one subject of each pair was held in a baseline observation (no treatment) phase until treatment was completed for the other subject of the pair. In all cases, the posttreatment analysis was based on a probe (see below) elicited immediately following the completion of a subject's treatment.

For purposes of analyzing the posttreatment phonetic inventories and assessing change in those inventories, the same methods and materials employed in Dinnsen et al. (1990) for the analysis of pretreatment inventories were used. Specifically, a 306-item single-word spontaneous speech sample was elicited (before and) after treatment, using a probe procedure adapted from Gierut (1985). The entire speech sample was tape-recorded, and all items were phonetically transcribed by two independent judges (certified speech-language pathologists or graduate students in speech pathology), using a narrow form of the International Phonetic Alphabet with major diacritic markings. One-hundred percent of the transcribed consonants were compared for point-by-point agreement; all disagreements (the majority of which related to diacritic markings and voicing distinctions) were resolved by reexamination and consensus. Only fully resolved transcriptions served as the basis for all analyses.

Along the lines of Stoel-Gammon (1987) and Dyson (1988), any sound that occurred more than once in a speech sample was considered as occurring in the phonetic inventory of that system. For each subject, a chart displaying the occurring sounds in a conventional place, voice, manner format (for example, see Elbert and Gierut 1986) was prepared in order to facilitate further analysis of the phonetic inventory. A sound's occurrence was assessed inde-

pendently of its function within the system (that is, its phonemic status) or any substitution pattern.

Subsequent to the characterization of individual inventories, all posttreatment phonetic inventories were compared to one another and to pretreatment inventories to discover commonalities in the use of distinctions or features and to determine the relationship, if any, to previously proposed principles governing cross-sectional variation. The primary focus of the comparison was in terms of required feature distinctions.

3. Results and discussion

A central concern of this study was to determine how inventories changed and to what extent the posttreatment inventories conformed to the typological constraints that presumably govern pretreatment inventories, as set forth in Dinnsen et al. (1990). All subjects' phonetic inventories changed following treatment. That is, all subjects added sounds, lost sounds, or both. However, not all changes involved English sounds, nor were all changes directly attributable to the treatment. That is, the sounds added were not always those treated, and the sounds treated were not always added. In addition, some of the changes entailed changes in the typological characteristics of an inventory by adding (or losing) sounds associated with crucial feature distinctions. Other changes also occurred without any change in the typological characteristics of an inventory.

3.1. Typological conformity

Despite differences in the number and types of specific sounds treated and despite individual differences in how inventories changed, no inventory after treatment deviated from the pattern of levels and implications established for pretreatment inventories. Each of the 34 posttreatment inventories could be uniquely and unambiguously assigned to one of the preestablished levels of complexity.

The nature of the posttreatment inventories and the lawfulness of the changes that produced them are described in more detail below. Table 1 presents representative examples of the full range of posttreatment inventories, along with the pretreatment inventory for that subject and its level characterisation. Also given are the relevant features that are added at each level. In this table and all subsequent discussion, subject numbers are consistent with those in Dinnsen et al. (1990).

Table 1
Typology of posttreatment phonetic inventories for thirty-four functionally misarticulating children.

	Posttreatment inventory	Pretreatment inventory
Level A: [syllabic], [consonantal], [sonorant]		
Subject 4:	b d g m n ŋ w j ʔ h	b d m n ŋ w j ʔ h (Level A)
Level B: [voice]		
	(No examples)	
Level C: [continuant], [delayed release]		
(1) Subject 26:	p b t d k g f v θ ð m n ŋ w j ʔ h	p b t d k g m n ŋ w j ʔ h (Level B)
(2) Subject 27:	p b t d f s z ʃ m n w j h	p b t d s z ʃ m n r w j ʔ h (Level D)
Level D: [nasal]		
Subject 16:	p b t d k f v m n ŋ l w j h	p b t d k v m n ŋ r w j ʔ h (Level D)
Level E: [strident], [lateral]		
(1) Subject 15:	p b t d k g f v θ ð s z ʃ ʧ ʤ m n ŋ l w j ʔ h	p b t d k g f v θ ð ʃ m n ŋ l w j ʔ h (Level D)
(2) Subject 30:	p b t d k g f v θ ð s z ʃ ʧ ʤ m n ŋ l r w j h	p b t d k g f v s ʃ d͡z ʧ ʤ m n ŋ w j ʔ h (Level C)

Note: Relevant features added at each level are listed after the level indication. Examples of posttreatment inventories are given for each level, along with the pretreatment inventory and level for each example subject.

The only example of a Level A posttreatment inventory was for Subject 4, whose pretreatment inventory was also the only example of a Level A inventory. After treatment, the subject had added [g], extending his stop series to three places of articulation. A velar place of articulation, however, was already present in the nasal series before treatment, so even though the inventory increased in the actual number of sounds, this did not involve the addition of any new featural distinctions.

Although we believe that a Level B inventory is possible posttreatment, no examples were available in the present sample. The absence of Level B inventories posttreatment is most likely attributable to the limited number of Level A and B inventories pretreatment; pretreatment, there was only one Level A inventory and one Level B inventory.

There were three examples of Level C posttreatment inventories, two of which are presented in table 1. The first example of a posttreatment Level C inventory is for Subject 26, whose pretreatment inventory was characterized as Level B (i.e. a voice distinction but no manner distinction). After treatment, this subject had retained the voice distinction and had added a manner distinction, i.e., four fricatives at two places of articulation. Note that all of the added fricatives are anterior, and further, that although there are both strident and nonstrident fricatives in the posttreatment inventory, they do not constitute a stridency distinction (a Level E distinction), because they have different places of articulation. Thus, the stridency of the fricatives in this inventory is redundant or predictable from the place of articulation of the fricatives.

The second example of a Level C posttreatment inventory in table 1 is from Subject 27, whose pretreatment inventory was characterized as Level D, i.e. a voice and manner distinction among obstruents and a nasal/nonnasal distinction among sonorant consonants. This child originally had an [r] in his inventory, albeit infrequently; after treatment, this sound did not occur in the inventory. Note, however, that the actual number of sounds remained unchanged pre- to posttreatment, because this subject continued to fill in gaps in the fricative series. More will be said below about this as a form of regression.

Two subjects exhibited Level D inventories posttreatment. The example of a posttreatment Level D inventory in table 1 is from Subject 16, whose pretreatment inventory was also at Level D. Although the pretreatment inventory had occurrences of [r], the posttreatment inventory revealed the loss of this sound but the addition of [l]. Thus, although one sound was lost, another was added; but the typological complexity of the inventory remained unchanged.

Twenty-eight of the subjects exhibited Level E inventories posttreatment. The first example of a posttreatment Level E inventory in table 1 is for Subject 15,

whose pretreatment inventory was classified as Level D. This subject originally had interdental fricatives, but after treatment, she also had alveolar fricatives, having added a stridency distinction for [+anterior, +coronal] fricatives. (Affricates were also added.) The second example of a posttreatment Level E inventory in table 1 (Subject 30) developed from a pretreatment Level C inventory by the addition of both a stridency distinction and a laterality distinction.

One further example of a change from Level C to Level E is shown in table 2, which shows the pre- and posttreatment inventories for Subject 3.

Table 2
Lawful increase in phonetic inventory complexity: Pretreatment Level C to posttreatment Level E (Subject 3).

Pretreatment phonetic inventory: (Level C)	p	b	t	d		k	g	
	f	θ	ð					
		m		n			ŋ	
		w				j		h
Posttreatment phonetic inventory: (Level E)	p	b	t	d		k	g	
	f	v	θ	ð	s z			
		m		n			ŋ	
				l				
		w				j		h

Note that this subject's pretreatment inventory included all necessary distinctions associated with Level C (i.e. a voice and manner distinction), but the subject did not have a liquid consonant (i.e. a nasal/nonnasal distinction) or a stridency distinction among fricatives. For this subject, treatment targets were /d/ versus its substitute [t] in final position, /θ/ versus its substitute [f] in initial position, and /s/ versus its substitute [θ] in final position. Note that one component of the treatment was directed at a Level E distinction; that is, the stridency distinction that differentiates [s] from [θ] was the focus of one treatment pair. Also, note that no treatment was directed toward acquisition of a liquid consonant, which is in principle differentiated from nasal consonants at Level D. The stridency distinction, a Level E distinction, was acquired following treatment, as might be expected, because it was one focus of treatment; but along with that, a liquid consonant, that is, a sound reflecting an implicationally related Level D distinction, was also acquired without direct treatment.

The latter two examples crucially illustrate the implicational nature of the hierarchy and its relationship to the principles that govern change, More specifically, of the thirty-four subjects who completed the treatment program,

there were six subjects who had pretreatment Level C inventories and posttreatment Level E inventories. In half of these cases, treatment was directed at some sound involving a Level E distinction. In the other half, treatment focused on some sound involving distinctions from less complex levels. In all of these cases, however, not only were Level E distinctions acquired, but so was the untreated but implicationally necessary nasal/nonnasal distinction associated with Level D. In such cases, it seems possible that treating a Level E distinction may have facilitated the acquisition of the Level D distinction, because it remains true, at least descriptively, that no inventory had a Level E distinction without also having the requisite Level D distinction. This has important clinical implications, as will be discussed below, and should be further tested experimentally.

3.2. Regression

Although treatment was generally successful in that the majority of the subjects generalized by increasing the number of sounds in their inventories and/or advanced from one level of complexity to another by critical feature additions, in a few cases, treatment did not yield this effect. That is, in some cases, subjects who showed correct productions during treatment sessions failed to generalize those productions in the posttreatment speech sample. In even fewer cases, subjects actually lost sounds that were only minimally represented in their pretreatment inventories. Such losses of sounds in some cases involved the loss of a distinction characteristic of a particular level; and so in terms of our hierarchy, such subjects actually regressed in the complexity of their phonetic inventories. Table 3 presents an example of such a regression.

Table 3
Lawful decrease in phonetic inventory complexity: Pretreatment Level D to posttreatment Level C (Subject 20).

Pretreatment phonetic inventory:	p	b		t	d		k	g
(Level E)	f	v	θ	ð				
			t͡θ	d͡ð				
	m			n			ŋ	
				l		r		
	w					j		ʔ h
Posttreatment phonetic inventory:	p	b		t	d		k	g
(Level D)	f	v	θ	ð				
			t͡θ					
	m			n			ŋ	
				l				
	w					j		h

Subject 20's pretreatment inventory was characterized as a Level E inventory in that it had a laterality distinction among the liquid consonants along with all required distinctions of simpler levels. The nonoccurrence of [r] in the posttreatment inventory signalled the loss of the laterality distinction. All other distinctions were retained. Consequently, the posttreatment inventory was assigned to Level D. Two other subjects also evidenced similar regressions, one of which was described in the discussion of the posttreatment typology in table 1, Level C, Subject 27. Importantly, however, in all of these cases of regression the posttreatment inventory could still be assigned to one of the established levels. In all of these cases, the sounds lost reflected the most complex distinction characteristic of a level, and no inventory regressed more than one level. Thus, to the extent that the inventory levels represent a hierarchy or order of acquisition, it would seem that the weakest distinctions are those last acquired; and if regression occurs, it is the last acquired that is the first lost.

The question may arise at this point whether the loss of any (English) sound from an inventory is a case of regression. Certainly, in the broad sense of 'regression', any reduction in complexity would be. However, it is perhaps important to differentiate between segmental complexity on the one hand and featural or typological complexity on the other, as regards phonetic inventories. The view being taken here is that an increase or decrease in the complexity of a phonetic inventory involve features rather than specific segments. In a narrow view (i.e., the one taken here), then, 'regression' occurs only if there is a decrease in featural complexity.

Consequently, although inventories change by adding or losing various different sounds, certain patterns emerge if those changes are viewed as changes in the instantiation of feature distinctions. Those distinctions are either preserved, added, or lost consistent with the principles that govern the five typologically distinct but implicationally related levels of complexity. The lawful properties of inventories appear to be formulated in terms of a limited set of implicationally related feature distinctions and not sounds per se. One pattern of change, then, might be labelled 'level-internal change', which involves the addition (or loss) of sounds consistent with the inventory's existing critical feature distinctions. In such cases, the typological characteristics of the inventory do not change even though the set of sounds in the inventory has changed; the inventory maintains the same level of featural complexity. Thus, a typical Level C inventory with only the one fricative [s] and all stops except for velars could, for example, add [k] or [g] because stops and a voice distinction already exist in the inventory or could as well add affricates or other fricatives (except for [θ]), because a manner distinction already exists in the inventory. All these changes would be consistent

with the preservation of a Level C inventory. We would, however, not expect in the case of level-internal change for such an inventory to add the fricative [θ]. The reason is that the addition of [θ] would introduce a stridency distinction which implies a nasal/nonnasal distinction which would necessitate the addition of at least one liquid consonant. Subjects in our study who exhibited level-internal change included Subjects 4 and 16, whose inventories are displayed in table 1.

The other pattern of change could be labelled 'level-external change' and involves the addition (or loss) of sounds that change the typological characteristics of the inventory. In such cases, the featural complexity of the inventory is increased (or decreased). This latter type of change is especially interesting because it necessitates certain other changes. That is, because every inventory at any point in time must be well-formed (at least according to the principles set forth herein), and because these principles specify an implicational relationship, the addition of a relatively complex distinction to a relatively simple inventory can occur only if all implicationally related distinctions are also added. Subjects from our study who exhibited level-external change included Subjects 15, 26, 27, and 30 in table 1; Subject 3 in table 2; and Subject 20 in table 3.

It may be noted that level-internal change and level-external change are not mutually exclusive categories. In fact, of our 34 subjects, 15 displayed both types of change. Of the remaining 19 subjects, 18 showed only level-internal change, and 1 showed only level-external change.

If level-external change and level-internal change are indeed governed by constraints expressed in terms of implicationally related feature distinctions as set forth here, some insight is afforded concerning the apparent contradiction of, on the one hand, orderly development as seen in developmental norms and, on the other, widespread individual differences. That is, one reason that individual differences arise is because the constraints that govern inventories are defined in terms of general feature distinctions that can be satisfied by any one of a number of sounds. Thus, with or without treatment, many different changes are possible that are consistent with level-external change and level-internal change. For example, a child with a very limited Level C inventory could effect level-internal change by filling in any or all voiced/voiceless gaps in the stops, fricatives and/or affricates. This is precisely the finding commonly reported in treatment research (e.g. Elbert et al. 1967, Tomes 1990) in which treatment on one sound often results in correct production of its voiced/voiceless cognate. Since the vast majority of inventories already include a voice distinction, it is predicted by level-internal change that other voiced/voiceless pairs will likely (but not necessarily) be added to those inventories.

The apparent orderly development of inventories also obtains and seems to be largely attributable to the other pattern of change, namely level-external change, because there are fairly strict requirements on what distinctions must occur if a particular distinction is to be added to the inventory. Thus, a voice distinction will be added before (or concomitant with) a manner distinction, a manner distinction before a nasal/nonnasal distinction, and a nasal/nonnasal distinction before either a stridency or laterality distinction. Level-external change will also be the principal source for the common but seemingly problematic changes of the sort where a later developing sound (according to developmental norms) such as [l] is added to an inventory before an early developing sound such as [f]. This is precisely what would be expected, for example, for a child with a Level C inventory and [s] as the only fricative. The typological characteristics of the inventory would change to Level D with the addition of [l] associated with the nasal/nonnasal distinction; subsequently, the [f] could be added by means of level-internal change, because a manner distinction already existed in the inventory. In other words, all cases of the sort where a later developing sounds occurs before an early developing sound will arise from level-external change preceding some or all of the possible level-internal changes.

3.3. Clinical implications

Both level-internal change and level-external change have potential implications for various aspects of clinical intervention. First, for purposes of assessment, it should be possible to determine to what extent a child's phonetic inventory conforms to one of the established levels of complexity. Based on this assessment, either or both types of change will be called for. Treatment targets can then be selected in accord with one or the other type of change, whichever is deemed most appropriate. Thus, if the goal of treatment were to induce typological change to increase the typological complexity of the inventory, then a sound or pair of sounds reflecting an implicationally more complex distinction might be selected for treatment. For example, then, a child with a Level C inventory (i.e. a voice and manner distinction but no liquid consonants and no stridency distinction) might be taught the stridency distinction (i.e. [s] vs. [θ]) from Level E. If the Level E distinction were acquired, the typological complexity of the inventory should have increased. More importantly, we could expect a liquid consonant associated with a Level D distinction to also be acquired without direct treatment on that class of sounds. However, other gaps in the inventory may or may not persist, because there is nothing about this type of change that requires all the sounds associated with a particular distinction to

occur. Another example along the same lines would select the liquid consonant [l] as a treatment target for a subject with a Level B (i.e. a voice but no manner distinction) inventory. The addition of [l] to the inventory would introduce a nasal/nonnasal distinction among sonorant consonants, which according to the hierarchy implies a manner distinction among the obstruents, which should facilitate the addition of at least one fricative or affricate without direct treatment on that class of sounds.

If, on the other hand, the goal of treatment were to induce level-internal change in order to fill in missing sounds consistent with the existing distinctions of the current level of complexity, then the sound(s) selected for treatment might relate to implicationally equal or less complex distinctions. For example, a child whose consonantal inventory was limited to [w], [j], [m], [n], [p], [t], and [s] (i.e. a Level C inventory) might be treated on either the voice distinction (e.g., [d] vs. [t]), the manner distinction (e.g., [f] vs. [p]), or even a place distinction (e.g. [k] vs. [t]). Under this treatment plan, however, liquid consonants and [θ] would not be targeted for treatment, because such sounds relate to implicationally more complex distinctions than those already evident in the child's inventory. While the typological complexity of the inventory may increase spontaneously, this treatment plan in no way necessitates such a change. Ultimately, then, if the typological complexity of the inventory does not increase, additional treatment of the sort described above may be required.

It remains to be determined whether there is any difference in the relative ease (or difficulty) of inducing either type of change with treatment. It is possible that treatment directed at the different types of change could result either in differences in the time required to acquire the treatment target or in differences in the extent and type of generalization to other untreated sounds and distinctions. It is likewise unknown whether different treatment methods, such as conventional minimal pair (e.g., Weiner 1981), maximal opposition (Gierut 1989), cycles (Hodson and Paden 1983), or traditional (see Bernthal and Bankson 1988) will be more or less successful when directed at either of these two types of change. That is, one approach to treatment may be more conducive to effecting level-external change, whereas another approach may be more conducive to effecting level-internal change.

Finally, although clinical intervention could in some sense be viewed as an 'unnatural' or artificial mode of linguistic input for a child, it is noteworthy that treatment, at least as presented in this study (and elsewhere we believe), has not yielded phonetic inventories or changes in phonetic inventories that are in any sense unnatural or that depart from the typological characteristics of pretreatment inventories.

4. Conclusion

All the inventories in this study changed following treatment by adding or losing various sounds. Despite individual differences in treatment and change, all the changes resulted in individual phonetic inventories that were entirely consistent with the typological characteristics of pretreatment inventories. It would, thus, appear that change is governed by the same principles that govern cross-sectional variation as set forth in Dinnsen et al. (1990). Those principles restrict the range of possible inventories to five typologically distinct but implicationally related types. The only changes, then, that are possible are those that will result in one of the five permissible types of inventories. The implicational nature of these principles further imposes a strict acquisitional order such that certain changes can occur only if certain other changes also occur. Thus, the acquisition of a stridency or laterality distinction is dependent on the acquisition of a nasal/nonnasal distinction among the sonorant consonants. Additionally, the acquisition of a nasal/nonnasal distinction is dependent on the acquisition of a manner distinction among the obstruents. The acquisition of a manner distinction is in turn dependent on the acquisition of a voice distinction. And finally, the acquisition of a voice distinction is dependent on the acquisition of the major class distinctions [consonantal], [sonorant], and [syllabic].

Two basic patterns of change have emerged, namely level-external change and level-internal change. Taken together, they provide a principled account for individual differences that are consistent with both orderly development and apparent exceptions. These findings have clinical implications that will need to be evaluated experimentally.

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