To the Graduate Council:

I am submitting herewith a thesis written by Lori Ann Bass entitled "Patterns in the Phonological Development of Children with Down Syndrome." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master's of Arts, with a major in Speech-Language Pathology.

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PATTERNS IN THE PHONOLOGICAL DEVELOPMENT OF CHILDREN WITH DOWN SYNDROME

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DEDICATION

This thesis is dedicated to the children and families who participated in the project. Their enthusiastic interest in and support for this study allowed an idea to become a reality.

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Abstract

Down syndrome is a genetic disorder that has several well-documented characteristics, not the least of which is delayed speech and language development. The delay in speech and language development emerges in infancy and is present throughout the course of development. The research purposes of the present study were to determine: (1) if the patterns of phonological development in children with Down syndrome were similar to those predicted by their general developmental levels; (2) whether unusual phonological behavior was characteristic of the speech of children with Down syndrome; and (3) whether these children were able to perceive their own production errors. Five children with Down syndrome (one male, four female) between the ages of four years and seven years served as subjects. All subjects were administered an assessment battery that included a language test, an oral mechanism screening, an articulation test, a language sample, and a perceptual assessment.

The results indicated that these children with Down syndrome showed greater delays in their phonological development than predicted by their general developmental levels. There was a large amount of individual variation across subjects in both the complexity of and patterns within each phonological system. The phonological patterns of these subjects were captured in a broad manner using phonological processes. In contrast, the independent analysis combined with the child-based relational phoneme collapses provided more focal descriptions. Unusual phonological behaviors were not a primary characteristic of the speech of these children with Down syndrome: Three subjects each produced one unusual form. The results of the Speech Production-

Perception Task were generally unreliable across subjects. Only one subject was able to complete any portion of the task.

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Chapter I

Review of the Literature

Introduction to Down syndrome

Down syndrome is a genetic disorder that is typically diagnosed at birth. This disorder has a prevalence rate of 1:600-700 births (Cole & Cole, 1989). Individuals with the disorder present a wide range of characteristics, most notably the presence of 47 chromosomes rather than the normal 46. Unaffected persons have two chromosomes at each of the 23 positions. Ninety-five percent of individuals with Down syndrome have three chromosomes in the twenty-first position, or trisomy 21 (Cole & Cole, 1989). The remaining five percent will have a chromosomal rearrangement (translocation), or mosaicism (Koch, Fishler, & Melnyk, 1976). An individual who is karyotyped as mosaic will have a ratio of normal cells with 46 chromosomes to abnormal cells with 47 chromosomes. The degree of involvement in individuals with mosaicism is variable and dependent solely upon the ratio of normal to abnormal cells (Koch et al., 1976). In translocation, one of the paired twenty-first chromosomes will have migrated to another chromosome, leaving only one chromosome in the twenty-first position (Cole & Cole, 1989). Translocation is the form of Down syndrome which is hereditary (Koch et al., 1976).

The gene mutation that causes Down syndrome occurs during the meiotic division of the ova. It appears to be caused by exposure to environmental factors such as viruses, pollutants, and radiation. Advanced maternal age has been identified as a factor in increasing the risk of having a child with Down syndrome. The older a woman is, the more exposure she has had to harmful environmental factors. However, research has shown that older fathers could be responsible for up to twenty-five percent of the cases of Down syndrome (Davison & Neale, 1990).

There are a number of physical features that are usually present in individuals with Down syndrome. These features include: epicanthal folds of the eyelids; flat facial profiles; larger, protruding tongues; mouths that may be small with lower than normal roofs; delayed eruption of the teeth, malocclusions; abnormal size, structure, and placement of the ears; short necks; and short, broad hands and feet (Jung, 1989).

Persons with this disorder have a greater likelihood of general developmental delays, thyroid abnormalities, and cardiovascular problems. About forty percent of children with Down syndrome will have congenital heart disease severe enough to warrant medical intervention. One hundred percent of these children will have hypotonia which will contribute to the general developmental delays. The degree of these impairments will vary across children. Additionally, fifty percent of children with Down syndrome will have correctable visual difficulties (Crocker & Rubin, 1989; Jung, 1989).

Between fifty to seventy-five percent of children with Down syndrome will have recurrent serous otitis media (Crocker & Rubin, 1989). Schwartz (1990) has hypothesized that the high occurrence of middle ear pathologies in these children may be a factor in their poor perceptual and productive phonological abilities. A study investigating whether otitis media affects later phonological development was completed using normally developing subjects (Roberts, Burchinal, Koch, Footo, & Henderson, 1988). Previous studies found conflicting evidence for and against the role of early otitis media in phonological disorders, with the authors concluding that differences in methodology was the causal factor.

In the Roberts et al. (1988) study, 55 normally developing children between the ages of 2 years 6 months and 8 years 0 months were followed longitudinally for five years. The results of this study appear to indicate that there is not a significant relationship between number of incidents of otitis media in the first three years of life and the number of common phonological processes seen until 4 years 6 months. However, the authors reported that the children who had the highest incidence of early otitis media used twice the number of phonological processes between the ages of 4 years 6 months and 7 years 0 months than children who had lower incidences of early otitis media.

As all individuals with Down syndrome will suffer from hypotonia, it is important to look at its potential effects upon motor function. Of interest to the speech-language pathologist is the impairment in oral-motor functioning. Spender et al. (1995) studied three sets of fraternal twins in which the female of the twin pair had Down syndrome and the male was unaffected. The subjects' ages ranged from 11 months to 16 months. Each subject was given the Schedule for Oral Motor Assessment (SOMA; Skuse, Stevenson, Reilly, & Mathisen, in press) and results from this study showed that the areas of greatest impairment appeared to be in the lips, tongue, and jaw. In the infants with Down syndrome, the authors found lip closure to be less continuous and more intermittent than that seen in the unaffected twins. It was reported as well that both the upper and lower lips of the affected twins appeared to be less active during eating. Tongue protrusion was reported to be common in the infants with Down syndrome, while there was no instance of this behavior in the unaffected twins. Jaw strength was also reported to be inadequate in the infants with Down syndrome, as measured by the inability to bite off a piece of cracker. The authors concluded by stating that they attributed the differences between the typically developing subjects and the subjects with Down syndrome to deviant development.

Beckman (1990) describes characteristics of the hypotonic face. She lists illustrations of the ranges of motion or appearances one could expect to see in the following areas: lips, gums, cheeks, jaw, palate, tongue, and teeth. She indicated that characteristics of the lips include: limited range of movement at the corners, protrusion at the midline, a flaccid lower lip, dimpling around the lips during lip rounding, and weak strength especially at the midline. Characteristics of the cheeks include: limited range of movement, puffiness along the jaw line, and a possibility that the right cheek may be tighter than the left. The jaw may present with weak strength, especially when closing on hard items, open positioning, vertical movements during chewing, and bruxism (grinding of the teeth). Beckman (1990) also states that the tongue may be thickened and puffy, while showing a depression at the midline. The tongue may also show a limited range of movement, and may show fasiculations both at rest and during movement.

Throughout their lifespan, individuals with Down syndrome will be more prone to several other health problems such as leukemia and respiratory infections (Cole & Cole, 1989). Researchers have also found that a plaquing, or coating, of the axons of the neurons occurs in some individuals with Down syndrome between the ages of 40 and 50. This plaquing appears to be similar to that of Alzheimer's disease and is implicated in the high mortality rate after the age of 40 (Davison & Neale, 1990).

A majority of individuals with Down syndrome have some degree of mental retardation. When mental retardation is present, the degree of impairment usually falls in the mild to moderate categories (75-40 IQ; Davison & Neale, 1990). In light of both the high incidence of developmental delay and mental retardation, it is not unexpected that children with Down syndrome acquire developmental milestones more slowly than normally developing children. As an example, Crocker and Rubin (1989) state that the average age for a child with Down syndrome to begin walking is 24 months (range 12-65 months), whereas the average age for a normally developing child is around 13 months.

Previous Research

Early Vocalizations

Given that there are delays in the emergence of motoric milestones for children with Down syndrome, it follows that the onset of prespeech vocalizations would also be delayed in these children. Prespeech vocalizations go through a number of stages in both normal and Down syndrome infants. According to Stark (1980) these stages and their approximate ages of emergence in normally developing infants are: (1) reflexive vocalizations, 0-6 weeks, (2) cooing, 6-16 weeks (3) vocal play, 16-30 weeks (4) reduplicated (canonical) babbling, 6-10 months (5) nonreduplicated (variegated) babbling, 10-14 months, and (6) single-word productions, approximately 10 months.

Research has indicated that the vocalizations of infants with Down syndrome pass through these stages within the time range for normal development (Oller, 1978; Oller, Leonard, Rice, Locke, & Chapman, 1995; Smith & Oller, 1981). However, this is not to say that the vocalizations of the two groups are identical. Berger and Cunningham (1983) found that infants with Down syndrome had lower vocalization levels as compared to normally developing infants until four months of age. At this age, the amount of vocalization began to approach the level seen in the normally developing infants. Smith and Oller (1981) indicated that infants with Down syndrome appeared to produce a greater number of labial trills, or raspberries, than normally developing infants between the ages of 6 and 12 months.

Smith and Oller (1981) also investigated vowel quality in the prespeech vocalizations of both typically developing infants and those with Down syndrome. The authors state that both groups of infants appeared to favor front and central vowel positions over vowels in back position. However, the infants with Down syndrome showed frequencies of occurrence across all vowel positions that were more variable than the frequencies of occurrence observed in typically developing infants from the ages 0 to 15 months.

Canonical Babbling

Some studies have investigated the emergence of canonical babbling in infants with Down syndrome and those infants who are normally developing. Canonical babbling is defined as a consonant-vowel (CV) syllable. When these syllables emerge, they are reduplicated in the child's vocalizations and more closely resemble speech in their timing (Stark, 1980). Again, canonical babbling first appears in a normally developing child's behavioral repertoire at 6-10 months of age (Stark, 1980). Interestingly, canonical babbling in children with Down syndrome appears to emerge only about eight weeks later than in typically developing children. This is within the range observed for typically developing infants (Oller et al., 1995). In contrast, canonical babbling in children with severe or profound congenital hearing impairments begins to appear after 10 months of age (Oller, Eilers, Bull, & Carney, 1985; Oller et al., 1995).

Some differences in the canonical babbling of infants with Down syndrome have been reported. Steffens, Oller, Lynch, and Urbano (1992) studied the onset of canonical babbling in 27 typically developing infants and 13 infants with Down syndrome. All subjects were followed from 4 to 18 months of age, and were seen individually for bimonthly recording sessions to investigate the age of onset and stability of canonical syllables in each infant's babbling. The canonical syllable ratio was calculated for each infant by dividing the number of canonical syllables by the total number of syllables in each infant's vocalization sample. These researchers reported that typically developing infants had a reliably higher proportion of sessions meeting the canonical syllable ratio of .15 than did infants with Down syndrome (e.g., $t(17) = 2.12$, $p < .05$). This ratio indicates a greater frequency of post-onset canonical babbling for the normally developing infants. In additional support of this finding, one recent study indicated that the syllables in the canonical babbling of infants with Down syndrome appeared to be less stable over time than what was observed for typically developing infants (Lynch et al., 1995).

Early Language Development

The age of emergence of first words and multi-word utterances for children with Down syndrome is delayed (averaging 16 and 28 months, respectively; Crocker & Rubin, 1989) when compared to the ages of emergence observed in typically developing children, (first words averaging approximately 10 months; Stark, 1980; multi-word utterances averaging 21 months; Crocker & Rubin, 1989). Several factors influence the ages of onset for first words and multi-word utterances in children with Down syndrome. Some of these factors include the degree of developmental delay, the degree of mental retardation, and the child's environment (Jung, 1989; Koch et al., 1976). Stoel-Gammon (1981) found that on average, infants with Down syndrome typically begin producing meaningful speech about seven months later than normally developing children.

One study indicated that infants with Down syndrome may have difficulties with early turn taking (Berger & Cunningham, 1983). By five to six months of age, the typically developing infants began to show a decrease in the amount of vocalization while their mothers were talking; in other words, a decrease in clashing. Clashing is defined as concurrent vocalization by two individuals. The normally developing infants in the study also showed an increase in vocalizations while their mothers were silent. The authors suggest that this may be indicative of a shift toward more active listening and discrimination of speech and early turn-taking. The infants with Down syndrome did not show a similar decrease in clashing. Rather, the data indicate that there was a sharp increase in the amount of clashing for these infants (Berger & Cunningham, 1983). Though not explicitly stated, this finding suggests that infants with Down syndrome may not make the same shift toward more active listening and discrimination of speech or engage in early turn-taking as normally developing infants.

Oller (1978) states that some ability to imitate is necessary for the emergence of speech. He claims the morphemes must be coded receptively so that they can be reproduced and recognized by a listener. Although studying imitation in two groups of children with Down syndrome with mean ages of 73 and 74 months, Sokolov (1992) reported differences in the amount and progression of imitation in children with Down syndrome. He reported that children with Down syndrome imitated their mothers less than normally developing children. Sokolov also reported that the normally developing children showed a sharp decrease in imitation of speech as their mean length of utterance (MLU) increased. Some decrease in imitation was noted for the children with Down syndrome as their MLUs increased, but it was not the same sharp decrease seen in normally developing children. Sokolov (1992) summarized these findings by stating that the different rate of change in imitativeness observed in these children may be indicative of a developmentally different pattern of behavior.

Speech Perception

The development of speech perception in children is a necessary prerequisite to the development of speech production. This is well evidenced in studies examining the onset of pre-meaningful and meaningful vocalizations in infants who are hearing impaired. Infants with hearing impairment show delayed patterns of development in their prespeech vocalizations not observed in any group of hearing infants (Lynch et al., 1995; Oller et al., 1985; Oller et al., 1995).

Most of the research in infant speech perception has focused on normally developing infants' perceptions of categorical, or consonantal, stimuli. Typically developing infants' perceptions of voicing contrasts have been studied the most extensively. Eimas, Siqueland, Jusczyk, and Vigorito (1971) reported that one to four month old normally developing infants were able to discriminate /ba/ versus /pa/ across phonemic categories. However, these infants were not able to discriminate within either phonemic category.

Additional research has looked at normally developing infants' perception of place of articulation. The data indicate that normally developing infants at two months of age appear able to discriminate place of articulation among stop consonants (Miller & Morse, 1976; Moffitt, 1971; Morse, 1972). However, it appears that normally developing infants have more difficulty discriminating the place of articulation for fricatives than for stop consonants. Some studies have reported that infants were unable to discriminate certain fricative contrasts (e.g., Eilers, Wilson, & Moore, 1977), while others have reported that infants were able to discriminate the same contrasts categorically, and in more than one position (e.g., Eilers & Minifie, 1975). Differences in methodology may be the causal factor in the discrepancies between the results of these studies.

In contrast, Eilers, Bull, Oller, and Lewis (1985) reported that infants with Down syndrome at the canonical babbling stage may have difficulty discriminating place of articulation contrasts in fully formed syllables. The authors reported that when the syllabic rate was slowed to more closely match pre-canonical (marginal) babbling rates, the ability to discriminate improved in these infants.

Although additional research on the speech perception abilities of infants with Down syndrome needs to be completed, some speculations can be made from the existing body of research. Research on the early vocalizations of infants with Down syndrome has shown that differences exist when compared to the early vocal development of normally developing infants. These differences include: a lack of variation in canonical babbling (Smith & Oller, 1981), less stability in the syllables of canonical babbling (Lynch et al., 1995), greater variability in vowel quality, and more frequent use of labial trills as compared to normally developing infants (Smith & Oller, 1981). The emergence of canonical babbling is later in infants with Down syndrome, although it is still within the range for normal development (Oller et al., 1995). Clashing in these infants appears to increase sharply at the same time there is a decrease in this behavior in normally developing infants (Berger & Cunningham, 1983). Additionally, Eilers et al. (1985) reported that infants with Down syndrome may have difficulty in discriminating place of articulation in canonical syllables. When all of these factors are taken together, it would not be unexpected to find that children with Down syndrome have more sound errors as the result of perceptual difficulties.

Overview of Dual Lexicon Theory

Studies have shown that phonologically disordered but otherwise normally developing children tend to have difficulty perceiving sounds in error, especially within the context of that error (Locke, 1980a,b). Such results prompted Locke (1980a,b) to claim that the perceptual difficulties a child presents may be linked to his or her production difficulties.

This evidence also calls into question any given child's knowledge of the ambient phonological system. The child's production may or may not be a realization of what the child has learned about the sound system of the ambient language. To account for this possibility, one theory has postulated the notion of levels of representation. In the dual-lexicon theory, each individual has two levels of representation for the sounds of the ambient language. These levels are termed the underlying representation and phonetic representation. Phonological rules intercede between these representations to cause the contextual changes observed in the phonetic representation.

Dinnsen (1984) described the underlying representation as a lexicon that includes the unpredictable properties of pronunciation and the phonemic properties of the ambient phonological system. The phonetic representation contains the predictable and unpredictable properties for production of the ambient phonological system. The phonological rules that transform the underlying representation into the phonetic representation are the regularities and patterns for pronunciation.

Locke (1980a,b) alludes to, and Dinnsen (1984) states that a child who evidences production errors may have a different underlying representation for the sound in error, at least in that particular context. There are several different ways to assess a child's underlying representation. These include identifying: morphophonemic alternations, imperceptible acoustical differences, the presence of neutralization rules, differential phonological behavior, and the nature of change in the child's phonological system. A morphophonemic alternation refers to different productions of a morpheme when that morpheme is placed in another environment. For example, a child who produces 'dog' as [dɔ:] and 'doggie' as [dɔgi] is showing evidence of a morphophonemic alternation. Additionally, children may also make imperceptible acoustic distinctions between phonemes that can be detected spectrographically. Thirdly, a given child may show evidence of neutralization rules. Neutralization rules operate under the following circumstances: there must be an alternation, and the alternating segments must contrast phonemically in some contexts, but not in other well-defined contexts. Next, children can show evidence of differential phonological behavior. This can be seen in the following example: three normally developing children produced "toot" as [tuw?] and "suit" as [tuwt]. The occurrence of [t] is conditioned by context in these children's productions, hence differential phonological behavior. Finally, the nature of change in a child's system can indicate the representations of an item in a child's lexicon. If the child has the correct (ambient) underlying representation, then change in that child's system will occur across all positions and all words. On the other hand, if change is restricted to only one lexical item at a time, the child may be showing evidence for idiosyncratic or systematically different underlying representations (Maxwell, 1984).

Speech Production-Perception Task

One additional way to assess a child's underlying representation is to assess the child's perception of an incorrect production in context. To this end, Locke (1980 b) developed the Speech Production-Perception Task (SP-PT). During administration of the SP-PT, each child is asked to name a series of pictures, objects, or body parts. His or her responses are noted and coded as the response phoneme ([RP]). For each sound in error, two other phonemes are also coded. One of these is the standard English production of the target phoneme, or stimulus phoneme ([SP]), and the other phoneme is a perceptually similar control phoneme ([CP]). The child is presented with the same stimulus that was used to elicit the production for the perceptual portion of the task. The child is then asked yes/no questions ("Is this a /fʌm/?" [RP], "Is this a /θʌm/?" [SP], and "Is this a /sʌm/?" [CP]). There are a total of 18 trials, six of each of the three ([RP], [SP], [CP]) phonemes associated with each of the child's production errors in this procedure (Locke, 1980b).

Locke (1980b) stated that if a child accepted the [SP] and rejected the [CP] and the child's own [RP], then one could conclude that the child had adult-like representations stored in his mental lexicon. If, however, a child were to accept both the [SP] and the [RP] while still rejecting the [CP], then it could be assumed that the child did not have an adult-like representation in the mental lexicon for that particular phoneme, at least in the context in question. Locke (1980b) presented this task to 131 normally developing children between the ages of 3 years 1 month to 9 years 9 months, and his data showed no evidence of any child accepting the control phoneme as the correct production.

In the development of and the literature on the SP-PT (Locke 1980a,b), this author noted that Locke failed to explicitly account for two common occurrences in the misarticulations of children's speech. The first of these is variability in the substitution patterns of a child's misproductions. Children can and do vary the sounds used in substitution for the target phoneme, both within and across word positions. The second commonly occurring misarticulation in children's speech is the use of a substitution or omission/deletion in clusters. An example of an omission/deletion includes the production of "spot" as [pat], and an example of a substitution is the production of "flag" as [fwæg] or as [həlæg]. This author noted that Locke (1980a,b) made no mention of how to represent such errors in clusters during the perceptual task.

Previous Phonological Research on Children with Down syndrome

Studies completed during the 1980's (Smith & Stoel-Gammon, 1983; Stoel-Gammon, 1980) gave some indication that children with Down syndrome acquire sounds like younger, normally developing children. Stoel-Gammon (1980) investigated the development of phonological systems in four children with Down syndrome, between the ages of 3 years 10 months to 6 years 3 months. In this article, Stoel-Gammon summarized Dodd's (1976) findings which indicated that, as a group, children with Down syndrome most frequently used the processes of cluster reduction, velarization of alveolar consonants preceding syllabic [l], deletion of word initial [h], and deletion or substitution of the fricatives [s, z,θ,ð] and the affricates [tʃ, dʒ]. Additionally, Stoel-Gammon (1980) discussed Dodd's (1976) lack of data supporting the individual error patterns of her subjects.

The purpose of Stoel-Gammon's (1980) study was to investigate the individual phonological systems of each of the four subjects. She analyzed the spontaneous utterances from these subjects in three ways: (1) identifying the phonetic inventories, (2) comparing the errors to the appropriate adult targets to obtain error types, and (3) analyzing the errors in terms of phonological processes. Stoel-Gammon transcribed 250 to 300 utterances for each subject for use as data in this study. These utterances met the following criteria: (1) they were spontaneously produced, (2) they were audible to unfamiliar listeners, and (3) they had an identifiable adult target.

Stoel-Gammon's (1980) results showed that English nasal and stop sounds were generally produced correctly (corresponding to the adult target). Stoel-Gammon stated that the other consonantal sounds in error contained systematic patterns of substitution and deletion. Group patterns for consonant singletons included: (1) deaspirating word initial voiceless stops, (2) stopping of word initial fricatives and affricates, (3) gliding of liquids in initial position, (4) voicing of stops in medial (intervocalic) position, (5) deletion of nasal and alveolar flaps, (6) vocalization of final syllabic liquids, and (7) weakening of consonants in final position. However, while these processes were general group trends, they were neither optional nor obligatory in the phonetic inventories of each of the subjects. In other words, not all of these processes occurred in the productions of each subject.

Stoel-Gammon (1980) also investigated group trends in the patterns of substitution or deletion of clusters. Generally, she found that the subjects had a preference for CV (canonical) syllables. Two patterns were realized word initially across subjects. These were: (1) in /s + stop/ clusters, the /s/ was deleted and the stop was either voiceless and unaspirated, or voiced, and (2) in stop + liquid and /f + liquid/ clusters were simplified by deleting the liquid, substituting a glide for the liquid, or using epenthesis (vowel insertion between members of a cluster). Word final clusters were simplified in the following three ways: (1) in nasal clusters, nasalization was shifted to the vowel, (2) in liquid + unvoiced stop clusters, the liquid was deleted, and (3) in liquid + voiced stop clusters, the stop was devoiced, or alternatively, the whole cluster was deleted.

Stoel-Gammon (1980) also described the individual patterns of processes she observed in each child. She stated that the processes observed in the individual children with Down syndrome were also observed in the productions of typically developing children. Two of the four subjects used consonant harmony, and deletion of initial liquids. Other identifiable processes that occurred in the productions of one child include depalatalization, denasalization, voicing of stops in initial position, and metathesis.

Two other findings in this study were of note. The first of these was two of the children produced at least one word that could not be accounted for in a "pattern of adult-child correspondences evident in the majority of forms" (Stoel-Gammon, 1980, p. 45). Additionally, Stoel-Gammon (1980) found that variability in substitutions was found both within and across word positions in all subjects. She reported that these substitutions appeared to be in free variation rather than conditioned by context.

Despite the above idiosyncrasies, the general findings of the study led Stoel-Gammon (1980) to state that children with Down syndrome exhibit a delayed pattern of phonological development as compared to normally developing children. Most of these children's productions could be accounted for by identifiable phonological processes. She further stated that the children with Down syndrome who participated in the study appeared able to produce most of the phonemes of English, regardless of production errors. This last finding calls into question the role of structural and functional abnormalities in the oral mechanisms in the incorrect productions of children with Down syndrome (Stoel-Gammon, 1980).

Smith and Stoel-Gammon (1983) presented data concerning stop consonant production in both typically developing children and those with Down syndrome. Four normally developing children between the ages 1 year 6 months and 3 years 0 months, and five children with Down syndrome ages 3 years to 6 years were followed longitudinally. The typically developing children were followed for a year and a half, while the children with Down syndrome were followed for four consecutive years. Data for both groups was collected by eliciting productions during administration of the Photo Articulation Test (Pendergast, Dickey, Selmar, & Soder, 1969).

Smith and Stoel-Gammon (1983) used two different procedures to analyze the results. The first of these was a description of trends across both groups. Both the younger, normally developing children and the children with Down syndrome exhibited greater use of stop consonants in word-initial position as compared to word-final position. However, the two groups differed quantitatively in this respect. Accuracy percentages indicated that the typically developing children produced stop consonants correctly an average of 91% of the time word initially, and 67% of the time word finally. The corresponding percentages for correct production for the children with Down syndrome were 67 and 57%, respectively. An analysis of errors in stop consonant production revealed that voicing errors accounted for 75% of the typically developing children's errors word initially and 78% of the errors word finally. The corresponding percentages for voicing errors in the productions of the children with Down syndrome were 63 and

60%, respectively. Omission of stop consonants in word final position accounted for 6% of the errors for the normally developing children and 22% of the errors for the children with Down syndrome.

The authors also analyzed the phonological processes operating on the productions of stop consonants for both groups of children. Four processes were targeted. These were: (1) final stop devoicing, (2) initial stop deaspiration, (3) final stop deletion, and (4) initial stop cluster reduction. For the normally developing children, productions were sampled every six months over the course of a year and a half. For the children with Down syndrome, productions were sampled yearly between the ages of 3 years 0 months and 6 years 0 months. The data indicate that both groups showed a decrease in the use of all four targeted phonological processes. The average combined frequencies of the four processes for the four typically developing subjects ranged between 32 and 44% over the year and a half the children were followed. The average combined frequencies of the same processes for the children with Down syndrome ranged between 30% for one subject to 52 to 68% for the four remaining subjects for the duration of the study.

The data also revealed that improvements in the suppression of the four targeted processes occurred over time for both groups. By age three, the typically developing subjects showed a 25% deviation from the adult targets. In contrast, the subjects with Down syndrome showed a 61% deviation from the adult targets at age three. By the ages of 6 to 7 years, the subjects with Down syndrome still evidenced a 40% deviation from adult-like productions. Smith and Stoel-Gammon (1983) concluded by stating that children with Down syndrome appeared to evidence a four year delay in their development of stop consonant productions. The authors also implied that the improvements seen over time indicate, that while still delayed in acquisition, children with Down syndrome may benefit from intervention.

The conditions that promote unusual phonological behavior in both normally developing children and children diagnosed with specific language impairment (SLI) have been examined (Leonard, Schwartz, Swanson, & Frome Loeb, 1987). Data was collected from 11 typically developing children between the ages of 1 year 6 months to 1 year 10 months and five children with SLI between the ages of 3 years 4 months to 5 years 0 months. All subjects were presented with 24 nonsense words in a naming task. Unusual phonological behavior was defined as sound changes affecting two or more phonemes in the nonsense words that could not be accounted for by the processes of final consonant deletion, cluster reduction, syllable reduction, reduplication, fronting, stopping, glottal replacement, affrication, liquid simplification, denasalization, assimilation, prevocalic voicing, or final consonant devoicing (Leonard et al., 1987). The results indicated that the subjects with SLI showed nearly twice as many unusual phonological behaviors as compared to their younger language-age matched controls.

The reader is reminded that the data from Stoel-Gammon (1980) indicated that two of the four subjects with Down syndrome spontaneously produced at least one word that could not be accounted for by the phonological processes used in the analysis. These productions meet the conditions of unusual phonological behavior as defined by Leonard et al. (1987). More importantly, these unusual productions occurred in spontaneous, connected speech rather than during a task designed to elicit such behaviors. In contrast, Smith and Stoel-Gammon (1983) did not report any unusual phonological behavior when looking only at the stop consonant development of children with Down syndrome. However, the authors did report quantitative differences between the two groups across several measures including correct use of stop consonants both word initially and word finally.

Stoel-Gammon (1980) also indicated that variability in substitutions occurred in all four of the children with Down syndrome. This variability was observed both within and across all word positions and appeared to be context free. The data presented by Leonard et al. (1987) indicated that three of the five children with SLI also evidenced variability in substitutions in their unusual productions during the nonsense word task.

Current Phonological Theories

The studies discussed above have focused the explanation of their respective findings upon a phonological processes, or relational account. The phonological process construct was developed from Stampe's (1969) theory of natural phonology. Stoel-Gammon and Dunn (1985) state that according to Stampe (1969) a phonological process is "a mental operation that merges a potential phonological opposition into that member of the opposition which least tries the restrictions of the human speech capacity" (p. 66).

In Stampe's account, these processes are viewed as innate and universal. Therefore children must learn to suppress the processes that do not occur in the ambient sound system, and to limit or reorder the processes which do occur in the ambient sound system. Leonard (1985) described this process as a "linear progression of unfolding abilities" (p. 8). Errors in production are considered to be systematically related to the adult form.

Stoel-Gammon and Dunn (1985) discussed the implications of claiming that a child has the same underlying representation for a given word as the ambient adult form. Such a claim would imply that children's perceptual abilities would be fully developed by the onset of meaningful speech. Fully developed perceptual abilities would be a necessity as phonological development is seen as a maturational phenomenon. Further, the child is assumed to be a passive participant in the process of phonological development according to this account.

Current phonological theories have shifted toward viewing the child as a more active participant in the acquisition of a phonology (Leonard, 1985). Inherent in this view is the opportunity for individual variation, as the child is seen as capable of making choices regarding phonological acquisition. This view accounts for such anomalies as a child's use of a phoneme not found in the adult realization of the language. Additionally, recent theories do not assume that a given child has adult-like representations for items stored in the mental lexicon.

Phonological Processes Perspective

There are two opposing approaches that attempt to explain patterns in the phonological development of children. These are: (1) the phonological processes approach and (2) the featural acquisition approach. Phonological processes attempt to first identify a child's phonetic representation. This is usually accomplished using a two-time occurrence criterion, or requiring that a phone be used in a child's productions at least twice in any of the three word positions. While determining the phonetic inventory, the child's productions are analyzed independently of the adult targets. However, when attempting to identify error patterns, the child's productions are compared to an adult target. This is the basis for the phonological processes analysis, during which broad patterns of speech deviations are identified and tallied (e.g., Hodson & Paden, 1991; Khan & Lewis, 1986; Shriberg & Kwiatkowski, 1980).

There are differences in the definition, number, and terminology of phonological processes across investigators. As an example, in terms of the number of processes applied to a child's phonological system, Shriberg and Kwiatkowski (1980) collapsed possible error patterns into eight natural processes. Khan and Lewis (1986) use 12 developmental processes and three non-developmental processes to classify the errors in children's productions.

Discrepancies in what defines a phonological process are also apparent among researchers. McReynolds and Elbert (1984) summarized this challenge to the relational approach by stating that the problem stems from a lack of definitions for the terms used within the definition of a phonological process. Elbert and Gierut (1986) have argued that the term phonological process implies that assumptions have been made concerning the child's underlying representation.

Hodson (1991) replied to this criticism by stating that phonological process analysis attempts to identify broad patterns lacking in a child's speech, without regard to the knowledge a child may have of the ambient sound system. Therein lies another difficulty with the relational analysis approach. Because it is attempting to identify broad patterns operating within a child's productions, the relational account may not be sensitive to subtle and unusual phonological behaviors.

Intervention under this approach is based upon stimulability and developmental appropriateness, as well as remediating the most frequently occurring process. Selection of intervention targets is based upon those sounds not used in a child's system which are the most stimulable. An additional consideration is determining which developmental phonological pattern a given child is using. Intervention would be aimed the next earliest acquired pattern. For example, intervention for a child using only vowels and grunts would consist of targeting syllables and prevocalic anterior stops, nasals, and glides (Hodson & Paden, 1991). Others have proposed that intervention focus upon the most frequently occurring process in the child's phonological system (Khan & Lewis, 1986; Shriberg & Kwiatkowski, 1980). The underlying assumption is that the most frequently occurring process is the greatest hindrance to the child's intelligibility.

Featural Acquisition Perspective

Opposing the phonological processes approach is the featural acquisition perspective. This approach advocates that analysis of the patterns in a child's phonological system be carried out independently of any adult targets. It is based upon the system of distinctive features developed by Chomsky and Halle (1968). A distinctive feature is an "articulatory or acoustic parameter whose presence or absence defines a phoneme" (Creaghead & Neuman, 1989, p. 9).

Analysis from this approach also begins with a phonetic inventory that is determined using the two-time occurrence criterion described previously. The phonetic inventory can then be characterized as one of five levels ranging from the most simple (Level A) to the most complex (Level E) (Gierut, 1990). The complexity of each level is determined by the number of distinctive feature characteristics.

The simplest level (least complex), Level A, includes nasals, stops, and glides. Feature distinctions at this level are: (1) consonants are differentiated from glides by the feature [consonantal]; and (2) obstruent stops are differentiated from nasal stops by the feature [sonorant]. These two features, [consonantal] and [sonorant] are considered major class features.

At Level B, the child's inventory includes all of the components of Level A as well as both voiced and voiceless obstruent stops. The added feature distinction is [voice].

Increasing in complexity is the Level C inventory. This inventory includes fricatives and/or affricates as well as the elements of both Levels A and B. Affricates will emerge after both the voicing distinction and at least one fricative have been acquired (D. A. Dinnsen, personal communication, February 21, 1995). The additional features which are acquired at this level are [continuant] to account for the occurrence of fricatives, and [delayed release] to account for the occurrence of affricates.

Level D inventories have the addition of either [l] or [r], as well as all of the feature distinctions of Levels A through C. The new feature acquired at this level is [nasal]. The acquisition of this feature allows a distinction between nasal sonorants (i.e., nasals) and non-nasal sonorants (i.e., liquids).

The most complex inventory is found at Level E. As well as containing all of the featural distinctions of the previous levels, this level contains either a stridency distinction among the fricatives (i.e., [s] and [θ] or [z] and [ð]) and/or a laterality distinction among the liquids (i.e., [l] and [r]).

Because the independent perspective does not compare the child's productions to an adult target, both broad and more narrow patterns that may be occurring in a child's phonological system may be identified. Additionally, this approach makes no assumptions regarding a child's underlying representations. To assist in determining the underlying representation, a phonemic inventory is determined. To account for discrepancies between the underlying and phonetic representations, phonological rules are posited. By determining what knowledge a child has of the sound system of the ambient language, the independent analysis is more likely to detect subtle and unusual phonological behaviors.

Targets for intervention from this perspective are based upon increasing the complexity of a child's inventory. If a child were functioning with an inventory characteristic of Level B (nasals, voicing distinction between the obstruent stops, and glides), then, taken to the extreme, this approach would teach the child a Level E distinction such as a stridency distinction (i.e., /z/ and /ð/). The child must first acquire the Level C and Level D distinctions, however, no direct intervention is reported to be necessary (Gierut, 1990). The child will acquire the lower level distinctions "for free". The greatest amount of change in a child's phonological system is observed when he or she is taught two non-stimulable, unknown sounds as targets during treatment (Gierut, 1990).

Conclusions

In conclusion, the present study will focus upon three aspects of the phonological development of children with Down syndrome. The first purpose of the present investigation is to examine whether the phonological and developmental levels are similar in children with Down syndrome when phonological behavior is determined by both the independent and relational analyses. The previous research into the phonological development of children with Down syndrome has used only the relational phonological processes approach to analyze the data. For the purposes of this study, the phonological processes analysis and the independent analysis will both be used to identify and analyze patterns in the phonological development of children with Down syndrome.

The second purpose of this study is to determine if children with Down syndrome exhibit unusual phonological behavior. Normally developing children, phonologically disordered children, and children with specific language impairment have all shown evidence of unusual productions. The difference among the groups is the frequency of occurrence of these unusual productions. Children with specific language impairment have been found to use almost twice as many unusual productions as normally developing children. It is possible that children with Down syndrome will show more evidence of unusual phonological behavior as well. If children with Down syndrome exhibit unusual phonological behavior, do they demonstrate a frequency of occurrence of this behavior closer to that of normally developing children or children with specific language impairment?

The final purpose of this study is to investigate the role of speech perception in the general phonological development of children with Down syndrome. Are the phonological errors of children with Down syndrome a result of misperceptions? Studies that have investigated speech perception in infants with Down syndrome suggest that these infants perceive speech differently from typically developing infants. It is possible that these differences carry over into the later development of speech perception in children with Down syndrome.

Chapter II

Method

<u>Subjects</u>

Six children (one male, five female) with Down syndrome participated in this study. The five children (one male, four female) with the most complete data sets served as subjects. All of the subjects were between the ages of 4 years 6 months and 6 years 11 months. The subjects met the following selection criteria: (1) they were monolingual, native speakers of English, (2) they had normal hearing as assessed by minimal response levels of 25 dB HL or less on a speech awareness task and/or a standard screening involving conditioned play or conventional response audiometry at 500, 1000, 2000, and 4000 Hertz (Hz) at 20 dB HL (ANSI, 1989), and (3) they scored cognitively within two standard deviations below the norm as measured by the Arthur Adaptation of the <u>Leiter International Performance Scale</u> (Arthur, 1952) or the <u>Lexington Developmental Cognitive Scale-Long Form</u> (Irwin et al., 1974).

All subjects were recruited through the Down Syndrome Awareness Group of East Tennessee. A letter of cooperation was obtained from the director of this group (see Appendix A). A short summary of the rationale for this study and the experimental procedures were given to the director along with the parental consent forms (see Appendices B and C). The director distributed this information to interested parents, and contacted families whose children were between the ages of 4 years 0 months and 7 years

0 months. Parents willing to have their child participate in the study either gave their consent to the director to release their names and telephone numbers to the experimenter or contacted the experimenter directly.

Stimuli

The published, standardized measures used in this study were: the (1) Sounds-in-Words and Stimulability subtests of the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986); (2) Test of Early Language Development-2 (TELD-2; Hresko, Reid, & Hammill, 1991); (3) Oral Speech Mechanism Screening Examination-Revised (OSMSE-R; St. Louis & Ruscello, 1981); (4) Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952); and (5) Lexington Developmental Cognitive Scale-Long Form (Irwin et al., 1974). Appendix F includes a description of all tests in alphabetical order.

One published non-standardized assessment protocol used in this study was the Speech Production-Perception Task (SP-PT; Locke, 1980b). The stimuli used for this task were the picture plates of the GFTA. This task attempted to determine whether the child's production errors on the GFTA stemmed from misperceptions. Furthermore, an elicited speech sample of 150-250 imitative and non-imitative utterances was collected from each subject. Target words obtained during the speech sample and the GFTA were analyzed using the published, computer-assisted phonological analysis procedure entitled Profile of Phonology (PROPH+), a portion of Computerized Profiling (Long & Fey, 1993).

Procedure

All subjects were seen individually for four or five one hour sessions. For all subjects, the first and second pre-experimental sessions were conducted in each child's home. The third and fourth experimental sessions were held in the University of Tennessee Child Language Laboratory. Three of the five subjects participated in a fifth session at the child's home (Subjects 1, 2, and 3). For each subject, all sessions were completed over a maximum of four weeks. All sessions were both video-taped and audio-taped. The video-recordings were made with a Sony AG-195 MUP videorecorder. The audio-recordings were made with a Sony TC-RX606ES audiocassette deck and with Sony Tie-Pin ECM-T150 microphones placed approximately one foot from each subject.

During the first session, the parents of each subject were given a questionnaire that included items related to their child's: (1) history of any previous and/or current speech-language therapy, (2) educational placement, (3) history of otitis media and pressure equalization tubes, (4) speech intelligibility to familiar and unfamiliar listeners, and (5) preferences regarding toys and/or topics of conversation (see Appendix D for complete questionnaire). The subject's parents were also asked to complete the <u>MacArthur Communicative Development Inventory</u> (<u>CDI</u>; Fenson et al., 1993). Completion of the <u>CDI</u> enabled the experimenter to assess the complexity of each subject's verbal language via parental report. The experimenter was present to assist with the completion of both items.

During the initial session, the Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952) was administered to each child. The testing took place in a one-on-one situation between the child and the experimenter. In this, and in all other testing sessions, each subject was required to sit on the floor or in a child-sized chair. The test was administered according to the standardized protocol with the addition of the verbal prompt, "Put the blocks where you think they go," if necessary. A basal level was not obtained upon the Arthur Adaptation of the Leiter International Performance Scale for one subject. The Lexington Developmental Cognitive Scale-Long Form (Irwin et al., 1974) was then administered to this subject during the second session.

During the second session, the OSMSE-R and the TELD-2 were given to each subject. Modifications of the tasks of the OSMSE-R included having a familiar adult or older sibling perform the tasks as a model and changing the stimuli of the three syllable diadochokinetic task to "buttercup" or "pattycake." An additional modification for one subject included counting the number of repetitions of the diadochokinetic task upon her fingers. The TELD-2 was administered according to the standardized protocol in the test manual.

During the third session, which took place at the University of Tennessee Child Language Laboratory, each subject was given the Sounds-in-Words subtest of the GFTA and a hearing screening. Four of the five subjects were also given the initial and final position syllable portion of the Stimulability subtest of the GFTA. These two subtests of the GFTA were selected to allow the experimenter the opportunity to evaluate patterns in the phonological inventory of each subject. The experimenter attempted to elicit each word of the Sounds-in-Words subtests through spontaneous productions. However, both delayed and direct imitation procedures were used to elicit responses if necessary. The GFTA assesses 23 of the 26 phonemes of English. The phonemes /ʒ, ts, dz/ are not targeted due to their relative infrequent occurrence in English.

The hearing screening and tympanometry were completed in an audiological suite. The hearing screening was completed using either conditioned play or conventional response audiometry. The method of screening was determined by each subject's chronological age and ability to comprehend the task. Minimal response levels of 25 dB or less for speech reception were obtained for all subjects. Tympanometry for four of the five subjects revealed normal (Type A) tympanograms. Due to resistance to the task, tympanometry was not obtained for Subject 3. All audiological testing was completed by a certified audiologist with previous experience testing children.

The fourth session was also conducted at the University of Tennessee Child Language Laboratory and consisted of administration of the Speech Production-Perception Task (Locke, 1980b) and collection of the speech sample. The stimuli for the SP-PT were intelligible, whole words containing phones in error from each subject's productions on the GFTA. Prior to beginning the SP-PT, each subject completed a training procedure. This training consisted of presenting each subject with several picture plates that were not used in the actual task and asking concrete yes/no questions. For example, the subject was presented with the picture of the house and asked Is that a house? Is that a dog? Is that a car?. The training continued until each subject was consistently answering the questions positively or negatively as appropriate. During the actual task, each subject was presented with the GFTA picture plates corresponding to the word(s) with production errors. Each subject was then asked yes/no questions using the stimulus phoneme ([SP]; "Is it a /θʌm/?"), the response phoneme ([RP]; "Is it a /fʌm/?"), and the control phoneme ([CP]; "Is it a /sʌm/?"). Variations of the task questions included, Is it a(n) (brush)?, Is the (duck) (yellow)?, and Is he (fishing)?. In the event that a subject had difficulty making verbal yes/no choices either during the training procedure or the task, he or she was provided with pictorial and graphic supports to indicate yes or no. All items presented in this task were produced by the experimenter. Two restrictions affected the sound(s) used in the control word: (1) the control word could not represent another word in English (Locke, 1980b), and (2) the sound(s) could not already be present in either the standard production of the task item or the child's production of the same item (see Appendix E for the list of control phonemes; Miller & Nicely, 1957). There were 18 trials (henceforth called trials) per phoneme; six occurrences each of the [SP], [RP], and [CP]. Presentation of these items was randomized in accordance with Locke (1980b). Each item was repeated a second time if necessary and if a subject did not respond after the second repetition, that item was scored as "No Response." Due to the limited attention span of these subjects, the 18 trials were mixed to alleviate fatigue, and were also distributed among other more reinforcing activities for each subject, such as coloring or playing with toys.

The speech sample consisted of an experimenter-child interaction designed to elicit 150-250 imitative and non-imitative, intelligible child utterances. Each experimenter-child interaction took place in a sound-proof booth free from equipment. The purpose of this conversational sample was to obtain productions of the phonemes targeted on the GFTA in connected speech. The child and experimenter played with a collection of toys intended to elicit words containing the target phonemes. All target phonemes were contained within nouns, verbs, and adjectives. Each subject was provided with the opportunity to produce at least two different words containing each target phoneme in two positions (e.g., /d/ in dog, doll, and red). All parents were invited to either accompany their child in the booth or watch the interaction on a television monitor. This interaction lasted approximately 30 minutes so that each subject had the opportunity to become familiar with the booth. Another graduate student in the area of speech-language pathology or the project director were present during this interaction to tally the number of target words spoken by the child and to operate the recording equipment.

Three of the five subjects participated in an extra session. This session took place at each child's home. For two of these subjects (Subjects 2 and 3), this session consisted of an additional attempt to obtain results on the Speech Production-Perception Task. These subjects again went through the training procedure before beginning the actual task. The extra session for the third subject (Subject 4) consisted of completion of the GFTA and collection of the speech sample.

Reinforcement Procedures

All subjects were positively reinforced throughout each testing session by motivators identified by his or her parents (e.g., verbal praise, stamps, or stickers) following a variable-ratio schedule of reinforcement. Each subject was given a small toy at the end of each session.

If at any time a child expressed a desire to stop a test procedure, the experimenter offered the child the option of changing activities or taking a short (five minute) break. The child was then asked, "Are you ready to start again?" If the child again stated disinterest or was uncooperative in performing the task, the testing was discontinued for that session. The child and his or her parents were invited to complete the session at a later date.

Reliability

Intra- and interjudge reliability comparisons were computed for the target words (productions containing GFTA phonemes) collected during the speech samples and each production from the Sounds-in-Words subtest of the GFTA for all subjects. Point-to-point comparisons were made for consonants. Intrajudge agreement across all subjects was 94.23% for consonantal point-to-point comparisons from the transcriptions of the speech samples and 93.61% for the transcriptions from the GFTA. Interjudge agreement was 92.48% for all subjects for the speech samples and 90.68% for all subjects for the GFTA across the same comparisons. The interjudge was a doctoral level graduate student in speech-language pathology who was experienced in the transcription of phonologically disordered children's speech.

Chapter III

Results

Standardized Test Scores

The standardized tests used in this investigation were the: (1) Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986); (2) Test of Early Language Development-2 (TELD-2; Hresko, Reid, & Hammill, 1991); (3) Oral Speech Mechanism Screening Evaluation-Revised (OSMSE-R; St. Louis & Ruscello, 1981); (4) Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952); and (5) Lexington Developmental Cognitive Scale-Long Form (Irwin et al., 1974). All subjects' scores on the standardized tests are presented in Table 1. As can be seen, all subjects were functioning cognitively approximately two years below their chronological ages. In addition, each subject's performance upon the GFTA was more than two standard deviations below what was expected for the subject's respective age-level, indicating a significant delay in phonological development.

Case studies for each subject will be presented. However, prior to their presentation, an explanation of each of the analysis procedures used in this study is provided.

Speech Sample Analysis

The speech sample collected during the final session was analyzed using Profile of Phonology (PROPH+; Long & Fey, 1993). Although intended to be a spontaneous speech sample, all subjects required either modeling or direct questioning in order to

Table 1

Subjects' Scores on the Standardized Test Battery

Subject	CA	GFTA	TELD-2	Leiter	Lexington
1	4:8	64	3:1	--	2:6
2	4:6	62	3:11	3:3	--
3	5:6	43	3:6	4:2	--
4	4:8	64	4:4	4:4	--
5	6:6	11	3:11	4:4	--

Note. Chronological ages are given in years:months. GFTA scores are presented as the number of targeted phonemes from a total of 73 produced in error. TELD-2 scores are presented as age equivalents. The Leiter and Lexington scores are presented as mental age equivalents.

elicit intelligible utterances. Each child's intelligible utterances were glossed on line and then transcribed phonetically from the audio-cassette recordings within 48 hours. The utterances were then entered in the program as per the authors' instructions.

Phonetic Inventories

Each subject's phonetic inventory was determined by a two-time occurrence criterion from each subject's productions obtained during administration of the GFTA and during collection of the speech sample as analyzed by PROPH+. Two-time occurrence is defined as two manifestations of a given sound in either word initial, medial, or final positions. This was the case whether or not the phone was produced correctly in relation to the target sound. The phonetic inventories were used to determine the level of complexity of each subject's inventory.

Phonemic Inventories

Each subject's phonemic inventory was based upon the phones that were used contrastively in the child's phonological inventory. The phonemic inventories were determined by looking at a child's production of true and near minimal pairs. True minimal pairs were defined as words that differ by only one sound which signals a difference in meaning. Near minimal pairs were defined as words that differ by one consonant which signals a difference in meaning, but contain different vowels (e.g., /læmp/ and /dʒʌmp/). Each subject's phonemic inventory was based upon a one-time occurrence criterion. The phonemic inventories were used in an attempt to determine each subject's underlying representation and phonological rules operating in his or her phonological system.

Phonological Processes: A Relational Analysis

Phonological processes, an adult-based relational analysis, systematically compare the child's phonological system to the ambient adult system by mapping the child's errors onto the standard adult production (Williams, 1993). Phonological processes were discussed following the terminology of PROPH+ (Long & Fey, 1993). PROPH+ was performed upon each subject's productions from the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1986) and the speech sample. PROPH+ provided information regarding the processes being applied to the child's system and the contexts that may have conditioned those processes to occur. The percentage for each process in each subject's speech is a ratio of the number of occurrences to the total number of opportunities.

Additionally, using Grunwell's (1982) Profile of Phonological Development, the processes present in each subject's speech that affect production at the syllable level (e.g., assimilation, cluster reduction, final consonant deletion, and reduplication) were highlighted. These processes are not observed in the speech of typically developing children beyond the age of three years and their presence beyond this age is indicative of severe phonological delay. Vihman's (1996) three point scale was used to "score observed frequency of use" (p. 218). The scale is as follows: sporadic (point value - 1: less than 25% occurrence); inconsistent (point value - 2: 25%-75% occurrence); and regular (point value - 3: greater than 75% occurrence).

Phonological Rules: An Independent Analysis

A basic assumption of the independent analysis is that each child's system is unique and self-contained. An independent analysis contains a description of the system and its structure, but no description of the accuracy of the child's production (Williams, 1993). Each subject's phonetic inventories were discussed in terms of the hierarchy of distinctive feature levels discussed in the review of the literature (Gierut, 1990). As stated previously, the phonetic and phonemic inventories were used to determine and then discuss the phonological rules operating within each child's phonological system.

The rules that may be present in a child's system include morphophonemic alternations, neutralization rules, and differential phonological behavior. A morphophonemic alternation refers to different productions of a morpheme when that morpheme is placed in another environment. For example, a child who produces "bath" as [bæf] and "bathtub" as [bæθtʌb] is evidencing a morphophonemic alternation. Neutralization rules act solely upon the lexicon and only occur under the following conditions: 1) there must be an alternation, and 2) the alternating segments must contrast phonemically in some contexts, but not in other well-defined contexts. The following example illustrates this principle: In English the verbs [raɪːd] "ride" and [raIt] "write" are produced as distinctly different forms. However, both nouns are typically produced as [raIɾɚ], and the intended meaning is inferred by the listener in context. Children can also show evidence of differential phonological behavior, which is illustrated in the following example: a child produces "cup" as [pʌp] and "duck" as [kʌk]. Finally, children can indicate knowledge of word final consonants in the following ways: 1) by lengthening the vowel preceding voiced, obstruent stops, and 2) by placing nasalization on the vowel preceding nasal consonants.

Phoneme Collapses: A Child-Based Relational Analysis

The phoneme collapses present a visual representation of patterns in the one-to-many correspondences between the child's system and the adult system. One sound in the child's system may correspond to several adult phonemic contrasts. Williams (1993) stated that, "[t]his type of relational analysis is child-based...in that the child's error patterns are not described by a predetermined and finite set of phonological processes..." (p. 45).

Unusual Productions

Unusual phonological behavior as defined by Leonard et al. (1987), will be highlighted in the case summaries of those subjects who exhibited it. Unusual phonological behaviors are defined as those productions that cannot be accounted for by the processes of final consonant deletion, cluster simplification, syllable reduction, reduplication, fronting, stopping, glottal replacement, affrication, liquid simplification, denasalization, assimilation, prevocalic voicing, or final consonant devoicing.

Perception

The Speech Production-Perception Task (Locke, 1980b) was administered according to the published protocol with the addition of graphic and pictorial supports. To reiterate, the stimuli for this task were intelligible, whole words that contained phones in error from each subject's responses on the GFTA. For each whole word response, the subject was presented with the corresponding picture plate from the GFTA. There were

18 trials per phoneme; six occurrences each of the stimulus phoneme ([SP]; adult form), response phoneme ([RP]; child form); and control phoneme ([CP]; perceptually similar to stimulus phoneme). Each subject was then asked yes/no questions. Examples of the yes/no questions were described in Chapter II. The number of "YES" responses to each of these three phonemes was tallied and if there was at least a two-to-one ratio between the response phoneme and the stimulus phoneme, the child's form was assumed to be the result of misperception (Locke, 1980b).

Only one subject was able to reliably complete any portion of the Speech Production-Perception Task. Subject 2 completed two sets of trials with pictorial and graphic supports, and verbal prompting following each question. The results from these trials will be presented in Subject 2's individual case summary.

Individual Case Summaries

Each subject's results are discussed as separate case studies. The high variability of developmental and language skills across subjects warranted the presentation of the results in this form. General conclusions about the results of all subjects are presented in the summary of the results.

Subject 1

Phonetic and Phonemic Inventories

The phonetic and phonemic inventories for Subject 1 (CA: 4 years 8 months) are presented in Table 2. This subject had 64 errors out of a possible total of 73 errors on the GFTA. S1 was not stimulable for any of the sounds in error. Both inventories are a

Table 2

<u>Phonetic and Phonemic Inventories for Subject 1</u>

Phonological System			
Phonetic Inventory			
Nasals	m n		
Stops	p b t d g		
Fricatives			
Affricates			
Liquids			
Glides	w		
Examples from data	[bʌbo] "shovel" [pɪdou] "zipper" [dɪmʌdi] "Christmas tree"	[tɪtɪ] "chicken" [ga:] "car" [naɪ] "knife"	[wau] "house" [wædu] "vacuum" [bæ:] "flag"
Phonemic Inventory			
Nasals	m n		
Stops	p b t d		
Fricatives			
Affricates			
Liquids			
Glides	w		
Examples from data	[naɪ] ~ [waɪ] "knife" - "lamp" [bɔ] ~ [dɔ] "ball" - "dog"	[pæ] ~ [bæ] "plane" - "bath" [tu:] ~ [du] "tooth" - "juice"	

<u>Note</u>. *The phonetic inventory is based upon a two-time occurrence criterion. The phonemic inventory is based upon a one-time occurrence criterion. Both inventories are presented in a standard Place-Voice-Manner format. Manner of production is labeled; place of production progresses posteriorly from bilabial to velar; voiceless cognates are presented on the left, and voiced on the right.*

combination of the data obtained from the GFTA and the speech sample, and appropriate examples for both inventories are listed in the table.

Phonological Processes: A Relational Analysis

Phonological processes that occurred with 25% or greater frequency in Subject 1's speech are included in Table 3. Any additional processes that affected the syllable, regardless of frequency of occurrence, are presented in bold type face along with the corresponding point values. PROPH+ was not able to analyze 23 of S1's misproductions.

Table 3

Phonological Processes and Percentages of Occurrenece in Subject 1's Speech

Process	Percentage	Example
Velar Fronting	25% (4/16)	[dʌ] for /gʌn/
Early Stopping	29% (4/14)	[bɛdʌ] for /fɛðɚ/
Final Consonant Deletion (3)	**97% (37/38)**	**[bæ̃] for /bæ̃θ/**
Cluster Reduction (2)	**75% (21/28)**	**[bu] for /blu/**
Liquid Simplification	38% (5/13)	[wæbel] for /ræbɪt/
Later Stopping	39% (7/18)	[dɪ] for /ðɪs/
Normal Vocalization	46% (6/13)	[wɪ] for /hwil/
Reduplication (1)	**6% (2/31)**	**[tɪtɪ] for /tʃɪkən/**

Note. *Percentage of occurrence is a ratio of the number of occurrences to the total number of opportunities across word contexts. Processes affecting the syllable are given a point value ("3" occurring regularly; "2" inconsistently, "1" sporadically) described by Vihman (1996).*

Phonological Rules: An Independent Analysis

S1's phonetic inventory was presented in Table 2. The phones in this subject's inventory are characteristic of Level B (Gierut, 1990), and minimally included one phone with each of the following features: [sonorant], [consonantal], and [voice]. This inventory level precludes the use of fricatives, affricates or liquids. The CV pattern was the most commonly occurring throughout both the administration of the GFTA and collection of the speech sample. Descriptions of the phonological rules and examples from the data set are presented in Table 4.

Phoneme Collapses: A Child-Based Relational Analysis

Diagrams of the one-to-many correspondences of S1's phonemic inventory are provided in Figure 1. These collapses provide a visual representation of the sounds produced in error as well as the adult targets. Nine collapses were present with the largest collapsing 12 sounds to one (d/#_). As displayed in the figure, there is a high degree of variability in this child's speech.

Unusual Productions

S1 did not show any evidence of unusual productions as defined by Leonard et al. (1987). Given this subject's limited phonetic and phonemic inventories, all productions could be accounted for through the phonological processes used by PROPH+ with the addition of the processes of assimilation, denasalization, and prevocalic voicing.

Table 4

Phonological Rules Operating in Subject 1's Phonological System

1. Sequence Constraint - Consonants only occur as singletons; Additionally, consonants only occur word-initially or intervocalically	
Examples: [tɪtɪ] - "chicken", [pæ̃] - "plane"	Exception: [bwʌ] - "drum"
2. Inventory Constraints - Inventory limited to Stops, Nasals, and Glides	
Examples: [bɛ:] - "bed", [wɪ] - "wheel", [naɪ] - "knife"	
3. Vowel Conditions Presence of Preceding Consonant - The front vowels [ɪ, e, æ] conditioned presence of [p]; The back vowels [a,ʊ, ʌ] conditioned the presence of [g].	
Examples: [pæ̃] - "plane", [ga:] - "car"	
4. Nasalization and Lengthening of the Vowel Preceding Final Consonants	
Examples: [bɛ:] - "bed", [dʌ̃] - "gun"	
5. Labial and Coronal Assimilation	
Examples: Labial [bʌbo] - "shovel"	Examples: Coronal [dɪdɪdi] - "Christmas tree"

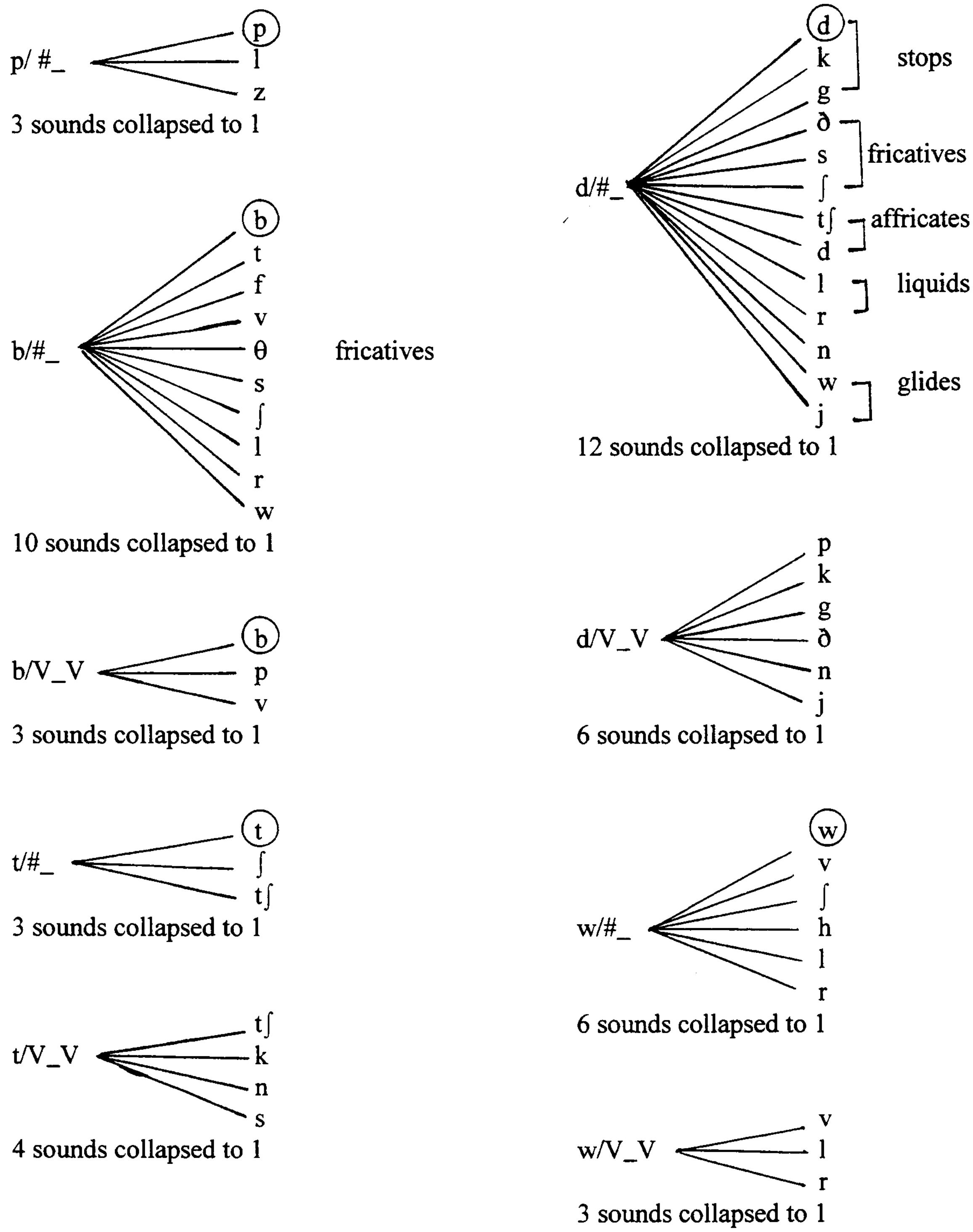


Figure 1. Phoneme collapses for Subject 1. Collapses occurred either word initially (#_) or intervocalically (V_V).

Subject 2

Phonetic and Phonemic Inventories

The phonetic and phonemic inventories for Subject 2 (CA: 4 years 6 months) are presented in Table 5. Both inventories are a combination of the data from the GFTA and the speech sample. S2 had 62 errors out of a total of 73 targeted phonemes on the GFTA. Stimulability was assessed for the following phonemes: /m, n, w, k, f, d, ŋ, t, ʃ, tʃ, l, r, θ, v, s, ð, fl/. S2 was stimulable for [m, n, w, d, s] only in syllable initial position and for [r] only in syllable final position. This subject was not stimulable for [ŋ, k, f, ʃ, tʃ, θ, ð] in either initial or final position. Subject 2 was also not stimulable for [fl] in initial position.

Phonological Processes: A Relational Analysis

Phonological processes that occurred in Subject 2's speech with at least 25% frequency are presented in Table 6. All processes that affected the syllable, regardless of percentage of occurrence, are presented in bold type face with their corresponding point values. There were 31 misproductions throughout the data set that were not analyzed by PROPH+.

Phonological Rules: An Independent Analysis

S2's phonetic inventory was displayed in Table 4 and minimally included one phone with at least one of the following features: [sonorant], [consonantal], [voice], [continuant], and [non-nasal sonorant]. These features are consistent with a Level D inventory. The CV word shape was the most commonly occurring throughout

Table 5

Phonetic and Phonemic Inventories for Subject 2

<table>
<tr><th colspan="5">Phonological System</th></tr>
<tr><td colspan="5">Phonetic Inventory</td></tr>
<tr><td>Nasals
Stops
Fricatives
Affricates
Liquids
Glides</td><td colspan="4">m n
p b t d k g
s ʃ h

l
w</td></tr>
<tr><td>Examples from data</td><td>[bæ] "bath"
[kɪkɪ] "Christmas"</td><td>[hau] "house"
[gʌ] "gun"</td><td>[sæ] "sit"
[ʃi] "sheep"</td><td>[wæwə] "wagon"
[naɪ] "knife"</td></tr>
<tr><td colspan="5">Phonemic Inventory</td></tr>
<tr><td>Nasals
Stops
Fricatives
Affricates
Liquids
Glides</td><td colspan="4">m n
p b t d k g
s ʃ h

l
w</td></tr>
<tr><td>Examples from data</td><td colspan="2">[mu] ~ [bu] "moo" - "blue"
[bi] ~ [di] "beach" - "tree"
[li] ~ [ʃ i] "leaf" - "sheep"</td><td colspan="2">[haɪ] ~ [naɪ] "hi" - "knife"
[gɪgɪ]~[dɪdɪ] "chicken" - "Christmas"
[kʌ] ~ [bʌ] "Claus" - "brush"</td></tr>
</table>

Note. *The phonetic inventory is based upon a two-time occurrence criterion. The phonemic inventory is based upon a one-time occurrence criterion. Both inventories are presented in a standard Place-Voice-Manner format. Manner of production is labeled; place of production progresses posteriorly from bilabial to velar voiceless cognates are presented on the left, and voiced cognates on the right.*

Table 6

<u>Phonological Processes and Percentages of Occurrence in Subject 2's Speech</u>

Process	Percentage of Occurrence	Example
Velar Assimilation (2)	**33% (1/3)**	**[kɛ kɛ] for /kɛrɪt/**
Final Consonant Deletion (3)	**100% (35/35)**	**[bʊ] for /bʊk/**
Cluster Reduction (3)	**82% (23/28)**	**[bu] for /blu/**
Later Stopping	28% (5/18)	[bæ̃] for /væn/
Normal Vocalization	50% (8/16)	[bɛ] for /bɛr/
Reduplication (1)	**15% (6/39)**	**[gɪgɪ] for /tʃɪkən/**

<u>Note.</u> *Percentage of occurrence and the actual ratio of occurrences to the number of opportunities across word positions are presented. Processes affecting the syllable are given a point value ("3" occurring regularly; "2" inconsistently; "1" sporadically) described by Vihman (1996).*

both the administration of the <u>GFTA</u> and collection of the speech sample. Phonological rules that were present in Subject 2's speech are presented with examples in Table 7.

Phoneme Collapses: A Child-Based Relational Analysis

Diagrams of the one-to-many correspondences of S2's phonemic inventory are provided in Figure 2. Seven word-initial and three intervocalic phoneme collapses were present in the phonological patterns of this subject. These phoneme collapses had between two to 11 sounds collapsed. Many of the phoneme collapses overlap, indicating a high degree variability.

Table 7

Phonological Rules Operating in Subject 2's Phonological System

<table>
<tr><td colspan="2">1. Positional Constraints - [ʃ, s] only occur word-initially</td></tr>
<tr><td colspan="2">Examples: [ʃi] - "sheep" [sɪ] - "sleep"; [bɪbɪ] - "fishing"</td></tr>
<tr><td colspan="2">2. Sequence Constraint - Only consonant singletons occur; Consonants do not occur in final position</td></tr>
<tr><td>Examples: [kɪkɪti] - "Christmas tree"
[bæbʌ] - "bathtub"</td><td>Exception: [dʌmpi] - "jumping"</td></tr>
<tr><td colspan="2">3. Vowel Conditions Presence of Consonant: Velar consonants are present when they occur as targets intervocalically or word-finally and when preceded by [ɪ] or back vowels</td></tr>
<tr><td>Examples: [kɪkɪti] - "Christmas tree"
[gɪgə] - "finger"</td><td>Exceptions: [gæga] - "vacuum"
[gigi] - "puppy"</td></tr>
<tr><td colspan="2">4. Labial and Velar Assimilation</td></tr>
<tr><td>Example: Labial
[pɪpə] - "zipper"</td><td>Example: Velar
[gegu] - "thank you"</td></tr>
<tr><td colspan="2">5. Nasalization and Lengthening of Vowels Preceding Final Consonants</td></tr>
<tr><td colspan="2">Examples: [pɛ̃] - "pencils", [bæ:] - "flag"</td></tr>
</table>

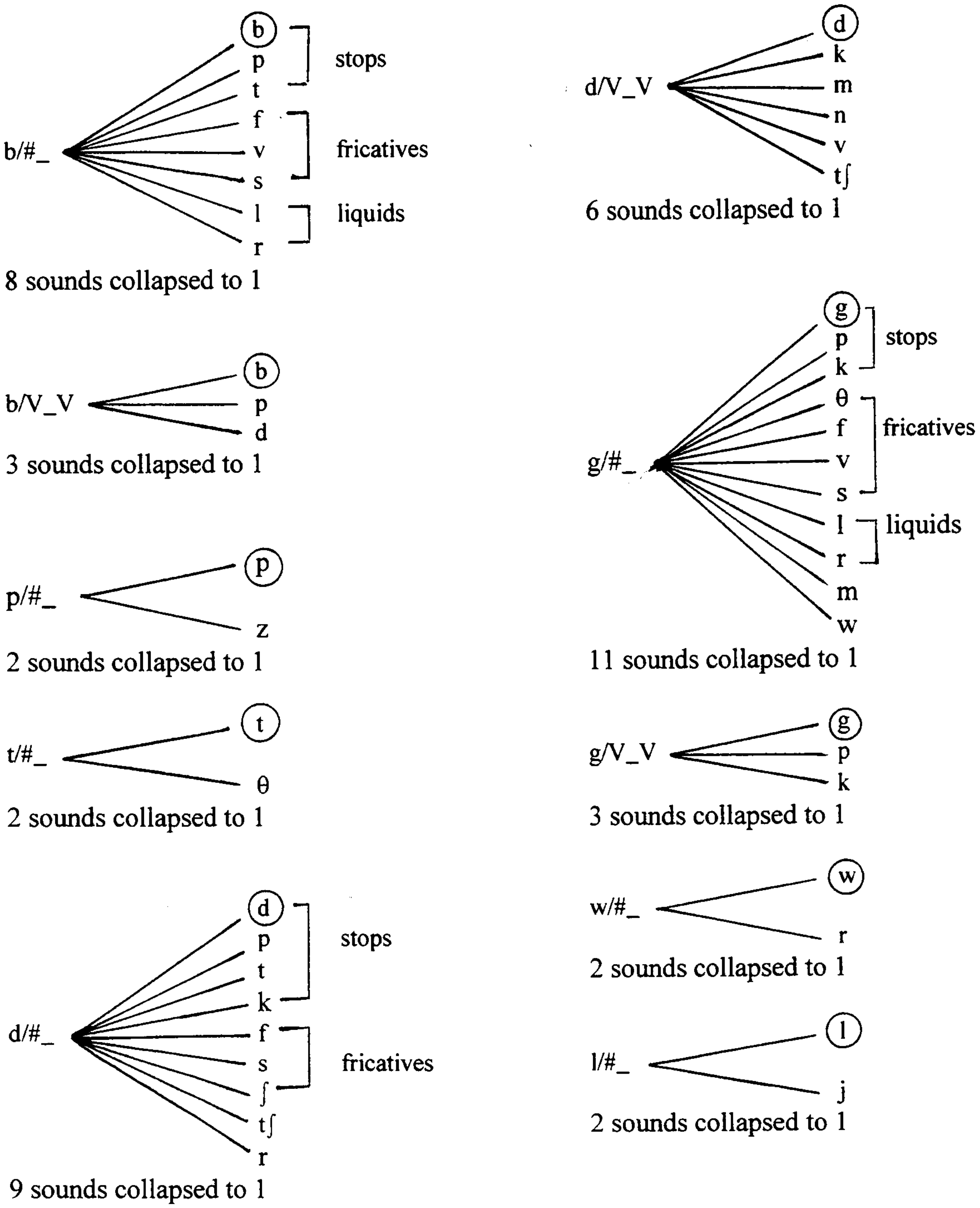


Figure 2. Phoneme collapses for Subject 2. Collapses occurred either word initially (#_) or intervocalically (V_V).

Unusual Productions

Given this subject's inventory and sequence constraints, it was not unexpected to find no evidence of unusual phonological behavior. The 31 productions that PROPH+ was not able to analyze can be explained through the processes of final consonant deletion, prevocalic voicing, and assimilation.

Perception

As mentioned previously, Subject 2 was the only subject who was able to reliably complete any of the trials. This subject was able to complete two sets of trials, indicating that her productions of "finger" (target - /fiŋgɚ/; child's - [gɪgə]) and "wagon" (target- /wægən/; child's production - [wæwə]) were the result of misperceptions. The score form for the SP-PT can be found in Appendix G.

Subject 3

Phonetic and Phonemic Inventories

The phonetic and phonemic inventories for Subject 3 (CA: 5 years 6 months) are displayed in Table 8, with corresponding examples from the data set. Both inventories are, again, a combination of the data obtained from the GFTA and the speech sample. This subject had 43 errors from a total of 73 phoneme targets on the GFTA. Stimulability was not assessed for this subject as most productions were obtained through imitation.

Phonological Processes: A Relational Analysis

Phonological processes that occurred with 25% or greater frequency in Subject 3's speech are listed in Table 9. The processes that affected the syllable (i.e., cluster

Table 8

<u>Phonetic and Phonemic Inventories for Subject 3</u>

Phonological System				
Phonetic Inventory				
Nasals	m n ŋ			
Stops	p b t d k g			
Fricatives	f v s z h			
Affricates				
Liquids	l r			
Glides	w			
Examples from data	[bæf] "bath" [kʌk] "duck"	[rɛlo] "yellow" [bɛdz] "feather"	[wæk] "flag" [gwou] - "squirrel"	[dʌm] - "drum" [ɪndo] - "window"
Phonemic Inventory				
Nasals	m n ŋ			
Stops	p b t d k g			
Fricatives	f v s h			
Affricates				
Liquids				
Glides	w			
Examples from data	[bo] ~ [ko] "bow" - "comb" [sæk] ~ [wæk] "sack" - "flag"		[fʌm] ~ [dʌm] "thumb" - "drum" [wɪs] ~ [hɪs] "fishing" - "matches"	

<u>Note</u>. *The phonetic inventory is based upon a two-time occurrence criterion. The phonemic inventory is based upon a one-time occurrence criterion. Both are presented in a standard Place-Voice-Manner format. Manner of production is labeled; place of production progresses posteriorly from labial to velar; voiceless cognates are presented on the left, and voiced are presented on the right.*

Table 9

Phonological Processes and Percentages of Occurrence in Subject 3's Speech

Process	Percentage of Occurrence	Example
Cluster Reduction (2)	**62% (21/34)**	**[pis] for /pliz/**
Palatal Fronting	50% (3/6)	[su] for /ʃu/
Later Stopping	30% (6/20)	[dɪs] for /ðɪs/
Fricative Simplification	33% (2/6)	[bæf] for [bæθ]
Normal Vocalization	47% (9/19)	[wi] for /hwil/
Velar Assimilation (1)	**19% (3/16)**	**[kʌk] for /dʌk/**
Final Consonant Deletion (1)	**19% (8/51)**	**[bʌ] for /brʌʃ/**

Note. *Percentage of occurrence and the ratio of the number of occurrences to the number of opportunities across word contexts are provided. Processes that affected the syllable are given a point value: "2" used inconsistently or "1" used sporadically as described by Vihman (1996).*

reduction, final consonant deletion, and velar assimilation) are presented in bold type face with their corresponding point values regardless of frequency of occurrence. Within the data set, there were 20 productions that PROPH+ was not able to analyze.

Phonological Rules: An Independent Analysis

Table 8 provided Subject 3's phonetic and phonemic inventories. Following the featural hierarchy proposed by Gierut (1990), this child's inventory included, minimally, one phone with at least one of the following features: [sonorant], [consonantal], [voice], [continuant], [non-nasal sonorant], and [lateral]. These features are characteristic of a

Level E inventory. Presentation of the phonological rules with corresponding examples from the data set can be found in Table 10.

Phoneme Collapses: A Child-Based Relational Analysis

Diagrams of the one-to-many correspondences of S3's phonemic inventory are provided in Figure 3. There were 16 phoneme collapses present in this subject's phonological patterns: 10 occurred word-initially and six occurred intervocalically. There is overlap among the sounds that are collapsed, further indicating that there is a high degree of variability in this child's speech.

Unusual Productions

Subject 3 produced /mɪlk/ as [sɪlk] during collection of the language sample. This production meets the criteria as defined by Leonard et al. (1987) for unusual phonological behavior. This substitution pattern did not occur again within the data set. The remaining 20 misproductions that PROPH+ was not able to analyze can be accounted for by the processes of initial consonant deletion, assimilation, deaffrication, and final consonant deletion (deletion of word or syllable final /m, n, p, b/) .

Subject 4

Phonetic and Phonemic Inventories

The phonetic and phonemic inventories for Subject 4 (CA: 6 years 6 months) are presented in Table 11. Both inventories are a compilation of the combined data set. S4 had 11 errors out of a total of 73 targeted phonemes on the GFTA. Stimulability was assessed for the following phonemes: /j, r, θ/. Stimulability for /j/ was assessed only in

Table 10

Phonological Rules Operating in Subject 3's Phonological System

1. Positional Constraint: [f] occurred word-initially only as a replacement for [θ, l] (occurred correctly word-finally); [l] occurred as a singleton only intervocalically	
Examples for [f]: [fif] - "leaf" [fʌm] - "thumb"; [ɪŋgɚ] - "finger"	Examples for [l]: [wɛlo] - "yellow"; [wæmp] - "lamp"
2. Labial and Velar Assimilation	
Example: Labial [pʌp] - "cup"	Example: Velar [kʌk] - "duck"
3. Consonant Clusters: Only [stop + liquid] and [stop + glide] form word-initially; Only [nasal + stop] and [nasal + fricative] form word-finally	
Example: Syllable-initial [blu] - "blue" [gwʊɚ] - "squirrel"	Example: Syllable-final [kænz] - "crayons" [dʒʌmp] - "jump"
4. Morphophonemic Alternations	
Example: [bæf] ~ [æθtʌb] - "bath" - "bathtub"	
5. Differential Phonological Behavior	
Examples: [pʌp] for /kʌp/, [kʌk] for /dʌk/	
6. High Variability in Production	
Examples: [wɛlo] ~ [rɛlo] - "yellow"; [wæk] ~ [sæk] - "flag"	
7. Nasalization of Vowels Preceding Final Consonants	
Examples: [wɪ̃] - "ring", [gʌ̃] - "gun"	

Note. *High variability in production can be indicative of high allophonic variation in the surface or phonetic representation.*

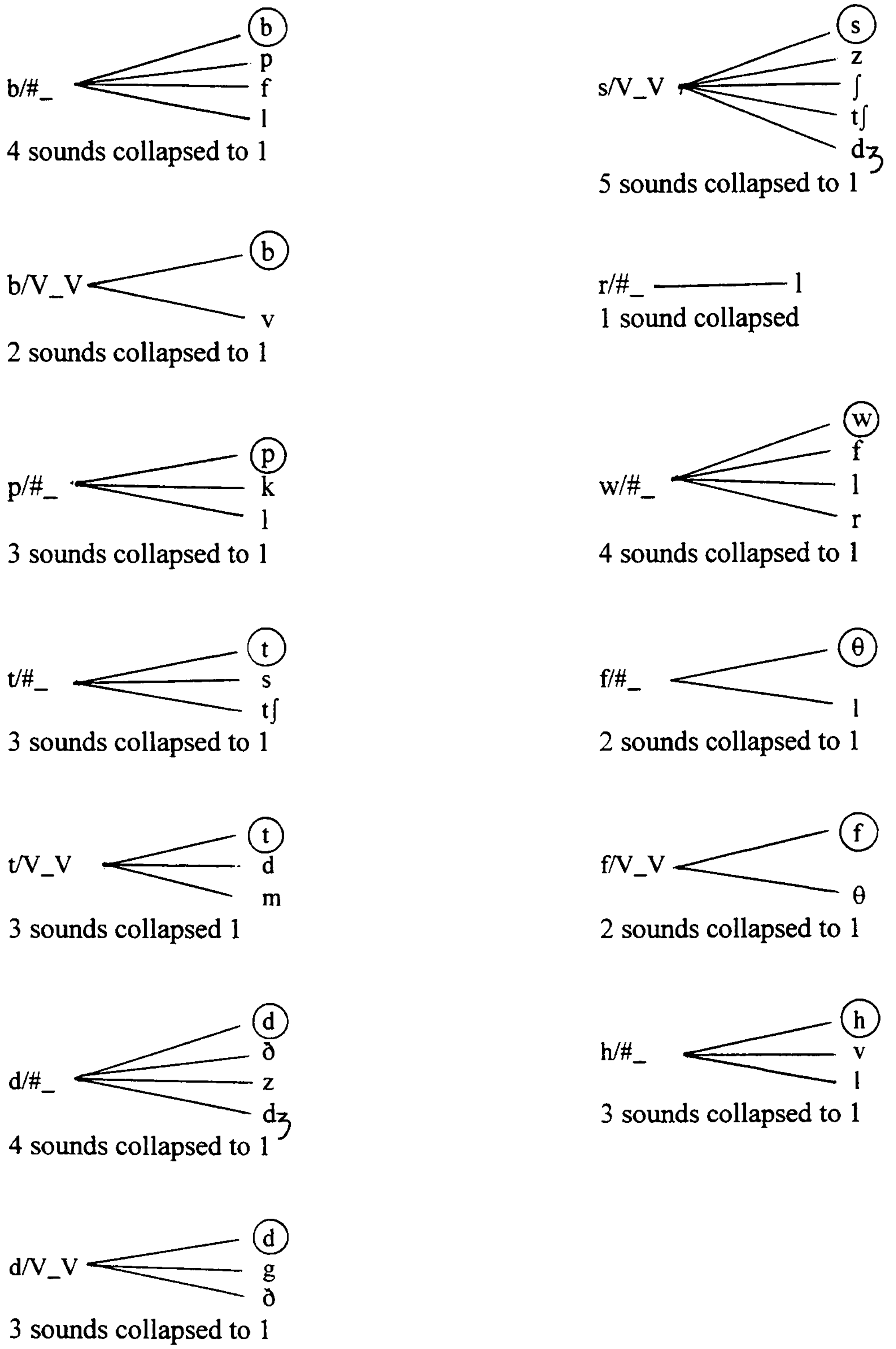
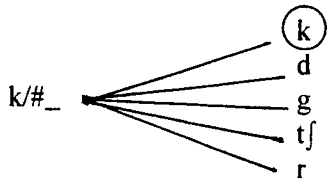
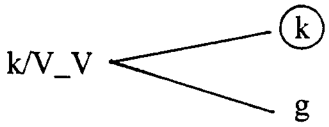


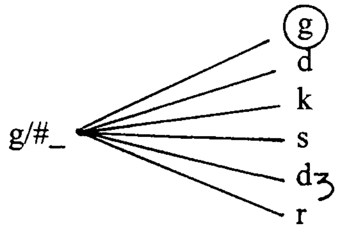
Figure 3. Phoneme collapses for Subject 3. Collapses occurred either word initially (#_) or intervocalically (V_V).



5 sounds collapsed to 1



2 sounds collapsed to 1



6 sounds collapsed to 1

Figure 3 Continued.

Table 11

<u>Phonetic and Phonemic Inventories for Subject 4</u>

Phonological System				
Phonetic Inventory				
Nasals	m n ŋ			
Stops	p b t d k g			
Fricatives	f v θ ð s z ʃ h			
Affricates	tʃ dʒ			
Liquids	l r			
Glides	w			
Examples from data	[blu] "blue" [flæʃ] "flag"	[kar] "car" [wæmp] "lamp"	[mætʃɪz] "matches" [drʌm] "drum"	[haus] - "house" [oɪndʒ] - "orange"
Phonemic Inventory				
Nasals	m n ŋ			
Stops	p b t d k g			
Fricatives	f v s ʃ h			
Affricates	tʃ dʒ			
Liquids	l r			
Glides	w			
Examples from data	[tʃɛr] ~ [hɛr] "chair" - "hair" [wɛd] ~ [bɛd] "red" - "bed"		[plet] ~ [plen] "plate" -"plane" [dus] ~ [gu] "juice" - "you"	

<u>Note</u>. *The phonetic inventory is based upon a two-time occurrence criterion. The phonemic inventory is based upon a one-time occurrence criterion. Both are presented in a standard Place-Voice-Manner format. Manner of production is labeled; place of production progresses posteriorly from labial to velar; voiceless cognates are presented on the left, and voiced are presented on the right.*

syllable initial position. S4 was stimulable for [j] in initial position and [r] in initial and final positions. However, this subject was not stimulable for /θ/ in either position.

Phonological Processes: A Relational Analysis

The processes that occurred with 25% or greater frequency in Subject 4's speech are listed in Table 12. Though it occurred with less than 25% frequency, the process of cluster reduction and its point value are presented in the table because this is a process that affects the syllable. There were 11 misproductions within the complete data set that PROPH+ was not able to analyze.

Phonological Rules: An Independent Analysis

S4's phonetic inventory was given in Table 11 and included, minimally, one phone with at least one of the following features: [sonorant], [consonantal], [voice], [continuant], [non-nasal sonorant], and [lateral]. These features are characteristic

Table 12

Phonological Processes and Percentages of Occurrence in Subject 4's speech

Process	Percentage	Example
Fricative Simplification	29% (2/7)	[fʌm] for /θʌm/
Cluster Reduction (1)	**15% (6/39)**	**[pelo] for /pledo/**

Note. *Percentage of occurrence and the ratio of the number of occurrences to the number of opportunities across word contexts are provided. Cluster reduction affects the syllable and occurred sporadically ("1") in S4's speech.*

of a Level E inventory. The CVC pattern was the most commonly occurring throughout both the administration of the GFTA and collection of the speech sample, however, there is ample evidence throughout the data set of word initial, medial, and final clusters. Examples of the phonological rules operating in Subject 4's phonological system are presented in Table 13.

Phoneme Collapses: A Child-Based Relational Analysis

Diagrams of the one-to-many correspondences of S4's phonemic inventory are provided in Figure 4. As can be seen, this child collapsed few of the salient contrasts of English, indicating that she produced and used most of the phonemes of English contrastively.

Unusual Productions

Subject 4 produced /flæg/ as [flæʃ] spontaneously during administration of the GFTA and collection of the speech sample. This production meets the criteria as defined by Leonard et al. (1987) for unusual phonological behavior. This substitution pattern did not occur again within the data set. The remaining productions, including the 11 misproductions that PROPH+ was not able to analyze can be accounted for by the process of assimilation.

Subject 5

Phonetic and Phonemic Inventories

The phonetic and phonemic inventories for Subject 5 (CA: 6 years 9 months) are presented in Table 14. Both inventories are a combination of the data obtained from the GFTA and the speech sample and examples from the data set are provided. This subject

Table 13

Phonological Rules Operating in Subject 4's Phonological System

1. Positional Constraints: [θ] occurred only word-finally; [ð] occurred only intervocalically	
Examples for [θ]: [bæθ] - "bath"; [fʌm] - "thumb"	Examples for [ð]: [wɛðɚ] - "feather"; [dæt] - "that"
2. Free Variation - s/z and w/r	
Examples: Incorrect [sIpɚ] - "zipper" [wIŋ] - "ring"	Examples: Correct [zIpɚ] - "zipper" [rɛd] - "red"
3. Coronal and Velar Assimilation	
Example: Coronal [lɛlo] - "yellow"	Example: Velar [gengu] - "thank you"
4. Epenthesis (insertion of a vowel between members of a cluster)	
Example: [sæntəkəlɔz] - "Santa Claus"	

<u>Note</u>. *Some misproductions appeared to specific to particular lexical items.*

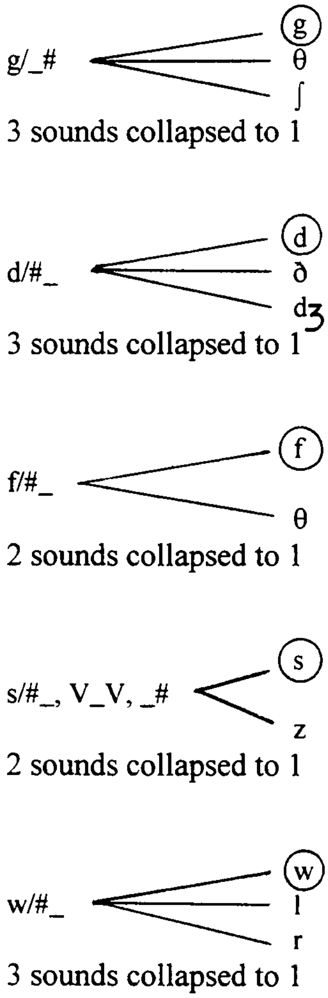


Figure 4. Phoneme collapses for Subject 4. Collapses occurred word initially (#_), intervocalically (V_V), or word finally (_#).

Table 14

Phonetic and Phonemic Inventories for Subject 5

Phonological System				
Phonetic Inventory				
Nasals Stops Fricatives Affricates Liquids Glides	m n ŋ p b t d k g f v θ s ʃ h tʃ dʒ l r w			
Examples from data	[baeθ] "bath" [plen] "plane"	[tʃɛr] "chair" [flaeg] "flag"	[ʃʌvəl] "shovel" [haus] "house"	[dʌk] "duck" [wɪŋ] "ring"
Phonemic Inventory				
Nasals Stops Fricatives Affricates Liquids Glides	m n ŋ p b t d k g f θ s ʃ tʃ dʒ l w			
Examples from data	[baeθ] ~ [baeg] "bath" - "bag" [wɛd] ~ [bɛd] "red" - "bed" [drʌm] ~ [θʌm] "drum" - "thumb"		[haus] ~ [nos] "house" - "nose" [slip] ~ [ʃip] "sleep" - "sheep" [laemp] ~ [dʒʌmp] "lamp" -"jump"	

Note. *The phonetic inventory is based upon a two-time occurrence criterion: Phonemic inventory is based upon a one-time occurrence criterion. The inventories are presented in a standard Place-Voice-Manner format. Manner of production is labeled; place of production progresses posteriorly from labial to velar; voiceless cognates are presented on the left, and voiced cognates on the right.*

had nine errors out of the 73 total targeted phonemes on the GFTA. Stimulability was assessed for the following phonemes: /j, r, v/. S5 was stimulable for [j, v] in the initial and final positions of syllables and [r] only in final position.

Phonological Processes: A Relational Analysis

Phonological processes in Subject 5's speech that occurred with at least 25% occurrence are listed in Table 15. Cluster reduction was the only process observed in this subject's speech that affected the syllable and is presented in bold type face with the corresponding point value. A point value of (1) indicates that the rule was applied sporadically throughout the data set. There were, however, four misproductions in the data set that PROPH+ was not able to analyze.

Table 15

Phonological Processes and Percentages of Occurrence in Subject 5's Speech

Process	Percentage of Occurrence	Example
Liquid Simplification	38% (7/18)	[wæbɪt] for /ræbɪt/
Cluster Simplification	25% (4/16)	[kwɔz] for /klɔz/
Cluster Reduction (1)	**16% (5/31)**	**[sæ̃nə] for /sæntə/**

Note. *Percentage of occurrence is a ratio of the number of occurrences to the number of opportunities across all word contexts. The point value of (1) indicates sporadic use of the process of cluster reduction.*

Phonological Rules: An Independent Analysis

S5's phonetic inventory was presented in Table 15. According to the featural hierarchy proposed by Gierut (1990), this child's inventory falls within Level E, which minimally included one phone with at least one of the following features: [sonorant], [consonantal], [voice], [continuant], [non-nasal sonorant], [laterality], and [stridency]. The CVC word shape was the most commonly occurring throughout both the administration of the GFTA and collection of the speech sample. The phonological rules present in S5's phonological system are presented in Table 16 along with corresponding examples from the data set.

Phoneme Collapses: A Child-Based Relational Analysis

Diagrams of Subject 5's phoneme collapses are provided in Figure 5. As can be seen in the figure, this subject collapsed only a few of the salient contrasts of English. In other words, this subject produced and used most of the phonemes of English contrastively.

Unusual Productions

S5 produced the target /vækjum/ as [kæθum] during administration of the GFTA. The substitution of [k] for /v/ is unusual because a voiceless, velar stop was substituted for a voiced, labial-dental fricative. Additionally, the voiceless, non-strident fricative [θ] was produced in place of the target /velar stop + glide/ cluster /kj/ intervocalically. Neither substitution pattern was observed for any other production in this subject's data set.

Table 16

<u>Phonological Rules Operating in Subject 5's Phonological System</u>

<table>
<tr><td colspan="2">1. Positional Constraints for [v, r] word-initially; [z] word-initially and intervocalically</td></tr>
<tr><td>Examples: Incorrect
[kæθum] for /vækjum/
[wæbɪt] for /ræbɪt/
[sɪsɚz] for /sɪzɚz/</td><td>Examples: Correct
[ʃʌvəl] - "shovel"
[tʃɛr] - "chair"
[noz] - "nose"</td></tr>
<tr><td colspan="2">2. Free Variation - w/r and w/l</td></tr>
<tr><td colspan="2">Examples: [brʌʃ]/[bwʌʃ] - "brush" [blu] - "blue" / [kwɔz] - "Claus"</td></tr>
<tr><td colspan="2">3. Coronal Assimilation</td></tr>
<tr><td colspan="2">Example: [lɛlo] for /jɛlo/ - "yellow"</td></tr>
<tr><td colspan="2">4. Nasalization of Vowels Preceding Nasal Consonants</td></tr>
<tr><td colspan="2">Examples: [gʌ̃] - "gun", [hɛlɛfõ] - "telephone"</td></tr>
</table>

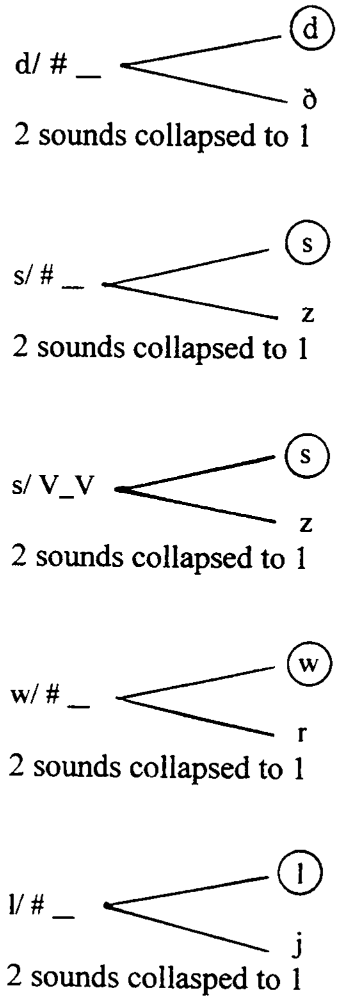


Figure 5. Phoneme collapses for Subject 5. For all collapses, word position is indicated by #_ (word initial) or V_V (intervocalic).

Summary

Although there were wide differences in the developmental and language skills across the five subjects, several general statements can be made. All of the subjects used only phones and phonemes that normally occur in English, indicating that these children were acquiring the ambient phonological system. The initial purpose of this study was to determine whether the phonological and developmental levels are similar in children with Down syndrome when phonological behavior is determined by the relational and independent analyses. The results indicated that all of the subjects exhibited greater delays in their phonological development than expected for their general developmental levels. The phonetic inventories of these subjects ranged from eight to 22 consonants, while the phonemic repertoires ranged from seven to 19 consonants. Both of the inventories were based upon sample sizes of 125-150 utterances per child. It should be noted that these speech samples were not entirely spontaneous; many productions could only be elicited through imitation. All subjects had at least one phonological process that affected the syllable shape (e.g., final consonant deletion, cluster reduction) in their speech. The independent analysis revealed that at least one type of assimilation was present in the rule systems of all subjects. The number of phonological rules operating in these children's systems ranged from four to seven. The number of child-based relational phoneme collapses ranged from five to 16 across subjects.

The second purpose of this study was to determine if children with Down syndrome show evidence of unusual phonological behavior. If these children did exhibit this type of behavior, would the frequency of occurrence be closer to that reported for typically developing children or children with Specific Language Impairment? The three chronologically older subjects each exhibited only one unusual phonological behavior in their spontaneous speech (e.g., [kæθum] for /vækjum/). The frequency of occurrence of this behavior more closely resembles that reported for normally developing children (cf. Leonard et al., 1987). However, all subjects produced many unintelligible strings of jargon, which may have included unusual productions that were not included in the above analyses.

The third purpose of this study was to determine how children with Down syndrome perceived their own phonological errors. Locke's (1980) Speech Production-Perception Task was used to assess the perception of these subjects. The results of the Speech Production-Perception Task were unreliable for all subjects, indicating that this was not an effective measure for assessing the perception of phonological errors of these subjects. Only one of the five subjects was able to complete even a portion of the task: This subject completed trials for only two of her many production errors on the GFTA. Results of the SP-PT indicated that these two misproductions were the result of misperceptions.

Chapter IV

Discussion

Patterns Observed in the Phonological Systems of these Children

As reported in the presentation of the results, all subjects exhibited greater delays in their phonological development than expected by their general developmental levels. In general, the developmental levels of these children with Down syndrome were approximately two years below their chronological age levels. This finding was determined by the presence of phonological processes in the speech of these school-age children with Down syndrome that are absent in the phonological patterns of normally developing children by the age of three years. All of the subjects had at least one process that affected the syllable shape in their speech (e.g., final consonant deletion, cluster reduction). However, it should be noted that the phonological processes approach captured the phonological patterns of these subjects in a broad manner, with little information regarding the context that conditioned the presence of the patterns. In contrast, the independent analysis combined with the phoneme collapses provided more focal descriptions of the patterns that occurred in these subjects' phonological systems. While these analyses did not provide comparisons between the phonological patterns of these subjects and those of normally developing, they did provide more accurate descriptions about the contexts that conditioned the presence of certain patterns.

<u>**Unusual Phonological Behavior**</u>

Unusual phonological behaviors were not a primary characteristic exhibited by these children with Down syndrome. However, three of the five subjects presented one production each that met the criteria for unusual phonological productions as defined by Leonard et al. (1987). The infrequent occurrence of this behavior is equivalent to that reported by Stoel-Gammon (1980). These unusual productions were produced by the three subjects with the most complex phonetic and phonemic inventories. For reference, each of the unusual productions is listed in the case summaries for Subjects 3, 4, and 5.

This finding suggests two separate but related possibilities. First, it raises the possibility that these productions are stored as such in each respective subject's underlying representation. Secondly, this finding also indicates that a child's phonological system much reach a certain level of complexity before unusual forms can be produced as such. The suggestion that each unusual production is stored as such in each subject's underlying representation can be further supported by the finding that the pattern present in the unusual production was not found elsewhere in the data set for each of the three subjects. In terms of the level of complexity, the data appear to suggest that children with less complex phonological systems have fewer phonemes from which to "choose." Children with more complex phonological systems have more choices in terms of phonemes that can be substituted across word positions.

Leonard et al. (1987) investigated the conditions that promoted unusual phonological behavior in children with specific language impairment (SLI) and normally developing age-matched peers. Both groups of subjects were taught nonsense labels of unfamiliar items through fast mapping. The subjects with SLI exhibited twice as many unusual phonological behaviors than the normally developing children. The children with Down syndrome exhibited unusual phonological behavior with a known referent in spontaneous speech or in imitation of the examiner. While the frequency of this behavior is equivalent with that reported by Stoel-Gammon (1980) and for normally developing children, if these children with Down syndrome had been taught nonsense words, as was the case in Leonard et al. (1987), one would expect that the frequency of unusual phonological behavior would increase.

Speech Production-Perception Task

The results of the Speech Production-Perception Task (Locke, 1980b) indicated that this task was not an effective measure for assessing the perception the phonological errors of these children with Down syndrome. There are several possibilities for the general failure of this task. The first of these involves the design of the task, which is described in the presentation of the methods. The Speech Production-Perception Task was initially designed for and used with normally developing children. The yes/no question that is posed during the task (e.g., Is it a (/dʌk/)? Is it a (/kʌk/)?) is more advanced than a question such as Do you want juice? The question used in the task requires children to make a comparison between their output form and their underlying representation in the mental lexicon. It then essentially becomes a comparison between same and different, a higher order cognitive function.

All parents expressed concern that their child may not have been exposed to the this type of question in either the home or school environment. Parents were asked to pre-train their child prior to administration of the SP-PT if they indicated that their child had difficulty with yes/no questions. Four of the five children received the pre-training which entailed having the child practice answering concrete yes/no questions appropriately and consistently during familiar home routines. Subject 2 was the only child who was able to reliably respond to any portion of the task. Two of six sets of trials were completed, indicating that her productions in those cases were the result of misperceptions. It is unclear if Subject 2's four remaining productions were the result of misperceptions as the subject's responses were unreliable. Locke stated in the development of the SP-PT that all production errors are equally likely to be the result of perceptual errors.

A second possibility for the general unreliability of the task was identified during the analyses of the data. In many cases the "perceptually similar" control phoneme was contained within at least one phoneme collapse for each subject. In other words, many of perceptually similar control phonemes were allophonic variations of the response phonemes for each subject.

A third source of the unreliability of the SP-PT could have been included in a necessary modification of the task. Because of the limited attention span of these subjects, each set of trials was distributed among other sets or more reinforcing activities for each subject. As an example, nine of the 18 trials for one production would be given to a child, and then to alleviate fatigue nine trials for another would be given.

Several modifications to the task appear to be warranted for this population. These modifications include performing additional phonological analysis prior to administering the task to each subject. This modification would ensure that the control phoneme was not an allophone in each subject's phonological system. Additionally, rather than using a "perceptually similar" phoneme as a control, further modifications could include using a perceptually dissimilar control phoneme. Preliminary testing revealed that this modification would further eliminate the possibility that the control phoneme was an allophonic variation of the response phoneme in each child's phonological system.

Recommendations and Goals

An essential part of completing extensive analyses such as these is augmenting the results with clinical applications. Potential treatment targets are considered from both the phonological processes (PROPH+; Long & Fey, 1993) and independent analysis (Maximal Oppositions; Gierut, 1990) approaches. For Subjects 1-3, these treatment approaches and their targets are compared with those of a third (Multiple Oppositions; Williams, 1993). The Multiple Oppositions approach relies heavily on information obtained from the independent analysis as well as the phoneme collapses, however, the goals and treatment strategies differ from Maximal Oppositions (Gierut, 1990).

Recommendations and goals based on different analysis approaches vary for all subjects. A brief presentation of each analysis approach's recommendations, probable treatment targets, and expectations for change are presented in appendices for all subjects (see Appendices H-L).

Subject 1

Subject 1 (CA: 4 years 8 months) was the least intelligible of all of the subjects. This subject's phonetic inventory was characterized as Level B (Gierut, 1990). Three processes that affect the syllable (final consonant deletion, cluster reduction, and reduplication) were present in S1's speech. Based upon chronological age, the presence of these processes indicate a severe phonological delay. However, S1's developmental level was approximately two years below age level, and the processes of final consonant deletion and cluster reduction frequently appear in the speech of normally developing 2 year 6 month to 3 year old children. Grunwell (1982) indicated, however, that reduplication of syllables does not typically occur in the speech of normally developing children beyond the age of 18 months to 2 years. The presence of this process is indicative of a delay in phonological development beyond what would be expected for S1's developmental level.

Potential treatment goals and expectations from three phonological treatment approaches, phonological processes (PROPH+; Long & Fey, 1993), Maximal Oppositions (Gierut, 1990) and Multiple Oppositions (Williams, 1993), are provided in Appendix H. The phonological processes perspective would implement change in the child's system by eliminating the processes of final consonant deletion, cluster reduction and stopping. This approach would be most likely to follow a developmental sequence when introducing new sounds in therapy.

In contrast the two approaches that rely on information from the independent analysis would seek to affect change not only in the child's phonetic inventory, but also in the phonemic. Change in both inventories is especially important, given this child's limited repertoires. Maximal Oppositions (Gierut, 1990) could increase complexity of the phonological system in several ways. The child could be taught a Level C distinction such as teaching /z/, an unknown, unstimulable sound paired with /b/ in either real or nonsense words. Minimally, this child would be expected to learn /s, z/, increasing the manner classes. Alternatively, the child could be taught a Level E distinction such as the unknown, unstimulable pair /l, r/ in a nonsense word story. In order to acquire /l, r/, the child would first have to acquire fricative and/or affricates. The child would be expected to acquire these distinctions without direct intervention. Alternatively, Multiple Oppositions (Williams, 1993) could also be implemented. This approach relies on information from the independent analysis which is subsequently supplemented by the phoneme collapses. This approach fosters change by attempting to make the phonemic contrasts of English more salient through the pairing of multiple real words. As an example, real words containing /d/ could be multiply opposed with real words containing /n, ʃ, r/. It would also be expected that either of these approaches would address "syllable-finalness" as an additional goal.

Subject 2

Subject 2's (CA: 4 years 6 months) phonetic inventory was characterized as Level D, with corresponding examples from the data set in the presentation of the results. S2 was the only subject who was able to reliably complete any portion of the SP-PT (see

Appendix G). Recall that this subject's errors on the two items were found to be perceptually based. If further testing revealed similar findings, this could influence the selection of intervention procedures. Given the incomplete SP-PT results, the subject's goals were selected without regard to the perceptual results.

Four processes identified by Grunwell (1982) that affect the syllable are present in the speech of S2. These processes are again, velar assimilation, final consonant deletion, cluster reduction, and reduplication. Although final consonant deletion and cluster reduction are not typically present in the speech of a normally developing 4 year 6 month old child, they are still present in the speech of a normally developing 2 year 6 month to 3 year old child. Therefore, the presence of these processes in this subject's speech is to be expected. However, Grunwell (1982) reported that the process of reduplication does not appear in the speech of normally-developing children after the age of 18 months to 2 years. The presence of this process is indicative of a severe phonological delay.

Recommendations for therapy from three phonological approaches are provided in Appendix I. These approaches are phonological processes (PROPH+; Long & Fey, 1993), Maximal Oppositions (Gierut, 1990), and Multiple Oppositions (Williams, 1993). Each of these approaches has the same ultimate goal, to increase this child's intelligibility; however, each has different goals and techniques for therapy. The phonological processes approach would initially seek to eliminate the process of final consonant deletion, then continue with therapy to eliminate other regularly occurring processes such as cluster reduction and vocalization. This approach would be the most likely to follow a developmental sequence to teach phones to this child. In contrast to this approach are the

Maximal and Multiple Oppositions approaches. Both of these rely upon information from the independent analysis. In the case of Maximal Oppositions (Gierut, 1990), change in this child's phonological system would be facilitated by increasing the level of complexity. This would be accomplished by teaching the child the unknown, unstimulable phoneme /ð/ paired with the unknown phoneme /z/ in nonsense word stories that create new lexical items. Additionally, the concept of "syllable-finalness" could be taught either in the nnonsenseword stories or through maximally opposed (based upon the number of distinctive features by which two sounds differ) minimal pairs. Multiple Oppositions (Williams, 1993) takes into account information from the independent analysis, but also seeks to create phonemic splits for the sounds collapsed by the child identified through the phoneme collapses. This approach would as an example, pair real words containing /b/ with real words containing /s/, /t/, and /r/. These multiple pairings are intended to make each of the phonemic contrasts more salient to the child.

Subject 3

The phonological system for Subject 3 (CA: 5 years 6 months) was displayed in the presentation of the results. Three processes affecting production of the syllable were present in this child's speech; cluster reduction, velar assimilation, and final consonant deletion. The presence of these processes given either this subject's chronological age or developmental level indicates a delay beyond what would normally be expected.

As with Subjects 1 and 2, recommendations and goals from three treatment approaches are presented (see Appendix J). The phonological processes approach would focus upon increasing correct production of all members of a cluster and the palatal fricative /ʃ/ and affricate /tʃ/ in order to increase intelligibility. Again, in contrast to this approach are the independent approaches, Maximal and Multiple Oppositions. Both of these approaches seek to expand the child's phonetic and phonemic inventories, but would accomplish this goal in different ways. Maximal Oppositions (Gierut, 1990) would affect change in the child's system by teaching either the known phoneme /s/ paired with the unknown phoneme /θ/ or pairing the phonetically-realized /z/ with the unknown phoneme /ð/ in nonsense word stories. Multiple Oppositions (Williams, 1993) on the other hand, would implement change within the phonological system by creating phonemic splits for the identified phoneme collapses for this child. For example this approach would teach real words containing /g/ with real words containing /d , s, d/ in order to make the phonemic contrasts of English more salient.

It should be noted that there was a greater deal of intra- and inter-word variability in production for this particular subject. Variability in production is indicative of a phonological system that contains optional rather than obligatory phonological rules. Variability in production has a clinical application as well. It has been shown that generalization does not occur as rapidly in children with variability in productions as for children with more stable phonological rules (Dinnsen, personal communication, March, 1995).

Subject 4

Subject 4's (CA: 6 years 6 months) phonetic inventory was characterized as Level E (most complex; Gierut, 1990). The process of cluster reduction, which affects the syllable, was present in the speech of this subject. Again, like Subject 3, its presence is indicative of a phonological delay beyond what would be expected for this subject's chronological age or developmental level. It should be noted that this subject's errors tended to be specific to individual lexical items. That being said, potential treatment targets from both the phonological processes and the independent analysis are presented in Appendix K.

The phonological processes approach would implement change by eliminating the process of fricative simplification. The process affects only /θ/ and /ð/; therefore the goal for therapy would be to increase correct production of these phonemes. An additional goal might be to increase correct production of all members of a consonant cluster.

The independent analysis identified that this subject was using /θ/ and /ð/, however, there was a constraint on the positions in which these sounds could occur. Therefore the goal for therapy from this perspective would be to eliminate the positional constraint rather than increase correct production. Additionally, this approach would seek to create a phonemic split for /s/ and /z/, and /w/ and /r/. This subject used these sounds interchangeably, indicating that they were merely variations of the same underlying phoneme.

Subject 5

Subject 5's (CA: 6 years 9 months) phonological system was described in the presentation of the results This subject's phonetic inventory was characterized as Level E (most complex). Cluster reduction was observed in the speech of this subject and its presence indicates that S5's phonological development is delayed beyond what is expected for both her chronological age and developmental level. Recommendations for treatment targets from both the phonological processes and independent analysis are provided in Appendix L. This table contrasts potential treatment targets from both analysis perspectives. As is apparent, for this subject, both approaches have different goals as well as different expectations for change. The goals from the phonological processes perspective focus solely upon increasing correct production of liquids in singletons and clusters. This goal could be accomplished through any number of clinical techniques ranging from cycling to traditional minimal pair therapy. Goals from the independent analysis perspective focus upon creating a salient phonemic distinction (creating two separate phonemes) for the subject. Additionally, this perspective would seek to eliminate the positional constraints for the phones [z, v, r], a pattern not detected by the phonological processes analysis.

Summary

Each of the analysis procedures compared and contrasted above have the same ultimate goal in clinical applications, to increase intelligibility. The assumptions underlying each approach and the ways changes are affected in a child's system differ greatly, however. The phonological processes approach seeks to increase correct production on the assumption that change need only be enacted in production. In other words, the child already has the adult-like contrast, he or she needs to begin to use the contrast in production. The independent analysis, on the other hand, may attempt to implement change in the phonetic inventory or the phonemic inventory or both depending upon the needs of the child. This approach makes no assumptions regarding a child's knowledge of the contrasts of the ambient phonological system. These assumptions translate into clinical practice as goals that are intended to increase correct production or goals that are intended to create phonetic or phonemic contrasts in the child's phonological system.

With regards to the cases described above, there are individual differences among the treatment programs regardless of the theoretical approach. However, some general trends emerge. For the phonological processes approach, these include addressing the process of cluster reduction for each subject. In contrast, for the independent approach, these trends include further expansion of the phonological systems of all subjects.

Limitations of the Present Study

The "Spontaneous" Speech Sample

The data analyzed from the speech samples collected during the last experimental session of this study were not entirely spontaneous. In order to obtain these samples, intelligible productions with identifiable referents were elicited through modeling and both delayed and direct imitation. Stoel-Gammon (1980) also reported the same difficulty in obtaining spontaneous speech samples from her subjects with Down syndrome.

All of the subjects that participated in this study produced long (phrase and sentence length) spontaneous strings of unintelligible jargon. The parents of these subjects were often able to identify the topic of "conversation" and enough of their child's speech to know when questions were being asked of them. However, all of the parents were not always able to identify what their child was trying to communicate. A prime example of strings of jargon can be found in several subjects' attempts to repeat the "Pledge of Allegiance" when presented with a small toy flag during the collection of the language sample. No child that attempted to repeat this familiar school routine was able to repeat it well enough for all phrases to be understood by an unfamiliar listener, or in two cases well enough to be understood by a familiar listener.

The strings of spontaneous jargon may be unknowingly reinforced by significant individuals in each child's life. The parent or care giver who smiles and nods at seemingly appropriate pauses in the child's attempt at communication may in actuality be reinforcing the unintelligibility through non-committal verbal praise. The strings of jargon appear to fulfill a pragmatic purpose for these children as well. The subjects in this study were aware that individuals must mark turns in conversations and used the strings to mark their turn in the conversation.

Stoel-Gammon (1980) reported production of strings of spontaneous jargon intermingled with intelligible utterances across all of her subjects. The results of this study appear to replicate her findings. It is conceivable that, because of these strings of jargon, a complete picture of the phonological development and/or capabilities of children with Down syndrome has not yet been realized. Because of the nature of both Stoel-Gammon's investigation and the present study, it was only possible to analyze intelligible utterances or those with an identified referent for each subject.

Future Research

Future research in this area could include a longitudinal study of the phonological development of children with Down syndrome from the age of 4 years to the age of 7 years. Through such a study, one would gain a better insight into the individual development of phonological systems in this population. Two benefits could be expected: 1) identify more appropriate treatment targets to increase overall intelligibility, and 2) gain insight into whether children with Down syndrome acquire phonemes in a specific order, including the word position in which the phonemes first appear. Language samples could be obtained through familiar home and/or school routines. In these situations, the routine would be familiar to both the child and the parent and referents in spontaneous speech would then be more easily identified. In addition to investigating the development of consonants over a span of several years, the development of vowels could also be investigated. The distortion of vowels contributed to the unintelligibility of the five subjects with Down syndrome. However, no previous research has been completed regarding the production and development of vowels in this population.

A possible phonological treatment study could involve applying Williams' (1993) multiple oppositions approach to this population. The basis of her approach is the creation of phonemic splits dependent upon the phoneme collapses of a given child. All of the subjects in this study collapsed phonemes, in some cases as many as 10 or more sounds collapsed to one. The ideal subject with Down syndrome for this type of investigation would have an expressive vocabulary at least as large as his or her developmental level would predict.

Acoustic analyses could be performed upon the seemingly homophonous productions of subjects with Down syndrome. It has been suggested by Schwartz (1981) that homonymy is a child's way to circumvent phonological inventory and positional constraints during a transitional phase in phonological development. However, as mentioned in the review of the literature, children do occasionally make imperceptible acoustic distinctions that serve to avoid homonymy. The question to be asked then is are children with Down syndrome also making these imperceptible acoustic distinctions.

To further answer the question regarding the frequency of unusual phonological behavior, the method developed by Leonard et al. (1987) could be implemented with this population. In the Leonard et al. study, children with SLI and normally-developing age-matched peers were taught nonsense words for unfamiliar objects. In this proposed study, children with Down syndrome would be matched by developmental age to younger normally developing peers. Given this situation, it would be expected that given the limitations in their phonological systems, the children with Down syndrome would exhibit more unusual phonological behavior.

In order to assess perception in this population, several modifications need to be considered. Modifications such as those mentioned in the discussion of the SP-PT are warranted for children with Down syndrome. In addition, in order to assess general phonological awareness, a task such as the ABX paradigm could be employed. In this paradigm, children need only indicate whether two syllables were the same or different. Although this task requires children with Down syndrome to make same or different choices, this paradigm might prove easier for them because it makes use only of auditory memory and matching of two nonsense syllables. During the administration of the SP-PT children are asked to make a judgement between same and different as well as retrieve the stored template for a real word from the mental lexicon.

Summary

The patterns in the phonologies of these five children with Down syndrome were the result of delay rather than deviance. These results support Stoel-Gammon's (1980) investigation into the phonological development of children with Down syndrome. However, there was a greater degree of delay in these subjects' phonological development than would be expected based upon either the chronological ages or developmental level across subjects. Furthermore, all of the subjects were able to complete only the non-speech tasks of the speech mechanism screening. The possibility exists that a partial reason for the unintelligibility of this population may lie in delayed or different motoric abilities. Additional research, currently underway at the University of Tennessee - Knoxville, is needed to address this possibility. It was not generally possible to determine how these children with Down syndrome perceived their own phonological errors and several possible explanations for this finding were described above. This investigation may be a first step in determining whether the characteristic unintelligibility of children with Down syndrome is the result of differences in speech perception or differences in motoric abilities, or potentially an interaction of the two factors.

Conclusions

Down syndrome is a well-documented disorder with several frequently observed characteristics. One of these is the delay in the development of speech and language.

Because of this delay, this study investigated the phonological development in this population. Specifically, three purpose were addressed. These purposes were to determine: (1) if the patterns of phonological development in children with Down syndrome were similar to those predicted by their general developmental levels; (2) whether unusual phonological behavior was characteristic of the speech of children with Down syndrome; and (3) whether these children were able to perceive their own production errors. Five children with Down syndrome (one male, four female) served as subjects for this study. All of the subjects were between the ages of four and seven years. Each subject was administered an assessment battery that included a language test, an articulation test, an oral mechanism screening, a speech sample, and a perceptual assessment.

The results indicated that these children with Down syndrome showed greater delays in their phonological development than predicted by their general developmental levels. Individual variation was observed across subjects in both the complexity of and patterns within each phonological system. The phonological patterns of these subjects were captured in a broad manner using phonological processes. In contrast, the independent analysis combined with the child-based relational phoneme collapses provided more focal descriptions. Unusual phonological behaviors were not a primary characteristic of the speech of these subjects with Down syndrome; three subjects each produced one unusual form. The results from the Speech Production-Perception Task were generally unreliable across subjects. Only one subject was able to complete even a portion of the task.

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APPENDICES

APPENDIX A

Letter of Cooperation

Down Syndrome Awareness Group of East Tennessee

P.O. BOX 53575 • KNOXVILLE, TENNESSEE 37950-3575

Ms. Lori Bass

March 1, 1996

Dear Ms. Bass:

Thank you for agreeing to speak at our Down Syndrome Awareness Group March 12th meeting. We are interested in learning more about current research in speech development in children with Down syndrome and are willing to have you recruit families interested in participating in your study.

The meeting will take place at West High School and is scheduled to start at 7:00 p.m. Please enter the main school entrance off Tobler Avenue and look for signs directing you to the meeting room.

See you on the 12th!

Sincerely,

Kurt Anderson

Kurt D. Anderson, President

APPENDIX B

Parental Fact Sheet

Dear Parents:

Please consider allowing your child to participate in this research project. Your child's help would be greatly appreciated.

Lori A. Bass and Lori A. Swanson

Fact Sheet About the Speech Sound Development in Children With Down Syndrome Study
Conducted by Lori A. Bass, B.A. and Lori A. Swanson, Ph.D.
Department of Audiology and Speech Pathology
The University of Tennessee

Number of Sessions:	Four 1-hour sessions
Site of Testing:	2 sessions at child's home; 2 sessions at the University of Tennessee Child Language Laboratory
Time of Testing:	Summer of 1996
Tasks:	Hearing screening, nonverbal intelligence test, oral movement screening, language test, speech sound production test, and speech sound perception assessment.
Test Administrator:	Lori A. Bass
Number of Children being tested:	6 children with Down syndrome, ages 4 to 7 years
Test Results:	A diagnostic report will be made available to parents upon request. Collapsed results will be shared with local speech-language pathologists working with your child.
Approval for Study Has Been Obtained From:	The University of Tennessee Committee on Research Participation
Benefit of Project:	Information obtained in this study will be used to gain a better understanding of the development of speech sounds. This information will be used to assist

speech-language pathologists plan more effective treatment.

For Additional Information Call:

Dr. Lori Swanson
(423) 974-5019
Hearing and Speech Center
The University of Tennessee

PLEASE SIGN AND RETURN THE ATTACHED CONSENT FORM
THANK YOU!

APPENDIX C

Parental Informed Consent

<u>Parental Informed Consent for Speech Sound Research Project</u>

Lori A. Bass, B.A. and Lori A. Swanson, Ph.D.
Department of Audiology & Speech Pathology
The University of Tennessee

We are interested in examining the patterns of speech sound development in children with Down syndrome who are speaking in words. The children will range in age between 4 to 7 years. Your child will be assessed in four individual sessions approximately one hour in length each. Two of the sessions will take place at your home and two at the University of Tennessee Child Language Laboratory. The activities will include a hearing screening supervised by a certified clinical audiologist to evaluate your child's hearing; a speech mechanism screening to screen your child's ability to make speech sound movements; an experimenter-child play session to obtain a conversational speech sample; a test of language to evaluate your child's understanding and use of English; an articulation test to observe which sounds your child is using; and a test of the perception of speech sounds to determine your child's knowledge of the speech sound system of English. You will be asked to complete a language inventory checklist. This checklist will be used to help determine each child's ability to use language. Participation in this project poses no significant risk to you or your child. Each session will be stopped if your child indicates that he or she wants to stop.

All testing will be audiotaped and videotaped to insure accurate record keeping. All audio- and videotaping will be conducted by Lori Bass. All information will be kept completely confidential. Both the audiotapes and the videotapes will be kept in a locked cabinet in Lori Swanson's private office. No identifying information (i.e., parents' or child's names) will be used during the presentation or publication of these results.

Information collected during this project will be used to gain a better understanding of the patterns of speech sound development in children with Down syndrome so that more effective intervention may be planned. Parents may request a diagnostic report for their child. A summary of the general findings of this project will be made available to parents upon request.

Permission Form

Name of Parent or Legal Guardian ____________________________________

Name of Child ____

Child's Date of Birth ____

I have read this informed consent and agree to allow my child to participate in this study. *I understand that my child's participation in this study is completely voluntary. I am also aware that I may withdraw my child from the study at any time without any penalty to me or my child.* I also understand that I may request a summary of the general findings of this study.

______________________________ __________

Signature of Parent or Legal Guardian Date

CONSENT FOR AUDIOTAPING AND VIDEOTAPING
Lori A. Bass and Lori A. Swanson

Audiotapes and videotapes will be used to ensure accurate data collection, and they may also be kept by the investigators for future research. Full names or other identifying information will not be used at any time thereby maintaining privacy. The investigators assume full responsibility for maintaining the data in a secured location. Only the investigators indicated above will have access to the tapes. If it is determined that within five years (the year 2001), either the audio- or videotapes no longer fulfill a research purpose, the audio- or videotapes will be erased. At any time during this study you may request to view the videotapes to determine whether you are comfortable with the use of the tapes in the present research project and any future research purposes.

I give my permission for my child, ________________________________, to be audiorecorded and videorecorded as part of the data collection for this research project.

______________________________ ______________________

Signature of Parent or Legal Guardian Date

______________________________ ______________________

Signature of Witness Date

I give my permission for the tapes of my child, ____________________________ to be used beyond this research project for the purposes described above.

______________________________ ______________________

Signature of Parent or Legal Guardian Date

______________________________ ______________________

Signature of Witness Date

APPENDIX D

Subject Information Form

Information Form

I. IDENTIFYING INFORMATION:

Child's Name: ______________________________

Birthdate: ______________ Age: ______ Sex: _____

Parent/Guardian Names: ______________________________

Home Address: ______________________________

____

City State Zip Code (County)

Telephone No.: (Home)______________________

Father (Work)________________

Occupation: ________________

Mother (Work)________________

Occupation: ________________

Ages: Father: __________ Mother: __________

Are other children living with you? __________

If yes, please list names and ages:

1. Name: ______________________________

   Age: ______

2. Name: ______________________________

   Age: ______

3. Name: ______________________________

   Age: ______

II. BIRTH HISTORY

Were there any complications during pregnancy and/or birth? ______

If yes, please describe briefly:

What is your child's diagnosis (karyotype)?

____

At what age was your child diagnosed?

____

By who? ________________________________

III. EARLY DEVELOPMENT

Please give approximate ages for the following:

Sitting up unsupported _____ Crawling _______

Walking ______ Babbling _______

First single words ______ Sentences _______

Overall, how would you describe your child's development? ________________

____

Is your child's coordination: good ____ fair ____ poor ____

IV. HEALTH

Please list any injuries or operations your child may have had. Please include tonsillectomy, adenoidectomy, or myringotomy (tubes in the ears), if applicable. (Use back of sheet if necessary).

Injury/Operation Date Age

Does your child have allergies? _______

If yes, to what is s/he allergic?

Has your child previously or is your child presently taking any medications? ____

If yes, please describe:

Does your child have any visual problems? ______
If yes, please describe:

Does s/he wear glasses? ________

In general, how would you describe your child's health? good ___ fair ___ poor ___

IV. SPEECH-LANGUAGE AND HEARING INFORMATION

Please list your concerns about your child's speech:

Is English the only language spoken in the home? _______

Has your child received previous speech-language therapy? ______

If yes, please describe the focus of therapy, (i.e., language, articulation, etc.):

Is your child enrolled in speech-language therapy at the present? ______

If yes, please describe the focus of therapy:

How much of your child's speech are you able to understand? __________

How much are siblings able to understand? ________________________

How much are other adults familiar with your child able to understand? ________

How much are unfamiliar adults able to understand? ___________________

Do you think your child has trouble hearing? _______

Why?

Has your child had any ear infections/aches? _________

If yes, please list date of the most recent: __________

How many ear infections/aches has your child had?:

0 to 5 ___ 5 to 10 ___ 10 or more ___

Do the ear infections/aches usually occur in:

one ear _____ both ears ______

Has your child had his or her hearing tested previously? _______

If yes, please list date of most recent evaluation: _______

V. SCHOOL

Is your child attending school? ______

If yes, please give:

______________________ ___________

Name of school Grade

____

Teacher

What is your impression of your child's learning abilities?

VI. PREFERENCES

What are some things your child likes to talk about?

What types of toys does your child like/favorite activities?

What types of toys, food, etc. are motivating for your child?

Please list any additional comments/helpful hints for working with your child:

APPENDIX E

List of Control Phonemes for <u>SP-PT</u>

Target Phonemes	Control Phonemes
/m/	/n, w, b, ð, l/
/p/	/t, k, θ, f, s/
/b/	/v, z, d, g, ð/
/w/	/m, n, ð, b, l/
/f/	/θ, ʃ, s, t, k/
/v/	/θ, ʃ, s, t, k/
/θ/	/f, s, p, t, k/
/ð/	/v, z, b, d, g/
/n/	/m, b, w, l, ð/
/t/	/s, p, k, h, θ/
/d/	/z, b, g, n, ð/
/s/	/ʃ, f, θ, t, k/
/z/	/ʒ, v, ð, d, g/
/l/	/r, w, g, d, ð/
/ʃ/	/s, θ, tʃ, h, t/
/tʃ/	/t, ʒ, s, f, θ/
/d/	/d, n, g, w, l/
/r/	/l, j, w, ð, g/
/j/	/w, l, r, h, g/
/ŋ/	/n, m, g/
/k/	/t, p, θ, f, s/

/g/	/d, b, ð, v, z/
/h/	/w, k, ʃ, j, p/

APPENDIX F

Test Descriptions

A brief description of each test used in this study will be presented. The protocols will be presented in alphabetical order.

Arthur Adaptation of the Leiter International Performance Scale

The Arthur Adaptation of the Leiter International Performance Scale (Leiter; Arthur, 1952) is a non-verbal intelligence test that involves the manipulation of small cubes. It is intended for use with children between the ages of 3 years 0 months and 7 years 11 months, or alternatively, with children whose cognitive abilities are expected to fall within this age range. The children are expected to match patterns that range in difficulty from identical color matching to arranging the circumference of a circle in incremental steps. During testing only limited verbal interaction is permitted, with no direct comments on the child's performance allowed. Each subtest of the Arthur Adaptation is untimed and is scored differently from the standard Leiter International Performance Scale. One important modification was implemented for this study: The verbal prompt, "Put the blocks where you think they go," was used if necessary.

Goldman-Fristoe Test of Articulation

The Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986) assesses children's production of the speech sounds of English, in both consonant singletons and syllable initial clusters. It is intended to be used with children between the ages of 2 years 6 months and 16 years 11 months. The test consists of the following three subtests; 1) Sounds-in-Words, 2) Sounds-in-Sentences, and 3) Stimulability; however, for the purposes of this study only the Sounds-in-Words and Stimulability subtests were administered. This test assesses 23 of the 26 phonemes of English; the phonemes /ʒ, t͡s, d͡z/ are not assessed because of their infrequent occurrence in the language.

Lexington Developmental Cognitive Scale-Long Form

The Lexington Developmental Cognitive Scale-Long Form (Lexington; Irwin et al., 1974) is a protocol that measures the cognitive development of children between the ages of 0 months and 6 years. It requires both expressive and receptive responses to stimuli such as, Which ball is hard? Which is soft? and How old will you be on your next birthday?. In addition, the child is asked to perform tasks such as separating beads from blocks and singing with or dancing to music. This measure was used with the one subject who was not able to achieve a basal score on the Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952).

MacArthur Communicative Development Inventory

The MacArthur Communicative Development Inventory (CDI; Fenson et al., 1993) is a parental/caregiver checklist that provides an indication of the productive vocabulary of children between the ages of 12 months and 5 years. There are two versions of the checklist. Part I assesses pre-linguistic communicative abilities such as gestures and 1-word utterances. Part II assesses words, phrases, and sentences that a child is producing. Part II is further divided into sections measuring nouns, verbs, adjectives, and prepositions used by the child. For the purposes of the present study, Part II was used to collaborate the results from the Test of Early Language Development-2 (Hresko, Reid, & Hammill, 1991).

Oral Speech Mechanism Screening Evaluation-Revised

The Oral Speech Mechanism Screening Evaluation-Revised (OSMSE-R; St. Louis & Ruscello, 1981) is a screening tool that assesses the structure and function of the oral mechanism. It is designed to be used with preschool children through adulthood and assesses the following areas: lip movement, tongue movement, hard and soft palate, dentition, velopharyngeal function, and syllable repetition. Scores are derived for the structural tasks and for the function tasks, which are then combined for a total score. Norms are provided for both the structural and function scores. In addition, norms based upon chronological age are provided for the syllable repetition tasks. For the purposes of this study, several modifications were made. Some of these modifications included using a mirror or having a sibling or parent model a task in order to elicit it, and changing the multi-syllabic task /pʌtʌkʌ/ to "patticake" or "buttercup".

Speech Production-Perception Task

The Speech Production-Perception Task (SP-PT; Locke, 1980a,b) is a non-standardized measure that attempts to evaluate a child's perception of his or her own phonological errors. It is designed to be used with any stimuli that single word elicit misproductions from children. A child is presented with three versions of his or her production. These are the stimulus phoneme ([SP] - adult form; e.g., /wægən/), the response phoneme ([RP] - child form; e.g., [wævə]), and the control phoneme ([CP] - perceptually similar foil production; e.g., /wædən/). There are six of each of the productions for a total of 18 trials per misproduction. The child is asked yes/no questions in a carrier phrase such as "Is it a _ ?" If there is a two-to-one ratio between the [RP] and [CP], the child's misproduction is assumed to be the result of a perceptual error. Modifications of the task for this study included pictorial and graphic supports for yes/no responses and mixing the trials in order to alleviate fatigue. Additionally, variations of the task questions included Is it a(n) (duck)?, Is the (duck) (yellow)? and Is he (fishing)?.

Test of Early Language Development-2

The Test of Early Language Development -2 (TELD-2; Hresko, Reid, & Hammill, 1991) assesses the linguistic skills of children between the ages of 1 year 6 months to 7 years 11 months. While there are no formally separated subtests; the test assesses both the receptive and expressive systems of a given child. More specifically, this protocol measures the syntactic and semantic features of the child's linguistic system. The test is formally divided only by chronological age levels and provides both a language-age equivalency and percentile rank.

APPENDIX G

SP-PT Score Form for Subject 2

Speech-Production Perception Task

Child's Name S2 Birthdate ____________

Date 8/27/96		Date 8/27/96		Date ________	
Production Task		Production Task		Production Task	
Stimulus	Response	Stimulus	Response	Stimulus	Response
/fɪŋgɚ/	[gɪgə]	/wægən/	[wæwə]	/ /	[ ]
SP /f/ RP /g/ CP /θ/		SP /g/ RP /w/ CP /d/		SP/ / RP / / CP / /	
Stimulus-class	Response	Stimulus class	Response	Stimulus class	Response
1 /θ/-CP	Y **N** NR	1 /g/-SP	**Y** N NR	1 / /-RP	Y N NR
2 /g/-RP	Y N **NR**	2 /d/-CP	Y **N** NR	2 / /-CP	Y N NR
3 /f/-SP	**Y** N NR	3 /g/-SP	Y **N** NR	3 / /-CP	Y N NR
4 /f/-SP	**Y** N NR	4 /d/-CP	Y **N** NR	4 / /-SP	Y N NR
5 /g/-RP	**Y** N NR	5 /w/-RP	**Y** N NR	5 / /-SP	Y N NR
6 /θ/-CP	Y **N** NR	6 /w/-RP	**Y** N NR	6 / /-RP	Y N NR
7 /θ/-CP	**Y** N NR	7 /g/-SP	**Y** N NR	7 / /-RP	Y N NR
8 /f/-SP	Y N **NR**	8 /w/-RP	**Y** N NR	8 / /-SP	Y N NR
9 /g/-RP	**Y** N NR	9 /g/-SP	Y **N** NR	9 / /-CP	Y N NR
10 /f/-SP	Y **N** NR	10 /d/-CP	Y N **NR**	10 / /-SP	Y N NR
11 /g/-RP	**Y** N NR	11 /d/-CP	**Y** N NR	11 / /-CP	Y N NR
12 /θ/-CP	Y **N** NR	12 /w/-RP	**Y** N NR	12 / /-RP	Y N NR
13 /g/-RP	**Y** N NR	13 /g/-SP	Y N **NR**	13 / /-SP	Y N NR
14 /f/-SP	Y **N** NR	14 /d/-CP	**Y** N NR	14 / /-RP	Y N NR
15 /θ/-CP	Y **N** NR	15 /w/-RP	Y **N** NR	15 / /-SP	Y N NR
16 /g/-RP	**Y** N NR	16 /g/-SP	Y **N** NR	16 / /-CP	Y N NR
17 /f/-SP	Y **N** NR	17 /w/-RP	**Y** N NR	17 / /-CP	Y N NR
18 /θ/-CP	Y **N** NR	18 /d/-CP	Y N **NR**	18 / /-RP	Y N NR
RP 5 CP 1 SP 2		RP 5 CP 2 SP 2		RP __ CP __ SP __	

APPENDIX H

Summary of Treatment Approaches for Subject 1

Comparison of Treatment Approaches for Patterns in the Phonological System of Subject 1

Treatment Approaches	Potential Treatment Targets	Expectation for Change
Phonological Processes	Elimination of the following processes: Final Consonant Deletion, Cluster Reduction, and Stopping	Increase: Production of final consonants, production of fricatives, and production of all members of a consonant cluster.
Maximal Oppositions (Gierut, 1990)	Increase complexity of the phonological system. Several options are available: Teach /b, z/ minimal pairs; or teach /l, r/ through nonsense word stories.	Expansion of the phonological system; Changes teaching /b, z/ pairs would minimally include acquisition of fricatives; with /l, r/ changes would include acquisition of fricatives, affricates, and liquids.
Multiple Oppositions (Williams, 1993)	Create phonemic splits from child's phoneme collapses. Example: Pair /d/ words with /n, ʃ, r/ words.	Expansion of the phonological system by increasing the phonemic inventory and making distinctions more salient to child.

APPENDIX I

Summary of Treatment Approaches for Subject 2

Comparison of Treatment Approaches for the Patterns in the Phonological System of Subject 2

Treatment Approach	Potential Treatment Targets	Expectation for Change
Phonological Processes	Eliminate the most frequently occurring processes: Final Consonant Deletion, Cluster Reduction, and Stopping.	Increase: Production of final consonants, Correct production of fricatives, and produce all members of a cluster.
Maximal Oppositions (Gierut, 1990)	Increase complexity of phonological system by teaching /z/ and /ð/ in a nonsense word story.	Expand inventory; Child must aquire lower-level distinctions without direct intervention.
Multiple Oppositions (Williams, 1993)	Create phonemic splits of phonemes collapsed by child. Example: Pair /b/ words with /s, t, r/ words	Eliminate or reduce phoneme collapses; Expand inventory by making contrasts more salient to child.

APPENDIX J

Summary of Treatment Approaches for Subject 3

<u>Comparison of Treatment Approaches for Patterns in the Phonological System of Subject 3</u>

Treatment Approach	Potential Treatment Targets	Expectations for Change
Phonological Processes	Elimination of the following processes: Cluster Reduction and Palatal Fronting.	Increase correct production of /ʃ/ and /tʃ/ and produce all members of a consonant cluster.
Maximal Oppositions (Gierut, 1990)	Greater change is observed when child is taught 2 unknown sounds such as /z/ and /ð/ in nonsense word story.	Further expansion of the phonological system; Child must learn lower-level distinctions without direct intervention.
Multiple Oppositions (Williams, 1993)	Create phonemic splits from child's phoneme collapses. Example: Pair /g/ words with /dʒ, s, d/ words	Expand the inventory by creating phonemic distinctions and making them salient to the child.

APPENDIX K

Summary of Treatment Approaches for Subject 4

Comparison of Treatment Approaches for Patterns in the Phonological System of Subject 4

Treatment Approach	Potential Treatment Targets	Expectation for Change
Phonological Processes	Eliminate the process of Fricative Simplification	Increase correct production of /θ/ and /ð/
Independent Analysis	Create phonemic splits for [s/z] and [w/r] through the use of minimal pairs. Address positional constraints for /θ, ð/ through nonsense words	Develop phonemic realization of /s, z, w, r/ and eliminate positional constraints for /θ, ð/.

APPENDIX L

Summary of Treatment Approaches for Subject 5

Comparison of Treatment Approaches for the Patterns in the Phonological System of Subject 5

Treatment Approach	Potential Treatment Targets	Expectation for Change
Phonological Processes	Elimination of the following processes: Liquid Simplification, Cluster Simplification, and Cluster Reduction.	Increase: Correct production of liquids, and all members of consonant clusters.
Independent Analysis	Minimal pair therapy to induce a phonemic split for [w/r]; Teach /z, v, r/ as nonsense words in initial position.	Develop both /w/ and /r/ as phonemes; Eliminate positional constraints.

VITA

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