The Description and Comparison of Feature Retention Patterns for Children with Phonological Impairment Developmental Apraxia of Speech and Typically Developing Children.

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The Description and Comparison of Feature Retention Patterns
For Children with Phonological Impairment, Developmental
Apraxia of Speech, and Typically Developing Children.

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Master of Science in Communicative Disorders

by
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May 2001

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ABSTRACT

The Description and Comparison of Feature Retention Patterns for Children With Phonological Impairment, Developmental Apraxia Of Speech, and Typically Developing Children.

by
Amanda N. Lambert

The purpose of the present study was to compare feature retention patterns between children developing speech typically (TD) and children with phonological impairment (PI) and to discuss these findings in terms of characteristics, severity, and implication for the identification of developmental apraxia of speech (DAS). A second purpose was to determine if a relationship exists between phonological knowledge and feature retention.

This study consisted of a PI group and a TD group of children, ages four to six. A 245-item speech sample was collected from each subject. Feature retention percentages as well as percent correct underlying representation (PCUR) were calculated for each child.

Both PI and TD groups retained place the least, voice the most, with manner falling in between. These patterns corresponded with what past researchers found in studies of children with phonological impairment and children diagnosed with DAS. No significant correlation was found between PCUR and feature retention.
DEDICATION

This thesis is dedicated to my family, who taught me that with hard work and dedication I could accomplish anything I set my mind to; and to my husband, Chad, whose love and support kept me moving forward.
ACKNOWLEDGMENTS

With sincere appreciation, I would like to thank Dr. A. Lynn Williams, my thesis committee chair, for her constant support and dedication to this project. Her words of encouragement and belief in me, helped me to obtain one of the biggest accomplishments of my life. I would also like to thank my committee members, Dr. Nancy Scherer and Teresa Boggs, whose suggestions and words of wisdom greatly added to this thesis. A special thank you is extended to Dr. John Kalbfleish for graciously lending his time and assistance to the statistical analysis portion of this study. I could not have accomplished this project without the children and families who participated in this study. To them, I extend my sincere appreciation.

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CHAPTER 1
REVIEW OF THE LITERATURE

Introduction

Developmental apraxia of speech (DAS), also known as developmental verbal dyspraxia (DVD), has been a subject of controversy in the field of speech language pathology since its first introduction. Lack of strong objective evidence concerning relevant speech characteristics make it difficult to differentiate this disorder from other speech production disorders. Diagnosis is the key to deriving an efficacious intervention plan and therefore it is imperative to study the characteristics of this suspected population to determine if DAS is a viable diagnosis or if it is what past researchers have referred to as “a label in search of a population” (Forrest & Morrisette, 1999, p.187).

Current Controversy

Based on a review of the literature on DAS and phonological disorders, many similarities and few differences were found between the two. Developmental apraxia of speech as a viable speech disorder has been an area of controversy for several years (Crary, 1984; Ekelman & Aram, 1984; Hall, 1992; Robin, 1992; Shriberg, 1993; Shriberg, Aram, & Kwiatkowski, 1997a, 1997b, 1997c). This lack of differentiation is what leads the controversy in the field of speech-language pathology today. Before this entity of DAS can be accepted as a viable disorder, a greater multitude of valid experimental research must be completed and reviewed critically. In experimental research to date, sample sizes are extremely small and DAS selection criterion is questionable considering that no truly unique symptoms of this disorder have been validly
discovered. Literature today is still relying on past researchers, such as Yoss and Darley, to support this suspected disorder even though succeeding research has raised serious questions of validity. Further, there have been no three-way comparisons involving all three groups of children: DAS, phonological impairment, and typical phonological development.

Epperly, Gaffney, O’Malley, and Williams (1999) summarized many of these following their critical review of the literature concerning DAS as a clinical entity. Among several studies, they found variation among participant descriptions, inconsistent diagnostic criteria, and the lack of a normal developing control group. Epperly et al. created a table that summarizes these findings concerning the controversy of DAS versus phonological impairment (see Table 1).

### Developmental Apraxia of Speech

**Definition of DAS**

Developmental apraxia of speech (DAS), also known as developmental verbal dyspraxia, and articulatory apraxia, is a controversial disorder with numerous conflicts regarding the reality, nature, and treatment of DAS. This label, DAS, is used most often to refer to children who show severe, persistent, and irregular speech patterns with a suspected motoric origin (Crary, 1993; Shriberg et al., 1997a, 1997b, 1997c; Strand, 1995; Williams, Ingham, & Rosenbec, 1981). Love and Webb (1992, p. 8) defines DAS as “an impaired ability of the child, in the absence of obvious muscular disturbance of the speech mechanism, to execute voluntarily the expected motor gestures and programming of gestures needed for the articulation of speech.”
# Table 1

## Point and Counterpoint Evidence in the Controversy of DAS vs. Phonological Disorder

<table>
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| DAS is a separate clinical entity from PI on the basis of its motor component (Robin, 1992; Hall, 1992) | Presence of concomitant language impairments in children with suspected DAS  
- Phonological awareness deficits (Velleman, 1994)  
- Relationship to later reading difficulties (Catts, 1993)  
- Links between speech disorders and language impairments (Fey, Cleave, Ravida, Long, Dejmal, & Easton, 1994; Tyler, 1997) |
| DAS is similar to acquired apraxia in adults (Robin, 1992) | Absence of neurological impairments (Hall, 1992; Love, 1991) |
| DAS is defined as a cluster of symptoms (cf., Love, 1991) | No consensus as to what cluster could define the disorder (Thoonen et al, 1994)  
- Symptoms are not mutually exclusive |
| Speech Characteristics of place of articulation being the least retained feature in DAS (Thoonen et al., 1994) | Place of articulation was least retained feature in speech of children with phonological impairment (Forrest & Morrisette, 1999) |
| Inappropriate stress proposed as a diagnostic marker for DAS (Shriberg, Aram, & Kwiatkowski, 1997b) | Only 52% of the children with suspected DAS exhibit inappropriate stress (Shriberg, Aram, and Kwiatkowski, 1997c) |
| Limited studies on treatment outcomes for children with DAS; primarily motor-based interventions | Numerous studies on treatment outcomes for children with phonological impairment; exclusively linguistic based intervention |
| Lack of improvement often cited as evidence of DAS (Shriberg, Aram, & Kwiatkowski, 1997a) | Children with similar characteristics to DAS in terms of place of articulation feature benefited from linguistic-based intervention (Forrest & Morrisette, 1999; evidence from case presented here) suggests that lack of improvement in motor-based interventions may be related to possible inappropriate treatment approach. |

Although an accepted differential diagnosis for DAS has not been clinically proven, researchers have developed several lists and descriptions of probable features of which a child with DAS might exhibit. Shriberg et al, (1997a) lists two. First, their speech errors differ from children with a speech delay, and second, they resemble error patterns commonly seen in adults with acquired apraxia of speech. The most commonly reported symptoms of DAS include deviant consonant and vowel productions; groping and trial and error behaviors; and inconsistency in articulation (Thoonen, Maassen, Gabreels, Schreuder, & Swart, 1997; Velleman, 1994).

Some view DAS as a purely motoric disorder resulting from neurologic immaturity, however, a linguistic component is also evident in case studies of children diagnosed with DAS (Smith, Goffman, & Stark, 1995). A frequently discussed perspective of DAS is the motor-linguistic theory. This theory represents a continuum in which motor and speech-language dysfunctions overlap. The frontal areas, primarily in the left hemisphere, are responsible for the motoric or execution tasks while more posterior areas are responsible for the planning aspects of speech, such as selecting and sequencing (Crary, 1993). DAS is described as having deficits in both areas of planning and execution. The affected areas of the brain are reflected in the degrees of severity and the areas of deficit. As Crary (1984) stated, productions are dependent upon the motor-linguistic environment at the particular time of production.

There are three common perspectives of DAS that are currently found in the literature (Crary, 1993; Shriberg et al., 1997a). One of the most prevalent perspectives is the unitary entity perspective in which the goal is to determine a synthesis or isolated characteristic that differentiates DAS. A second perspective is referred to the syndrome perspective in which DAS is described as a cluster of symptoms (Crary, 1993). According to this perspective, not all
characteristics associated with DAS must be present in all children with the disorder. The third and least researched perspective deals with the possibility of subtypes to account for the variability of symptoms that are exhibited in children with DAS. Because of the wide range of characteristics said to be associated with DAS, all components of speech and language must be reviewed.

**Language Component**

There is a general agreement that language deficits also frequently accompany DAS (Velleman, 1994). Ekelman and Aram (1983) conducted a study to describe spoken syntax of eight children between 4 and 12 years of age who were diagnosed as verbally apraxic. Mean length of utterance (MLU), Developmental Sentence Score (DSS), 14 grammatical markers, and analysis of yes-no and wh-questions were analyzed. They found that although MLU measures were within normal limits, a large percentage of their grammatical markers were omitted or in error. DSS scores were below chronological age expectations and subjects showed difficulties with personal and main verbs.

Aram and Nation (1982) found similar results in their previous study of six children diagnosed with DAS. DSS scores were analyzed and results indicated that each child’s score was below the 50th percentile for his or her age. Subjects demonstrated difficulty in word order, pronouns, clauses, and most significantly, morphological endings. However, in Comeau and Crary’s study of 14 children ages 3 to 13 years old (cited by Crary, 1993), they found that an average of 86% of syntactic errors demonstrated by the children with DAS were the direct result of phonological simplification.
Inappropriate Stress

Several studies of prosodic features conducted by Shriberg et al. (1997a; 1997b) have proposed that inappropriate stress may serve as a diagnostic marker for a subtype of DAS. In one initial study and two cross-validation studies, they found that children diagnosed with DAS had significantly lower scores on inappropriate stress based on the Prosody-Voice Screening Profile (PVSP) (Shriberg, 1993) than age-matched children with a speech delay (SD). Across the three studies, 52% of children diagnosed with DAS had inappropriate stress as compared to 10% of SD group. However, this characteristic was only exhibited in one-half of the DAS subjects; therefore, further research is much needed to support this claim.

The idea of inappropriate stress as a compensatory behavior has also been discussed (Shriberg et al., 1997a, 1997b; Yoss & Darley, 1974). Yoss and Darley suggested that “monotony of stress and lack of sound blending can be explained as attempts to compensate for a severe speech production problem” (p. 348).

Phonological/Articulation Deficits in DAS

A primary symptom of DAS is a severe speech disorder that is characterized by a limited sound inventory (Crary, 1984; Marion, Sussman, & Marquardt, 1993; Shriberg, 1997a). Velleman (1994) reported that although some patterns of phonological errors are found across the board in children with DAS, each child’s response to his or her physical limitations results in an idiosyncratic phonological system. As discussed previously, Ferguson and Farwell (1975) also found early signs of variation in typically developing children.

Children with DAS also exhibit difficulty combining smaller units into larger wholes. Velleman (1994; p. 69) proposed that “children with DAS are impaired in their ability to
generate and use hierarchical structures.” Without the ability to scaffold, it is difficult for these children to make necessary transitions from sounds to speech patterns or sequences causing further difficulty in building a phonological system. She referred to DAS as a problem of “bridging among elements” (p. 69).

One of the best-known studies of DAS was completed by Yoss and Darley (1974). The purpose of this study was to identify differences between children who speak normally and children with defective articulation (DAC) and to identify characteristics which might isolate a subgroup (with suspected DAS) from the DAC group. The DAC group, consisting of 30 children ages 5 to 10 years, who demonstrated moderate to severe defective articulation, and a normal control group were given a battery of speech and nonspeech tasks. The researchers found that the DAC group demonstrated poorer speech; poorer auditory perception, and auditory sequencing abilities; and more difficulty with volitional oral movements and sequences.

Performance on the isolated volitional oral movement task (IVOM) divided the DAC group into DAC group 1 (good performance on IVOM) and DAC group 2 (poor performance on IVOM). DAC group 2 exhibited poorer performance on isolated and sequential movement tasks and displayed a greater incidence of neurological findings as demonstrated on a neurological rating scale. DAC group 2 also demonstrated greater articulatory pattern errors, consisting of distortions, prolongations, repetitions, and additions. Children in the DAC group 2 also demonstrated fewer place errors than did those in DAC group 1. No significant differences were found between the two DAC groups based on auditory perception and discrimination tasks. Yoss and Darley concluded that the DAC group 2 demonstrated performance that supports the diagnosis of DAS.
In 1981, Williams, Ingram, and Rosenthal reported results of their study that closely replicated the study completed by Yoss and Darley (1974). Their study resulted in few similarities and many differences to the previous study. This study revealed a significant difference between DAC sub-groups based on isolated volitional movements (IVOM), however, this task served as the determinant in the division of the DAC group therefore, differences would be invariably expected. Unlike Yoss and Darley, Williams et al. (1981) found no significant differences among any other speech and nonspeech tasks in the study. Very few distinctions could be made between the two groups. No differences were found by Williams et al. in terms of neurological ratings, which Yoss and Darley reported to be “the best predictor variable” (p. 411). Williams et al. reported that “none of the data in this study could be interpreted as identifying a developmental apraxia of speech” (p. 502).

In Yoss and Darley’s (1974) study, neurological findings were based on a subjective rating system. Horwitz (1984) conducted complete neurological examinations on ten children diagnosed with DAS. His examinations consisted of patient and family history; examination of cranial nerves II through XII; examination of motor and sensory systems; and computed tomography (CT) scans as well as electroencephalograms (EEG). Results of this study were highly varied, finding no consistent neurological evidence or specific anatomical locations that would serve as an indication of DAS.

Another study was also completed that contradicts the findings of Yoss and Darley (1974). Dworkin and Culatta (1985) conducted a study to determine structural or neuromuscular differences in children with articulation disorders as compared to typically developing children. Based on tongue strength, diadochokinetic rates, oral structural and/or physiological examinations, their findings revealed no significant differences between the two groups. This
finding contradicts the findings of Yoss and Darley that claim children with articulation disorders in general, have weaker tongues, slower diadochokinetic rates and more difficulty on tasks of volitional oral movement difficulties than typically developing children.

Thoonen, Massen, Gabreels, and Schreuder (1994) conducted a study that examined feature retention patterns of children diagnosed with DAS as compared to age-matched typically developing (TD) children. Subject selection of the DAS group was based on diagnosis by the school speech-language pathologist and diagnostic features of DAS summarized by Hall (1992). All children were administered speech tasks consisting of both real and nonsense words to examine speech-sound production, as well as their performance with regard to respiration, voicing, and articulation. Results indicated that the DAS group produced 3-5 times more one- and multiple-feature errors than the TD control group resulting from higher substitution and omission rates.

The DAS group was shown to retain the feature of place the least, followed by manner and voicing. A comparison of the two groups revealed that the control group demonstrated similar feature retention pattern whereas voice was retained the greatest. A correlation analysis revealed that poorer retention of place corresponds to an increase in severity of DAS as rated by the SLP. Thoonen et al. (1994) concluded that place retention is a significant characteristic of DAS and a notable factor in determining severity. Crary (1984) also noted the importance of place substitutions in the suspected DAS population.

Forrest and Morrisette (1999) conducted a study to determine if the findings of Thoonen et al. (1994) could be generalized to children with phonological disorders (PD). Following the same procedures as Thoonen et al., comparisons were made between the feature retention patterns of children with phonological disorders and the feature profiles of DAS children.
described by Thoonen et al. As found in the DAS group, the PD group also exhibited place of articulation as the least retained feature followed by manner and then voicing. They concluded that children with PD could not be differentiated from this DAS group on the basis of feature retention patterns.

A second analysis was performed in this study to compare the feature retention patterns of the subjects to their phonological knowledge based on percent correct underlying representation (PCUR). They found that children with greater phonological knowledge retained place less often than children with less phonological knowledge. Forrest and Morisette (1999) concluded that the children with a greater PCUR may have more flexibility in their substitutions whereas those with lower PCUR may be limited to place as their only mode for differentiation.

In summary, several studies of speech disorders exhibited by children diagnosed with DAS have been conducted. However, a high number of discrepancies between the research studies have questioned their results. Findings of Yoss and Darley (1974) supporting the evidence of specific DAS diagnostic characteristics were rejected by studies conducted by researchers such as Williams et al. (1981), Horwitz (1984), and Dworkin and Culatta (1985). More recently, Thoonen et al. (1994) concluded that feature retention of place was a distinguishing feature of DAS. This finding that differentiated DAS, was challenged by Forrest and Morisette (1999) who found that children with phonological disorders also exhibit this characteristic. More experimental studies must be conducted before differential diagnostic speech characteristics of DAS can be accepted.
An important question that many researchers are attempting to answer is how does a child diagnosed with DAS differ from a child diagnosed with a phonological disorder? A phonological disorder, as described by Crary (1993; p. 66) is “a degree of disorganization within the rule system used to organize phonemes”. Many studies, primarily case studies, have been completed that have found diversity in individual developing phonological systems. Camarata and Gandour (1984) found that even atypical phonologies are characterized by an orderly system. Due to the individuality of the phonological systems exhibited in children with speech disorders, methods of analysis are extremely important in both the assessment and the treatment process.

The earliest attempts at analyzing disordered speech focused on individual sound errors rather than general patterns. Treatment of errors typically targeted one phoneme at a time. In children with several speech errors, this sound-by-sound analysis of speech resulted in limited efficacious treatment with minimal generalization (Bernhardt & Stoel-Gammon, 1994; Edwards, 1992; Gierut, 1998; Hodson & Paden, 1981). In the 1970s, more systematic ways of analyzing speech errors of children were introduced with the goal of enhancing generalization. Two main approaches that have derived from this era are the distinctive feature analysis and the phonological process analysis (Bernhardt & Stoel-Gammon, 1994).

The distinctive feature analysis serves as a way to analyze speech based on a set of rules, which describes errors in terms of present or absent. Chomsky and Hale (cited by Ingram, 1990) were strongly involved in this approach offering a binary system of pluses (+) or minuses (-) to describe the presence or absence of features. The features in error were targeted in intervention
believing that if a child learned a particular feature, then other sounds containing that feature would also improve.

In the mid 1970s the phonological process analysis came into view led by Stampe’s theory of natural phonology. According to this theory, phonological processes are referred to as “mental operations” that serve to simplify the adult targets (cited by Edwards, 1992; p. 369; Bernhardt & Stoel-Gammon, 1994; p. 37). This analysis describes processes that affect not only the sounds, but also the syllable and word classes as well. (Fey, 1992; Hodson & Paden, 1991). It provides a relational analysis that compares the child’s system to the adult target. Treatment, based on this analysis, are designed to eliminate the processes in error. Selecting a treatment target, which represents a process in error, will lead to generalization of other phonemes affected by that process (Hodson & Paden 1991). Although phonological process analyses is fairly comprehensive in determining systematic errors, Camarata and Gandour (1984) found that it should be accompanied by other analyses to fully detect and describe unusual distribution patterns.

Hodson and Paden (1981) analyzed and compared the phonological systems of 60 unintelligible children, ages three to eight years old, and 60 normally developing intelligible four-year-olds. All 120 children were given The Assessment of Phonological Processes (Hodson, 1980). Of all the processes demonstrated, all 60 of the unintelligible children demonstrated these five processes in particular: (a) cluster reduction, (b) stridency deletion, (c) stopping, (d) liquid deviation, and (e) assimilation. Fewer than five children in the intelligible group demonstrated any of these. Hodson and Paden (1981) concluded that these five processes are fundamental indicators of a deviant system.
Weiner (1981) and Ingram (1990), among others, have discussed the common finding that children with unintelligible speech exhibit systematic sound preferences. Weiner (1981) conducted a study to see if phonological patterns could be predicted based on sound preference. He found that 8 of the 14 children demonstrated a sound preference. He found that in each of the 8 children, one class of sounds was replaced by one or few similar sounds (sound preferences) primarily in word-initial position. Weiner refers to this as a “collapsing process wherein a group of sounds having certain features in common are represented by a restricted feature arrangement” (p. 286).

Shriberg and Kwiatkowski (1994) studied clinical profiles of 178 children with developmental phonological disorders. As expected, the children with phonological disorders (PD) had a higher percentage of errors on speech tasks then speech-normal children. PD group errors consisted primarily of omissions and substitutions across all sounds. Of great importance, this study revealed that error patterns in the PD group deviated significantly from error patterns seen in the speech of typically developing children. Revealing not only a delay of speech, but a deviance in their phonological systems.

In summary, children with phonological disorders have been found to vary greatly from each other according to their phonological systems. Due to methods of analysis, clinicians and researchers are able to discover individual organized rule systems found in children exhibiting phonological disorders. Common processes have been found among groups of PD children. However, evidence of individual preferences of sounds and avoidance of others result in unique systems. Shriberg & Kwiatkowski (1994) found a delay as well as a deviance in the systems of PD children.
Typical Development

The production of speech is a complex motor skill requiring precise timing and amplitude yet most children acquire it with apparent ease (Smith, Goffman, & Stark, 1995). To investigate those children who do exhibit developmental speech disorders, it is important to first understand typically developing children.

Neurological Influences on Speech Development

There are two main perspectives regarding neurological development. The first is a hierarchical model of cortical development. This model states that the primary sensory and motor projection areas are the first to mature followed by secondary and tertiary areas. Poliakov and Decrinis (cited by Crary, 1993) reported that the first areas to reach maturity are the projection areas of vision and audition and the Rolandic strips for sensory and motor function. The next areas to mature are the secondary association areas that receive input from the projection areas, which mature at approximately 2 years of age. Between the ages of 2 and 4 years, the final stage of maturation begins in which the tertiary areas (parts of the frontal and parietal lobes) begin to mature.

The second perspective developed by Rakic, Bourgeois, Eckenhoff, Zecevic, and Goldman-Rakic (1986) alternately describes cortical development as a whole rather than a hierarchical process. In their findings, neural connections occurred at about the same time in all areas of the cortex. They imply that the maturing of the subsystems may be a product of synaptic “pruning” from infancy mediating more refined behaviors. Therefore, it has been hypothesized that some speech disorders may attributed to deviant or delayed maturation of the neurological system.
It is generally accepted that the left hemisphere is the dominant hemisphere for spoken language. Simonds and Schiebel (1989) studied the growth of dendrites in the right and left hemispheres of the frontal lobe areas in infant brains between 3 and 72 months. Their results indicate early dominance of the right hemisphere in children 12 months and younger. From 1 year to between 2 and 4 years the left hemisphere shows a gradual shift in dominance. In younger children, the oral motor areas exhibited advanced development over motor speech development. However in children 2 and 3 years of age, the motor speech areas surpassed the oral motor areas in neural complexity (Crary 1993). This study poses that a lack of shift in dominance to the left hemisphere may contribute to speech disorders.

In summary, several researchers state that maturation is the key element in neurological speech development. All three of the perspectives previously discussed relate to processes that develop, advance, or evolve over a period of time. According to this body of literature, a delay or divergence in the neurological paths of development could create delayed or divergent speech.

**Phonological Acquisition Theories**

There are many theories proposed in the literature to describe the acquisition of speech and language. Although several theorists have stated that children possess an innate ability, recent researchers also found children to be active participants in the way they acquire speech and language.

From a linguistic perspective, there is a regularity or universal and innate order of acquisition regulated by a hierarchical set of laws. The Generative phonology theory emphasizes the use of *features* in phonological acquisition where sounds are broken down into various parts (place, voice, and manner; Vihman 1996). Phonemes emerge in a sequential manner as the
features are developed. Therefore, child forms are predictable and rule-based. According to this theory, children contain an underlying representation that is the basis for the acquisition of all phonology (Schwartz, 1992).

Cognitive views of phonological acquisition, like those proposed by Ferguson & Farwell (1975), view children as active participants in acquisition following “individual paths of development” (p. 437). In their long-term study of three one-year old children, they discovered three main findings. First, they discovered variation in the production of words. During the acquisition process, children show alternations in the use of phonemes. Second, they found that children sometimes have a higher level of accuracy earlier on in development than they do later on. The third finding showed evidence that children are highly selective in the sound patterns of words they acquire by showing preference and avoidance of certain features (Ferguson & Farwell, 1975; Weiner, 1981).

Stoel-Gammon and Cooper (1984) found similar results in their analyses of early lexical and phonological development in three children. The three subjects showed the greatest similarities in the late-babbling-very first word stage and became more diverse as they proceeded in development. They found that “in general, children seem to select words with sounds they can produce correctly or with syllable structures they are capable of producing, while avoiding words with sounds or syllabic shapes they are unable to articulate” (p. 263). Hodson and Paden analyzed a much larger sample size consisting of 120 children. From speech samples of 60 intelligible children, ages 4 to 5 years old, and 60 unintelligible children, ages 3 to 8 years old, they determined that “no two subjects’ phonologies were identical” (1981, p. 371).

Mitchell (1995) discussed a developmental view referred to as a dynamic interactive developmental model that combines theories from developmental psychology and motor
development. This view moves away from the traditional models of development and focuses on a more interactive and dynamic perspective. Whereas most traditional models are considered linear in which development is predetermined, this dynamic theory provides a nonlinear, individualized model in which “development is viewed as the probabilistic outcome of interactions between the organism and environment” (Mitchell 1995, p.101). A dynamic systems perspective assumes that the nervous system, information from the environment, and the influence of time and space patterns produced by the body interact to generate movement patterns. Through the process of exploration and discovery, the acquisition of motor timing and sequencing skills emerge.

In summary, theorists agree that the acquisition of a phonological system is crucial to the development of an effective oral communication system. However, variations are present among their beliefs concerning the manner and order in which children acquire phonology. Whereas linguistic models view phonological acquisition as a universal and innate process, cognitive models see children as active participants following individual paths. More dynamic views agree with cognitive models in that acquisition is both nonlinear and individual, however elements of the environment are greatly taken into consideration. From this discussion of theories of phonological acquisition, it can be seen that acquisition of a sound system of language is complex and involves an intricate and dynamic interaction of innate abilities, active learning, neurological maturation, and environmental influences.
Conclusions

There are many works of literature on the topic of DAS, however most are descriptive works, reports, opinions, or summaries of past ideas. Unfortunately, there are few reliable research studies that provide sound evidence or factual findings. Most studies found in the literature are comparative studies comparing a suspected DAS group to another age-matched group of children. Because there is no proven set of diagnostic criteria for DAS, using comparative studies for the purpose of discovering a differential diagnosis tends to be weak. On the other hand, a comparative study between a suspected DAS group compared with another speech-disordered group and a typically developing group may in fact reveal a lack of differentiation.

In conclusion, the purpose of this project is to expand on the work of two recent studies in order to provide a comparison involving three groups of speakers. Specifically, this study will: (1) describe the feature retention patterns (in terms of place, voice, and manner) for children with moderate-to-profound phonological impairments; (2) describe the feature retention patterns for age-matched typically developing children; (3) compare these patterns to children with phonological impairments described by Forrest and Morissette (1999); and (4) determine if a relationship exists between phonological knowledge and feature retention. These results will be further examined with regard to children with developmental apraxia of speech described by Thoonen et al. (1994) to determine any patterns associated with these three groups of speakers.
CHAPTER 2

METHODS

In this study, two groups of children were investigated. The first group consisted of 10 children diagnosed with a phonological impairment (PI) described by Williams (1997). Ages of these children ranged from 4;0 to 6;0 (years;months) with a mean age of 4;10. The second group consisted of 10 typically developing (TD) children who were selected from public schools in northeast Tennessee and southwest Virginia. Their ages ranged from 4;2 to 6.5 with a mean age of 4;7.

Subject Selection

PI Subjects

Children from Williams’ (1997) research study were selected based on the following requirements: (1) exclusion of at least six sounds across three manner categories of sound production, as determined by performance on the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1986); (2) normal hearing, as determined by a pure-tone audiometric screening at 25 dB minimal response level, presented at 500, 1000, 2000, and 4000 Hertz; (3) no known history of organic or motor disorders, as determined by an oral mechanism examination and a case history; (4) non-verbal cognitive abilities within normal limits, as determined by the Test of Nonverbal Intelligence (Brown, Sherbenou, & Honsen, 1982); (5) not currently enrolled in speech therapy or have received speech therapy in the previous six months; (6) be between the ages of 42 and 78 months; and (7) reside in a monolingual English-speaking family (see Table 2).
Table 2

Subject Profiles of PI Group (Williams, 1997) and TD Group

<table>
<thead>
<tr>
<th>Child</th>
<th>Age</th>
<th>Gender</th>
<th>GFTA (% ile)</th>
<th>PPVT-III</th>
<th>Hearing Screening</th>
<th>Oral Mech. Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4:10</td>
<td>male</td>
<td>&lt; 1%</td>
<td>102</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>5:01</td>
<td>female</td>
<td>&lt; 1%</td>
<td>103</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>4:03</td>
<td>male</td>
<td>&lt; 1%</td>
<td>123</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>4:10</td>
<td>male</td>
<td>NR</td>
<td>99</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>4:10</td>
<td>male</td>
<td>18%</td>
<td>108</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>6:00</td>
<td>female</td>
<td>&lt; 1%</td>
<td>90</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>4:02</td>
<td>female</td>
<td>4%</td>
<td>110</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td>4:07</td>
<td>male</td>
<td>NR</td>
<td>114</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9</td>
<td>4:00</td>
<td>male</td>
<td>&lt; 1%</td>
<td>101</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td>5:10</td>
<td>male</td>
<td>NR</td>
<td>111</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**M** 4;10 106.1
**SD** 0.07 9.1

PI Group

<table>
<thead>
<tr>
<th>(% ile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

TD Group

<table>
<thead>
<tr>
<th>Child</th>
<th>Age</th>
<th>Gender</th>
<th>GFTA (% ile*)</th>
<th>PPVT-III</th>
<th>Hearing Screening</th>
<th>Oral Mech. Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>6:05</td>
<td>male</td>
<td>63%</td>
<td>113</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>4:06</td>
<td>female</td>
<td>70%</td>
<td>108</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>4:06</td>
<td>male</td>
<td>63%</td>
<td>99</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td>4:03</td>
<td>female</td>
<td>70%</td>
<td>110</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>15</td>
<td>4:08</td>
<td>male</td>
<td>96%</td>
<td>114</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>16</td>
<td>5:03</td>
<td>female</td>
<td>&gt;83%</td>
<td>109</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>17</td>
<td>4:07</td>
<td>male</td>
<td>83%</td>
<td>100</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>18</td>
<td>4:03</td>
<td>female</td>
<td>93%</td>
<td>103</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>19</td>
<td>4:02</td>
<td>male</td>
<td>96%</td>
<td>123</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>20</td>
<td>4:03</td>
<td>female</td>
<td>88%</td>
<td>124</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**M** 4;07 110.3
**SD** 0.07 8.6

Key. + (unremarkable)
NR (not reported)
* (TD group scores were taken from the GFTA-II)
TD Group

Subjects between the ages of 4 and 7 years old demonstrating normal intelligence and age-appropriate speech, as determined by their classroom teacher, participated in a screening session. During this session, subjects met the following criteria: (1) normal hearing, as determined by a pure-tone audiometric screening at 25 dB minimal response level, presented at 500, 1000, 2000, and 4000 Hertz (Hz); (2) no oral structural or functional abnormalities, as determined by the Oral Speech Mechanism Screening Examination (St. Louis & Ruscello, 1981); (3) no known history of speech disorders, as determined by case history; (4) receptive language skills within normal limits, as determined by the Peabody-Picture Vocabulary Test III (Dunn & Dunn, 1997); and (5) articulation skills within normal limits on the Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation - II (Goldman & Fristoe, 1999).

Procedures

PI Group

Once participants were selected, a speech sample was collected in an extensive single-word elicited probe (Williams, 1997). The sample was taken over two 45-minute individual sessions. The sample consisted of 245 items, which examined each child’s production of all English phonemes, a minimum of 5 times in each possible word position. The probe items were elicited by picture presentation using a cueing hierarchy to avoid direct imitation. If the child did not spontaneously name the picture correctly, a cue was given. If the cue was unsuccessful in eliciting the item, the examiner moved to delayed imitation where the child was given a choice between two items, with the targeted item named first. For example, if the targeted word was dog, the examiner would present the card and say, “is this a dog or a house”. Direct imitation
was used if the child was still unsuccessful in achieving the correct response. Narrow phonetic transcriptions were completed by two graduate clinicians using the International Phonetic Alphabet (IPA).

**TD Group**

Using the same procedures as with the PI group, 10 subjects who met the selection criteria were also given the 245-item probe (Williams 1997) testing all consonants in all positions in which they occur in the English language. Two sessions were conducted in which items were elicited by picture presentation and responses were transcribed by two graduate clinicians using IPA.

**Analysis**

Responses of the 245-word probes from the PI and TD groups were analyzed according to the procedures outlined by Forrest and Morrisette (1999) and Thoonen et al. (1994). Only sounds that were omitted from the child’s phonetic inventory were included in the analyses. A confusion matrix was constructed for each subject in the PI and TD groups to determine feature retention patterns for phonemes that were substituted for the target sounds. Each substituted phoneme was compared to the target for consistency of place, voice, and manner. If a target sound was characterized as an omission, no features were retained. A percentage of retention was calculated for each feature by dividing the number of substituted phonemes retaining the correct feature by the total number of substitutions and omissions (see Table 3).
Table 3

Example Calculation of Place Retention for Subject 4, PI Group

<table>
<thead>
<tr>
<th>Target Substitute</th>
<th>Labiodental</th>
<th>Lingual</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
<th>Ø</th>
<th># retained</th>
<th>Total</th>
<th>% retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>/s/</td>
<td>l</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>k</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>j</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>7</td>
<td>22</td>
</tr>
</tbody>
</table>

**Note.** The shaded column represents the correct place for the target sound, /s/.

A second analysis was conducted to determine each child’s productive phonological knowledge by calculating percent correct underlying representation (PCUR; cited by Forrest and Morrisette, 1999). In this analysis, each child was given 1 point for each consonant produced correctly in each word position. For example, if the child produced the target /d/ in the initial, medial, and final position of a word, a score of 3 was assigned for that phoneme. In this 245-item probe, there is a maximum score of 65. PCUR was determined by dividing the child’s score by the maximum score of 65.

**Reliability**

**Phonetic Reliability**

**PI Group.** The responses of all subjects were transcribed by two graduate clinicians during each session, using the International Phonetic Alphabet (Williams, 1997). Reliability was calculated according to a consonant by consonant comparison of transcription. The number of consonants in agreement between the two transcribers was divided by the total number of
consonants transcribed (agreement/disagreement + agreement). Reliability ranged from 88.7% to 99.0% with a mean of 96.7%.

**TD Group.** Reliability was calculated using the same procedures as the PI group (William, 1997). Reliability ranged from 91.2% to 99.0% with a mean of 97.0%.

**Reliability of Feature Analysis**

To assess the interjudge reliability of the feature analysis, four randomly selected speech samples (20% of the total) from the PI and TD groups were selected and reanalyzed by a second judge trained in completing this analysis. Results from the first analysis (A1) were compared with results from the second analysis (A2) to determine agreement between the two. Reliability of the analyses ranged from 96.7 to 98.6 with a mean of 97.4%.

**Data Analysis**

Measurements made on study participants were stored in a computer file in which subjects were distinguished only by an assigned study number. The data values (% place retention, % manner retention, % voice retention and PCUR) of the PI and TD groups were summarized by the mean and standard deviation. To answer the questions addressed in this study, the mean responses for % place, % manner, and % voice retention were compared by two-way analysis of variance and the least significant difference procedure within each group of speakers. The data from the PI group were compared with the TD group using the independent t-test (for % place retention, % manner retention and % voice retention) to compare means and the Mann-Whitney nonparametric procedure to compare medians. In a similar fashion, the t-test
was used to compare mean PCUR values; PI group versus TD group. Finally, the values of % place retention, % manner retention and % voice retention were correlated with PCUR using the linear correlation coefficient.

Data values were stored in Excel and analyzed for group effects and correlations in Minitab software. A probability level of 0.05 or smaller was used to indicate statistical significance.
CHAPTER 3

RESULTS

The purpose of this project was to describe the feature retention patterns for two groups of speakers (children with phonological impairment and children developing speech typically) and to compare these patterns with PI subjects described by Forrest and Morrisette (1999). A further component of the study was to determine if a relationship exists between phonological knowledge and feature retention. The reported results will be discussed in terms of: (1) feature retention patterns found in the present study categorized by PI and TD subjects, (2) PI subjects described by Forrest and Morrisette, and (3) phonological knowledge in relation to feature retention.

Feature Retention Patterns Found in Present Study

Based on the analysis from responses on the 245-word probe, feature retention patterns were obtained. The mean percentage of retention for the feature voice was shown to be the greatest for both the PI and TD groups. Table 4 compares the percentage of feature retention between the PI and TD groups for each child. As shown in this table, the mean percentage of feature retention for the PI group was lowest for place (10.96%) and highest for voice (54.28%) with manner falling in between (17.00%). The TD group, which revealed the same pattern as the PI group, exhibited mean place retention of 60.00%, mean manner retention of 98.22%, and mean voice retention of 100%.
Table 4

Summary of Feature Retention Patterns and PCUR for Each Subject

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Place (%)</th>
<th>Manner (%)</th>
<th>Voice (%)</th>
<th>PCUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.64</td>
<td>6.56</td>
<td>52.87</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>14.90</td>
<td>20.70</td>
<td>30.20</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>7.89</td>
<td>11.83</td>
<td>52.90</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>13.33</td>
<td>0.00</td>
<td>56.97</td>
<td>31</td>
</tr>
<tr>
<td>5</td>
<td>5.75</td>
<td>6.32</td>
<td>69.54</td>
<td>34</td>
</tr>
<tr>
<td>6</td>
<td>6.09</td>
<td>21.74</td>
<td>48.70</td>
<td>34</td>
</tr>
<tr>
<td>7</td>
<td>19.35</td>
<td>15.05</td>
<td>91.40</td>
<td>71</td>
</tr>
<tr>
<td>8</td>
<td>7.08</td>
<td>7.96</td>
<td>27.43</td>
<td>58</td>
</tr>
<tr>
<td>9</td>
<td>11.41</td>
<td>39.26</td>
<td>59.73</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>22.20</td>
<td>28.40</td>
<td>53.10</td>
<td>43</td>
</tr>
<tr>
<td><em>M</em></td>
<td>10.96</td>
<td>17.00</td>
<td>54.28</td>
<td>35.5</td>
</tr>
<tr>
<td><em>SD</em></td>
<td>6.50</td>
<td>11.88</td>
<td>18.21</td>
<td>17.7</td>
</tr>
</tbody>
</table>

| TD Group       |           |            |           |      |
| 11             | 100.00    | 100.00     | 100.00    | 100  |
| 12             | 100.00    | 100.00     | 100.00    | 100  |
| 13             | 0.00      | 100.00     | 100.00    | 95   |
| 14             | 0.00      | 100.00     | 100.00    | 95   |
| 15             | 100.00    | 100.00     | 100.00    | 100  |
| 16             | 100.00    | 100.00     | 100.00    | 100  |
| 17             | 0.00      | 88.89      | 100.00    | 92   |
| 18             | 100.00    | 100.00     | 100.00    | 100  |
| 19             | 100.00    | 100.00     | 100.00    | 100  |
| 20             | 0.00      | 93.33      | 100.00    | 95   |
| *M*            | 60.00     | 98.22      | 100.00    | 97.70|
| *SD*           | 51.60     | 3.89       | 0.00      | 3.09 |

Note. *Group mean and standard deviation (SD).
PI Group

Figure 1 illustrates individual as well as mean percentages of feature retention for the PI group. Data analysis revealed that the mean responses among the three features (place, manner, and voice), for the PI group, contained significant differences (2-way ANOVA, P<0.001). The least significant difference procedure declared the mean for percentage of voice retention to be significantly different than the means observed for percentage of place and manner. However, mean percentages of place and manner were not significantly different from each other.

TD Group

For the TD group, measurements of feature retention were at or close to 100% on most occasions, except for the percentage of place retention in which four subjects were assigned a “0”. This extremely low percentage was because only sounds in error in each subject’s phonetic inventory were analyzed. Therefore the typically developing group, as expected, showed little or no omissions in their inventory. The only errors recorded from the group were the voiceless /θ/ (in all 4 cases with errors) and the voiced /ð/ (in one case with errors). The primary substitution for the phoneme /θ/ was /f/ which only differs by place (labio-dental substituted for a lingua dental), and does not differ in manner or voice. This accounts for place retention of 0%.

Mean values for percentage of manner retention and percentage of voice retention were significantly different than the group mean for percentage of place retention (P<0.05, least significant difference procedure) for the TD group, however, inspection of the individual values showed that this is due to the four subjects who recorded a “0” score. As expected, mean values
for feature retention percentages for place, manner, and voice of the TD group were significantly different than the corresponding mean level of the PI group (P<0.02, t-test).

Feature Retention Patterns for PI Groups Described by Forrest and Morrisette

The same pattern of feature retention was found by Forrest and Morrisette (1999) in two additional groups of subjects with phonological impairment. Figure 2 compares the mean feature retention percentages of the PI group in the present study with the two groups of PI subjects from the Forrest and Morrisette study. The feature of place was retained the least in both Forrest and
Morrisette’s PI groups with a combined mean retention of 7.35%. The feature of voice was retained the most with a combined mean retention of 76.05%. Manner retention fell in between with a combined mean of 40.45%. Follow-up t-tests indicated significant differences between place, manner, and voice retention within both of their PI groups.

**Relationship Between Phonological Knowledge and Feature Retention**

Phonological knowledge, as represented by PCUR values, was compared and related to the feature retention scores within the PI and TD groups. As expected, the TD group had an average PCUR of 97.7, which was significantly higher than 35.5, the mean PCUR of the PI group (t-test, P<0.001). Figure 3 presents a scatter plot of PCUR values as related to feature retention percentages for the PI group. In both PI and TD group, however, PCUR did not correlate with any of the feature retention percentages for place, manner, and voice.
Figure 2. Mean feature retention percentages for TD and PI groups in the present study and PI groups 1 and 2 in the study conducted by Forrest and Morrisette (F&M).
Figure 3. Scatter plot of PCUR values and feature retention percentages for PI group.
Summary

1) Describe the feature retention patterns (in terms of place, voice, and manner) for children with phonological impairments.
   a) Mean percentages of feature retention indicated that place was least retained feature, followed by manner, with voice being the feature retained the most.
   b) Place and manner were not significantly different from each other.

2) Describe the feature retention patterns for age-matched typically developing children.
   a) Mean percentage of feature retention was lowest for place and highest for voice with manner falling in between.
   b) Little or no substitutions or omissions occurred in the phonetic inventories of this group.

3) Compare these patterns to children with phonological impairments described by Forrest and Morrisette (1999).
   a) Feature retention in both groups of PI subjects, studied by Forrest and Morrisette (1999), followed the same pattern as the PI group in the present study -- place was retained the least, voice was retained the most, and manner fell in between.
   b) Significant differences were found between place, manner, and voice retention within both PI groups studied by Forrest and Morrisette.
4) Determine if a relationship exists between phonological knowledge and feature retention.

a) No relationship was found in the present study between phonological knowledge and feature retention.
CHAPTER 4
DISCUSSION

The purpose of this study was to provide a comparison of feature retention patterns between children developing speech typically and children with phonological impairments. Specifically, the feature retention patterns for children with moderate to profound phonological impairments were compared to age-matched typically developing children. This study revealed that mean scores for both the PI and TD groups followed the general trend that place was retained the least whereas voice was retained the most, with manner falling in between. In this chapter, these findings will be discussed in relation to current literature and theoretical and clinical implications.

Comparison of Present Study to Literature

Phonological Characteristics

A specific characteristic or set of characteristics must exist in order to define or label a disorder. In this section findings from the present study will be related to literature based on similarities and differences of phonological characteristics in regard to DAS, PI, and TD groups of children.

In order to differentially diagnose DAS, researchers have set out to determine specific characteristics that make up this disorder. Shriberg et al. (1997a) described the phonological system of children with DAS as severe, persistent, and irregular. As was seen in the present study, subjects in the PI group contained these same characteristics. Of the PI group, 80% of the subjects were considered severe or profound based on PCUR; and although subjects generally
followed the same pattern of feature retention, all phonological systems were unique and specific to each individual child. Just as researchers claim that DAS children exhibit “irregular” and “variable” phonological systems, the present study indicated variety in each PI subject as well.

Another phonological characteristic associated with DAS is a deviant rather than delayed system (Shriberg, 1997a; Velleman, 1994). Children with phonological impairment have also been found to follow atypical patterns of development (Hodson & Paden, 1981; Weiner, 1971; Ingram, 1990). In the present study 5 out of 10 PI subjects contained an /r/ in their phonetic inventories; however, several “earlier developing sounds” were absent. According to Grunwell’s Profile of Phonological Development (as cited by Vihman, 1996, p. 219), /r/ is generally not fully developed in typically developing children until the last stage of phonological development. This “atypical” pattern of phonological development seen in the present study exemplifies that this characteristic of deviant development is not exclusive to the DAS population.

A limited sound inventory is also a characteristic reported of DAS (Crary, 1984; Marion et al., 1993; Shriberg, 1997a). Again, this characteristic was also found in the present study as well as in the study conducted by Forrest and Morrisette (1999). The mean percent correct underlying representation (PCUR) for the PI group in the present study was 35.5. This figure represents the percentage of the phonological system that is “known” to the subjects. This is a low percentage that reflects a very limited phonetic inventory.

Feature Retention Patterns

The results of the present study found similar results to the Forrest and Morrisette (1999) study concerning feature retention patterns of two groups of children with phonological impairment. Like the present study, they also found that the feature of place was the least
retained followed by manner, with voicing being retained the most. Forrest and Morrisette’s data indicated a significant difference between all three feature retention percentages based on follow-up t-tests. In the present study a significant difference was not found between the features of place and manner although means did follow the same patterns. The lack of a significant difference between place and manner could be due to the severity of the children investigated in this study, which will be examined later in this section.

The present study also paralleled the results of the study conducted by Thoonen et al. (1994) involving children diagnosed with DAS and typically developing children. With the DAS group, Thoonen et al. (1994) reported the same pattern of feature retention as found in the present study and the study conducted by Forrest and Morrisette (1999). Thoonen et al. (1994) concluded that this feature retention pattern of place being least retained, is a significant characteristic of children with DAS and could serve as a diagnostic marker for the disorder. Their results were duplicated by Forrest and Morrisette with a second population (phonological impairment) and reduplicated in the present study with another group of children with PI, as well as a typically developing group, thus weakening their claims that this pattern is an exclusive feature to DAS. The present study also found similar results to Thoonen et al. (1994) concerning typically developing subjects. Thoonen et al. found that the children in the typically developing group produced very little substitutions and omissions, which resulted in 100% feature retention for the majority of subjects. Six out of ten TD subjects in the present study retained 100% of features. The low rate of errors made it difficult to compare retention. However, when errors did occur in the TD groups of both studies, mean percentages indicated that place was retained the least followed by manner and voice.
Although patterns revealed similarities, there were several differences between the study conducted by Thoonen et al. (1994) and the present study. First, stimulus for their study included 36 words and 36 nonsense words, whereas the present study utilized a much larger data set of 245 words. Interestingly, Thoonen et al. did not find the same feature retention pattern with the nonsense words. In fact, among nonsense words, voicing was the least retained feature followed by place and then manner. The percentages of retention in the Thoonen et al. study were also much greater than the percentages found in the present studies (see figure 4). This could be attributed to the classification systems used in the analysis. Whereas the present study and the Forrest and Morrisette (1999) study examined seven classes of the place feature and six classes of the manner feature, Thoonen et al. only analyzed the phonemes by three classes of place and four classes of manner. Another important component that differentiates these subjects from the subjects in the present study is that the DAS subjects reported by Thoonen et al. (1994) had at least two years of speech treatment prior to the analyses.

![Figure 4](image_url)

**Figure 4.** Comparison of mean feature retention percentages between the present study and the study conducted by Thoonen et al. (1994)
As in the present study, Forrest and Morrisette (1999) also examined the relationship between phonological knowledge and feature retention. They found that the strongest relationship occurred with voicing and PCUR ($r = .714$). The relationship for place retention and PCUR was significant but negative ($r = -.54$) and a significant relationship was found between manner and PCUR ($r = .46$). They concluded that children with greater phonological knowledge retained place less often than children with less phonological knowledge. In the present study, PCUR did not significantly correlate with any of the feature retention percentages. This discrepancy could again be attributed to a difference in severity of the subjects.

No significant differences were found, based on PCUR, between the PI subjects in the present study and the PI subjects in Forrest and Morrisette (1999) study. However, mean PCUR values were less for the PI subjects in the present study. Mean PCUR for the Forrest and Morrisette subjects was 47.8, whereas mean PCUR in the present study was lower (35.5) for the PI group. A difference in severity can also be seen as subjects were classified by three levels of severity based on PCUR values—profound (< 30), severe (30-50), and moderate (51-75). Of the PI subjects in the present study 40% were classified as profound, 40% were classified as severe, and 20% were classified as moderate. The subjects in the Forrest and Morrisette group showed fewer children in the profound (25%) and severe categories (20%), with more children in the moderate category (55%).
Theoretical Implications

Developmental Levels of Phonological Acquisition

In three different groups of speakers (PI, TD, and DAS), a similar pattern of feature retention is evident. Many questions are left to be answered concerning the reason for this specific pattern seen in both disordered and typically developing children. Dinnsen, Chin, Elbert and Powell (1990) examined the phonological systems of 40 “functional misarticulators” ages 40 to 80 months. These systems were characterized typologically into a hierarchy of levels (A through E). Level A, the first level, characterized the more severe phonologically impaired systems, which contained the least amount of distinctions among features. As the levels progress, more feature distinctions are added to the phonological system. In Level A, distinctions were made among stops, nasals, and glides (3 manner classes), and among two places of articulation, which included labials and alveolars, but only among the obstruents. In this level, voicing was not distinct. By level B, a voice contrast was present along with one additional place of articulation, still occurring only within the obstruents. Fricatives and/or affricates were added in level C, however no additional place distinctions were made. Level D contained all of the above distinctions, but now liquids were added into the inventory. By level E, the last level reported, the retroflex/lateral distinction was made between liquids. This hierarchy of developmental levels is paralleled with normal development as well (Locke, 1983 as reported by Dinnsen et al., 1990).

This explanation of the typological levels may help explain why place is generally the least retained feature and voice is found to be retained the most. Dinnsen et al. (1990) found that nonanterior sounds were generally acquired only after some anterior sounds are present and that “nonanterior obstruents did not occur in relatively simple inventories and might not occur in
systems even as complex as level E” (p.34). Generally, distinctions are made between all the manner and voice classes by level E, however, all place distinctions may or may not be occurring. In level B the number of place and manner distinctions are relatively equal. From this level on, however, manner distinctions continue to emerge, as place distinctions start to level off until later in development. Voice contrasts are made fairly early in level B. This could account for voice being the most retained feature. Exceptions to this common feature retention pattern could very well be attributed to the particular “level” of phonological development. For example, a child in level A could exhibit the least amount of feature retention in voice because that contrast has not yet developed.

Physical and Neurological Development

The present study as well as studies conducted by Thoonen et al. (1994) and Forrest and Morrisette (1999) revealed that voicing is retained the most in DAS, PI, and TD groups of speakers. In the earliest vocalizations of infants, contrasts between voiced and voiceless sounds occur. Cry is generally voiced, whereas clicks, trills, and friction noises produced by infants, are generally voiceless (Vihman, 1996). According to Stark (as cited by Vihman, 1996), “the emergence of cooing is dependent on increased control over voicing, which is found only in cry” (p.106). Thus, voicing is the first feature that can be volitionally controlled by a human being. A greater retention of the voice feature may be attributed to the fact that voice contrast is developed earlier and has occurred in vocalizations for a longer period of time – since the first few weeks of birth.

The timing of neurological development may account for the place and manner features being retained the less often than voice. Simonds & Schiebel (1989) studied the growth of
dendrites in the brain in typically developing children. They found that children ages 2 and 3 years of age experience a shift in dominance in which the motor speech areas of the brain exceed the general oral motor areas in neural complexity (Simonds & Schiebel, 1989). This shift in dominance results in greater neuromuscular control of the articulators, which plays a critical role in the ability to manipulate the outgoing air stream in order to produce different sounds (Vihman, 1996). Place and manner of articulation are dependent upon neuromuscular control of the articulators more so than voicing that is dependent upon the vibration of muscles in the larynx (Boysson-Bardies, 1999). Therefore, place and manner features are not as refined, neurologically, as the voice feature, which has been present in vocalizations since birth.

Clinical Implications

Thoonen et al. (1994) concluded that retention of place of articulation could be used as a diagnostic marker for children suspected of DAS. This study was conducted using only a suspected DAS population and a typically developing group. Forreset and Morrisette (1999) challenged this idea and found that PI groups also shared this pattern of feature retention. From the present study, Forrest and Morrisette’s claim is reinforced with further evidence that there is a lack of differentiation between their PI groups and the DAS group (Thoonen et al. 1994). This lack of differentiation weakens the speculation that DAS is a separate clinically entity or that place retention is a diagnostic marker for DAS. Clinically, feature retention cannot be used to diagnosis DAS on the basis that feature retention is not an exclusive characteristic to this population.
Future Research

Future research is greatly needed concerning the clinical entity of DAS. There were several differences among the Thoonen et al. (1994) study and the present study. An investigation that more closely duplicates the present study using children diagnosed with DAS would provide a more reliable level of comparison between feature retention patterns among DAS, PI and TD populations. The following aspects would be of great importance in studies to follow regarding feature retention patterns: 1) subjects should include English speaking children diagnosed with DAS; (2) a larger stimulus probe of 245 words should be used; and (3) the probes should be analyzed using a classification system of seven places of articulation, six manner classes, and two voice distinctions, as in the present study.

Future research involving treatment outcomes may also yield beneficial information. It would be interesting to compare pre and post feature retention patterns of children diagnosed with DAS to children diagnosed with a phonological impairment. It would also be interesting to use feature retention patterns to compare the effects of a phonological approach versus a motor approach with a group of children diagnosed with DAS.

In the present study, no significant relationship was discovered between PCUR and feature retention. Forrest and Morrisee (1999), however, did find significant relationships concluding that children with greater PCUR had less retention of place and greater retention of voice. Duplicating this study using a larger sample size for PCUR may provide greater insight as to the degree that severity effects feature retention patterns.
REFERENCES


Appendix A

Informed Consent

PRINCIPAL INVESTIGATOR: Amanda N. Lambert, B.S.

PROJECT TITLE: The Description and Comparison of Feature Retention Patterns for Children with Phonological Impairment, Developmental Apraxia of Speech, and Typically Developing Children

This is a research project. This Informed Consent will explain about being a research participant in an experiment. It is important that you read this material carefully and then decide if you wish your child to be a volunteer.

PURPOSE

The purposes of this study are as follows:

1) to describe speech patterns for typically developing children.
2) to compare these patterns to children with speech disorders that have been described by previous research.

DURATION

Children will participate in a maximum of three 60-minute individual sessions.

PROCEDURES

In this study, your child’s speech will be evaluated using a list of 245 words. Your child will be shown pictures and will be asked to name them.

POSSIBLE RISKS AND DISCOMFORTS

The possible risk and/or discomfort of your child’s involvement include fatigue or boredom during the picture-naming task. This is a standard clinical practice.

BENEFITS

The possible benefit of your child’s participation include:

1) An extensive evaluation of your child’s speech.
2) Society may gain information concerning speech patterns of typically developing children and how they compare to children with speech disorders.
PRINCIPAL INVESTIGATOR: Amanda N. Lambert, B.S.

PROJECT TITLE: The Description and Comparison of Feature Retention Patterns for Children with Phonological Impairment, Developmental Apraxia of Speech, and Typically Developing Children

CONTACT FOR QUESTIONS

If you have any further questions about this study, you may call Amanda Lambert at (423) 926-0742 or Dr. Lynn Williams at (423) 439-7188. You may call the Chairman of the Institutional Review Board at (423) 439-6134 for any questions you may have about your rights as a research subject.

CONFIDENTIALITY

Every attempt will be made to see that my study results are kept confidential. A copy of the records from this study will be stored in Dr. Lynn Williams’ office in a locked file cabinet, for at least 10 years after the end of this research. The results of this study may be published and/or presented at meetings without naming your child as a subject. Although your rights and privacy will be maintained, the Secretary of the Department of Health and Human Services, The East Tennessee State University Institutional Review Board, and the ETSU Department of Communicative Disorders have access to the study records. Your child’s records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above.

COMPENSATION FOR MEDICAL TREATMENT

East Tennessee State University (ETSU) will pay the cost of emergency first aid for any injury which may happen as a result of your child being in this study. They will not pay for any other medical treatment. Claims against ETSU or any of its agents or employees my be submitted to the Tennessee Claims Commission. These claims will be settled to the extent allowable as provided under TCA Section 9-8-307. For more information about claims call the Chairman of the Institutional Review Board of ETSU at (423) 439-6134.

VOLUNTARY PARTICIPATION

The nature demands, risks, and benefits of the project have been explained to me as well as are known and available. I understand what my child’s participation involves. Furthermore, I understand that I am free to ask questions and withdraw from the project at any time, without penalty. I have read, or have had read to me, and fully understand the consent form. I sign it freely and voluntarily. A signed copy has been given to me.
Your child’s study record will be maintained in strictest confidence according to current legal requirements and will not be revealed unless required by law or as noted above.

PRINCIPAL INVESTIGATOR: Amanda N. Lambert, B.S.

PROJECT TITLE: The Description and Comparison of Feature Retention Patterns for Children with Phonological Impairment, Developmental Apraxia of Speech, and Typically Developing Children

___________________________________________________________
SIGNATURE OF PARENTS OR GUARDIAN                             DATE

___________________________________________________________
SIGNATURE OF INVESTIGATOR                                     DATE

___________________________________________________________
SIGNATURE OF WITNESS                                          DATE
Appendix B

Child History Form

**Identifying Information**

Child’s Name:_____________________________________  Birthday: _______________

Name of Parent or Guardian ______________________________________________________

Address ______________________________________________________________________

Home Phone:___________________________ Office Phone: ___________________________

School:__________________________________________________Grade: _______________

Siblings (Name/Ages): ___________________________________________________________

Has your child received previous speech-language therapy?___________ If so, please describe the focus of therapy_____________________________________________________________

Is English the only language spoken in the home ____________?

**Medical and General Developmental History**

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

If yes, please describe ___________________________________________________________

_____________________________________________________________________________

_____________________________________________________________________________

Postnatal Feeding: Normal intake/ability _______ ; Abnormal intake_______

Describe____________________________________________________________________

_____________________________________________________________________________
1. **Movement Skills**: Check the box at which your child did the following: (age in months)

<table>
<thead>
<tr>
<th>Action</th>
<th>1-3</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>13-18</th>
<th>19-24</th>
<th>25-36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouthing toys</td>
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<td>Sitting alone</td>
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<td>Belly scooting/ creeping</td>
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<td>Crawling</td>
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<td>Standing alone</td>
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<tr>
<td>Walking alone</td>
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<td>Running</td>
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<td>Feeding self</td>
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<td>Dressing Self</td>
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<td>Bladder trained</td>
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<tr>
<td>Stool trained</td>
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</tbody>
</table>

Overall, how would you describe you child’s development? ________________________________

Describe any movement, coordination problems, or unusual habits. _______________________

__________________________________________________________________________

**Childhood Illnesses** (please indicate age)

<table>
<thead>
<tr>
<th>Illness</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croup</td>
<td></td>
</tr>
<tr>
<td>Influenza</td>
<td></td>
</tr>
<tr>
<td>Mastoidectomy</td>
<td></td>
</tr>
<tr>
<td>Mumps</td>
<td></td>
</tr>
<tr>
<td>High Fever</td>
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<tr>
<td>Ear Infections</td>
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<tr>
<td>Chicken Pox</td>
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<tr>
<td>Heart Problems</td>
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<tr>
<td>Meningitis</td>
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<tr>
<td>Scarlet Fever</td>
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<tr>
<td>Cross Eyed</td>
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<tr>
<td>Seizures</td>
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<tr>
<td>Tonsillitis</td>
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</tr>
<tr>
<td>Head Injury</td>
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<tr>
<td>Others (please list)</td>
<td></td>
</tr>
</tbody>
</table>

Adenoidectomy
Measles
Mumps
Pneumonia
Ear Aches
Whooping Cough
Diphtheria
Ear Drainage
Rheumatic Fever
Cataracts
Encephalitis
Tonsillectomy
Headaches
Muscle Disorder
Vocal Nodules
Current medication or medical procedures your child is undergoing: ______________________
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

Has your child had his or her hearing tested previously? ______________
If yes, please list date of most recent hearing evaluation__________

**School and Social Behavior**

Please indicate any school/social problems ________________________________
_____________________________________________________________________________
_____________________________________________________________________________

**Speech, Language, and Hearing Development**

Check the age at which your child did the following:  (age in months)

<table>
<thead>
<tr>
<th>Action</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>13-18</th>
<th>19-24</th>
<th>25-36</th>
<th>37-48</th>
<th>49-60</th>
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<tbody>
<tr>
<td>Gurgling Sounds</td>
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<td>Babbling “Babababa-Dadada”</td>
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<td>First Word</td>
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<td>Two or more words together</td>
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<td>Said his/her name</td>
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<td>Naming 10-20 objects</td>
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<td>Naming 10-20 actions</td>
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<tr>
<td>Asks “What”, “Where” Questions</td>
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</tbody>
</table>

What are some things your child is interested in (activities, favorite toys/cartoons, etc.):
Appendix C

Word List – 245-word probe

1. Jimmy
2. gauge
3. fudge
4. wash
5. path
6. ship
7. tongue
8. chicken
9. keyhole
10. father
11. visit
12. magic
13. beehive
14. zoom
15. elephant
16. gun
17. them
18. jug
19. go
20. shave
21. Kathy
22. zero
23. dinosaur
24. teeth
25. buy
26. pig
27. zip
28. behind
29. ladder
30. charge
31. witch
32. gush
33. doll
34. giraffe
35. scissors
36. eat
37. pitch
38. shadow
39. nose
40. view
41. rope
42. chop
43. come
44. gum
45. gain
46. cheep
47. page
48. catch
49. rub
50. jelly
51. hop
52. mom
53. donkey
54. fan
55. fun
56. robe
57. chase
58. rob
59. cookie
60. cut
61. fill
62. boss
63. show
64. big
65. hug
66. sob
67. sing
68. mail
69. thumb
70. zombie
71. cook
72. push
73. wish
74. coyote
75. yawn
76. leaf
77. thirteen
78. watch
79. fog
80. laugh
81. they
82. reach
83. yo-yo
84. hide
85. do
86. dive
87. zipper
88. lawyer
89. think
90. seven
91. cough
92. python
93. duck
94. nail
95. van
96. yahoo
97. Matthew
98. pay
99. walk
100. shower
101. rain
102. yes
103. feather
104. ride
105. tall
106. nothing
107. vote
108. you
109. wait
110. read
111. long
112. those
113. use
114. monkey
115. valley
116. kayak
117. tack
118. knee
119. bed
120. that
121. join
122. thing
123. doughnut
124. kiss
125. bathe
126. this
127. booth
128. live
129. south
130. heavy
131. happy
132. toothache
133. rethink
134. review
135. rewash
136. rebuy
137. recharge
138. refill
139. reread
140. rezip
141. rejoin
142. repay
143. renail
144. resing
145. remail
146. rehide
147. retack
148. recut
149. reshhip
150. relive
151. regain
152. redo
153. gauges
154. bridges
155. noses
156. pages
157. matches
158. taller
159. smoother
160. eating
161. rubbing
162. going
163. showing
164. charging
165. pushing
166. wishing
167. fanning
168. singing
169. diving
170. quacking
171. riding
172. blooming
173. pitching
174. reading
175. growing
176. shipping
177. closing
178. coughing
179. walking
180. robbing
181. shopping
182. coming
183. watching
184. chasing
185. throwing
186. crashing
187. grabbing
188. shaving
189. breathing
190. mailing
191. dragging
192. washing
193. driving
194. hiding
195. sneezing
196. bathing
197. kissing
198. hopping
199. sniffing
200. sobbing
201. dressing
202. waiting
203. catching
204. voting
205. hugging
206. zooming
207. reaching
208. cutting
209. stirring
210. laughing
211. gushing
212. using
213. bossy
214. mommy
215. piggy
216. foggy
217. funny
218. scary
219. rainy
220. froggy
221. ducky
222. dolly
223. drive
224. frog
225. sniff
226. breathe
227. close
228. scare
229. playhouse
230. strawberry
231. dress
232. bloom
233. stir
234. sneeze
235. glove
236. quack
237. tweed
238. crash
239. grab
240. cloth
241. sweater
242. drag
243. bridge
244. sleeve
245. smooth
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