SPONTANEOUS AND IMITATED UTTERANCES OF CHILDREN WITH PHONOLOGICAL DISORDERS

by

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ABSTRACT

The phonological relationship between spontaneous and imitated utterances has been discussed by many researchers in the past 30 years, yet it remains equivocal. The purpose of the present study was to investigate further this relationship so that researchers and clinicians in child phonology may interpret (assessment) data in a more valid and informed manner.

Spontaneous and imitated single word utterances of 19 pre-school aged children with phonological disorders were compared for phonological differences in production. At a segmental level, utterances were analyzed in terms of percentage of consonants correct (PCC) in three word positions. At a prosodic level, productions were analyzed in terms of percentage of wordshapes matched (%WSM), and percentage of CVC and CVCV wordshapes matched for number of syllables (i.e. "length-match").

Overall group results revealed no significant differences between the speech modes, suggesting that a model of spontaneous speech production suffices to delineate the mechanisms underlying both spontaneous *and* imitated utterances at a group level. Despite this finding, a review of individual data, along with certain methodological issues, suggest that group results be interpreted with caution since differences may exist at an individual level and be masked due to methodological procedures.

A significant age effect was found only for % WSM, where younger children (i.e. age 36 to 45 months) performed significantly better in spontaneous production than in imitation and older children (age 45 to 60 months) did not. This implies that younger children may use a different production strategy in imitation than do older children.

Overall, the results of this study suggest that imitation may be used as a means of eliciting utterances during phonological assessment with the general expectation that such utterances will not differ significantly from most children's typical, or spontaneous productions. However, individual data should be inspected for differences between spontaneous and imitated utterances, as well as for variability in productions, in order that assessment results are validly interpreted.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

I. Introduction

Imitation, and its relationship to language acquisition, has been discussed and studied by many researchers in the past 30 years. Some investigations provide evidence to support the notion that imitation facilitates addition of new lexical items to a child's existing repertoire (Stewart & Hamilton, 1976; Bloom, Hood, & Lightbown, 1974; Ramer, 1976). Other investigations have shown that imitation may serve to facilitate acquisition of new grammatical forms (Speidel & Herreshoff, 1989; Clark, 1976). Despite such findings, some studies failed to support the notion that imitation facilitates language acquisition, either in terms of lexical semantics (Leonard, Schwartz, Folger, Newhoff, Wilcox, 1979) or in terms of syntax (Ervin, 1964).

The nature of the role of imitation in phonological acquisition is also equivocal. Since this thesis concerns child phonology, the remainder of this chapter will be devoted to issues related to imitation and phonological acquisition, with particular emphasis on the comparison of speech produced spontaneously versus speech produced imitatively.

II. Phonological Development

A. Typical Phonological Development

For the purposes of this study, Stoel-Gammon & Dunn's (1985) definition of phonology was adopted.[1] It has been shown that most children who follow a pattern of normal phonological development acquire the segmental components of their language between 1;6 and 6;0.[2] Final aspects of suprasegmental development (e.g. adult-like timing patterns) are usually acquired by the age of 12;0 (Stoel-Gammon & Dunn, 1985).

In terms of manner of articulation in English, the classes of nasals, stops and glides are typically acquired early. Fricatives, affricates and liquids are typically acquired later.

In terms of place of articulation, progression of acquisition is typically from "front" to "back" (i.e. [labial] before [coronal] before [dorsal]).

Those segments acquired early often serve as substitutions for later-acquired classes of sounds (Stoel-Gammon & Dunn, 1985). There is considerable individual variation in the acquisition of sound segments, both in terms of order of acquisition and substitution patterns of sounds.

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Stoel-Gammon & Dunn (1985) define *phonology* as "... the organization of speech sounds that occur as contrastive units within a given language... it is used as a general term referring to *all* aspects of the study of speech sounds, including speech perception and production, as well as cognitive and motor aspects of speech", (p. 3-4).

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In this thesis, I adopt the standard nomenclature for indicating language age. For example, 1;6 = one year + six months.

The syllable shape "CV"[3] is the most common syllable shape in very early stages of acquisition. The syllable shape "CVC" usually appears around the ages of 1;6 to 2;0 for English-speaking children (Stoel-Gammon & Dunn, 1985). Prosodic (i.e. word/syllable shape) development is also subject to individual variation in terms of order of acquisition and syllable substitution patterns (e.g. cluster reduction: two segments reduce to one; CC ==> C).

B. Phonological Disorder Defined

All of the children in this investigation had *phonological disorders*[4]. The speech of children with phonological disorders is usually at least partly unintelligible. The phonological systems of such children are typically characterized by a reduced segmental inventory, simple syllable structures and constraints which may trigger persistent idiosyncratic phonological processes. Children with phonological disorders may acquire speech sounds in a different sequence than do children with normal phonological systems. Like normal children, children with disordered phonologies are least accurate in their production of fricatives, affricates, liquids (Stoel-Gammon & Dunn, 1985), and syllable patterns consisting of consonant clusters. Furthermore, these children often fail to maintain phonemic contrasts, perhaps due to a reduced

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3 C = consonant; V = vowel.

4 According to Stoel-Gammon & Dunn (1985), "...phonological disorders could be characterized as a disorder involving the *process* of acquisition therby creating atypical patterns associated with the *product* of acquisition..., "(p. 199).

phonological inventory or to incorrect use of a large one (Stoel-Gammon & Dunn, 1985). Finally, children with disordered phonologies are "... highly variable in their productions... they are also very different from one another", (Stoel-Gammon & Dunn, 1985, p. 127). Speech-language pathologists often work with children with phonological disorders, thus, it is essential to identify and describe the characteristics unique to a given child's speech sound system in order that an appropriate intervention plan may be developed. Identifying and describing such characteristics is not an easy task, since 'identification' and 'description' may require the use of a highly organized theory of phonological development as proposed in nonlinear frameworks.

C. Analyzing Phonological Data

Research in child phonology has resulted in the development of a number of theoretical positions from which to analyze phonological data. In this thesis, certain aspects of nonlinear phonological theory are assumed to describe phonological development.

D. Nonlinear Phonological Theory

Nonlinear phonological theory (NLP) assumes a hierarchical organization of words, syllables, segments and features (Goldsmith, 1976). A word or a phrase is comprised of several tiers, or levels of representation. Tiers are linked by association principles which map relations between them (e.g. one-to-one; one-to-many). The nature of tier associations in a phonological system determines the number and types of phonological phenomena which are produced.

The concepts of autonomy[5] and dominance[6] relationships for features provide support for the representation of phonological information in terms of a feature geometry (McCarthy, 1988; Sagey, 1986; Clements, 1985), or 'feature hierarchy.' The feature hierarchy for English consists of several nodes[7] with which various features (i.e. "terminal features") are associated. The Root node is a major class node which links the segment to the prosodic tiers (Bernhardt, 1992).

Two additional major nodes subordinate to the Root node are the Laryngeal node and the Place node. The Place node further dominates the individual nodes of Labial (referring to lip articulations), Coronal (referring to tongue blade and tongue tip articulations), and Dorsal (referring to tongue dorsum articulations).

A separate hierarchically organized level of representation ("tier") is posited for prosodic[8] units. Some of the proposed prosodic levels include the word, the foot, the syllable and the "skeletal (or "CV") sub-syllabic levels, all of which relate to stress and intonation patterns of the language (see Figure 1).

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5 A feature can operate independently in rules/processes within the constraints of the hierarchical structure (Bernhardt & Stoel-Gammon, 1994).

6 A feature may have a commanding role over other features subordinate to it.

7 A node is a feature which may dominate more than one other feature and serve as a link between the subordinate feature and higher levels of representation (Bernhardt & Stoel-Gammon, 1994).

8 Prosodic structure refers to all structure above the level of the segment.

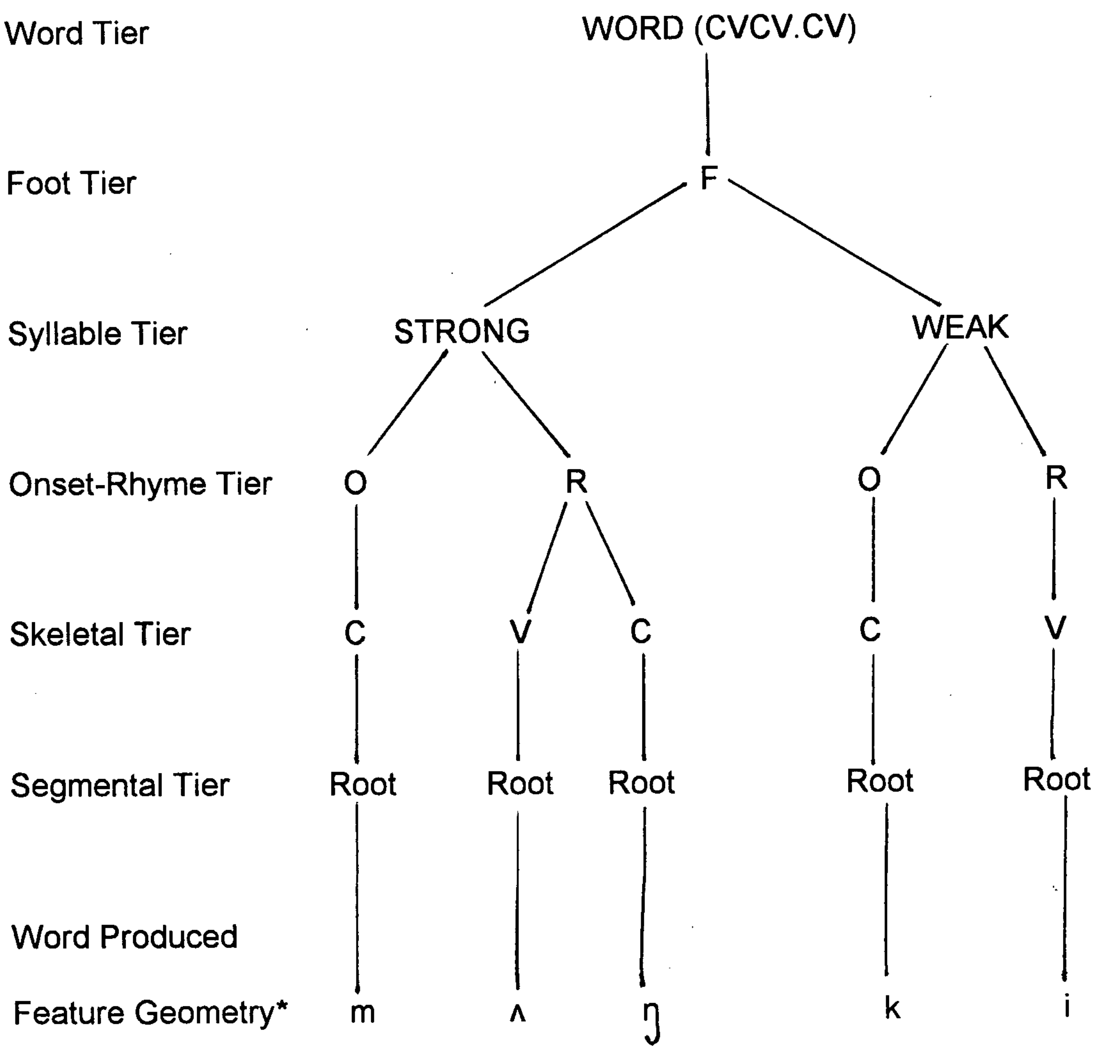

Figure 1: Hierarchical relationship among phonological units (adapted from Bernhardt & Stoel-Gammon, 1994)

In terms of the application of NLP in this thesis, I assume that feature representation is independent from prosodic (i.e. syllable and word structure) information. It is further assumed that the stages of syllabification during speech production occur independently of those involving segmental retrieval[9].

III. Methodological / Theoretical Questions with respect to Phonological Development and Imitation

Phonologists study and describe the development of normal and/or disordered phonology. Speech-language pathologists may use phonological analyses in order to (a) describe more precisely the nature of a child's phonological abilities and difficulties, and/or (b) determine goals for intervention. In either case, data must be representative of the child's typical speech performance (thus presumably reflecting the child's underlying phonological system) in order that descriptions are valid and/or intervention goals are appropriate.

Conclusions about the role of imitation in phonological acquisition must be tempered by the resolution of various methodological and theoretical questions. Such questions are apparent when clinicians and investigators collect and analyze phonological data. For example, one important question relates to method of elicitation: What method(s) should be used for elicitation? This question is particularly important

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9 A detailed description of the processes involved in speech production will follow under "Models of speech production" in this chapter.

because it bears on the discussion of whether phonological differences exist between spontaneous and imitated utterances. For investigators and clinicians, the decisions about whether to combine spontaneous and imitative utterances in phonological analyses or to analyze imitations separately, depend on an answer(s) to this question.

IV. Literature Review

Research findings from studies of imitative versus spontaneous utterances are equivocal. In reviewing the literature, terminology used by authors in original source material to describe a subject's speech sound difficulties will be maintained (e.g. "articulation disordered", "articulatory defective", etc). The term "phonological disorder" will be used by the present author in a generic sense to refer to all disturbances in a speech sound system.

A. Studies revealing differences between spontaneous and imitative speech: Certain studies show that imitated utterances are more accurately produced (phonologically) than are spontaneous utterances.

For example, Snow & Milisen (1954) found a statistically significant difference between speech sound errors found in picture naming responses elicited by imitation versus those noted in spontaneous speech. A sample of 164 school-aged subjects were found to have a lower overall articulation error rate when responding imitatively to the examiner's verbal model (picture stimulus provided) than when spontaneously naming pictures.

Children also made significantly fewer articulatory errors on imitative tests than on spontaneous (picture-naming) tests in Carter & Buck's (1958) study involving 175 first grade children with defective articulation. This finding was substantiated by the results of Johnson & Somer's (1978) study of 64 normally articulating children (mean age 5;0).

Data from Seigel, Winitz and Conkey (1963) implied that some sounds produced by children may match the adult model better when imitated than when produced spontaneously. One hundred normal kindergarten-aged children were presented with a spontaneous naming and an imitation-of-verbal-model task. There were significant differences among the articulations of eight of the forty phonemes measured. Better articulation (i.e. closer match to typical adult realization) occurred in the imitative mode.

Smith & Ainsworth (1967) tested 40 first-grade children with articulation disorders in three modes of spoken response elicitation: (1) spontaneous naming to picture; (2) imitation of verbal model with lip-reading cues (i.e. the children were allowed to see the examiner's face as the model was spoken) and (3) imitation of verbal model without lip-reading cues (i.e. the children were unable to see the examiner's face when the model was given). In an error analysis of total articulation scores for ten sounds, Smith & Ainsworth found that spontaneous naming to pictures elicited the maximum number of errors, followed by imitation without lip-reading cues, and, imitation with lip-reading cues. Error rates for spontaneous and imitative speech produced by 45 4-year-old children were examined by Kresheck & Socolofsky (1972). A significant difference between the error rates for the spontaneous and imitative methods of elicitation was found. Superior performance was evident in the imitative condition.

A studies of individual children (case study) substantiates these group findings. Faircloth & Faircloth (1970) isolated and compared nine words on spectograms of spontaneous and imitated speech from one articulatory deviant child. Their results showed that imitated forms were closer to the adult model overall in terms of syllable structure and individual sound segment production.

B. Studies revealing differences between spontaneous and imitative speech: Other studies have shown that imitated utterances are not produced more accurately (phonologically) than spontaneous utterances.

For example, Kehoe (1995), in a study of English stress pattern acquisition in young normal children, found a significant difference between the rate of stress shift (or, error) in spontaneous and imitated productions: Stress errors occurred more frequently in imitated than in spontaneous productions. There was also a significant difference between rate of truncation (i.e. final syllable deletion/reduction) in spontaneous and imitated productions: Truncations occurred more frequently in spontaneous productions.

C. Studies revealing no differences between spontaneous and imitative speech: Still other studies have shown no phonological differences between the speech modes.

For example, Templin (1947) studied the relationship of articulation responses in three elicitation contexts: (1) spontaneous elicitation to pictures (i.e. naming); (2) prompted imitation of an examiner's verbal model (picture stimulus absent), and (3) prompted imitation of a verbal model plus picture stimulus. The study was conducted with 100 normally articulating children between the chronological ages of two and six years. Only words produced spontaneously by the children were tested in imitative conditions to ensure that lack of knowledge of a stimulus item was not an experimental confound. In this elicitation paradigm, no statistically significant differences were found between total number of correct productions and correct articulation of specific speech sounds. Based on her data, Templin concluded that method of speech elicitation was not an important variable in measuring articulatory development. Therefore, she concluded that using imitation to measure speech sound development did not confound the data.

Leonard, Schwartz, Folger & Wilcox (1978) investigated eight children's (ages 1;3 to 2;0) unsolicited imitations of nonsense words and their relationship to spontaneous speech production. Accuracy of production of nonsense words consisting of syllable shapes and consonants which were both present in ("in phonology") and absent from ("out phonology") the childrens' phonological systems were analyzed in terms of production constraints and selection/avoidance characteristics. The results showed no differences in the phonological characteristics of young childrens' spontaneous and imitative speech. It was found that similar production constraints were operating when children imitated words as when they produced them spontaneously.

Bond & Korte (1983) investigated the possibility that imitative and spontaneous utterances may differ on the acoustic-phonetic and phonological levels. Ten typically developing subjects, ranging in age between 2;3 and 3;8, were included in the study. Concerned with any problems which may be associated with unfamiliarity of target lexical items, Bond et al. used only those test words which were known to their subjects. No significant differences were found between speech modes in terms of correct productions of consonant clusters and voice-onset time (VOT).

D. Summary

It is difficult to generalize across these studies, given that there are differences in number and ages of subjects tested, and differences in methodologies used. Nevertheless, the majority of results indicate a tendency for a slight difference(s) in terms of number of segmental errors produced when utterances were imitated versus produced spontaneously, with more segmental errors tending to occur in spontaneous speech (Snow & Milisen, 1954; Carter & Buck, 1958; Seigel, Winitz & Conkey, 1963; Smith & Ainsworth, 1967; Kresheck & Socolofsky, 1972; Faircloth & Faircloth, 1970; and Johnson & Somers, 1978; versus Templin, 1947; Leonard et al., 1978; and Bond & Korte, 1983). In terms of prosodic-based studies, findings appear equivocal (Faircloth & Faircloth, 1970 versus Kehoe, 1995).

E. Areas needing further research

A close inspection of the results of the above studies reveals that much work is needed in this domain in order to reach some consensus about the nature of the phonological characteristics expressed in spontaneous versus imitated utterances. The majority of the reviewed literature bearing on this issue entailed the comparison of overall "articulation" scores for the two speech modes on various articulation assessment tests or protocols. Very few studies have investigated more specific areas with respect to the phonological nature of imitative and spontaneous speech. More research is needed in terms of extent of match to adult model for segments (i.e. consonants and vowels) in general, specific phonological and/or phonetic features (e.g. aspiration, voicing, continuancy, nasalization, etc.) and prosodic (e.g. syllable and word) structure.

F. Major issue: Why might differences exist between spontaneous and imitated utterances?

Despite the equivocal nature of past research, a major issue has arisen from this pool of literature. It has been claimed that imitated productions do not necessarily reflect a child's true phonological abilities (Kresheck & Socolofsky, 1972; Leonard et al., 1978; Shibamoto & Olmstead, 1978). A child may be found to produce any number of phonological characteristics in imitation which are normally constrained by his/her current phonological system in spontaneous speech (Shibamoto & Olmstead, 1978). This implies that the processes underlying spontaneous and imitative speech production may differ.

Few of the investigators in the above studies attempted to address this issue and explain *why* differences might exist between imitative and spontaneous utterances. The majority of the research concerned the question of *whether* childrens' performance differed as a function of elicitation context (e.g. spontaneous versus imitated). The primary motivation behind such studies was to determine if it would be acceptable to encourage the use of imitated utterances in both articulation/phonological data collection and analysis (Templin, 1947; Snow & Milisen, 1954; Carter & Buck, 1958; Johnson & Somers 1968; Smith & Ainsworth, 1963; Kresheck & Socolofsky, 1972). In cases where a statistically significant difference(s) was found between speech produced spontaneously versus that produced imitatively, the general conclusion was to use only those utterances which were assumed to be most representative of the children's typical phonological/articulatory performance (i.e. spontaneous utterances). This was to ensure validity of assessment data. Readers were discouraged to elicit productions via imitation.[10]

In order to discuss *why* differences may exist between words produced via imitation versus those produced spontaneously, several other theoretical issues must first be considered. These include the mechanisms underlying spontaneous and imitative speech as delineated in a theoretical model(s) of speech production (including a model of the lexicon), working/short-term memory and attention factors, a child's processing capacities versus the demands for his/her production of speech, and a child's variability in speech production in general.

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This, of course, applies if the general goal of assessment is to discover how the child typically performs on his/her own. In some cases, clinicians attempt to find facilitative strategies which assist the child in making more accurate productions (e.g. stimulability testing), including imitation of a verbal model.

V. Models of Speech Production

Several models of speech production exist in the current literature, the majority of which are based on various sources of information-processing research. In this thesis, I will discuss Levelt's (1989) and Kay, Lesser & Coltheart's (1992) models of speech production. Levelt's model was chosen because it provides a thorough theoretical outline of the production of a spontaneous message by a normal adult speaker including associated underlying processes. The model of kay et al. was chosen since it outlines the theoretical processes involved in the production of imitative speech.

One issue which must be addressed at this point is how the processes underlying speech production might differ for children as compared with adults. In general, it is assumed by the present author that such processes (as described below) are intact in young children. It is further assumed that they are affected by a child's ability to simultaneously manage (other) CNS[11] processing demands relative to his/her capacities (see discussion on "Imitation and Other Issues" in this chapter).

A. Spontaneous utterances and Levelt's (1989) model of speech production

In Levelt's (1989) model, there are five major processing components: the Conceptualizer, the Formulator, the Articulator, the Audition component and the Speech

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11 CNS = Central Nervous System

Comprehension System (see Figure 2).

A spontaneous conceptual message is first generated at the level of the Conceptualizer. This preverbal message serves as input to the Formulator where it is subjected to a stage of grammatical encoding which produces the surface structure of the message. The surface structure consists of a phrase-structural organization of lemmas[12] and the syntactic relations among them. These aspects are relevant for the next step in the process, phonological encoding, as lemmas in a surface structure indicate the storage site of word-form information (i.e. underlying lexical representation(s), or UR).

According to Levelt, input to the Articulator consists of a series of easily pronounceable patterns, or, one's phonetic plan. In order to reach this stage, a number of processes involved in phonological encoding must be executed. In some circumstances, a speaker may choose to utter only a single word. Words are underlyingly structured at a morphological level and a phonological level. In terms of morphology, words may be composed of one or more morphemes, such as roots, prefixes and suffixes. In terms of phonology, words consist of syllables and segments (i.e. consonants and vowels). The phonetic plans for words are built on their morphology and are phonologically organized at various levels involving phonetic material (segments, features, etc.) and prosodic information (syllable stress [or metrical

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"Lemma" is a term used to refer to a word's meaning in conjunction with it's associated syntactic information (Caplan, 1993).

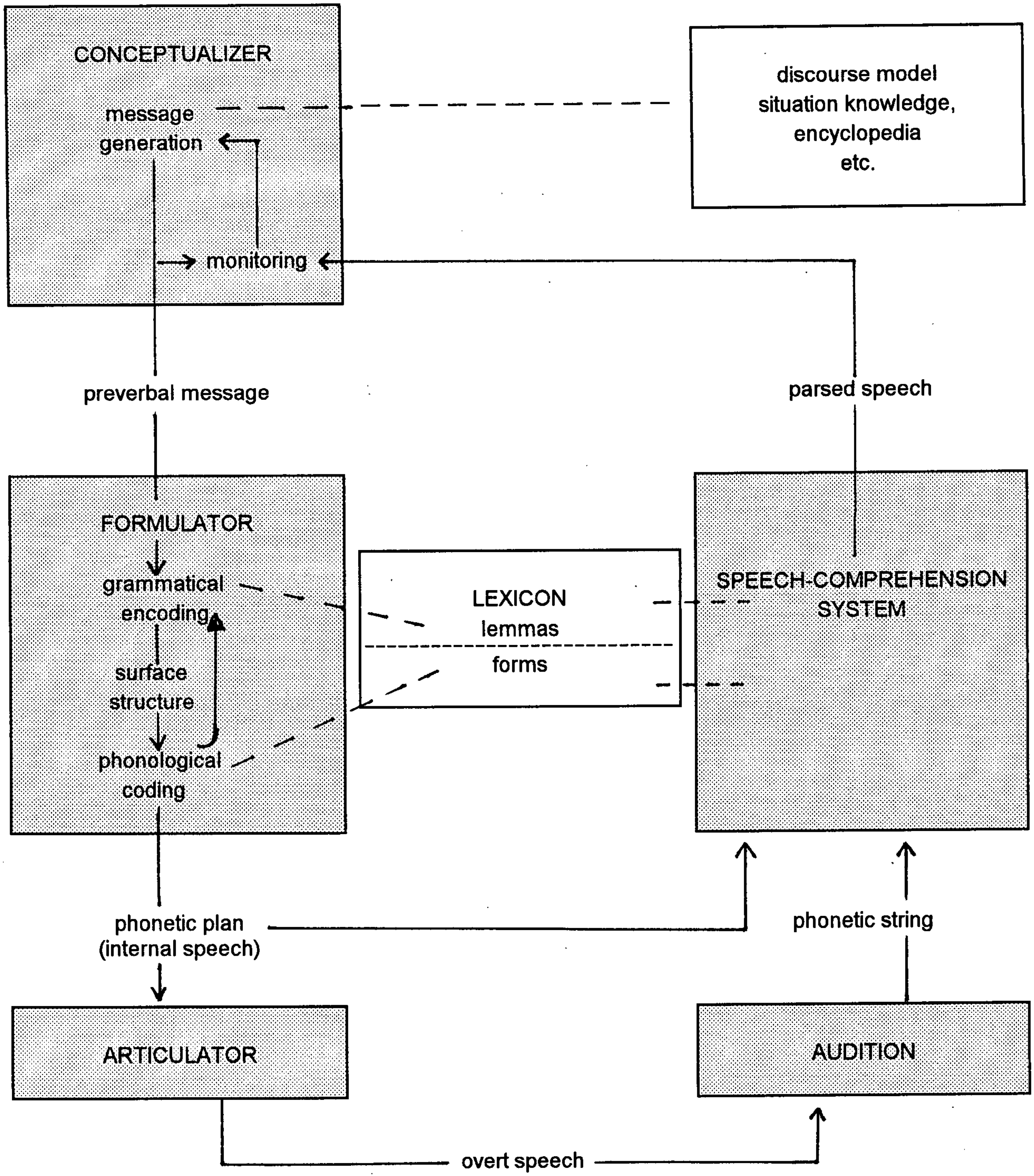

Figure 2: Model of spontaneous speech production (adapted from Levelt (1989)).

structure] and intonation).[13]

Phonological encoding of uttered words involves three major levels of processing. The first level is known as morphological/metrical spellout. At this stage, accessed lemmas are used to retrieve a lexical item's morphemes and syllable stress patterns. The second stage is known as "segmental spellout." Here, morphemes are used to retrieve a word's syllables and segments. The final stage is known as "phonetic spellout." It is at this stage that segments and clusters are used to indicate the storage sites of the phonetic syllable plans which will serve as input to the Articulator. The Articulator may then convert the plan into an overt message which in turn may be processed by the Audition component processor and sent to the Speech Comprehension System. From here, parsed speech may be sent to the self-monitoring component of the Conceptualizer.

Levelt's model of speech production assumes a single-lexicon model. Hence, it is assumed that there is only one pool of underlying phonological representations (UR) which is accessible during the processes of phonological perception and production. Moreover, Levelt's model is intended to delineate the processes involved in a mature speech production system wherein the URs for lexical items are presumably firmly established. However, there is still a considerable amount of debate with respect to the nature of the underlying representations in the child's system, and several models have been posited.

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Recall that levels of organization are assumed to be independent of one another (i.e. phonetic, or segmental information versus prosodic, or syllable and word structure information).

1. One-lexicon models and variability

Early one-lexicon models such as those proposed by Stampe (1969; 1973), Smith (1973) and Macken (1980) entailed conversion of the UR for a given lexical item into a surface representation through application of so-called rules or processes. The surface representation was then converted into final form (i.e. phonetic output) via "low-level" or "peripheral" phonetic rules.

One major problem with early single-lexicon models is that they failed to account for a considerable amount of variability in children's productions. In these models, it was assumed that when a child's production deviated from the adult spoken form, it was the result of (1) variability in application of rules/processes during production (Stampe, 1969; 1973; Smith, 1973), or (2) a divergent perceptually-based UR formed on the basis of a misperception of adult input or on the child's own deviant output (for words he/she frequently used [Macken, 1980]).

A child's developing phonological system is in a constant state of gradual change, giving rise to extensive variability in a child's productions both across and within words. Kehoe (in preparation) displays the six productions of "banana" made by one of her 22 month-old subjects. His productions are presented in Table 1 below:

Table1: Six examples of the production of "banana" by a 22 month-old (adapted from Kehoe, 1995).

target: banana	Production:	1 (Imitated, I)	[bʌndɪmɑ]
		2 (I)	[bæ̃nɜmæ̃]
		3 (I)	[bæ̃ndɪmɑ]
		4 (I)	[bɑʤɛn]
		5 (I)	[bɑdɪn]
		6 (Spontaneous, S)	[bɑ:dɛn]

A considerable range of such variability in phonological production remains which cannot be solely accounted for by early single-lexicon models. However, if the principles of operation in connectionist models of representation and processing are coupled with the one-lexicon model, then it may be possible to account for differences between perception and production.

2. Stemberger's (1985) connectionist model of representation/processing assumptions

Stemberger (1985) proposed six key assumptions in his connectionist model of language representation and processing:

(a) Phonological representation is multilinear.

(b) Information is encoded in terms of *units*, or points that sum activation from a variety of sources, and in turn send out activation to other units. Unless in an active state, a unit will be at its basic *resting level.*

(c) The units of the system are *connected.* The connections allow for passing of activation or inhibition between units. The unit attaining the highest level of activation may ultimately be retrieved. When one phonological form or unit is activated, other similar ones may be activated by what is known as a *gang effect*. Gang effects may have a significant impact on processing in the child's system, whose lexicon is presumably very small and contains limited stored phonological forms.

(d) Resting levels are subject to random fluctuations, or *internal noise* which may also result in activation and subsequent retrieval of an unintended unit.

(e) High-frequency units become more easily accessible as resting levels increase each time a unit is accessed.

(f) The process of spreading/passing activation from level to level must be learned. Discrepancies from the perceptually-based representation may arise if this process is insufficient. The learning process will take time as necessary adjustments to activation levels are small and are made gradually (Bernhardt & Stemberger, in preparation).

Considering these assumptions in addition to the single-lexicon model (Macken, 1980), much of the variability observed in children's productions is better accounted-for than in earlier, one-lexicon serial models. According to the "connectionist + single-lexicon" model, then, the child presumably attempts to remain faithful to the perceived form of the lexical item. The extent to which his/her production is consistent with this underlying form will depend on the child's ability to access a given unit (i.e. UR) in the production process. Bernhardt & Stemberger (in preparation) propose that accessibility will vary depending on a variety of factors, such as output capacity constraints, unit activation levels, internal noise, gang effects and interactive competitions between various levels of the phonology.

Levelt's 1989 model operates with parallel connectionist assumptions similar to those proposed by Stemberger (1985), although Levelt assumes that the process of spreading activation is already learned in an adult's system.

B. Imitation and Kay, Lesser and Coltheart's (1992) model of speech production

Despite Levelt's attempts to characterize the processes underlying the production of a spontaneous utterance, he does not attempt to account for those which may underlie the production of imitative speech. Another model which does account for imitatively produced speech was proposed by Kay, Lesser and Coltheart (1992) (see Figure 3). This model was devised primarily on the basis of communication profiles of patients who have acquired specific (and often unique) language disorders as a result of stroke. It delineates basic language processing mechanisms involved in various language-related activities including speaking, visual object naming, and oral reading. Like Levelt's model, this model is presented serially, although it is assumed that processing within a given area (module) may occur in a parallel-distributed fashion.

Many other basic assumptions inherent in Levelt's (1989) model are retained in the model of Kay et al., but certain differences also exist. Like Levelt, in terms of spontaneous speech production, it is assumed that a speaker selects certain meaning-based representations to be converted into appropriate words in connected speech. Furthermore, and more simply stated in the model of Kay et al., a speaker possesses

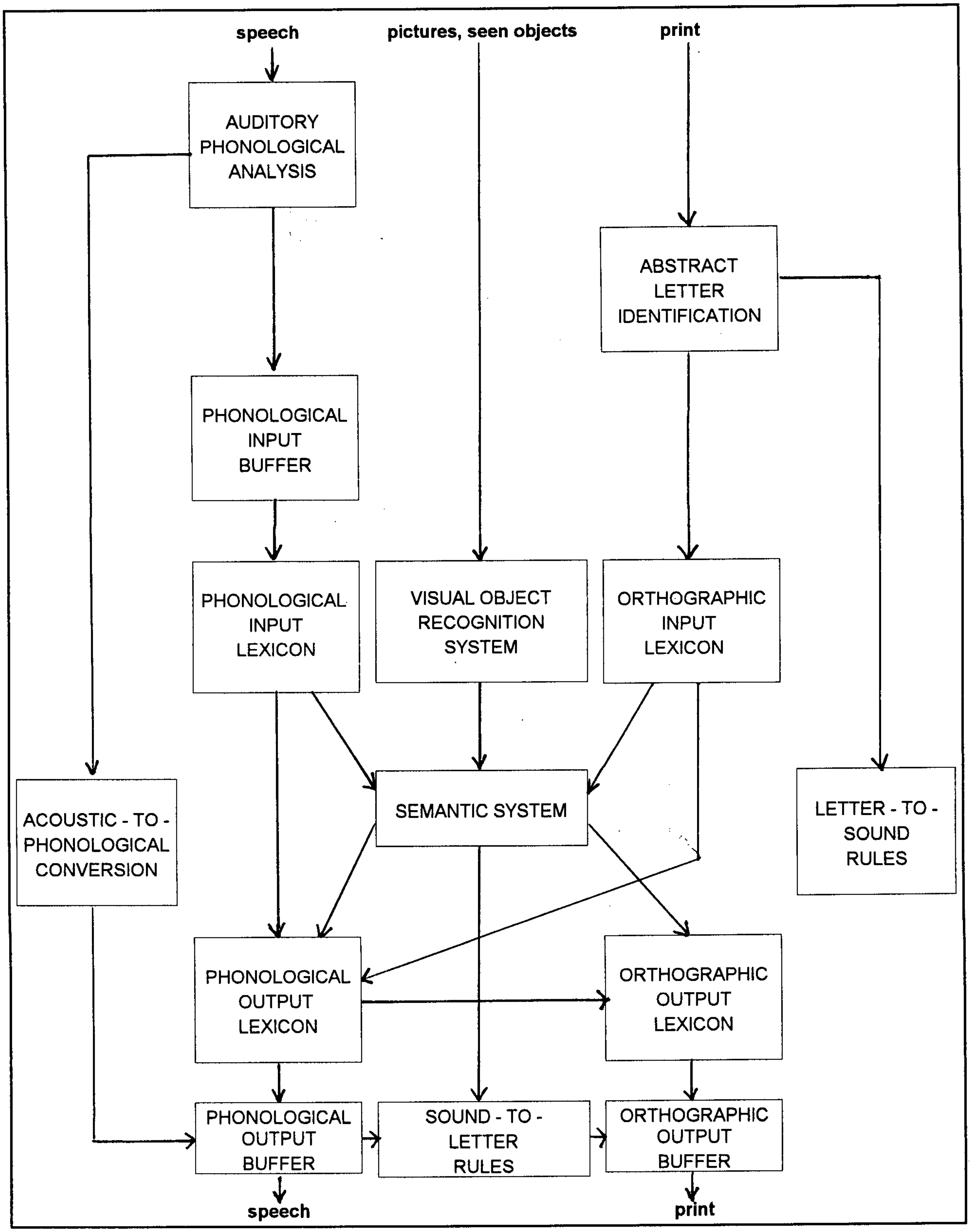

Figure 3: Model of speech production (adapted from Kay, Lesser, & Coltheart (1992)).

a set of phonological representations for all spoken words in his/her vocabulary for language production. This store is known as the phonological output lexicon and it is roughly equivalent to the word form storage locus (of the lexicon) which is accessed during phonological encoding in Levelt's model. Beyond this are further processes which may include a "buffer" system of temporary storage (wherein the phonetic string to be uttered is assembled) and neuro-muscular programming. This group of processes has been subsumed under the term "speech" in the model of Kay et al. Assemblage of the phonetic string in the model of Kay et al. would parallel the process of phonetic spellout in Levelt's model. A neuro-muscular programming level is roughly equivalent to Levelt's Articulator level.

Further processes are involved in recognizing and repeating spoken word utterances. The model of Kay et al. describes two routes for repetition: one for which lexical information about spoken word(s) may be accessed if necessary ("lexical" route for repetition) and one for which lexical information is not necessary, as when one repeats a nonword ("non-lexical" route for repetition).

In terms of the lexical route, when a speaker hears a real word, the speech signal is initially subjected to "auditory phonological analysis" where abstract phonological identification takes place. If the perceived signal is recognized, it is further processed via the lexical systems. (Note that the model of Kay et al. assumes a two-lexicon model: one for perceptually-based forms and one for production-based forms.) This information is communicated to the phonological input lexicon where *incoming* vocabulary word form information is accessed. From here, access to the semantic system may be achieved. The word is understood as meaning is mapped onto the retrieved phonological input word form. The processes involved at these levels would be roughly equivalent to those in the Speech Comprehension System of Levelt's model. Following this, the output word form is accessed in the phonological output lexicon and processing continues as described previously for spontaneous speech production.

Alternatively, output may be carried from the phonological input lexicon directly to the phonological output lexicon, by-passing the semantic system. In this case, a real word may be recognized as a word[14] and repeated, but meaning is not accessed and hence the word is not understood. The remaining processes follow those operating in spontaneous output.

Kay et al. further propose that it must be possible to repeat certain words (i.e. nonwords, and presumably words which are not part of one's vocabulary of production) by going directly from acoustic analysis of an incoming signal to speech output, by-passing lexical systems as well as the semantic system. This repetition route is referred to as the nonlexical route. The supportive evidence for such processing routes comes from data of patients with aphasia who are able to repeat real words, but who may not repeat nonwords. Repetition of nonwords would not be possible if the only route for repetition ran directly from an input to an output lexicon, since input to both of these systems must be "recognizable." This repetition route is referred to as the "nonlexical" route.

14 Assuming that the lexical form is familiar to the listener.

C. Limitations of speech production models

The model of Kay et al. (1992) model outlines numerous operations which may be involved in speech production. It should be noted, however, that the details of the theoretical underlying processes are not as explicitly delineated for this model as they are for Levelt's (1989). It is acknowledged by each of the authors, however, that there remain many unresolved complex theoretical issues upon which their respective approaches (i.e. models) are based.

Despite these limitations, it is believed by the present author that application of a theoretical speech production model can guide research in a more structured and systematic manner and provide explanatory bases for data interpretation. Furthermore, it promotes generation of testable hypotheses with respect to the debate about whether differences exist between spontaneous and imitated utterances.

It is acknowledged by the present author that there are advantages and disadvantages associated with the application of either of the two models of speech production reviewed above. For example, Levelt's model may be appropriately applied in studies of spontaneous speech. On the other hand, the model of Kay et al. offers the advantage of an explanatory basis for both spontaneous *and* imitative speech production.

To summarize, in spontaneous speech production, a speaker must rely on his/her own UR of the word to be uttered. However, when a speaker is asked to imitate a real word, the production may be based on his/her UR for that word (i.e. lexical route is used) or on the modelled form (Stoel-Gammon & Dunn, 1985) and the alternative nonlexical route for imitation is used. The nonlexical route must be used when the target is a nonword (i.e. a word for which the imitator has no UR) until such time that a UR is created in the system.[15]

D. Imitation and other issues

In addition to models of speech production, it is necessary to consider other issues in the discussion of *why* differences may arise in speech produced imitatively versus speech produced spontaneously. These issues involve working memory, attention, and the demands and capacities of one's CNS for speech processing.

1. Working (Short-Term) Memory

According to Baddeley and Hitch (1974), working memory has three principal components: the central executive (CE), the phonological loop (PL) and the visuo-spatial sketchpad (VSS). The CE's functions include controlling information flow within working memory, retrieval of information from other memory systems, and processing/storing information, including allocating input to the phonological loop (PL).

The CE uses processing resources which are limited in capacity. The efficiency with which it fulfills a given function, such as retrieving a phonological representation from long term memory (i.e. lexical storage) and allocating it to the PL (or Articulator in Levelt's model), depends on the amount of competition from other processing demands

15 Assuming that multiple exemplars are needed before a UR is established.

which are simultaneously placed on it (Gathercole & Baddeley, 1993).

2. Demands and Capacities model

The Demands and Capacities model was used as a means of explaining the etiology of stuttering by Starkweather (1987). This model proposes that speech fluency in individuals who stutter breaks down when self-imposed and/or environmental demands exceed one's capacities (i.e. cognitive, linguistic, motoric and/or emotional) for responding (Starkweather, 1987). It may also be applied in the event of other phenomena in speech production, such as differences in production within and across speech modes. Moreover, the phenomena of activation, gang effects, internal noise, attentional resource allocation, "peripheral" operations including auditory and articulatory components, etc. may be interpreted in terms of CNS demands and/or capacities for a given system.

VI. General Assumptions and Questions

For the purposes of the present study, the following general question and related assumptions were considered with respect to the critical issue of *why* phonological differences might be found between imitated and spontaneous utterances.

(1) Are there differences between spontaneous and imitated utterances?

(a) If no differences are found between spontaneous and imitated utterances, it will be assumed that the children in this study based their imitated productions on their own URs for those words (and disregarded the modelled forms). In terms of speech production models, it will be assumed that the lexical route for imitation was used (as in the model of Kay et al.,1992). (If the lexical route for imitation is used, imitated utterances are not predicted to differ significantly from spontaneous ones, assuming that both modes of production are processed similarly when this route is used.[16] In this case, Levelt's model of speech production would suffice as a means of explanation for both spontaneous and imitative speech at the single word level.)

(b) On the other hand, if differences are found between imitated and spontaneous utterances, it will be assumed that the children based their imitations on immediate perceptual (modelled) forms. In such cases, the imitated utterances are predicted to be different from (in either a positive or a negative direction) a spontaneous production, depending on the child's ability to manage internal CNS demands (including auditory analysis of perceptual signal, phonological working memory, attention, articulatory production, etc.) relative to his/her processing capacities at the time of production. In terms of models of speech production, it will be assumed that the subjects by-passed the lexical system (i.e. used the nonlexical route) in their imitated utterances or that the lexical route was used, but the semantic system was by-passed.

16 Assuming other conditions (e.g. CNS demands and capacities) are constant across speech modes.

VII. Summary

Imitative data are still commonly used in the clinic and in research despite at least some empirical support for the claims that (1) there are differences between spontaneous and imitated utterances, and (2) imitation may reflect phonological characteristics not produced in spontaneous speech. It is crucial that researchers in developmental phonology and speech-language pathologists have a better understanding about the phonological nature of speech produced spontaneously versus that produced imitatively so that (assessment) data are validly interpreted in a more informed manner. A more detailed analysis of word position data, and syllable and word structure data, is needed to approach a resolution to the issue.

VIII. Purpose of this study and Research Questions

This leads to the purpose of the present study: to investigate further the nature of the phonological differences between spontaneous and imitated single word utterances (if any) in terms of segmental and syllable structure characteristics.

In terms of word position, the following research questions will be addressed:

(1) Do spontaneous and imitated utterances differ in terms of percentage of consonants correct (PCC)[17] in word initial position?

17

PCC is divided by word position in order to investigate segmental characteristics more deeply across word position.

(2) Do spontaneous and imitated utterances differ in terms of PCC in word medial position?

(3) Do spontaneous and imitated utterances differ in terms of PCC in word final position?

In terms of syllable and word structure, the following questions will be addressed:

(4) Do spontaneous and imitated utterances differ in terms of percentage of wordshapes matched (%WSM)?

(5) Do spontaneous and imitated utterances differ in terms of length-match[18] for the syllable structure of CVC?[19]

(6) Do spontaneous and imitated utterances differ in terms of length-match for the syllable structure of CVCV?

18

Specific syllable structure match for the CVC and CVCV wordshapes are included in the %WSM values. Thus, a closer inspection of these two wordshape patterns was based on the subjects' ability to match them in terms of number of syllables, or length (i.e. monosyllable versus bisyllable).

19

The CVC and CVCV wordshapes are early standard wordshapes of English that often show problems in children with phonological disorders.

CHAPTER 2

METHOD

I. Overview

This investigation focuses on the general question of whether differences exist between spontaneous and imitated productions.

Spontaneous and imitative initial assessment data from nineteen preschool children were analysed and compared segmentally in terms of percentage of consonants correct (PCC) in word initial, word medial and word final positions, and prosodically in terms of percentage of wordshapes matched (%WSM)[1], length-match[2] for the CVC and CVCV syllable structures (%).

II. Null Hypotheses

The null hypotheses associated with the experimental questions regarding word position posed in Chapter 1 are:

(Ho1) Spontaneous and imitated utterances do not differ in terms of PCC in word initial

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[1] %WSM = Number of times all of the target wordshapes (i.e. consonant and vowel structure of the word) were matched by the child divided by the total number of times all target wordshapes occurred in a sample.

[2] If the syllable length of a child's utterance was equivalent to the syllable length of the target (i.e. CVC = monosyllable; CVCV = bisyllable) then the utterance was considered to be a "match" to the target in terms of length. The minimum constituents considered to make-up one syllable were at least one consonant (of any class) plus one vowel. Glottal stops (/ʔ/) were only included in the consonant category if they occurred in C2 position of **C1V1C2V2**.

position.

(Ho2) Spontaneous and imitated utterances do not differ in terms of PCC in word medial position.

(Ho3) Spontaneous and imitated utterances do not differ in terms of PCC in word final position.

The null hypotheses associated with the experimental questions regarding syllable and word structure posed in Chapter 1 are:

(Ho4) Spontaneous and imitated utterances do not differ in terms of %WSM.

(Ho5) Spontaneous and imitated utterances do not differ in terms of length-match for the CVC syllable structure.

(Ho6) Spontaneous and imitated utterances do not differ in terms of length-match for the CVCV syllable structure.

III. Subjects

Nineteen English speaking preschool subjects aged 3;2 to 5;0 (mean age 3;10) were included in this investigation. All subjects were British Columbia residents judged to be of low to middle socioeconomic status. Fifteen of the subjects were participants in a nonlinear phonological intervention study which examined the efficiency of phonological intervention based on a nonlinear phonology framework, conducted by Bernhardt (1994). Two participated in a previous study conducted by Bernhardt (1990). One subject was a participant in a NLP intervention study conducted by a University of

British Columbia speech-language pathology graduate student (Edwards, 1995).

Subjects had moderately severe to severe phonological disorders. Nine subjects displayed a language production delay at the time of initial assessment. All subjects displayed normal hearing and oral-motor structure and function. Each subject's language comprehension was assessed. All subjects scored in the average range or better (see Table 2). The following standardized assessment instruments may have been used for this task: (a) Peabody Picture Vocabulary Test - Revised (PPVT-R, Dunn & Dunn, 1981), (b) the Test of Auditory Comprehension of Language - Revised (TACL-R, Carrow-Woolfork, 1985), (c) the Reynell Developmental Language Scales - Receptive Language Score (Reynell, 1977), and (d) the Preschool Language Scale - Revised and/or 3 (PLS-R and/or PLS-3, Zimmerman et al, 1979).[3]

[3] Subjects originated from various regions in British Columbia. Consequently, different speech-language pathologists assessed each subject's comprehension of language. Thus, standardized measures were not consistent across subjects.

Table 2: Standardized language comprehension assessment measures.

SUBJECT	Sex	C.A.(months)	TEST	STANDARD SCORE	PERCENTILE
Brad	M	3;6 (42)	PPVT-R TACL-R	114 37	87 9
Roger	M	4;5 (53)	PPVT-R	106	66
Sally	F	4;0 (48)	PPVT-R TACL-R	104 45	60 31
Colin	M	5;0 (60)	TACL-R	102	56
Dean	M	3;6 (42)	PPVT-R PLS-3:AC	105 90	63 25
Lloyd	M	3;6 (42)	PPVT-R TACL-R	102 54	55 66
Gary	M	4;3 (51)	PPVT-R	100	50
Jeremy	M	3;4 (40)	PPVT-R	115	84
Kendra	F	3;9 (45)	PPVT-R PLS-3: AC**	101 105	52 63
Larry	M	4;4 (52)	PPVT-R TACL-R	38 90	12 25
Mandy	F	4;1 (49)	PLS-R: AC TACL-R	28* 46	 35
Marcy	F	3;4 (40)	PPVT RDLS:Receptive	 Av.score: -0.7	88
Dylan	M	3;10 (46)	PPVT-R	101	52
Craig	M	3;0 (36)	PPVT-R RDLS:Receptive	97 Av.score: -0.8	42
Sean	M	3;6 (42)	PLS-3	(age equivalent = 3;3)	
Shaun	M	3;5 (41)	PPVT-R	0.58	72
Serena	F	4;4 (52)	PPVT-R TACL-R	110 54	75 66
Terry	M	5;0 (60)	PPVT-R TACL-R	88 43	21 24
Jeanie	F	3;2 (38)	PPVT RDLS:Receptive	115 Av.range	84

* Reflects point score, not standard score.
** AC = Auditory Comprehension subtest.
*** Standard scores and percentiles were not available for all subjects.

IV. Procedures: Group Data

A. Data Collection

An identical 164-item word list was used to elicit productions from each child. During the elicitation session(s), the clinician engaged the subject in various play-based activities involving numerous common objects (toys, etc.) and picture cards. The objects and pictures depicted the majority of the items on the word list, although a few responses were prompted (e.g. 'mouthy,' 'tubby,' etc.). If a target (single word) could not be elicited spontaneously[4], the clinician provided a verbal model[5]. The subject was then encouraged to imitate the model. Delayed imitation[6] was encouraged and favoured over immediate imitation, although the latter was allowed. This approach was taken by clinicians in order to ensure that as naturalistic an environment and child-clinicial interaction as possible was maintained.

B. Data Coding

Four types of imitation were used (in various amounts): (1) spontaneous imitation/echoic (E)[7], (2) prompted imitation (PE)[8], (3) delayed imitation (DE); and (4)

4
A child's target utterance was considered spontaneous if it occurred in the absence of a verbal model or if greater than eight utterances intervened between the model and the child's production.

5
Different clinician styles may have resulted in variability of specific elicitation methods used across subjects.

6
An imitation was considered "delayed" if two to eight utterances and/or a period of 30 seconds intervened between the adult model and the child's production.

7

prompted delayed imitation (PDE)[9]. Generally, target words elicited via imitation involving prompting were embedded at the end of a carrier phrase of one to four words in length (e.g. "Say X.", "You tell me X."). Assuming that subjects possessed adequate auditory processing mechanisms and language comprehension, clinicians' use of carrier phrases was not considered to affect the subjects' perception/comprehension of target words.

It has been shown that pronunciation may be different in connected speech as compared with single word utterances (Levelt, 1989, Faircloth & Faircloth, 1970). As such, target words produced in connected speech were not included in the analysis. This did not reduce sample sizes greatly since most subjects produced single word utterances (in terms of language production status) at the time of data collection.

C. Data Analysis

Word lists were narrowly transcribed according to the International Phonetics Alphabet (IPA) at the University of British Columbia by three graduate students in the School of Audiology and Speech Sciences[10]. The present author re-transcribed 25-34%

An imitation was considered spontaneous if the child's production was preceded by an adult model, with no more than two intervening (child and/or adult) utterances and when the adult made no attempt(s) to elicit the utterance.

8

An imitation was considered "prompted" if the adult verbally commanded the child to repeat it (e.g. "Say *ball*").

9

An imitation was considered "prompted delayed" if the conditions as defined in footnotes (2) and (4) above applied (e.g. "It's a *doll*. You say that.").

10

There was only one transcriber for each individual subject.

of each subject's transcript. Interjudge reliability was calculated point-to-point (i.e. phone-to-phone) by assigning a "1" or a "0" for a 100% or a 0% match, respectively, and summing these values across the sample.[11] Diacritical features (i.e. IPA notation for aspiration, nasalization, etc.) were initially included in the counts for several subjects. Considerable variations in transcriptions were found for these elements, resulting in unacceptably low overall interjudge reliability scores. It was thus decided that they would not be included in the analysis. For compound phones (e.g. /ʧ/, /ʤ/, etc.), each component was assigned a value of 0.5. For example, if the original transcriber transcribed "chick" as [ʧɪk] whereas the second transcriber transcribed it as [tsɪk], interjudge reliability on /tS/ would be 0.5/[0.5+0.5], or 0.5. Interjudge reliability ranged from 90% to 96% (mean = 93%).[12]

The mean number of single words produced spontaneously was 135 (range = 26 to 244). The mean number of single words produced imitatively was 181 (range = 26 to 167). An average of 58% (range: 27% to 89%) of words elicited were spontaneous productions; an average of 42% (range: 11% to 73%) of productions were imitated. The percentage of spontaneous and imitated utterances produced by each subject are presented in Table 3 below.

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[11] Note that this procedure was used for interjudge reliability calculations on transcriptions of individual segments only (diacritical features such as aspiration, partial devoicing, were excluded).

[12] Note that these scores reflect counts which included vowels. The second transcriber accepted a vowel as being "reliably transcribed" if her transcription was a vowel produced in the same general "vowel space" as that of the original transcriber (e.g. /I/ for /E/ was acceptable, /a/ for /V/ was acceptable, /i/ for /u/ was not acceptable). The computer analysis program Speech.app would not have considered these to be matching segments. Therefore, vowels were not included in the analysis.

Table 3: Number and percentage of spontaneous and imitated productions for 19 subjects

SUBJECT	TOTAL # PRODUCTIONS	# SPONTANEOUS PRODUCTIONS	%SPONTANEOUS PRODUCTIONS	# IMITATED PRODUCTIONS	% IMITATED PRODUCTIONS
Brad	196	68	35	128	65
Roger	197	150	76	47	24
Sally	228	124	54	106	46
Colin	237	115	49	122	51
Dean	186	54	29	132	71
Lloyd	222	136	61	86	39
Gary	198	102	52	96	48
Jeremy	322	155	48	167	52
Kendra	79	44	56	35	44
Larry	163	135	83	28	17
Mandy	193	102	53	91	47
Marcy	98	26	27	72	73
Dylan	275	244	89	31	11
Craig	114	57	50	57	50
Sean	230	101	44	129	56
Shaun	284	243	86	41	14
Serena	210	184	88	26	12
Terry	248	187	75	61	25
Jeanie	179	84	47	95	53
RANGE	26 - 244	27 - 89	79 - 284	26 - 167	11 - 73

All subjects' utterances were coded as spontaneous (S), or echoic (E, PE, DE or

PDE) by the present author. Reliability was 97% across subjects. Files were created for spontaneous and imitated utterances, respectively.[13]

Spontaneous and imitated productions for each subject were analyzed with a computer program, Speech.app (Bernhardt & Cam, 1994). Speech.app provided measures of both Percentage of Consonants Correct (PCC) (Schriberg & Kwiatkowski, 1982) and Percentage of Wordshapes Matched (PWM). PCC was measured for individual word positions: word initial (WI), word final (WF), and word medial (M)[14].

Percentage of wordshapes matched (PWM) is a measure which compares a child's wordshape productions (e.g. CVCV) to those of the adult targets. Since the PWM measure does not provide detailed information with respect to the syllable structure patterns in one's productions, percentage of CVC matched (in terms of length, or number of syllables, only) and percentage of CVCV matched (in terms of length only) were also calculated. This was done because they are two of the earliest acquired syllable shapes and they occur with relatively high frequency in the vocabulary of preschool children.

The results of all these measures for spontaneous and imitated productions of each subject are shown in Tables A.1 and A.2 in the Appendices.

Fisher's t-tests for correlated groups (α=0.05, two-tail) were used to assess the significance of the difference scores (i.e. PCC, %WSM, and CVCV scores in

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13 Imitated utterances of all types were collapsed into a single file for each subject as there were insufficient data for separate analyses.

14 Word Medial included consonants which are syllable-initial and syllable-final within words (e.g. /d/ as in "muddy," and /n/ and in "candle").

spontaneous condition versus those individual scores in the imitative condition)[15], for group data (N = 19, where N = number of difference scores). This test was appropriate since the experiment consisted of two samples (i.e. spontaneous condition and imitated condition), and it is assumed that the sampling distribution of the difference scores is normally distributed, and the variance is constant.

V. Phonological Variability in Children's Productions

It was noted in Chapter 1 that children may be highly variable (phonologically) in their productions. Such variability should be taken into account in the interpretation of results of comparisons of spontaneous and imitative speech since observable differences may be a mere reflection of the wide range of phonological variable present in a given child's productions. In the present investigation, an attempt was made to quantify the variability exhibited in both the spontaneous and imitated utterances of each subject. The procedure, along with sample calculations of %-variability are outlined in detail in Appendix B.

The mean segmental variability score for all subjects for whom there were sufficient data to assess variability[16] was 12% (range: 1% to 26%) for spontaneous productions (N = 14) and 7% (range: 1% to 18%) for imitated productions (N = 11). The

15 There was insufficient variance in CVC scores to perform statistical analyses.

16 That is, at least 5% of spontaneous or imitated samples consisted of items for which there were two or more tokens.

mean prosodic variability score was 14% (range: 5% to 26%) for spontaneous productions (N = 14) and 28% (range: 0% to 73%) for imitated productions (N = 11). Table B.1 in the Appendices shows each subject's spontaneous and imitated phonological variability scores (i.e. for segmental and prosodic categories).

VII. Procedures: Individual Data

Ordinal raw data (i.e. raw PCC, %WSM, CVC, and CVCV scores) for each subject was scanned for notable differences. Six subjects were identified as having difference scores (i.e. between spontaneous and imitative conditions) which appeared of reasonable magnitude on one or more of the variables investigated. For two of these subjects, the raw scores (%) for those variables appearing to have notable differences between speech modes were compared to their respective %-variability scores. This comparison enables the present investigator to determine whether to inspect the subjects' data more closely on an individual basis. A student's t-test for correlated groups was then performed on one subject's data (i.e. Jeremy) to assess the significance of the notable differences between his spontaneous and imitated utterances. An individual case profile for Jeremy, whose difference scores are beyond the range of phonological variability (hence, presumably of note), is presented in Chapter 4.

CHAPTER 3

RESULTS

I. Overview

The purpose of this study was to determine whether certain phonological differences exist between spontaneous and imitated utterances of children with phonological disorders. Differences were measured in terms of percentage of consonants correct (PCC) in word initial (WI), word medial (WM), and word final (WF) positions and in terms of percentage of wordshapes matched (%WSM), length-match for the CVC and CVCV wordshapes, and for age and gender. Statistical measures revealed no significant differences between spontaneous and imitated utterances for group data (N = 19) for any of these variables, except with respect to age for %WSM. However, a close inspection of within subject data revealed a notable difference between the speech modes for several subjects. Statistical analyses of within subject data for one subject (Jeremy) confirmed an overall significant difference between his spontaneous and imitated utterances, where higher scores were achieved in spontaneous production.

II. Group Results

A two-tailed Fisher's t-test for correlated groups ($\alpha = 0.05$) was used to test the significance of group differences between spontaneous and imitated utterances for each of the variables listed above. The null hypotheses stated there would be no significant differences between spontaneous and imitated utterances for any of these variables,respectively (i.e. mean Yi = 0, where Yi = sum of difference scores[1]). Fisher's t-tests were performed on both ordinal and logit-transformed data[2]. Results were not significant on either measure for any of the variables listed above. Thus, the null hypothesis with respect to each of the phonological variables investigated was retained. Actual number of correct productions per total number of attempts for each variable for all subjects' spontaneous and imitated productions are shown in Tables A.1 and A.2, respectively, in the Appendices. Difference scores of p̂ values[3] are shown in Table A.3 in the Appendices.

The variables of age and gender were also included in the statistical analyses. A linear regression analysis revealed a significant age effect (age coefficient = 0.0132, α = 0.05) on the %WSM variable only. That is, the younger group of subjects (i.e. chronological age from 36 to 45 months) had significantly larger differences between their %WSM scores for spontaneous and imitated utterances than did the older group

---

1

A difference score = probability of success on a variable in spontaneous production (p̂s) - probability of success on that variable in imitative production (p̂e), where e = echoic or imitation.

2

This transformation is performed on (ordinal) p values (which may range from +/- 1) in order to stretch its limits to +/- ∞. The logit transformation is advantageous in that it accounts for different sizes of n across subjects, which may tend to skew analyses on straight ordinal data.

3

p̂ values reflect actual PCC, %WSM, length-match for CVC and length-match for CVCV values, divided by 100. For example, a p̂s (probability of success in spontaneous production) value of 0.673 for word initial position reflects a PCC of 67.3% for word initial consonants in spontaneous production.

(i.e. chronological age from 45 to 60 months (see Figure 4). No significant differences were found for age (or gender) on any other variable. A Student's t-test for correlated groups ($\alpha = 0.05$, 2-tail) on % WSM data revealed a significant difference between spontaneous and imitated utterances of the younger group only (t obtained = 4.358 > t critical = 2.262). There was no significant difference for the older group of subjects. A similar measure performed on PCC data in WI position revealed no significant differences between spontaneous and imitated utterances for either groups. Statistical values are summarized in Table C.1 in Appendices.

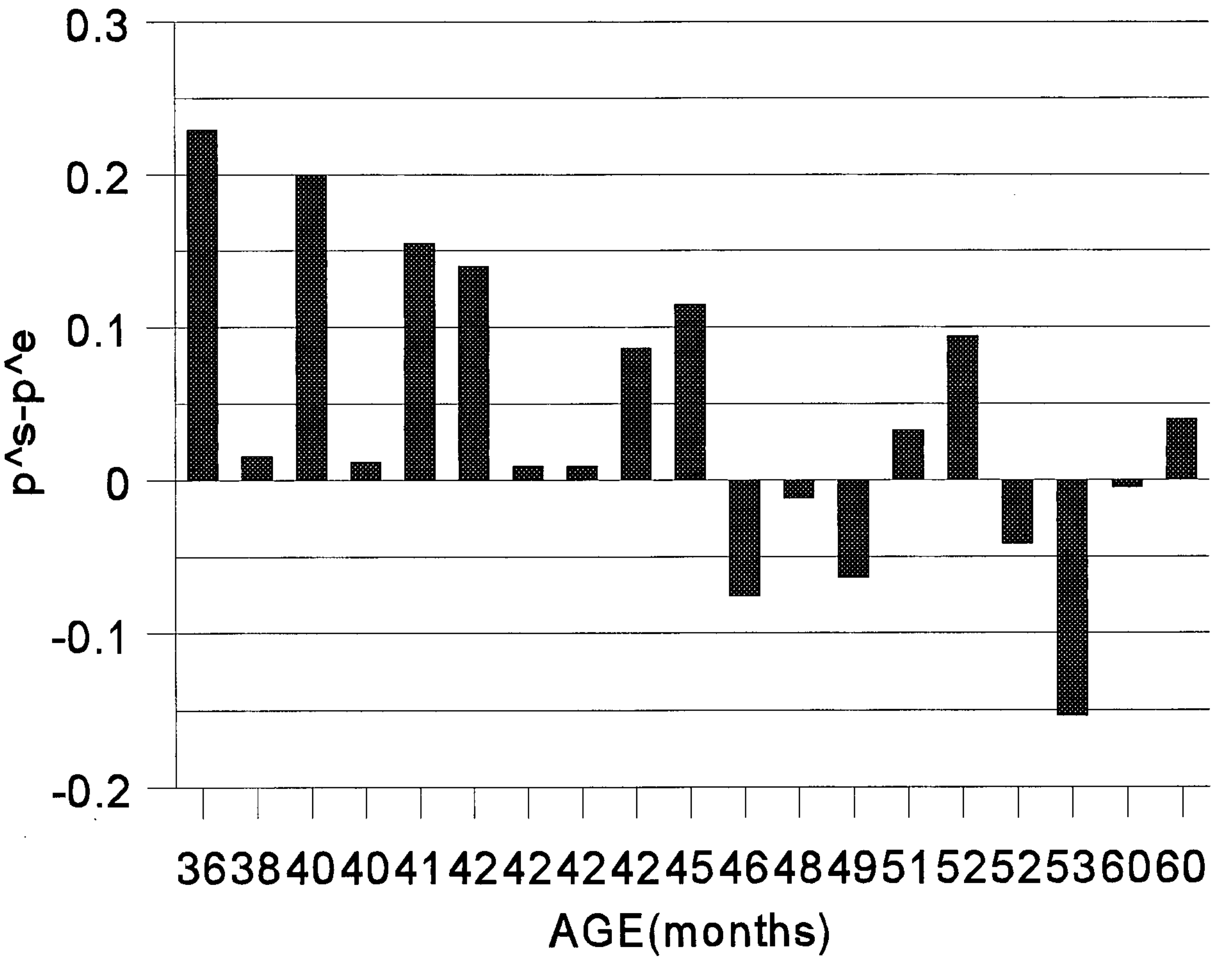

Figure 4: Difference scores (p^s - p^e) versus chronological age in months for 19 subjects on %WSM.

III. Individual Results

An examination of ordinal difference scores for each subject revealed that six subjects had a notable difference between their spontaneous and imitated utterances on at least one variable. Table 5 shows the variables, p^s and p^e values and respective difference scores for each of these six subjects.

The notability of the difference scores was assessed descriptively by comparing the difference scores with respective phonological variability scores. Unfortunately, there were insufficient data in the variability files for two of the six subjects (Brad and Craig) and they were thus excluded from further analysis. Shaun was also excluded as his clinician felt that he had performed atypically during the initial assessment session.[4] Furthermore, Sally was excluded because her p^ values were based on a small n. Table 6 shows the |p^s - p^e| values as well as the phonological variability scores (%)

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4 A UBC graduate student assisted in the initial assessment elicitation. Shaun's clinician suspected that the student's presence may have affected his performance, since he performed very well in imitation during subsequent assessment sessions.

Table 4: p^s (%) , p^e (%) and p^s - p^e (%) for six subjects showing notable differences between spontaneous and imitated utterances

SUBJECT	VARIABLE(S)	p^s (%)	p^e (%)	p^s - p^e (%)
Brad	%WSM	23	9	14
Sally	PCC in WI CVCV	100 14	64 31	36 -17
Colin	CVCV	100	60	40
Jeremy	PCC in WF %WSM	39 36	13 16	16 20
Craig	%WSM	29	6	23
Shaun	%WSM	34	18	16

Table 5: $|(p\text{^}s - p\text{^}e) \times 100|$ and $|Vs - Ve|$ (%) for Jeremy on PCC in WF position and %WSM and Colin on length-match for the CVCV wordshape

SUBJECT	VARIABLE	$|(p\text{^}s - p\text{^}e) \times 100|$	$|Vs - Ve|$ (%)
Jeremy	PCC in WF position	26	7*
	%WSM	20	2**
Colin	length-match for CVCV wordshape	40	48**

* Reflects segmental variability difference scores (%).
** Reflects prosodic variability difference scores (%).

for the remaining two subjects for which certain difference scores were notable (Colin and Jeremy). Comparing the difference scores of p^ values (x100) with those of the phonological variability scores (%) allowed for assessment of the p^ difference scores. $|(p\hat{}s - p\hat{}e) \times 100|$ was considered notable for that subject if his difference score was beyond the range of his phonological %-variability on that variable (i.e. if $|(p\hat{}s - p\hat{}e) \times 100| > |Vs - Ve|$, where V denotes %-variability). Using this method, only one subject's difference scores were found worthy of further investigation (i.e. Jeremy). A Student's t-test (α=0.05, 2-tail and N = 6, where N = number of difference scores) was performed on Jeremy's data (i.e. all variables were included). An overall significant difference was found between Jeremy's spontaneous and imitated utterances (t obt = 5.342 > t crit = 2.571).

IV. Summary

With respect to the specific experimental questions addressed in this study, the following results were found:

(1) First, group data revealed no significant differences between spontaneous and imitated speech on any of the phonological variables investigated, although a significant age effect was found for %WSM. Younger children showed significantly greater differences between their spontaneous and imitated utterances on this variable than did older children.

(2) Second, statistical measures on within subject data for one subject revealed an overall significant difference between his spontaneous and imitated utterances. Difference scores for this subject on %WSM and PCC in WF position were beyond the range of his phonological %-variability, which further denotes the significance of the difference between his spontaneous and imitated utterances.

CHAPTER 4

DISCUSSION

I. Overview

The present study examined the influence of mode of speech production on phonological accuracy of single word utterances of children with phonological disorders. The results indicate that there are no significant differences between spontaneous and imitated utterances in terms of percentage of consonants correct (PCC) in word initial (WI), word medial (WM), or word final (WF) positions (segmental aspects) or in terms of length-match for the CVC and CVCV wordshapes (prosodic aspects). The results further indicate that younger children (i.e. chronological age from 36 to 45 months) are likely to be more accurate in terms of %WSM in their spontaneous productions than in their imitated utterances. Older children (i.e. chronological age from 45 to 60 months) tend to show no significant differences between speech modes on this variable. Results of within-subject analysis for one subject (Jeremy) indicate that individual children may vary in the extent of difference between their spontaneous and imitated productions, suggesting that assessment data should be reviewed carefully on an individual basis. The following discussion will address the research questions posed in Chapter 1 in terms of the results of the present study. It will conclude with a discussion of clinical implications raised from the results as well as overall conclusions with respect to the issue of the phonological nature of spontaneous versus imitated utterances.

II. Group Findings

A. Addressing word position: Do spontaneous and imitated utterances differ in terms of PCC in (a) WI, (b) WM, or (c) WF positions?

The results indicate that single word spontaneous and imitated utterances are processed similarly, since no significant differences were found between the speech modes on any of these variables. Therefore, at the group level, Levelt's model suffices to explain the underlying mechanisms in both spontaneous *and* imitative speech production in terms of segmental processing. That is, young children's overall segmental production in imitation parallels that in spontaneous speech production for single words.

In terms of the Demands and Capacities model, the environmental demands were relatively constant across conditions. That is, the one-to-one play-based, relaxed atmosphere in which the children were allowed ample time to respond was maintained across instances of spontaneous and imitative elicitation. Since no significant differences were found on these measures, it may be assumed that any differences in internal CNS demands between spontaneous and imitative speech are negligible with respect to the childrens' productions at a segmental level. That is, underlying differences, if any, in terms of linguistic and/or cognitive processing, memory, attention, etc. are presumably managed similarly in both speech modes at the single word level in terms of segmental characteristics.

B. Addressing syllable and word structure: Do spontaneous and imitated utterances differ in terms of %WSM or length-match for the syllable structures of CVC or CVCV?

1. Age effect for %WSM

The results indicate that the younger children (i.e. chronological age from 36 to 45 months) had significant differences between their spontaneous and imitated utterances in terms of % WSM whereas the older children (i.e. chronological age from 45 to 60 months) did not. This age effect suggests that younger children may match adult wordshapes with greater accuracy in spontaneous speech than in imitated speech. Older children, on the other hand, tend to match adult wordshapes equally well or poorly in spontaneous versus imitated speech.

a) Selection / avoidance

One possible explanation for the younger children's better performance in spontaneous productions relates to the notions of selection and avoidance. It is possible that the children reserved those words which are difficult to produce for imitation, while attempting to produce only "easier" words spontaneously.

Child phonologists have observed that young children tend to select and attempt to produce words with certain phonological characteristics while avoiding words with other characteristics (Ferguson & Farwell, 1975; Ingram, 1976). These selection/avoidance patterns "... may be based upon the structure or syllabic shape of adult words as well as the sounds of which they are comprised", (Schwartz & Leonard, 1979). In general, children who use such patterns tend to select words which have characteristics consistent with their current phonological system.

The wordshape inventory for the older group consisted of an average of 64 unique wordshapes (range: 23 - 99), whereas that of the younger children consisted of 53 (range: 36 - 75).[1] A scan of the wordshape inventories for the younger subjects indicated a higher percentage of use of "easier" syllable structures such as CV, CVC and other monosyllabic patterns in spontaneous (57%) versus imitated productions (40%). The older children, on the other hand, tended to produce more monosyllabic wordshapes in imitated productions (47%) than in spontaneous ones (42%), although this difference was much smaller relative to the younger group. Hence, the younger children in this study may have been selecting words with familiar wordshapes for spontaneous production while leaving those with unfamiliar wordshapes for imitation.

(b) CNS demands and capacities

Another possible explanation for the age effect relates to models of speech production and CNS demands and capacities. Assuming that environmental demands were relatively constant for all children, and across speech modes, it appears that the younger children may have been insufficiently managing internal CNS demands in

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Average number and range of unique wordshapes were calculated in the exclusion of wordshapes containing non-intervocalic glottal stops (/ʔ/) because they were not considered reliable in terms of transcription. Calculations including glottal stops were not notably different between age groups from those without (i.e. the average number of unique wordshapes were 74 and 64 for the older and younger groups, respectively, yielding a difference of 10 between the age groups).

imitative circumstances relative to spontaneous speech conditions.

Any number of internal CNS demands in the younger children may have resulted in a difference in their performance relative to the older group. Such internal demands may have been related ot the nature of one's (a) phonological (short-term) working memory, (b) level of language production development, (c) cognitive and/or motor status, etc. The finding that younger children performed significantly better in spontaneous speech than did older children (relative to imitated utterances) suggests that perhaps the younger children were not as advanced in (any of) these areas as compared with the older children. For example, it may be that the younger children's phonological working memories were not as expanded as those of the older group, resulting in the younger children having greater difficulty in imitation.

(c) Model of speech production and demands and capacities

Yet another possible explanation relates to models of speech production as well as demands and capacities. The finding that younger children perform differently in overall syllable structure production than do older children suggests that the two groups may have been producing speech via different underlying mechanisms.

In Chapter 1, two routes for repetition were described in the discussion of the model proposed by Kay et al.: the lexical route and the non-lexical route. The non-lexical route was posited to only be used in the repetition of nonwords (or unfamiliar words) whereas the lexical route was reserved for words familiar to the speaker. Since an index of item familiarity was not administered at the time of the assessment, it is impossible to determine which words may gave been unknown to the children. Hence, the %WSM age effect results will only be interpreted with respect to the lexical route for imitation.

The younger children performed significantly more poorly in imitation. Perhaps they were attempting to map the perceived form onto its lexical information (i.e. they were accessing the semantic system) during imitation whereas the older children were not. That is, perhaps the older children were by-passing the semantic system and thus, disregarding the meaning-based information of the item whereas the younger children attempted to searchout this information. This would suggest that a direct lexical phonological input-to-output route may be used so that a child may match the incoming form as closely as possible, without the diversion/distraction of semantic processing. Furthermore, this strategy may not be adopted by children until they are at least 45 months of age.

On the other hand, the older children may have been accessing the semantic system during imitation also, but sufficiently managed this processing demand (alone, or in combination with others) relative to the younger children. It is interesting to note that of all the children in this study, six subjects showed at least a small difference (although not statistically significant) between their spontaneous and imitated utterances with better performance in the imitative condition (in terms of %WSM; see Figure 4) and *all* of these subjects are older than 45 months of age. That is, six out of nine children aged 46 months of age or older performed at least slightly better on this variable in imitation. This suggests further that the older children were either (1) producing imitated utterances via a different route (i.e. lexical route with semantic system by-pass versus without by-pass), or (2) managing CNS demands more appropriately than the younger children during wordshape imitation.

In terms of the variables of length-match for the CVC and CVCV syllable structures, there was insufficient variance to perform a statistical analysis on the difference scores between spontaneous and imitated utterances for the syllable structure of CVC. Thus, a statistical measure was not required to indicate that, overall, children were likely to perform equally well on this variable in imitation as in spontaneous speech. Statistical measures revealed a similar result for the variable of length-match for the CVCV syllable structure.

2. No age effect for PCC in WI position

Despite the fact that a significant difference was found for %WSM when the experimental group was divided according to age, no such result was found for the same measure performed on PCC difference scores in WI position. These results are interesting because they indicate that differences between spontaneous and imitated utterances may exist for prosodic aspects of phonology (e.g. %WSM) but not for segmental aspects (e.g. PCC in WI position).

For the purposes of this study, the present author assumed that prosodic characteristics (e.g. syllable and word structure) are derived and independent of underlying segmental representation. Hence, it can be further assumed that, in wordshape production, fine segmental differences segmentally will either be camouflaged or enhanced by the summation of minute differences and non-differences across segments. This may ultimately have resulted in statistically significant gross differences in terms of prosodic (i.e. %WSM) scores and not in terms of segmental (i.e. PCC) scores. This interpretation is supported by the finding that the Fisher's t-test results for the length-match for the CVCV syllable structure approached significance (P value = 0.056; $\alpha = 0.02$, 2-tail), whereas this did not occur for any PCC values.

III. Factors to Consider in Interpretation of Results

The present author wishes to encourage readers to consider several factors when interpreting results of this and any study involving spontaneous and imitated productions. A brief discussion of a few of such factors follows below. It is stressed, however, that I do not wish to imply that differences between spontaneous and imitated utterances do exist and were not found in this study simply due to methodological complications.

A. Pooling of imitated data

The imitated utterances were originally coded as spontaneous imitation, or, echoic (E), prompted imitation (PE), delayed imitation (DE), or prompted delayed imitation (PDE) and separated into respective files.[2] However, due to insufficient data

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[2] Refer to pages 32 and 33 in Chapter 2 for definitions of the various types of imitations.

in one or more files for several subjects, all imitated utterances were collapsed into one file. Perhaps significant differences would have been found between spontaneous utterances and any of the various types of imitated utterances used in this study since the nature of the imposed demands may be different in each case. For example, the occurrence of a PDE imposes a period of perceptual processing as well as an increase in phonological short term memory demands. This situation may be more difficult for a child to manage as compared to one in which he/she chooses to imitate a target item spontaneously, particularly if the child has any sort of information processing difficulties.

B. Pooling of ages

The concern that potential imitation effects may have been obscured by the pooling of ages was taken into account when %WSM and PCC in WI position data were reanalysed according to two age groups (i.e. less than or equal to 45 months and greater than or equal to 45 months). Given that the data for the remaining variables were not reanalysed according to age groups but that a significant age effect was found for % WSM and not PCC in WI position, this concern should be considered when interpreting results of these variables.

Furthermore, older children tended to produce more words spontaneously (mean = 69%) than did younger children (mean = 49%). (This may or may not have been the result of selection/avoidance characteristics.) Therefore, in the pooled analysis, the category of spontaneous will be biased towards the older children's productions and the category of imitation will be biased towards the younger children's productions.

C. The nature of the wordlist

The 164-item wordlist used in this study consists of a few items which contain inflectional word endings such as the present progressive form (-ing) and the plural form (-/s/). Though these are typically amongst the earliest acquired morphological endings, items containing these elements may have taxed other language functions (i.e. morphology) in addition to phonology. This may have been troublesome for certain subjects who had language production disorders (Brad, Marcy, Mandy, Jeanie, Dean, Sally, Colin, Jeremy, Sean), resulting in samples of somewhat reduced validity.

D. The nature of the analysis

Low transcription reliability scores for vowels and glottal stops resulted in exclusion of these segments in the analysis. Major differences in vowel production were only found for one subject, Colin. Colin tended to be more accurate in his vowel productions in imitation than in spontaneous production. However, it is not expected that inclusion of the utterances in the analysis would have greatly affected results since no notable differences between spontaneous and imitated productions of utterances were found for any other subject.

In terms of glottal stops, some subjects may have produced a greater number of these in imitation (e.g. Jeremy), resulting in a greater number of %WSM with respect to the adult target. This may have ultimately reduced the significance of the results on this variable, and, perhaps overall.

E. Summary

In summary, results of analyses of spontaneous versus imitated utterances for phonological differences must be interpreted with potential confounding factors in mind, such as pooling of types of echoic data and/or age groups.

IV. Individual Data: Jeremy

Results of within-subject analyses for one subject (Jeremy) indicate that differences may exist between spontaneous and imitated utterances for certain individuals. A comparison of Jeremy's performance in spontaneous and imitated production is presented below.

A. Overview of Jeremy's phonological system

As discussed in Chapter 2, most of the subjects (including Jeremy) in this investigation participated in various nonlinear phonological studies. For a more detailed description of Jeremy's phonological system than will follow here, readers are referred to Bernhardt (1990; see S3); Bernhardt & Gilbert, 1992 and Bernhardt & Stemberger, in preparation. For the purposes of the present investigaton, only a brief description of Jeremy's phonological system will follow.

1) Segmental development (based on collapsed spontaneous and imitated data)

Sound classes were found to be established[3] in the following order: glides > nasals > stops > fricatives (no affricates or alvelopalatals) > liquids (no /r/) (refer to Bernhardt (1990) and Bernhardt & Gilbert (1992) for a more detailed account of Jeremy's segmental phonological characteristics).

2) Prosodic development (based on collapsed spontaneous and imitated data)

Word structures for which the majority of matches occurred with respect to the adult model consisted of open syllables (CV, CVV) and reduplicated disyllables (C1VC1V) (Bernhardt & Gilbert, 1992).

Of the CVC wordshapes, the primary segments used to close syllables were nasals and [s]. CVC mismatches consisted of (in descending order of frequency): (a) default linking in either consonant position (usually [s], in word final position), (b) deletion of word final or word initial consonant, (c) harmony (i.e. assimilation or spreading of features from one position to maintain consistency with the other position), (d) metathesis (i.e. transposition of features from one position to another), and (e) addition of a syllable(s). An example of each of these is shown below (adapted from Bernhardt & Stemberger, in preparation):

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3 Criterion for establishment = 80% or more matches to adult target in obligatory contexts.

ITEM	TARGET	JEREMY'S PRODUCTION	CVC MISMATCH TYPE	UTTERANCE CODE
top	/tɑp/	[da s]	default [s] linking	PE
man	/m n/	[m]	deletion of final consonant	S
cup	/kʌp/	[bʌp]	harmony	S
lamb	/l m/	[m n]	metathesis	E
nine	/naɪn/	[naɪn]	addition	E

In terms of multisyllabic wordshapes, Jeremy had difficulty producing more than one consonant in a word. In spontaneous speech, Jeremy produced intervocalic consonants in reduplicative and highly frequent words. If reduplicative forms were not matches with the adult target, they were the results of assimilation, which facilitated realization of the second consonant. Some examples of such reduplicative forms are shown below:

ITEM	TARGET	JEREMY'S PRODUCTION	UTTERANCE CODE
daddy	/d di/	[d di]	S
t.v.	/ti:vi/	[t^hit^hi]	S
Fudgie	/fʌʤi/	[fafa]	S

In Jeremy's imitated productions, multisyllabic productions were also rare. For two items, consisting of more complex wordshapes, the use of syllable final nasals and [s] appeared to facilitate their production:

ITEM	TARGET	JEREMY'S PRODUCTION
monkey	/mʌnki/	[manʕɪs]
sewing machine	/soʊwɪnmʌʃ in/	[m ndɪs]

Jeremy's bisyllabic productions often involved deletion of the second syllable with a default [s] insertion in the coda position of the first syllable. An example of this pattern is show below:

ITEM	TARGET	JEREMY'S PRODUCTION	UTTERANCE CODE
butter	/bʌtɚ/	[bʌs]	E

This pattern is consistent with the word final [s] insertion in CVC targets as described above. Overall these patterns of [s]-default insertion occurred far more frequently in imitated utterances (80/167 = 48%) than in spontaneous ones (27/155 = 17%). This undoubtedly contributed to the significance of the difference between Jeremy's spontaneous and imitated utterances. Although this [s]-default pattern is rather unusual, default usage is not an uncommon phenomenon in syllable final and intervocalic production in child phonology (Bernhardt & Stemberger, in preparation).

V. Clinical Implications

The group results of the present study imply that clinicians do not need to be overly concerned about mode of elicitation of initial overall phonological assessment for most children (i.e. about 80%). However, individual results for Jeremy suggest that data be checked for any notable differences between a child's spontaneous and imitated utterances. For children who do evidence differences between speech modes, one may wish to analyze the utterances separately or at least make note of the area(s) of difference.

Information about how well or poorly a child performs in imitation may assist clinicians in developing their method of approach for phonological intervention. For example, if a child performs more poorly in imitation relative to his/her spontaneous speech, a speech-language clinician may opt not to use imitation as a means of stimulating accurate productions of target segments or wordshapes. He/she may choose an alternative method, such as an increased amount of auditory bombardment (or, perceptual training or listening practice) activities and subsequent stimulation of spontaneous production of target items.

In terms of wordshape (prosodic) assessment, the results of this study imply that children aged approximately 36 to 45 months should always be encouraged to produce spontaneous utterances. For children aged approximately 45 to 60 months, however, target wordshapes may be elicited either spontaneously or imitatively. A further implication is that a separate assessment wordlist be used for younger children. That is, one consisting of highly familiar words with simpler syllable shapes (such as monosyllabic and bisyllabic) as opposed to one with longer words of varying degrees of syllabic complexity for older children. On the other hand, inclusion of a few items with more complex wordshapes may be useful in determining whether younger children's imitated utterances are produced better or worse with respect to their spontaneous utterances.

Another clinical implication is that clinicians should obtain information about wordlist item familiarity for a child at the time of assessment. A frequency of use inventory may be used for this purpose. Those wordlist items unfamiliar to a child may be excluded such that spontaneous elicitation, especially for wordshape assessment with younger children, is encouraged. Furthermore, an index of phonological variability in a child's productions should be obtained. This will help ensure that observable differences between a child's spontaneous and imitated utterances are in fact differences and not mere reflections of variability expressed by his/her phonological system.

VI. Conclusions

The overall group results of the present investigation serve to substantiate the findings of earlier studies which revealed no significant differences between children's spontaneous and imitated utterances. It appears that a model of spontaneous speech production, such as that proposed by Levelt (1989) suffices to delineate the mechanisms underlying imitated utterances as well as spontaneous ones (at a group level).

Despite these findings, the individual data and methodological issues raised in this Chapter suggest that group results be interpreted with caution, since differences may exist between spontaneous and imitated data at an individual level and become masked due to methodological procedures.

An age effect found on a prosodic variable implies that the underlying mechanisms in imitative speech for younger children (i.e. aged approximately 36 to 45 months) may be different from those for older children (i.e. aged approximately 45 to 60 months). It appears that older children may use a semantic by-pass strategy during imitated utterance production whereas younger children may not. This strategy may reduce the processing demands in imitation, enabling the older children to perform comparably in both speech modes (in terms of percentage of match to adult target forms).

Clinically, the results of the present investigation suggest that clinicians may use imitation as an elicitation strategy with the expectation that most children's imitated utterances will not differ signifficantly (overall) with respect to their spontaneous utterances. However, individual child data should be checked carefully for notable differences between the speech modes (especially for prosodic differences and with children of 45 months of age or less) for range of phonological variability. This information will allow for a more valid interpretation of assessment results, and may help guide intervention planning.

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APPENDIX A:

Raw Group Data and Difference Scores

Table A.1: Number of correct productions / Total number of attempts for six variables in spontaneous productions (N = 19)

SUBJECT	SEGMENTAL			PROSODIC		
	WI	WM	WF	WSM	CVC	CVCV
Brad	26/36	5/21	3/31	14/60	10/10	5/7
Roger	51/76	43/69	17/66	30/127	15/15	11/12
Sally	18/54	6/43	11/63	17/101	13/13	5/5
Colin	11/61	1/44	2/61	14/112	11/17	9/9
Dean	11/28	3/19	5/30	7/49	7/7	1/1
Lloyd	24/79	4/50	1/71	7/126	21/23	8/15
Gary	31/78	1/61	8/77	8/126	17/20	6/7
Jeremy	53/91	7/22	29/74	50/138	39/39	6/10
Kendra	9/30	9/21	6/21	14/42	8/8	3/4
Larry	45/77	28/57	33/73	43/125	21/21	10/10
Mandy	31/65	5/55	5/62	8/111	17/18	6/13
Marcy	11/18	3/9	0/13	6/30	3/3	2/2
Dylan	72/140	27/133	33/132	21/231	31/33	12/21
Craig	21/31	5/22	0/20	14/48	4/4	6/6
Sean	33/61	4/18	5/48	19/94	27/28	1/2
Shaun	44/112	19/59	24/90	57/169	38/38	8/11
Serena	45/102	19/83	14/89	6/157	23/23	15/16
Terry	43/102	12/76	2/91	15/166	30/30	13/15
Jeanie	34/64	6/29	5/66	15/93	30/30	13/15

Table A.2: Number of correct productions / Total number of attempts for six variables in imitated productions (N = 19)

SUBJECT	SEGMENTAL			PROSODIC		
	WI	WM	WF	WSM	CVC	CVCV
Brad	42/74	9/61	0/73	12/128	22/23	9/11
Roger	18/28	9/18	10/27	16/41	14/14	4/4
Sally	31/74	16/52	7/55	20/111	20/20	7/11
Colin	8/56	5/45	2/46	12/92	17/19	6/10
Dean	17/72	13/62	18/75	17/127	22/26	5/5
Lloyd	23/55	4/51	1/43	4/86	14/15	6/10
Gary	20/47	1/37	2/35	2/65	11/13	6/8
Jeremy	48/111	7/82	12/93	26/159	31/32	5/12
Kendra	7/15	8/16	6/16	7/32	3/3	1/4
Larry	8/16	3/8	7/17	7/28	5/5	1/1
Mandy	25/57	2/27	4/49	11/81	16/17	0/2
Marcy	14/45	1/33	1/44	6/73	11/15	2/6
Dylan	15/21	4/13	7/22	5/30	5/5	NO DATA
Craig	24/41	2/24	0/37	4/64	16/16	4/6
Sean	38/76	13/63	3/70	14/121	15/17	6/9
Shaun	5/15	3/16	5/20	6/33	3/3	NO DATA
Serena	4/16	2/11	3/14	2/25	4/4	2/2
Terry	10/38	3/31	3/38	3/60	11/13	4/4
Jeanie	28/63	11/52	3/61	15/103	15/15	9/9

Table A.3: Difference scores of p^ values (i.e. p^s - p^e) for six variables (N = 19, where N = number of difference scores)

Subject	SEGMENTAL			PROSODIC		
	WI	WM	WF	WSM	CVC*	CVCV
Brad	0.155	0.091	0.097	0.140	0.043	-0.104
Roger	0.028	0.123	-0.113	-0.154	0.000	-0.083
Sally	-0.086	-0.168	0.047	-0.012	0.000	0.364
Colin	-0.037	-0.088	-0.011	-0.005	-0.248	0.400
Dean	0.157	-0.052	-0.073	0.009	0.154	0.000
Lloyd	-0.114	0.002	-0.009	0.009	-0.020	-0.067
Gary	-0.028	-0.011	0.047	0.033	0.004	0.107
Jeremy	0.150	0.233	0.263	0.199	0.031	0.183
Kendra	-0.167	-0.071	-0.089	0.115	0.000	0.500
Larry	0.084	0.116	0.040	0.094	0.000	0.000
Mandy	0.038	0.017	-0.001	-0.064	0.003	0.462
Marcy	.0300	0.303	-0.023	0.118	0.267	No Data**
Dylan	-0.200	-0.105	-0.068	-0.076	-0.061	0.667
Craig	0.092	0.144	0.000	0.229	0.000	0.333
Sean	0.041	0.016	0.061	0.086	0.082	-0.167
Shaun	0.060	0.135	0.017	0.155	0.000	No Data**
Serena	0.191	0.047	0.057	-0.042	0.000	-0.062
Terry	0.158	0.061	-0.057	0.040	0.154	-0.133
Jeanie	0.087	-0.005	0.027	0.016	0.000	-0.133

* Difference scores were extremely small for many subjects. Hence, there was insufficient variance to perform statistical measures on this variable.

** There were no data for these subjects on this measure.

APPENDIX B

Measuring Phonological Variability in a Child's Productions

MEASURING PHONOLOGICAL VARIABILITY IN A CHILD'S PRODUCTIONS

I. Overview

Items for which there were two or more tokens (or, productions) were grouped into spontaneous and imitated files, respectively.[1] Production sets (i.e. groups of productions of the same item) were compared point-to-point segmentally in terms of differences of consonantal segments in (1) place of articulation, (2) manner of articulation, and (3) [voice][2]. They were compared point-to-point prosodically in terms of differences in presence/absence of (1) WI, (2) WM, (3) WF consonants, and/or consonant cluster(s) (CC).

II. Procedure

A) The number of possible differences in each of the segmental and prosodic categories were counted for each token in a given production set. The token having the greatest *overall* number of possible differences was chosen as "the referent" (R) to which the other production(s) were compared.

1

Note that these variability files were created only for those samples which had at least 5% of items with two or more tokens.

2

Only those feature differences which would result in the production of a different segment (in a broad sense) were included. For example /n/ would only change in segmental nature if a difference occurred in terms of manner or place of articulation (i.e. stop /n/ > fricative /s/; coronal /n/ > dorsal /n/), and not in terms of voice (i.e. [n] - [voice] = [n]; segment remains as /n/).

Example (a):

Item: "piggy" Child's tokens: (1) /pɪni/
(2) /pɪdi/ *

Category	Child's tokens:	
	(1) # possible differences	(2) # possible differences
Place	1 (p) + 1 (n)	1 (p) + 1 (d)
Manner	1 (p) + 1 (n)	1 (p) + 1 (d)
Voice	1 (p) + 0 (n)	1 (p) + 1 (d)
Total Possible Segmental	5	6
WI	1	1
WM	1	1
WF	-	-
CC	-	-
Total Possible Prosodic	2	2
TOTAL	7	8

Total actual segmental differences = 1 (manner)
Total actual prosodic differences = 0

* In the above example, token (2) was designated as (R) to which token (1) was compared since this token had the greatest overall number of possible differences.

B. Differences between R and the remaining tokens in any segmental[3] or prosodic categories were assigned a value of 1**. In example (a) above, there is only one segmental difference (i.e. /n/ differs from /d/ in terms of manner of articulation) and no prosodic difference. Thus, the number of differences occurring between this child's productions for the item of "piggy" is 1 for the segmental categories and 0 for the

3

Glottal stops (/ʔ/) in WI and WF positions were excluded from this analysis and regarded as /0/ since they were considered of low reliability in terms of transcription.

prosodic categories.

> ** Differences occasionally occurred between R and additional tokens in terms of complex segments (e.g. affricates: /ʤ/, /ʧ/, etc.). In these cases, individual components of an affricate were generally assigned a value of 0.5 for differences with respect to the segmental categories. Both components had to be deleted or added in a comparison token with respect to R in order for a prosodic difference to be counted.

Example (b):

Item: "cherry"

Child's tokens: (1) /ʧɛri/ *
(2) /t ɛri/
(3) / ɛri/

Categories	**Child's tokens:**		
	(1)	(2)	(3)
place	0.5 + 0.5 + 0	0.5 + 0 + 0	0 + 0 + 0
manner	0.5 + 0.5 + 0	0.5 + 0 + 0	0 + 0 + 0
voice	0.5 + 0 + 0	0.5 + 0 + 0	0 + 0 + 0
Total Possible Segmental	*2.5*	*1.5*	*0*
WI	1	1	1
WM	1	1	1
WF	-	-	-
CC	-	-	-
Total Possible Prosodic	*2*	*2*	*2*
TOTAL	4.5	3.5	2

* Token (1) = R

Total actual segmental differences = 1
Total actual prosodic differences = 0

In cases where a production set differed on the basis of a singleton versus a consonant cluster (or a Wi, WM, WF segment and a 0), the only difference considered was in terms of prosodic structure. Segmental differences would have been difficult to account for in such cases, since it was difficult to predict the area(s) in which they might have arisen. Thus, segmental differences were not included in these cases. It is noted, however, that inclusion of segmental differences in these cases may have resulted in higher %-variability scores for certain subjects in the overall segmental category.

Example (c):

Item: "mask" Child tokens: (1) /m 0k/
(2) /m sk/ *

Category	**Child's tokens:**	
	(1)	(2)
place	1 + 1	1 + 1 + 1
manner	1 + 1	1 + 1 + 1
voice	0 + 1	0 + 1 + 1
Total Possible Segmental	5	8
WI	1	1
WM	-	-
WF	-	-
CC	1	1
Total Possible Prosodic	2	2
TOTAL	7	10

* Token (2) = R

Total actual segmental differences = 0
Total actual prosodic differences = 1

C. The number of possible differences in the overall categories of "segmental and "prosodic" for R tokens were summed across production sets for each file as were the number of actual differences produced. The total number of actual differences in each category was then divided by the total number of possible differences, and multiplied by 100, yielding %-variability in the segmental and prosodic categories, respectively. Example (d):

The items in Examples (a) through (c) will be used in the following sample calculation of %-variability scores.

$$\% \text{ segmental variability} = \frac{\text{Total acutal segmental differences}}{\text{Total possible segmental differences}} \times 100$$

$$= \frac{1 + 1 + 0}{6 + 2.5 + 5} \times 100$$

$$= \frac{2}{13.5} \times 100$$

$$=\sim 15\%$$

Tables B.2 and B.3 show the items used to calculate Jeremy's variability score for imitated productions and his variability summary sheet (including %-variability scores for segmental and prosodic categories), respectively.

Table B.1: Segmental and prosodic %-variability scores for spontaneous and imitated productions for 19 subjects

SUBJECT	SPONTANEOUS (%)		IMITATED (%)	
	Segmental	Prosodic	Segmental	Prosodic
Brad	I/D*	I/D	18	18
Roger	1	6	I/D	I/D
Sally	22	19	5	44
Colin	44	25	0	73
Dean	10	26	10	22
Lloyd	7	10	5	32
Gary	14	6	I/D	I/D
Jeremy	6	20	13	21
Kendra	I/D	I/D	I/D	I/D
Larry	I/D	I/D	I/D	I/D
Mandy	2	16	I/D	I/D
Marcy	I/D	I/D	7	22
Dylan	3	13	I/D	I/D
Craig	I/D	I/D	7	9
Sean	26	9	7	46
Shaun	9	11	4	23
Serena	17	22	I/D	I/D
Terry	3	13	0	0
Jeanie	8	5	I/D	I/D

* I/D = Insufficient Data in file to compute variability score (i.e. less than 5% of samples)

TABLE B.2: Imitated items used in calculation of Jeremy's %-variability scores

ITEM	JEREMY'S PRODUCTION	ITEM	JEREMY'S PRODUCTION
icy	ɪs əsʔɪs*	sleeping	mɪs bɛɪs bɪʔɪs*
man	m m m vm ʔ*	shoes	duʃ tʰus* dɛəs
milk	ɲʌs ɲmaəs*	rattle	w wɪis*
tub	bʌs* bʌʔs	laugh	ʔʌɪs* ʔaʊs
tubby	bʌs bʌnɪs*	one	wʌn w ɪs*
combing	komɪn* bowɪn	you	ju* ən
fishing	fɪʃ faɪs* fʌʃ	hanger	h s h s*
funny	fʌɪ* faɪ	hanging	ʔʊəs ʔʊs*
screwdriver	nas nuwʌəʃ*	home	ʔom* ʔʌm

Table B.3: %-variability score summary sheet for Jeremy's imitated utterances

ITEM	POSSIBLE CHANGES		ACTUAL CHANGES							TOTAL CHANGES	
			SEGMENTAL			PROSODIC					
	SEG*	PRO*	place	manner	voice	CC	WI	WM	WF	SEG*	PRO*
icy	3	3						2			2
man	2.5	2									
milk	5	2					1				1
tub	6	2									
tubby	6	3						1			1
combing	7	3	1	1	1					3	
fishing	6	3	1							1	
funny	3	2									
screwdriver	5	3	1					1		1	1
sleeping	6	3		1				1		1	1
shoes	6	2	1		1					2	
rattle	4	2							1		1
laugh	3	2									
one	4	2		1	1					2	
you	2	2					1		1		2
hanger	5	2									
hanging	3	3									
home	2	2									
TOTAL	78.5	43	4	3	3		2	5	2	10	9

SEGMENTAL CHANGES (%-VARIABILITY) = 13%
PROSODIC CHANGES (%-VARIABILITY) = 21%

* SEG = segmental; PRO = prosodic

APPENDIX C:

Summary of Statistical Analyses for Group Data

Table C.1: Summary of statistical analyses for group data (N = 19)

VARIABLE	P VALUE ORDINAL	P VALUE LOGIT	α (TWO TAIL)	N*
PCC - WI	0.094	0.086	0.050	19
PCC - WM	0.143	0.293	0.050	19
PCC - WF	0.793	0.439	0.050	19
%WSM	0.054	0.093	0.050	19
CVC**	-	-	-	-
CVCV	0.056	0.053	0.050	17***

* N = number of difference scores compared.
** Due to insufficient variance, statistical analyses were not possible.
*** Due to insufficient data for two subjects, N was reduced to 17.