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THESIS APPROVAL

The abstract and thesis of Karen Mary Ware for the Master of Science in Speech Communication: Speech and Hearing Science were presented November 5, 1996, and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Karen Mary Ware for the Master of Science in Speech

Communication: Speech and Hearing Science presented November 5, 1996.

Title: A Pilot Study: Normative Data on the Intelligibility of 3½-Year-Old Children.

Most of the previous published research involving intelligibility has focused on persons with various disabilities or delays. Minimal research has been conducted on intelligibility in young children with no diagnosed speech and/or language disorders. The result is a gap in normative data by which to set a standard to judge speech as being at an acceptable level of intelligibility for a particular age group. The focus of this pilot study was to collect normative data on the intelligibility of young children, ages 3:6 $\pm$ 2 months, with no diagnosed speech and/or language disorder.

Thirteen subjects, ages 3:6 $\pm$ 2 months, were recruited from the greater Portland/Vancouver area. These subjects were screened for normal development in speech sound production, expressive/receptive language, and hearing. It was also established that English was the primary language spoken in the home. Resonance, voice quality, and fluency were informally assessed by the researcher during the course of the session and found to be normal.

The 100-word speech samples were collected by the researcher on audiotape and later played back to two listeners, who were familiar with the topic but unfamiliar with the speaker. The listeners orthographically transcribed the samples and a comparison was made by the researcher between the two sets of written transcriptions. This comparison provided the percentage of intelligible words, out of a possible 100, which were understood by both listeners. The results showed the mean intelligibility percentage for 3½-year-old children with no diagnosed speech and/or language disorders to be 88% ($SD = 5.7\%$) with a range of intelligibility from 76% to 96%. Both the mode and the median for this sample were 90%. Several other variables were addressed as points of interest but the comparisons were not investigated in depth.

The focus of this study was to collect, in a methodically documented manner, normative data on intelligibility in 3½-year-olds. When the results from this study are compared to the only other available data (Weiss, 1982), they were found to fall within 1 SD of each other ($SD = 5.7\%$), indicating that there are no measurable differences between the findings.

A PILOT STUDY:
NORMATIVE DATA ON THE INTELLIGIBILITY OF
3½-YEAR-OLD CHILDREN

by
KAREN MARY WARE

A thesis submitted in partial fulfillment of the
requirements for the degree of

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CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

INTRODUCTION

Speech and language are the primary means of communication in our society. Any individual — child or adult — who has problems communicating has a distinct disadvantage. Social development is jeopardized; progress in school becomes a problem; future employment, which can fulfill a person's potential, is also put at risk. It would seem logical that normative data should exist on how an individual's intelligibility progresses in the crucial early years. However, there exists only very limited research in this area.

As Kent, Weismer, Kent, and Rosenbeck (1989) pointed out, methods for assessing intelligibility objectively are limited. Concomitant with this statement is the fact that there are very limited normative data available. Surprisingly, this problem exists even though intelligibility in children is a primary concern among speech-language clinicians. The intelligibility measure of choice for preschoolers is often a subjective, gross estimation, using vague criteria. This estimation can take the form of percentage-of-words understood or can be categorized on a continuum with descriptive

words such as easily understood to mostly not understood (Morris, Wilcox, & Schooling, 1995).

Most of the research on intelligibility to date has focused on the intelligibility of persons with hearing impairments, alaryngeal or esophageal speech, cleft palate, or other types of impairments (Fujimoto, Madison, & Larrigan, 1991; Kent, Weismer, Kent, & Rosenbeck, 1989; Monsen, 1983; Osberger, 1992; Yorkston & Beukelman, 1978). Data relating to the intelligibility of typically developing children are sparse. Weiss (1982) was one of the first to present normative data on intelligibility, but his data collection methods are unclear. Most researchers have studied normal phonological development (Hodson & Paden, 1981; Stoehl-Gammon & Dunn, 1985), normal articulation development (Bernthal & Bankson, 1993), or language development in typically developing children (Owens, 1992), but not normal development of intelligibility.

The collection of intelligibility data on young children with no diagnosed speech and/or language disorders, so that clinicians will have a standard against which to compare their clients, is overdue. These normative data are an important piece of the assessment and consequent treatment plan. These help clinicians answer the question of whether or not the children being assessed need treatment or if they are within the normal limits for their age. This standard of intelligibility in young children with no diagnosed speech and/or language disorders, could also affect funding for

children who need speech intervention by graphically showing need through comparison.

STATEMENT OF PURPOSE

The purpose of this study was to collect normative data on the intelligibility of 13 young children, ages 3:6 $\pm$ 2 months. The goal was to determine the percentage of intelligible words in continuous speech samples of children having no hearing, neurological, or cognitive impairments. Because speech generally consists of strings of words rather than isolated words, a continuous speech sample was seemingly the most valid measure for determining speech intelligibility in everyday communication (Gordon-Brannan, 1993).

Intelligibility for this study was defined as the percentage of words understood from 100-word speech samples of these subjects. Two listeners, unfamiliar with the speaker, but familiar with the topic, listened to and orthographically (that is, not in phonetic symbols, but according to the rules of proper spelling) transcribed these speech samples. The measure of intelligibility was the mean percentage of words understood by the two listeners.

This is only a beginning into the area of normative data collection. Perhaps an offshoot of this study will be the continuation of data collection with larger sample sizes and different age groups. Once again, it is important to obtain these data as a basis for helping clinicians on questions of client intervention.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review begins with an overview of speech development in young children with no diagnosed speech and/or language disorders. Also included is the development of children's speech mechanism and the neural maturation process, as well as articulation and phonological development. Following this, some of the types of research conducted in the area of intelligibility will be discussed. This discussion will briefly compare and contrast intelligibility with articulation and phonology. Methods available for measuring these area will also be described. The final section will include various factors influencing intelligibility.

Normal Speech Development

A brief overview of the research performed by Netsell (1986) regarding neural maturation concludes that preparation of the infant for speech begins even before birth. During this period of 4 to 9 fetal months, myelination of several basic neural structures is almost completed. Breathing, sucking, and swallowing are also being developed and practiced.

Netsell (1986) stated that during the period from 4 to 6 months after birth, internal changes are occurring that also influence speech development. The larynx

moves markedly downward; the upper airway becomes more adult-like in dimension; and growth of the mandible in a downward and forward direction is rapid. Front teeth begin to emerge, increasing tongue retraction. Two to four syllables can now be sustained on a single respiration.

From the perspective of neuronal maturation from 3 months to 1 year, Netsell (1986) posited that the major development in "hard-wiring" of the middle cerebellar peduncle is formed. In this case, hard-wiring refers to the longer axons that connect various centers of the nervous system. The infant, at this time, is also forming critical auditory-motor links.

Curran and Cratty (1978) believe there are several basic anatomical prerequisites for speech. Structure and positioning of the vocal folds, nasal cavity, mouth, lips, teeth, hard and soft palates, and breathing apparatus all must be normal. Muscles of the neck and face must also function properly for intelligible speech to be produced. Malfunctions in the auditory system can also lead to later problems with intelligibility.

Much information has been obtained on the beginnings of speech in infants. Some researchers (Curran & Cratty, 1978; Oller, 1980; Stoel-Gammon & Dunn, 1985) divide the initial periods of infant vocalization into stages. Typically, these stages fall into five time periods that are often overlapping. Stage I (0 to 1 month) is generally referred to as the "undifferentiated" or "reflexive/non-reflexive" crying stage (Curran & Cratty; Oller; Stoel-Gammon & Dunn). Stage II (approximately 2 to 4

months) is described as a vowel-like "cooing" stage. Stage III (approximately 4 to 6 months) is judged by many to be the beginnings of reciprocal communication. During this period, the infant begins to use sounds for a purpose. Different sounds are used for different reasons. Vocal play (babbling), and exploration of new sounds is also initiated (Curran & Cratty; Oller). Stage IV (approximately 6 to 9 months) is often referred to as the "reduplicated babbling" stage. During this time, the infant experiments with consonant-vowel (CV) combinations, for example mama. The emergence of inflection patterns is also linked to this period (Curran & Cratty; Templin, 1980). Stage V (approximately 10 to 12 months) is characterized by "variegated babbling". CV combinations are now not necessarily duplicated (*e.g.*, mama), but different combinations are attempted (*e.g.*, bibo) (Curran & Cratty; Oller).

By the end of the first year, infants attempt to imitate sounds, even though they may not yet be aware of the meaning. Positive response from parents rewards these verbalizations and infants begin to attach meaning to the sounds they make, sounds that were once merely vocal play (Curran & Cratty, 1978).

Stoel-Gammon and Dunn (1985) posited that the above described prelinguistic stages (as noted by Oller, 1980) seem to be determined primarily by maturation of the infant. It is interesting to note that Netsell (1986) linked the beginnings of true speech with the completion of "hard-wiring" which takes place at about the same period (around 12 to 18 months).

According to Curran and Cratty (1978), by the beginning of the second year, about half of the speech of young children with no diagnosed speech and/or language disorders is intelligible by non-family members. Children begin formulating their own two-word utterances. By the middle of the second year, true language, that is, "speech intended to bring about an event or influence something not physically in view" (Curran & Cratty, p. 15), is brought into use. Stoel-Gammon and Dunn (1985) agreed, placing the onset of meaningful speech at 1:0 to 1:6 (1 year to 1 year, 6 months). This period is aptly named "first words" and is characterized by the production of simple syllabic structures such as CV (consonant-vowel), CVC, or CVCV.

Sound segments in the child's system are often described as being learned and produced as whole units. These first contrastive units in the child's system are words rather than a sequence of segments. Thus, this period is sometimes known as the "whole-word" period. At this time, vocabulary grows to about 50 words, although there is considerable variation among children.

According to Stoel-Gammon and Dunn (1985), by the age of 1:6, the whole-word approach begins to diminish and the third stage, phonemic development, begins. By 1:6, an increase in vocabulary is seen, and the child begins to produce rule-governed forms. These forms correspond more to adult models. There is a concurrent increase in the number of different sounds and multisyllabic productions. Along with this, consonant clusters make their appearance. Although the complete adult phonemic repertoire is not fully acquired by the end of this stage (4 years), most phonemic

contrasts are produced correctly at least part of the time, by the majority of typically developing children.

Curran and Cratty (1978) stated that by the third year, a child is capable of rephrasing, and that by the middle of this year children will evidence individuality in their speech. By 4 years, enunciation is more adult-like, and articulation errors occur with decreased frequency. Templin (1980) added that by 3 or 4 years of age, children are able to recognize combinations of phonemes that appear and do not appear in their linguistic community.

By the age of 3 to 4 years, what Netsell (1986) termed "spatial-temporal coordination" is achieved. This term refers to the child's ability to coordinate a particular shape or place of the vocal tract, at a particular time, to effect a specific acoustic event. In other words, deliberate speech is being coordinated and produced. However, refinement of speech, in terms of motor control, takes place during an extended period from 2 to 14 years.

This typical course of speech development in children is inextricably linked to their phonological development. Phonology is the study of the speech sound system of a particular language. It includes how the sounds are organized, classified, and used contrastively. Speech production and perception are encompassed in this definition, and, according to Hodson and Paden (1991), articulation (the actual movement of the articulators during speech) is subsumed under this term.

Hodson and Paden (1991) listed two components to phonological structure: a particular and limited repertoire of sounds (phonemes) and a set of rules governing how these sounds can be used. They stated that by the time children have acquired a vocabulary of approximately 25 words, they exhibit an emerging phonological system.

The sequence that children follow in their phonological growth is from simpler arrangements of sounds to more complex combinations. This progression can be seen in Appendix A, from Weiss, Gordon, and Lillywhite (1987). During this time, children often need to simplify some of the more complex sounds or develop substitutes for them. These simplifications, substitutions, and sometimes omissions, are accomplished in predictable ways by typically developing children. Due to these simplification strategies (or phonological processes), children may be unintelligible to those adults not familiar with their simplification system (Hodson & Paden, 1991).

As Hodson and Paden (1991) stated, there are predictable phonological processes that most typically developing children employ. Grunwell (1983) formulated this development into a chart (see Appendix B). When a child develops atypical patterns, more severe unintelligibility can ensue. Grunwell (1981) listed four processes which, she stated, can identify deviant phonological processes. These include processes that are "idiosyncratic", that is, those that have not been ascribed to typical development. She differentiated these from "unusual" processes, which are those that occur but infrequently, in typical development. The next classification is that of "persisting" normal processes; those that are usually observed only very early on, but

continue beyond the earliest stages of language development. The final process used by Grunwell to describe deviant phonology is called "chronological mismatch of normal processes" (p. 100). This is a failure of the child to accommodate previously used processes to new additions in the repertoire.

Haeslig and Madison (1986) conducted a study that involved 50 typically developing children ages 2:10 to 5:2. The purpose of this study was to collect developmental data on phonological processes used by typically developing 3- to 5-year old children. In this study, they administered the Phonological Process Analysis (PPA) developed by Weiner (1979) with the purpose of drawing comparisons among age groups. The results indicated a decrease in phonological process deviations as children become older. Whereas, 3-year-old children exhibited 15 of a possible 16 process deviations, only 9 of a possible 16 were used by the 5-year-old group.

Vihman and Greenlee (1987) conducted a study on individual differences in phonological development in 10 typically developing children at age 1 year and again at age 3 years. The purpose of their study was to track the persistence of individual differences in phonological development and then to rate each child at age 3 on intelligibility. The intelligibility ratings at age 3 years were judged as 73 % intelligible as a mean, with individual scores ranging from 54 % to 80 %. The research showed that there was a correlation between intelligibility and phonological maturity, that is, the more intelligible children ranked lower on scales of phonological errors (see Table 1). At age 1 year, no similar relationships could be drawn due to the fact that children

of this age are seldom understood outside of the home. It does appear, however, that there is an important correlation between phonology and intelligibility (Vihman & Greenlee, 1987).

TABLE 1

Comparison of Intelligibility and Phonological Advance

Intelligibility			Phonological Advance	
Deborah	180/224	80%	Emily	26
Camille	60/79	76%	Deborah	44
Emily	73/97	75%	Timmy	49
Timmy	117/167	70%	Camille	54
Thomas	56/80	70%	Susie	81
Susie	83/128	65%	Sean	83
Andrew	62/204	60%	Thomas	83
Molly	105/179	59%	Molly	85
Jonah	90/159	57%	Andrew	90
Sean	61/113	54%	Jonah	90

Note: Intelligibility is the mean percent of utterances rated intelligible, summed over three judges. The phonological advance is ordered from least to most errors and is an indicator of phonological maturity.

Factors Influencing Intelligibility

Connolly pointed out in his 1986 study that the concepts of intelligibility and unintelligibility are ones of central importance in speech intervention. This is demonstrated by the fact that the issue of intelligibility appears in almost all areas of

speech intervention, including aphasia, dysarthria, laryngectomy, glossectomy, somesthetic deficit, and phonological problems.

There is, however, a lack of data on intelligibility in typically developing children. Weiss (1982) was one of the first to present us with normative data on the intelligibility of young children (Table 2), but his data collection methods were unclear (Gordon-Brannan, 1994). Hodson and Paden (1981) and Stoel-Gammon and Dunn (1985), among others, researched normal phonological development. Bernthal and Bankson (1993) investigated the area of normal articulation development, but, there still remains a dearth of normative data on intelligibility in typically developing children.

TABLE 2
Intelligibility of Young Children

Age in Months	Percent of Intelligibility
48	100
42	92
36	80
30	64
24	50
18	25

Note: Weiss, 1982, Weiss intelligibility test, Tigard, OR: CC Publications.

There are myriad factors that influence intelligibility. Calvert (1986) listed several of these factors, including: background noise, content complexity, familiarity with the speaker, rate of transmission, and environmental, linguistic, and phonetic redundancy. Weiss (1982) provided an additional list of factors influencing intelligibility (Appendix C). Gordon-Brannan (1993) added speech sound production factors to this list, including the number of speech sounds in error, speech sound error types, frequency of occurrence of error sounds, and types of phonological processes used. Suprasegmental factors such as voice characteristics, fluency, and prosody can also influence a speaker's intelligibility as can contextual/linguistic features such as syntax, mean length of utterance, semantics, morphophonemics, and the medium of transmission.

Weston and Shriberg (1992), after having reviewed the literature regarding articulatory variables and their interaction with suprasegmental variables, stated that these do not provide sufficient explanation for intelligibility problems in children. Rather, they investigated a third source that can affect intelligibility, that is, contextual and linguistic variables. Contextual variables include length, complexity, position of the word, fluency, and contiguity. Linguistic variables include canonical form, consonant form, and grammatical form. The authors then performed two studies to cross-validate findings.

In summarizing the results, Weston and Shriberg (1992) found that several contextual and linguistic variables contributed to unintelligible words. Words were

found to be less intelligible when (a) they occurred early in a sentence, (b) they were adjacent to other intelligibility problems, (c) monophthongs and consonant clusters were included in closed syllable, and (d) the words were not grammatically classified as nouns.

Coarticulation is another factor that influences intelligibility to varying degrees. Winitz (1975) defined coarticulation as neighboring sounds affecting each other. There are two processes proposed by Winitz (1975) that may account for coarticulation: (a) physiological constraints and (b) "a complex preprogramming mechanism" (p. 77). Speech production, according to Winitz (1975), is initiated by an idea, formed into a syntax, transformed into a specific motor unit, and finally resolved into language. This is all the result of a complex motor control system. Calvert (1986) also commented on the complexity of the speech act, pointing out the neurologic movement of articulators, sequences of muscle action, and aerodynamic variations that occur in coarticulated speech. He also noted that this phenomenon of coarticulation takes place, not just in connected speech, but even in simple monosyllabic words because their adjacent sounds influence each other.

Kent and Minifie (1977), in their review of different models of coarticulation, defined coarticulation as the speech mechanism adjusting simultaneously to two or more units of production. Because of these complicated interactions of speech sounds, a specific linguistic unit does not contain invariant characteristics. Linguistic units are influenced by their environments. Kent and Minifie went on to state that coarticulation

applies not only to the articulatory level, but also to the acoustic level. Coarticulation, then, can influence intelligibility on two levels simultaneously, that is, the level of the speaker and the level of the listener. For example, cues for consonants are different, depending on with what vowels they are paired, what position in reference to the same vowels, and types of cues (manner, place, voicing).

Nabelek (1990), in her research on factors influencing speech intelligibility, focused on the relationship between acoustic cues and the perception of phonetic contrasts. She found that adverse listening conditions can be modified to a certain degree by specific speakers who produce some phonetic contrasts better than others. These better contrasts overcome adverse listening conditions to a greater degree than less well-defined contrasts, thereby increasing intelligibility.

Kent (1993), in agreement with an earlier study by Kent and Minifie (1977), recognized the rôle of the listener in speech intelligibility on the acoustic level. Kent stated that if intelligibility is viewed solely as an attribute of a specific speaker rather than a communication situation between a speaker and a listener, the conceptualization of intelligibility becomes too narrow. He emphatically stated that narrow interpretation is "always incorrect" (p. 225) when used in clinical appraisal of an individual's speech.

Listeners, in the listener-speaker dyad, have several jobs. They must attend to the speech signal and decode it through their knowledge of the phonetic structure of the language, the context in which the words are spoken, speaker attributes, and

various other constraints. In Kent's (1993) definition of intelligibility, the speaker and the listener must both take part in a cooperative process. An intelligibility score is not simply that of the speaker, but, at the very least, a combination of speaker-listener dyad, speech material and context, and the speaking situation.

Gordon-Brannan (1993) reported results of a study on speech intelligibility in pre-kindergarten children. Subjects were 48 children, ages 4:0 to 5:6. The author found that one of the factors that influenced degree of intelligibility in this study was context. Using continuous speech provided a context for the words. In addition, the listeners were already familiar with the material. Results showed that as context decreased (imitated sentences and words), speech intelligibility also decreased.

Intelligibility Measures and Some Inherent Problems

Gordon-Brannan (1994) characterized speech intelligibility as "the single most practical measurement of oral communication adequacy" (p. 17). She went on to say that many factors influence intelligibility measures: types of test materials, testing procedures, topic familiarity, and listener familiarity with the speaker.

Grunwell (1981) stated that intelligibility is a notoriously difficult variable to measure because of its intrinsic connection to so many other variable (many of these have been noted in the previous section of this paper). The author went on to suggest that this could be the reason why frequently, in clinical practice, clinicians simply offer an "expert's" opinion as to an individual's communication adequacy.

Connolly (1986) concurred with Grunwell (1981) on her statement that intelligibility is very difficult to measure. One of the areas Connolly addressed in measuring intelligibility was the selection of testing materials. He viewed intelligibility from a linguistic perspective and stated that lists of unconnected words could not adequately predict continuous speech intelligibility scores.

McWilliams (1990) discussed two methods for evaluating intelligibility. The first method is objective but time consuming. According to this method, a panel of listeners orthographically transcribe what they understand of a speech sample and their responses are averaged. The second method, much more subjective and still time-consuming, is that of equal interval rating scales. This method places complete intelligibility on one end of the rating scale and unintelligibility at the other end. However, rater reliability must be developed before these ratings can be deemed as accurate as the first method.

Shriberg and Kwiatowski (1982) developed an objective system of measuring severity level of connected speech. Their system is called Percentage of Consonants Correct (PCC). It is the calculation of the number of consonants correct divided by the number of consonants correct and incorrect. The results are then multiplied by 100. This resulting measure of severity has been found to correlate positively with the child's degree of intelligibility. In 1992, Kwiatowski and Shriberg performed some additional research in this area. This study yielded evidence that a continuous speech sample provided a representative distribution of grammatical, canonical, and phonemic

exemplars in children ages 3 to 6 years. This implies that a continuous speech sample is a valid method of collecting data to measure severity level because it is a fairly comprehensive measure of a child's everyday speech. It includes exemplars of major areas which affect speech.

According to Haynes, Pindzola, and Emerick (1992), another objective measure of severity level, developed by Hodson and Paden in 1983, was the composite phonological deviancy score (CPDS). This particular method factored age into the calculation along with the number of phonological processes occurring on the analysis of phonological processes. The method that Hodson and Paden used to calculate the CPDS was derived through a single word sample.

Interestingly, although Shriberg and Kwiatowski's (1982) PCC was derived from connected speech, and Hodson and Paden's (1983) CPDS was derived from single word samples, both of them, according to Haynes et al. (1992), are highly correlated and are useful as clinical indicators of severity.

Another variable that factors into measurements of speech intelligibility is listener experience. Garret and Moran addressed this in their 1992 study. They had "experienced" listeners (speech-language pathology majors) and "inexperienced" listeners (elementary education majors) listen to speech samples and rate them on their severity. This rating was based on perceptual judgments. Garret and Moran's rationale for using "experienced" and "inexperienced" listeners was that, even though it was not a quantitative measure, this was a valid indicator of people's reactions to a

phonological disorder. Their findings indicated the two sets of listener ratings were highly correlated. The ratings by the "inexperienced" listeners, however, were consistently higher than those of the "experienced" listeners.

The influences of experienced and inexperienced listeners was also addressed by Ellis and Fucci (1991). The question they attempted to answer was whether to use one or both types of listeners when evaluating speakers' intelligibility through the use of magnitude-estimation scaling. For this type of rating procedure, the authors found no significant difference between experienced and inexperienced listeners when rating samples of adult speech in which consonants correct was the only variable being manipulated. A single nonsense sentence containing all the consonant phonemes of the English language, each used only once, was the stimulus. Ellis and Fucci hypothesized that the reason for there being no difference between the ratings of the experienced and inexperienced listener lies in the rather general criteria used for the term "experienced" listener.

Previous to this study, Fucci and Ellis (1990) had researched the test-retest reliability of direct magnitude-estimation scaling. The test-retest reliability findings of Fucci and Ellis indicated that there were no significant differences between the direct magnitude-estimation scaling responses by their listeners in two different sessions. This suggested direct magnitude-estimation scaling to be a reliable method to measure speech intelligibility. The use of direct magnitude-estimation scaling for assessing speech intelligibility had also been investigated by Schiavètti, Metz, and Sitler (1981).

The purpose of this study was to determine if the continuum of speech is prothetic (additive) or metathetic (substitutive). The authors concluded that the continuum of speech intelligibility is prothetic and therefore direct-magnitude estimation scaling has more construct validity for assessing this dimension than interval scaling.

Kent, Miolo, and Bloedel (1994) reviewed the available procedures for assessing children's speech intelligibility. One of their initial comments was that, even though the question of intelligibility is of paramount importance, the process of assessing it is "fraught with procedural and interpretative complications" (p. 81).

In their review of the literature, Kent et al. (1994) grouped assessment procedures into five main categories. The first category included procedures that emphasized phonetic contrast analysis. An example of an assessment tool from this category is Monsen's (1978) CID Word SPINE (SPeech INtelligibility Evaluation). The second category of assessment procedures emphasized phonological process analysis. An example of this is Hodson's (1986) Assessment of Phonological Processes-Revised (APP-R). The third category of assessment tools focuses on procedures restricted to word identification without phonetic or phonological analysis. One of the examples Kent et al. used for this category was The Weiss Intelligibility Test (Weiss, 1982). Procedures that derive phonetic indices from continuous speech were included next. Shriberg and Kwiatowski's (1982) Percentage of Consonants Correct (PCC) is one example of this type of procedure. The last of the five categories

focused on was procedures that relied on a scaling method. The Meaningful Use of Speech Scale (MUSS), developed by Osberger (1992), is an example in this category.

The conclusion at which these authors (Kent et al., 1994) arrived was that, rather than using one intelligibility measure for a child, it may make more sense that some combination should be considered. This would depend on the circumstances, the individual child, the purpose of the assessment, the time constraints, and other available information.

Gordon-Brannan (1994) described some general procedures used to measure speech intelligibility in children. She included: open-set, closed-set, and rating scales. Open-set identification is a traditional procedure and involves calculating the percentage of words understood either by using single words, conversational speech, or a reading sample. The sample is orthographically transcribed by the examiner, and the percentage of words understood is determined. The Weiss Intelligibility Test (Weiss, 1982) is an example of this type (Gordon-Brannan, 1994).

When using closed-set word identification or multiple-choice, words are identified from a word list. The Preschool Intelligibility Measure (P-SIM) by Morris et al. (1995) is an example of closed-set assessment. With this type of assessment, the test is scored by someone other than the examiner. The P-SIM has been found by Morris et al. to correlate highly with articulation test results and with speech severity ratings of speech-language pathologists (Gordon-Brannan, 1994).

Rating scales comprise the third major approach to procedures used to measure speech intelligibility. These scales require the listener to judge how well their responses match the list of intended words spoken. A value on a predetermined scale is then yielded. There are primarily two types of rating scales: equal interval scales and direct magnitude-estimation scales. When employing the former, the listener assigns a number to a speech sample. This number is drawn from a continuum, which often uses a 5-point, 7-point, or 9-point scale. Descriptors are provided along the scale, or at the end points. The National Technical Institute for the Deaf (NTID) developed a 5-point rating scale with descriptors at each point (Schiavetti, 1992).

The second type of rating scale discussed by Gordon-Brannan (1994) is direct magnitude-estimation scaling. This type of scale allows the listener, or in some cases the researcher, to choose an arbitrary number as a standard, relative to a speech sample. This number then becomes the standard against which other speech samples are rated.

According to Gordon-Brannan (1994), gross estimation of percentage of words understood seems to be the most frequently used method by clinicians for assessing speech intelligibility in children. However, according to the author, this method may be neither valid nor reliable.

Percentage of words understood in a speech sample may be the most valid method to determine intelligibility as it reflects most accurately everyday speaking situations and is more objective. The question of whether this is necessarily better than

single words can be posited. This depends on the purpose for the assessment. Does the clinician want to determine overall intelligibility in everyday speech or does the clinician want to determine which segmental components contribute to unintelligibility? In the end, it is still unclear which assessment tools are most reliable, valid, time efficient, and effective (Gordon-Brannan, 1994).

There is considerable overlap in degree of intelligibility and severity level (Yorkston & Beukelman, 1978). It is hypothesized that both intelligibility and severity are affected by many of the same factors. Some assessment tools, for example Shriberg and Kwiatowski's (1982) PCC and Hodson's (1991) APP-R, are examples of instruments which assign a severity level to a child's utterances. The recent study designed by Gordon-Brannan (1993) investigated which intelligibility/severity measures would most accurately predict a connected speech sample measure. The percentage of words understood in a continuous speech sample, using a familiar topic and an unfamiliar speaker, was the standard against which other procedures were evaluated. These other procedures included: (a) percentage of imitated single words understood, (b) percentage of words understood in imitated sentences, (c) listener rating of intelligibility, and (d) percentage of phonological deviations (APP-R) (Hodson, 1986). Results indicated that all of the measures were highly intercorrelated with the standard measure, with percentage of imitated single words having the lowest correlation.

Summary

Intelligibility has many dimensions. Though researchers have investigated many other factors in addition to these dimensions, the task of gathering normative data through continuous speech samples is still deficient. A search through the literature yields very little in this specific area. Since most researchers seem to agree on the importance of intelligibility in assessing communication problems, it seems odd that there should be such a lack of normative data. Perhaps it is time to begin serious efforts to collect this data on typically developing children so that speech-language pathologists have criteria against which to determine a child's need for clinical intervention. Hopefully, an offshoot of this study will be the continuation of data collection with larger sample sizes and different age groups.

CHAPTER III

METHODS

Subjects

Subject Recruitment

This study was conducted at the Portland State University Speech and Hearing Clinic. Fourteen children, ages $3;6 \pm 2$ months, were selected from various Mom's Clubs Organizations and from the Helen Gordon Child Development Center and other preschools in the greater Portland/Vancouver area. Teachers in the preschools were initially contacted by telephone by the researcher. The study was described to them, with additional information sent to their preschool on request (Appendix D). If the teachers consented to participate in the project, they were then given form letters (Appendix E) and informed consent forms (Appendix F) to be sent home with the children. These letters described the study to the parents/caregivers. Parents/caregivers who decided to allow their children to participate either returned a portion of the form to the preschool (where the researcher picked it up) or called the researcher to discuss the project. An appointment was then made with the parents/caregivers to bring their child to the University to participate in the screening and speech sample elicitation. Questionnaires (Appendix G) were also sent to parents/caregivers at this time to be filled out by them. The purpose of the

questionnaire was to collect some basic demographic information along with information on the child's developmental and medical history.

Presidents of the Mom's clubs were also initially contacted by phone. If the president consented, the above information was sent to them to review. The presidents, in turn, wrote a summary of the information for their newsletter, including the researcher's phone number so that parent/caregivers who were interested could contact the researcher.

Subject Selection

As with the preschools, if the parents/caregivers allowed their child to participate, the children were then screened to insure that they fell within the normal range for their age group regarding hearing, receptive and expressive language, and phonological development. The screening tools used were the APP-R screen (Hodson, 1986) and the Fluharty Preschool Speech and Language Screening Test (Fluharty, 1987).

The criteria for selection were as follows:

1. Informed consent signed by the parents/caregivers allowing their child to participate in this study (see Appendix F).
2. Hearing within normal limits as determined by a pure tone audiometric screening, conducted at the frequencies of 1000, 2000, and 4000 Hz at 20 dB HL, for one ear.

3. Receptive and expressive language within the normal range as determined by a pass criteria on the Fluharty Preschool Speech and Language Screening Test (Fluharty, 1978).
4. Phonological system within the normal range as determined by the screening portion of the Assessment of Phonological Processes-Revised (APP-R) (Hodson, 1986).
5. Standard English as the primary language used in the home as determined by information reported on the parent questionnaire (Appendix G).
6. Normal resonance, fluency, and the absence of any oral motor problems (such as dysarthria). These characteristics were assessed informally by the researcher while conversing with the child.

Resonance is defined as "the selective amplification of the vocal tone" (Darley, Aronson, & Brown, 1975, p. 4). Problems with resonance can adversely affect voice quality which can, in turn, affect intelligibility. Fluency is defined as the "effortless flow of speech" (Peters & Guitar, 1991, p. 9). Problems with fluency can result in repetitions or prolongations of syllables, words, or phrases which interrupt the flow of conversation and adversely affect intelligibility. Dysarthria is a "group of speech disorders resulting from disturbances in muscular control" (Darley et al., p. 2). Weakness, altered muscle tone, incoordination, and slowness (usually as a result of central nervous system or peripheral nervous system damage) characterize the speech mechanism affected by dysarthria.

Of the 14 children screened in this study, 13 were accepted. Seven of the subjects were male and 6 were female. The mean age of the group was 3:6. The mean age for males and for females was also 3:6. There were three modes: 3:8, 3:6, and 3:4, all appearing 4 times each. Subject 2, a female, was disqualified for two reasons: (a) she was bilingual, but spoke only Russian at home, and (b) there was a technical problem with the audio tape and only half of her sample was recorded. The remaining 13 subjects spoke English as their primary language in the home. Subject 4's father had some concerns about his son exhibiting a Philippine dialect, as this was his mother's native language. Subject 12 also frequently spoke Hebrew at home though English was her primary language. Neither of these subjects demonstrated any discernible accents.

All subjects demonstrated normal hearing (Martin, 1991) in at least one ear, that is hearing at 20 dB HL for the frequencies of 1000, 2000, and, 4000 Hz as measured by pure tone air conduction screening.

The APP-R screen (Hodson, 1986), which was used to screen for phonological deviations, was passed by all subjects. Subjects demonstrated as few as zero instances of deviations up to five instances of deviations.

The Fluharty Preschool Speech and Language Screening Test (Fluharty, 1978) was also passed by all subjects, with scores ranging from a low pass of 11/15 for expressive language (11 being the cutoff for 3-year-olds) to 14/15. Subjects 4, 5, 10, and 12 all received low passes. Subject 1, the oldest, and subject 11, the second youngest by 3 days, received the highest scores. The range for receptive language

(with the cutoff at 6 for age 3) was a low pass of 7/10 (subject 8, who had the highest intelligibility rating) to a high pass of 10/10 (subject 1, who was the oldest, and subjects 4, 5, and 11).

Procedures

Instrumentation and Screening

Normal hearing was defined as passing a pure tone audiometric screening at 20 dB HL for the frequencies of 1000, 2000, and 4000 Hz, in at least one ear. This testing was performed at the Portland State University Hearing Clinic using a GSI 17 Model 1717 portable audiometer.

Following completion of the hearing screening, the Fluharty Preschool Speech and Language Screening Test, which is a standardized screening test for receptive and expressive language, was administered to the child by the researcher. The test was given in the instrumentation lab at Portland State University Speech and Hearing Clinic according to test manual protocol. The test was scored during the session. The child must have passed this screening to be eligible as a subject for the study.

In the next step, 12 items, representing stimulus words from the APP-R, were shown to the child to elicit specific words. These words are designed to give the child opportunities to display certain typical phonological processes. The child's answers were audiotaped so that they could be replayed later for verification of the transcription by a second listener. All utterances were phonetically transcribed by the researcher on-line in accordance with the guidelines stated in the test manual. The 13

children who passed this screening, who had successfully passed the previous screening procedures, and who spoke English as the primary language in their home, became participants in the study.

Data Collection

Upon completion of the screening, and a short break, a 100-word speech sample was elicited from the child in the instrumentation lab. The researcher and the child looked at an age-appropriate book (either Good Dog, Carl by Day, or The Relatives Came by Rylant) and the researcher engaged the child in conversation about the story. Parents/caregivers were permitted to watch and listen from inside the instrumentation lab. The session was audiotaped using a Denon DTR 80P digital audio tape and a Sony ECM-FO1 capacitator flat microphone.

Transcription of Samples

Two listeners, unfamiliar with the child but familiar with the topic, were asked to participate. These listeners were two female graduate students from the speech-language pathology program at Portland State University. They were between the ages of 25 and 35 years and had hearing within the normal range, that is, 20 dB HL at 1000, 2000, and 4000 Hz.

Scoring and Data Analysis

At the completion of the data collection procedures, the two listeners were given written (Appendix H) and verbal instructions on methods for transcribing the

100-word speech samples. They were instructed to listen to the audiotapes and to transcribe them orthographically. They were directed to listen to an utterance no more than two times and to play the tape back a third time to fill in any gaps. The listeners were not trained in any special way and were only instructed to follow the above protocol.

Percentage of intelligibility was determined by listener agreement on words. If listeners disagreed on a syllable/word, that is, if one listener scored it with a slash (unintelligible) and the other transcribed it, the word was scored as unintelligible. If listeners disagreed on a word that they had transcribed orthographically with a question mark, that word was also scored as unintelligible. Also, if the two listeners transcribed two different words without a question mark, this word was also scored as unintelligible. If one listener included a word or phrase in her transcription which the other did not transcribe, this word was omitted from the 100-word count as there was no way of determining if the subject had actually uttered the word. The number of intelligible words agreed on in the two listener transcriptions was then determined by the researcher and a percentage of intelligibility for that particular subject was derived.

This is a descriptive study; therefore ordinal data were used. The subjects were ranked according to the percentage of intelligible words of the 100-word speech samples collected. Mean, median, range, and standard deviation for the 13 subjects were also calculated.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The purpose of this pilot study was to obtain normative data on the intelligibility of young children, ages 3:6 $\pm$ 2 months, with no diagnosed speech and/or language disorders. Investigation into the literature in this area revealed a lack of data on intelligibility in speech for this particular group. Most of the literature on intelligibility in children has focused on children with various disabilities which negatively affected their speech production.

In this study, intelligibility was measured as the percentage of words understood in a 100-word speech sample. Two listeners, unfamiliar with the speaker, but familiar with the topic, listened to audiotapes of each speech sample and orthographically transcribed them. The researcher later compared the pairs of transcriptions.

The mean percentage of intelligibility in this study for children ages 3:6 $\pm$ 2 months, with no diagnosed speech and/or language disorders, was 88% (see Table 3). The mode for all subjects was 90%, which occurred five times, and the median for all subjects was also 90%. The standard deviation (*SD*) was 5.7%.

TABLE 3

Mean, Standard Deviation, and Range of Intelligibility
In Continuous Speech Samples of 3½-year-olds

Age	<i>N</i>	<i>M</i>	<i>SD</i>	Range
3:4 to 3:8	13	88%	5.7%	76% to 96%

The mean percent of intelligibility for the 4 youngest subjects (3, 6, 11, and 14) was 90%. The average age of this group was 3:4 and had a range of intelligibility from 84% to 94%. The mean percent of intelligibility for the 4 oldest subjects was 86%, with a range from 76% to 90%. If the low outlier (76%, which was found in this group) is eliminated, the mean percent of intelligibility is 89%, with a range from 89% to 90%.

The mean percent of intelligibility for males was 89% and the mean for females was 87% (the lowest percentage of 76% belonging to a female). Again, if the high and low outliers are eliminated from this calculation, then the mean for males was 88% and the mean for females was 89% (Table 4).

TABLE 4

Percentage of Intelligibility as Compared to Number of Phonological Deviations,
Number of Diagnosed Ear Infections, Age, and Sex of Subjects

Subject	Percent of Intelligibility	Number of Phonological Deviations	Number of Diagnosed Ear Infections	Age	Sex
8	96	2	10	3.5.28	M
11	94	0	3	3.4.05	F
6	92	1	5-6	3.4.02	M
13	91	0	10	3.5.00	F
7	90	1	20	3.7.25	M
3	90	2	4	3.4.06	M
4	90	3	0	3.8.00	M
12	90	3	13	3.5.19	F
9	90	5	3	3.6.13	M
1	89	5	2	3.8.70	F
14	84	1	2	3.4.14	F
10	77	3	0	3.6.40	M
5	76	5	4	3.7.15	F

Discussion

As Kent et al. (1989) pointed out, methods for assessing intelligibility in children often involve a subjective, gross estimation by the clinician. The present study used strict criteria for objectively determining the intelligibility of each subject's speech. The criteria for specifying which words were considered to be intelligible and which were not, are described in the methods section.

Once typically developing children reach the age of 2:3, they are generally speaking in strings of two or more words (Brown, 1973); therefore, a continuous speech sample was used as the format to judge intelligibility in this study. Gordon-Brannan (1993) also stated in her study that a continuous speech sample is logically the most valid measure of speech intelligibility.

Results on the intelligibility of children in this study, ages 3:6 $\pm$ 2 months, were 88%. The mean for subjects whose age fell at exactly 3:6 was also 88%, differing from Weiss's (1982) study by only 4 percentage points. Interestingly, this sub-group of subjects, ages 3:6 (subjects 8, 9, 10, and 12) also contained the highest single intelligibility rating (96%) and the second lowest (77%). Weiss's study indicated a 92% intelligibility rating for children ages 3:6. Since the *SD* for the present study was 5.7%, the two sets of results (88% and 92%) are within 1 *SD* of each other, indicating measurable agreement.

Demographically, the parents who replied to the recruitment requests for the study were from homes in the greater Portland/Vancouver area. Of the 13 subjects, all but one was from a two-parent home. Of the 12 subjects who lived in two-parent homes, 6 had one parent who was either self-employed in the home or listed herself as a homemaker. Five of these 12 sets of parents had college degrees; in 3 other sets, at least one parent had a college degree; of the remaining set, both parents were students at the university. The parent in the single home held a GED (general education

degree). This is not a representative sample of the greater Portland/Vancouver area and this factor should be taken into account when considering the results.

The frequency of diagnosed middle ear infections, and the placement of tubes in the ears, did not appear to have an effect on speech intelligibility in this study. The 3 subjects with the most frequently diagnosed middle ear infections and tubes (subject 7 with 20 infections, subject 12 with 13 infections, and subject 13 with 10 infections) received intelligibility ratings of 90%, 90%, and 91%. Two of these 3 subjects (12 and 13) were females.

On the questionnaire (Appendix G), parents were asked to mark yes or no if they believed that people outside the immediate family had difficulty understanding their child's speech. The parents of subjects 5, 9, and 10 marked yes. Subject 5 (female) did receive the lowest rating in the study (76%). She was 3:7. She also received the highest, that is, exhibited the most instances (along with subjects 1 and 9) of phonological deviations, even though she passed the screening. Subject 10 (male) scored the second lowest rating on speech intelligibility in this study (77%), exhibiting three instances of phonological deviations. He was 3:6. Subject 9 (male) scored 90% on intelligibility even though he also scored high (5 instances) on phonological processes. He was also 3:6. However, subject 9 scored a 90% on intelligibility, placing him at the mode and 2 percentage points above the mean. These results indicate that two-thirds of the parents who perceived their children as not being easily understood by those outside the family, were making accurate judgments.

When screening the children for this study, Hodson's (1986) APP-R screen was used to determine the presence of phonological deviations. Many researchers have looked at articulation and phonological development in children and how these factors affect intelligibility (Curran & Cratty, 1978; Hodson & Paden, 1991; Stoel-Gammon & Dunn, 1985; Weiss et al., 1987). Grunwell (1983) produced a chart (see Appendix B) that listed predictable phonological processes that most typically developing children employ. Some examples of these predictable processes are: (a) gliding, replacing a phoneme from another consonant class (usually a liquid) with a glide (*e.g.*, rock to wock); (b) consonant sequence omissions, deleting part of a consonant blend (*e.g.*, block to bock); and (c) fronting, replacing a posterior consonant with an anterior consonant (*e.g.*, cat to tat) (Hodson & Paden, 1991). In her research, Grunwell found that degree of unintelligibility correlated positively with atypical patterns of phonological processes. Most of the subjects in the present study exhibited some predictable phonological processes only (for example, gliding or consonant sequence omissions) which should not have unduly compromised their intelligibility.

Vihman & Greenlee (1987) conducted a study in which a positive correlation was found between intelligibility and phonological maturity. In their study, the more intelligible a subject was rated at the age of 3:0, the lower that subject ranked on scales of phonological processes (that is, they made fewer phonological process errors) (see Table 1). Vihman & Greenlee interpreted this as an important relationship between phonology and intelligibility. In the present study, an in-depth analysis of

phonological processes was not performed, only a screening. Nevertheless, a comparison between intelligibility ratings and number of instances of phonological processes exhibited in the screening, resulted in a similar outcome.

In the Vihman & Greenlee study (1987), most of the subjects with intelligibility percentages in the upper half of their study (70% to 80%), except for one, demonstrated the least number of phonological processes (or the highest phonological proficiency). It should be noted, however, that the percentages did not necessarily coincide one to one. The subjects with percentages in the lower range of intelligibility (54% to 65%), in Vihman & Greenlee's study, demonstrated considerably more phonological deviations (or the least phonological proficiency) . In the present study, the relationship was similar. The highest four percentages of intelligibility (91% to 96%) coincided with two or fewer instances of phonological deviations. However, the lowest percentages in the present study (76% to 89%) demonstrated a wide range of instances of phonological deviations from one deviation to five. Though there are discrepancies between results when looking at both studies, there is a similar pattern of fewer instances of phonological processes in the upper ranges of intelligibility rankings in both studies.

Kent et al. (1994) agreed that, even though the question of intelligibility is of paramount importance, it is "fraught with procedural and interpretative complications" (p. 81). This was found to be a truism in this study also.

In an effort to decrease the variables affecting transcription of the tapes as much as possible, both of the listeners chosen were entering their second year as graduate students in a university speech-language program. This meant that both had been trained to a certain degree in transcribing from an audiotape and both had previously transcribed at least one speech/language sample. They were also both given a hearing screening to insure hearing acuity. Nevertheless, when comparing the results of the orthographic transcriptions of the 13 subjects, some discrepancies were noted. The listeners frequently disagreed on whether a subject used the article a or the, which resulted in a count of unintelligible. Even though this misperception did not affect the content (or message) of the sample, did it indicate unintelligibility or were these transcribed as different words due to expectations, that is, was one listener automatically transcribing what she expected to hear or what she actually heard? Some plural endings were also transcribed differently. Could this have been due to a very slight high frequency loss on the part of one listener or was it, again, a case of "expectations"? On occasion, a phrase was written by only one listener. How much of this was due to fatigue or unfocused attention on the part of the listener? The words in the latter case then had to be eliminated from the 100-word count.

As has been stated by many researchers (Connolly, 1986; Ellis & Fucci, 1991; Garret & Moran, 1992; Gordon-Brannan, 1994; Grunwell, 1981; Kent et al , 1994), intelligibility is a difficult construct to measure. Numerous and fluid variables need to be taken into account, both on the side of the listener and the speaker.

CHAPTER V

SUMMARY AND IMPLICATIONS

Summary

Most of the previous published research involving intelligibility has focused on persons with various types of disabilities or delays. Minimal research has been conducted on intelligibility in young children with no diagnosed speech and/or language disorders. The result is a gap in normative data by which to set a standard to judge speech as being at an acceptable level of intelligibility for a particular age group. The focus of this pilot study was to collect normative data on the intelligibility of young children, ages 3:6 $\pm$ 2 months, with no diagnosed speech and/or language disorder.

Thirteen subjects, ages 3:6 $\pm$ 2 months, were recruited from the greater Portland/Vancouver area. These subjects were screened for normal development in the areas of speech sound production, expressive and receptive language, and hearing. It was also established that English was the primary language spoken in the home. Resonance, voice quality, and fluency of the subjects were informally assessed by the researcher during the course of the session and found to be normal.

The 100-word speech samples were collected by the researcher on audiotape and later played back to two listeners who were familiar with the topic but unfamiliar

with the speaker. The listeners orthographically transcribed the samples and a comparison was made by the researcher between the two sets of written transcriptions. This comparison provided the percentage of intelligible words, out of a possible 100, which were understood by both listeners when the speaker was unknown, but the topic was familiar. Results showed the mean intelligibility percentage for 3½-year-old children with no diagnosed speech and/or language disorders to be 88% (*SD* = 5.7%) with a range of intelligibility from 76% to 96%. Both the mode and the median for this sample were 90%. Several other variables, such as youngest/oldest subject, male/female, frequency of diagnosed ear infections, and parental perceptions regarding how well others understood their child, were addressed as points of interest, but the comparisons were not investigated in depth as they were not a stated part of this study.

The focus of this study was to collect, in a methodically documented manner, normative data in 3½-year-olds. When the results are compared to the only other available data (Weiss, 1982), the results from both studies fall within 1 *SD* of each other, indicating that there are no measurable differences between the findings.

Implications

Research

Further research into the area of intelligibility in young children with no diagnosed speech and/or language disorders is warranted. This study is barely a beginning and should be considered a pilot study. Larger sample sizes need to be obtained, not only for ages 3:6 $\pm$ 2 months, but also for slightly younger and slightly

older children. These studies should be conducted in order to set a foundation for comparison of children's intelligibility against a standard, normative population.

The validity of the results of this study would also be strengthened if intra- and inter-rater reliability were first determined by the researcher. Another alternative might include using three or more listeners rather than two, in order to obtain a more reliable data base. It would be interesting to compare the listener transcriptions to determine what the individual ranges would be for each child. This would be a reflection of listener reliability.

Future researchers should also be cautious in choosing a book from which to gather the speech sample. One that contains material that is too old or too young for the child can result in difficulty eliciting a representative sample of the child's speech and consequently affecting the intelligibility rating in either direction. It might be beneficial to the researcher to try several different books on the targeted age group to determine which two elicit the most productive speech samples. By using this method, a researcher could empower the child by allowing the child to choose which book to talk about.

Future samples should also include children from more diverse socioeconomic groups. This might include children from inner city neighborhoods and/or rural areas. This diversity could be achieved more readily if the research could be made portable. Some quality in recording may need to be sacrificed since the researcher would not be recording in a laboratory, but the increase in diversity might be worth the slight

decrease in sound quality. Data should also be collected on other major dialects in our country, for example, Black English.

Another interesting area to develop in future research on intelligibility might be whether the subject has any siblings, and if so, the subject's birth order rank. And yet another possible question is whether gender has any effect on intelligibility.

Clinical Implications

Because of the limitations in size of this sample, it is difficult and misleading to do more than conjecture on its clinical implications until there is a follow through with a larger sample size or with additions to this sample. Nevertheless, the results of this study did come within 1 *SD* of Weiss's (1982) study, which is a strong indicator that the results of both studies are valid and can be used as future guidelines. The results of the present study also indicate that the method of screening and collecting data for future research, with the addition of some changes as stated in the research implications section, are both viable and feasible.

Clinicians need to do more than just estimate a child's intelligibility when parents bring in their child with a concern about speech (specifically, intelligibility). Clinicians need a time efficient and reliable method for assessing this child's speech. Collecting a 100-word speech sample, recording it, and then transcribing it to determine the percentage of words out of 100 that the clinician understood, would address this goal without being too time consuming. This, however, is the opinion of the researcher and is contrary to most of the literature, which finds this method too

time consuming. This researcher feels that the benefits of this method outweigh the slight increase in time. With this method, if the resulting percentage for a 3½-year-old child was within 1.5 *SD* of the results of Weiss's (1982) study or this study, intelligibility could be assumed to fall within the average or normal range. If the percentage falls below 1 *SD*, the clinician might want to pursue the issue further by looking at the child's phonological processes in comparison to the child's age, the child's fluency, or any of the other factors which can adversely affect intelligibility.

Another option for clinicians might be to gather local samples, using the methods (with suggested changes) described in this study, to determine the percentage of intelligibility and *SD* in their locale. With this information, clinicians could also accurately and efficiently assess intelligibility in their clients. This is especially important if there is a specific dialectal or cultural population in the clinician's area of practice which may differ from the population in general.

When these dialectical differences occur, it is the clinician's role to explain to the parents/caregivers the results of their assessment and compare the results to the dialectal norms. This would give the parents/caregivers a basis on which to make an educated judgment about whether to proceed with intervention. It should also lead to discussion with the clinician as to whether or not the parents/caregivers want some issues addressed.

Another interesting study on intelligibility might involve increasing the word sample from 100 to 300 to determine if that has any effect on how a child's intelligibility is rated by listeners. Does the listener become accustomed to the child's

speech and understand more as the word sample increases? Also, researchers could compare percent of intelligibility with how much of the message was understood. Were the unintelligible words high content words (nouns, verbs, etc.) or words with minimal content (articles, etc.)? It would also be interesting to compare the errors of children who scored 88% (the mean) with children who have been judged less intelligible. Were the errors different, and if so, in what way?

One of the points that this study can make to clinicians professionally, is that there are many variables that affect intelligibility and just as many that can affect listener transcription. However, the main point is that intelligibility is a major concern in the field of speech-language pathology, especially when dealing with young children. Clinicians need both a reliable and time efficient method for assessing intelligibility and a normative standard against which to judge their client's intelligibility.

Because the field of speech-language pathology deals with people, by people, there will never be a completely valid and reliable method for assessing the area of intelligibility or making diagnostic and treatment decisions. Nevertheless, a strong foundation of normative data is certainly an important addition to any clinician's arsenal of diagnostic tools.

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APPENDIX A

**SEQUENTIAL CHARACTERISTICS OF
PHONETIC DEVELOPMENT**

SEQUENTIAL CHARACTERISTICS OF PHONETIC DEVELOPMENT

Age	Behavior
Birth	Crying
1 Week	92% of front vowels present — /i/, /ɪ/, /e/, /ɛ/, /æ/ 7% of middle vowels present — /ɜ/, /ə/, /ʌ/, /ə/ No back vowels present — /u/, /ʊ/, /o/, /ɔ/, /a/
1 month	Reflexive vocalization (undifferentiated vocalizations) One half of the vowels and a few consonants present — /æ/, /ɛ/, /ʌ/, /ɪ/, /e/, /u/, /ɪ/, /h/, /k/, /g/, /m/, /n/
2 months	Vocal play and babbling (differentiated vocalizations) Perceptual development begins Behaviors up to and including this level are derivative of chewing, suckling, and swallowing movements Vowel distribution — front vowels, 73%; middle vowels, 25%; back vowels, 2% Consonants present /m/, /b/, /g/, /p/, /j/, /w/, /l/, /r/ Occasional diphthongs are heard
3 months	Sounds added - /ə/, /ɪ/, /h/ Increased vocal play and babbling
4 months	Sounds added - /t/, /v/, /z/, /θ/, /ɔ/, /o/ Vowel distribution - front vowels, 60%; middle vowels, 26%; back vowels, 14%
5 months	Syllable repetition 63 variations of sounds present
6 months	Lalling begins Imitation of sounds
7 months	Syllables and diphthongs continue to develop
8 months	Marked gain in front vowels and back consonants Babbling peaks
9 months	Echolalia appears Continued imitation of sounds Jargon More back vowels, central vowels, and consonants appear

10 months	Invention of words Continued imitation of sounds and words
11 months	First true word may appear
12 months	Vowel distribution — front vowels, 62%; middle vowels, 16%; back vowels, 22% Diphthongs continue to develop Word simplification begins Reduplication occurs
16-24 months	Intelligibility is 25% Deletion of unstressed syllables Word combinations begin to develop Use of holophrastic words Diphthongs continue to develop Better production of some sounds now than later
24-30 months	90% of all vowels and diphthongs are learned Mean length of utterance — three and one half words Articulation is intelligible 60% of the time Front consonants continue to develop
30-36 months	All vowels are learned except /ɜ:/ and /ə/ All rising diphthongs - /ai/, /au/, /ou/, /ei/ - are learned except /ju/ Consonants /p/, /b/, /m/, /w/ are learned Articulation is intelligible 75% of the time Mean length of utterance — five words
36-54 months	Centering diphthongs develop - /iə/, /eə/, /aə/, /ɔə/, /ʊə/ Some stops are substituted for fricatives Consonants /n/, /ŋ/, /j/, /t/, /d/, /k/, /g/, are learned Mean length of utterance - six words
54-66 months	Consonants /f/, /v/, /ʃ/, /θ/, /ð/, /l/ are learned
66-78 months	Consonants /r/, /s/, /z/, /tʃ/, /dʒ/, /ʃ/, /ʒ/ are learned The remaining middle vowels /ɜ:/ and /ə/ are learned as well as centering diphthongs
84 months	All consonant clusters are learned, and articulation is completely normal; morphophonemic rules continue developing until age 12 years

It should be noted that in this table, though some sounds appear early in the child's repertoire, these same sounds are not considered "learned" until they are used consistently and meaningfully (Weiss et al., 1987, p. 58).

APPENDIX B

CHRONOLOGY OF PHONOLOGICAL PROCESSES

	2:0-2:6	2:6-3:0	3:0-3:6	3:6-4:0	4:0-4:6	4:6-5:0	5:0→
Weak Syllable Deletion	-----						
Final Consonant Deletion	-----						
Reduplication	-----						
Consonant Harmony	-----						
Cluster Reduction (Initial) obstruent + approximant /s/ + consonant	-----						
Stopping							
/r/	-----						
/v/	-----						
/θ/	-----						
/ð/	-----						
/s/	-----						
/z/	-----						
/ʃ/	-----						
/ʒ, ʒ/	-----						
θ, ð → [f]							
/ð/ → [d] or [v]							
Fronting '[s] type'							
Fronting [ts, dz]							
Fronting /k, g, ŋ/	-----						
Gliding /r/ → [w]	-----						
Context-Sensitive Voicing	-----						

Chronology of phonological processes. (From Grunwell, P.: Clinical Phonology, Rockville, MD, Aspen Systems Corporation, 1983, p. 183.)

APPENDIX C

**FACTORS WHICH MAY INFLUENCE
INTELLIGIBILITY**

FACTORS WHICH MAY INFLUENCE INTELLIGIBILITY

- Adventitious sounds
- Articulation
- Communicative disfluency
- Inflection
- Juncture
- Mean length of utterance
- Morphology
- Morphophonemics
- Pauses
- Physical posture
- Pitch
- Pronunciation
- Speaking rate
- Redundancy
- Resonance
- Rhythm
- Semantics
- Stress
- Syntax
- Voice quality
- Voice loudness
- Pragmatics

Factors influencing intelligibility. From Weiss, C. E., Weiss Intelligibility Test (Tigard, OR: CC Publications, 1982, p. 2.)

APPENDIX D

PROJECT DESCRIPTION

Project Description

Project Title:
Normative Data on the Intelligibility of Young Children ages 3:4 - 3:8 Years

Determining intelligibility is a major concern for the speech-language pathologist when assessing preschool children. In order to have objective, normative criteria against which to compare children's intelligibility, it is first necessary to gather these normative data in an objective, measurable manner. However, few methods for assessing intelligibility objectively are available. The intelligibility measure of choice is often a subjective and gross estimation, using vague criteria.

The purpose of this study will be to collect normative data on the intelligibility of 14 children with no diagnosed speech/language disorders, 3:4 - 3:8 years of age. The study will measure the percentage of intelligible words in a 100-word continuous speech sample.

This study will be conducted at the Portland State University Speech and Hearing Clinic. Fourteen children will be selected from the Helen Gordon Child Development Center in Portland, and other preschool programs as necessary. The children will be screened to ensure that they fall within the normal range for their age group regarding hearing, language, and phonological processes. All screening tools used will be well established assessment tools used in the Portland Public Schools. The children will also be screened to exclude any organic or otherwise physically handicapping condition which may affect their speech.

Following the screening process, a short break will be taken, then the researcher will use an age appropriate book to engage the child in conversation. This conversation will be audiotaped using the Denton DTR 80P digital audiotape and a Sony ECM-F01 capacitor flat microphone.

At the completion of the above, two listeners unfamiliar with the subject but familiar with the material will be asked to listen to the audiotapes and transcribe them orthographically. Listeners will use a slash (/) to indicate unintelligible words; intelligible words will be written orthographically; words which are questionable will be written down with a question mark (?). The orthographic transcripts of the listeners will be compared. If two listeners disagree on a word, the word will be considered unintelligible and marked as such. The intelligible words will be counted and a percentage of the 100 words will be derived.

Subject Recruitment

The 14 prospective subjects for this study will be both male and female preschoolers, between the ages of 3:4 and 3:8 years. They will be selected through the Helen Gordon Child Development Center and other preschool programs as necessary. After explanation of the study, teachers will be asked by the researcher to distribute letters to parents/caregivers of age appropriate children. These letters will contain a letter of information and a response form for the parent/caregiver to return to the preschool. The letters will also contain the

researcher's phone number so that any further questions can be addressed. The researcher, upon receipt of the consent forms, will contact the parent/caregivers to further discuss the project, send out questionnaires, Letters of Informed Consent, and set up appointments.

When the parents/caregivers and researcher meet, the parents/caregivers will be asked to confirm the following information:

1. The child will have had no previous history of cognitive, organic, or otherwise physically handicapping conditions which adversely affect speech production.
2. Standard English will be the primary language spoken in the home.
3. The parents/caregivers will voluntarily sign the Informed Consent Form allowing the child to participate in the study.

Providing that this criteria are met, the child will begin participation in the study. The following areas will be screened:

1. The child's hearing will be screened at 20dB, at 1,000Hz, 2,000Hz, and 4,000Hz. Hearing must be normal in at least one ear.
2. Expressive and receptive language will be assessed by Fluharty's (1978) Preschool Speech and Language Test. The test will be scored after the session. To qualify, the child must pass all areas of this screening.
3. Phonological systems will be assessed using Hodslen's (1986) screening portion of Assessment of Phonological Processes - Revised (APR-R). In this assessment, the child chooses and names various objects. Phonological transcriptions are performed on-line by the researcher and audiotaped for later verification. Subjects must fall within the normal to mild range of the severity rating in order to qualify for this study.
4. An informal observation will be performed by the researcher to determine the presence of any organic or physical handicaps that may adversely affect speech production. Additional information will be gleaned from the questionnaire previously filled out by the parents/caregivers.

Informed Voluntary Consent in Writing

Before beginning this study, the researcher will meet with the parents/caregivers of the child and read the Informed Consent Forms together. The researcher will provide a summary and encourage and answer any questions. Also, the researcher will briefly and simply explain to the child what they will be doing in the clinic room.

APPENDIX E

FORM LETTER

Portland State University

P.O. Box 751, Portland, OR 97207-0751

Dear Parent/Caregiver:

I am a graduate student at the Portland State University Speech and Hearing Sciences Department. I am conducting a research project on the speech intelligibility of typically developing children between the ages of 3:4 and 3:8 years, under the guidance of Dr. Mary Gordon-Brannan. The purpose of collecting this information is to help speech-language clinicians make decisions on whether or not to intervene and provide clinical services for children with some degree of unintelligible speech. A standard, taken from children with no diagnosed speech disorder, will help clinicians make this decision and guide their clinical programming.

If your child participates in this study, your child will receive a free and complete hearing, language, and speech screening. These screenings will involve identifying common objects and pictures. You will be asked to fill out a brief questionnaire regarding your child's medical history and speech-language milestones. The screening process will last approximately 30 minutes. Your child will then take a short break. After this, your child will have a short story read to them from an age appropriate book and be engaged in a short conversation about the book. This portion will also last approximately 30 minutes. The entire session should take approximately 1 to 1 1/2 hours. Your child will probably only need to be seen for one session.

All of the above will be tape recorded and these audio tapes will be used only for research. Your child's name will not be used when results are written up.

Please sign the form below and return to your preschool as soon as possible. I will be scheduling appointments to begin June 17, 1996 at Portland State University Speech and Hearing Clinic. If you have any questions, please feel free to call me at (503) 233-2934. Thank you and I appreciate your participation in this project.

Sincerely,

Karen Ware
Karen Ware

Yes, I will allow my child to take part in this research project regarding speech development in typically developing children.

PARENT'S NAME: _____
CHILD'S NAME: _____
CHILD'S BIRTHDATE: _____
PHONE NUMBER: _____

College of Liberal Arts and Sciences   Department of Speech Communication
Speech and Hearing Sciences Program   503/725-3533

APPENDIX F

INFORMED CONSENT FORM

INFORMED CONSENT FORM

I, _____, agree that my child,
_____, may take part in this research project on
speech intelligibility (i.e. understandability) in typically developing children.

I understand that this study involves my child being screened for hearing and vocabulary and phonological development at the Portland State University Speech and Hearing Clinic by Karen Ware. The screening tools are commonly used for the age group being tested and results in no undue stress for my child. I understand that my child will talk about an age appropriate book for the purpose of eliciting a speech sample of approximately 100 words. This is also a standard activity in preschools and for this age group. My child will be seen for one session which will last approximately one hour.

I understand that, because of this study, my child may feel some initial anxiety due to being in unfamiliar surroundings and interacting with an unfamiliar person.

Karen Ware has told me that the purpose of this study is to begin collecting data on the intelligibility of typically developing children, ages 3:0 to 3:6. This research data will also aid future clinicians in diagnosis and treatment of children with intelligibility deficits by offering clinicians normative data against which to compare a client's intelligibility.

By taking part in this study, my child will receive the benefit of a complete hearing, language, and speech screening. The child will also be participating in a study that will help to increase knowledge that may help others in the future.

Karen Ware has offered to answer any questions that I may have regarding this study and what is expected of my child.

Karen Ware has promised that all information that I give will be kept confidential to the extent permitted by law, and that my child's name and my name will be kept confidential.

I understand that my child does not have to take part in this research and that I may withdraw my child from this research if I desire. This will not affect my relationship with the preschool.

I have read and understand the foregoing information and agree to take part in this study.

Date: _____ Signature: _____
Phone Number: _____

If you have any concerns or questions about this study, please contact the Chair of the Human Subjects Research Review Committee, Research and Sponsored Projects. 105 Neuberger Hall, Portland State University, (503) 725-3417.

APPENDIX G

QUESTIONNAIRE

QUESTIONNAIRE

Child's Name _____ Birthdate _____

Parent(s) _____

Address _____

Parent 1 - Level of education _____

Parent 2 - Level of education _____

Parent 1 - Occupation _____

Parent 2 - Occupation _____

Relationship of person completing the questionnaire _____

1. Has your child ever been diagnosed as demonstrating any of the following:

neurological impairment yes _____ no _____

orthopedic or physical handicap yes _____ no _____

motor or movement impairment yes _____ no _____

2. Has your child had a history of ear infections as indicated by the following:

complained of ear aches yes _____ no _____

had ear aches or ear infections yes _____ no _____

If so, how many times? _____

When was the last time? _____

Has your child had treatments for ear infections? yes _____ no _____

If so, how many times? _____

When? _____

had ventilation tubes inserted? yes _____ no _____

If so, when? _____

Are tubes currently in one or both ears? _____

3. Provide information about speech development:

Is English the primary language spoken in your home? _____

When did your child say his/her first word? _____

When did your child begin to put two words together? _____

Do family members have difficulty understanding your child's speech?

_____

Do persons outside the family have trouble understanding your child's speech?

_____

APPENDIX H

DIRECTIONS FOR LISTENERS

DIRECTIONS FOR LISTENERS

1. Familiarize yourself with each book. *The Relatives Came* was used by the first two subjects; *Good Dog, Carl* was used by the remaining 11 subjects.
2. You may listen to an utterance no more than two times. You may play back the tape a third time to fill in any gaps.
3. If you are unsure of a syllable/word, write what you think you heard with a question mark.
4. Use a slash (/) for each unintelligible syllable/word.

Karen Ware