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Intonation Production And Perception In Children With Developmental Language Impairment

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INTONATION PRODUCTION AND PERCEPTION IN CHILDREN WITH DEVELOPMENTAL LANGUAGE IMPAIRMENT

by

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To my dad, Dr. Dominic Blay

ABSTRACT

Studies on intonation production and perception in children with developmental language impairment (LI) have reported mixed outcomes. Some suggest that intonation processing is impaired in this population but others fail to find any evidence of such a deficit. The issue is further complicated by findings that indicate that these children perform poorly on some intonation tasks but not on others. The source of the discrepant findings is unclear. However, one shortcoming is that most previous studies do not report information on severity of LI of participants. Thus, it may be that the mixed findings on intonation processing in children with developmental language impairment is attributable to severity of the disorder. The present study sought to investigate this possibility. Participants were 33 children with LI and 36 age-matched typically developing controls. Thirteen of the children in the experimental group had mild, 10 had moderate and 10 had severe language impairment. In two experiments, these children's ability to produce (Experiment 1) and perceive (Experiment 2) intonation was assessed. In Experiment 1, participants were asked questions which required them to respond using broad or narrow focus constructions. Fundamental frequency, tonal alignment, word duration and intensity of the intonation contours produced were measured. In experiment 2, participants were presented sentences produced in broad and narrow focus and asked to discriminate between the two types of constructions. The results showed that children with mild LI performed comparably with typically developing peers on the production of all measures. However, the moderate and severe groups demonstrated difficulty producing word duration and intensity. In the perceptual experiment, all children with LI had difficulty discriminating between broad and narrow focus, with children in the severe group performing the poorest followed by the moderate and severe groups. The findings of the present study suggest that severity of language impairment plays a role in the discrepant findings on intonation processing in children with LI. It also suggests that these children may have more difficulty in the production of some acoustic correlates of intonation compared to others. The implications of these findings are discussed.

CHAPTER I

INTRODUCTION

Intonation refers to suprasegmental pitch variations in spoken language that span whole utterances such as sentences and phrases. It is suprasegmental in the sense that it extends beyond more than one segment. The main physical correlate of intonation is fundamental frequency (F0). However, other components of the speech waveform such as intensity and duration may vary concomitantly. Studies suggest that some components of the F0 contour are phonological whereas others are phonetic (Ladd, 1983; Seddoh, 2000; t Hart, Collier & Cohen, 1990).

Intonation conveys grammatical distinctions such as the difference between statements (e.g., “He ate the cake”) and matched echo questions (e.g., “He ate the cake?”). It also signals emotional (e.g., happiness) and attitudinal (e.g., politeness) meanings, as well as speaker intent including speech acts such as requesting, affirming and questioning. Further, it conveys new and contrastive information in focus constructions such as (1) and (2) below, respectively (Cruttenden, 1997; Halliday, 1967; Krifka, 2008; Ladd, 1980).

(1) New: Did anything newsworthy happen today? *Her dad mailed the books.*

(2) Contrastive: Did her mom mail the books? No, her *dad* mailed the books.

Studies of intonation in children with developmental language impairment (LI) are limited, and findings are mixed. Some show that these children have impaired ability to identify emotional meanings conveyed by intonation in different syntactic structures including phrases (Berk, Doehring & Bryans, 1983), sentence (Courtright & Courtright; 1983; Trauner, Ballantyne, Chase & Tallal, 1993) and discourse (Fujiki et al., 2008). For example, Berk, Doehring and Bryans, (1983) reported that their subjects were impaired in perception of emotions conveyed in phrases and sentences that were 2-5 syllables long. A similar finding was reported by Fujiki and colleagues (2008) who used short stories as stimuli.

These findings suggest that intonation perception problems in LI may be rooted in grammatical processing deficit. However, this population has been reported to have emotional processing problems that can also account for these findings (Botting & Conti-Ramsden, 2008; Taylor, Maybery, Grayndler & Whitehouse, 2015). Botting and Conti-Ramsden's (2008) subjects performed significantly worse than their age-matched peers on tasks requiring identification of emotions shown in photographs of the eye region. Similarly, the 5-9 year-old children with LI tested by Taylor, Maybery, Grayndler and Whitehouse (2015) had difficulty identifying emotional information in photographs of whole faces. It is possible that the poor performance on perception of intonation in emotional speech in this population is due to primary impairment in processing emotion. However, it could also result from both linguistic and emotion processing deficit.

The involvement of underlying linguistic deficit is consistent with the nature of LI as a language disorder. Data indicate that these children are impaired in processing various levels of language including phonology (Briscoe, Bishop & Norbury, 2001; Estes, Evans, & Else-Quest, 2007) syntax (Deevy & Leonard, 2004; de Villiers, de Villiers & Roeper, 2011), pragmatics (Norbury, 2005a; Norbury, 2005b), morphology (Bishop, 1994; Leonard, 2014; Oetting & Rice, 1993; Rice, Wexler, & Cleave, 1995) and semantics (Kan & Windsor, 2010). They also perform poorly on intonation processing in not only emotional speech, but also focus constructions (Baltaxe & Guthrie, 1987; Highnam & Morris, 1987; Wells & Peppé, 2003). Baltaxe and Guthrie (1987) reported that their 3-year old subjects with LI erroneously assigned focus to the first stressable syllable instead of the last one when describing an action performed by a toy. Highnam and Morris (1987) also asked a group of children with LI to distinguish appropriately marked focus from inappropriately marked ones in questions paired with answers. They found that the children failed to perceive the difference.

These reports also implicate primary linguistic deficit as the basis of the intonation processing problem for children with LI. However, some studies suggest that the degree of involvement of this underlying deficit might be limited. Van der Meulen, Janssen and Os (1997) reported that 4- to 6- year old children with LI performed comparably with their age-matched peers on identification but not imitation of intonation conveying emotional or grammatical distinctions. The 8-year old children tested by Wells and Peppé (2003) also performed well on production but not perception of focus or production and perception of intonation in emotional contexts. The poor performance of these children on some but not all stimuli suggests that the problem for these children may go beyond an underlying linguistic deficit. Further, Snow (Snow, 1998; 2001; 2015) reported that four-year olds with LI performed comparably with age-matched controls on tasks involving imitation and spontaneous production of falling and rising intonation contours in statements, yes/no questions and list constructions (pig, dog, horse, puppy). These data, taken together, suggest that there may be additional factors that contribute to the poor performance of children with LI on intonation processing tasks.

The source of the discrepant findings is unclear. One possibility has to do with methodology. Stimulus and elicitation procedures vary for different studies. The studies that failed to find abnormality in the children's productions used tasks involving imitation (Snow, 1998) and spontaneous productions of lists of nouns (Snow, 2015) or single words, phrases and short sentence-like structures (Snow, 2001) elicited during play. By contrast, subjects in studies that reported abnormality (e.g., Baltaxe, 1984; Baltaxe & Guthrie, 1987) were required to produce and/or perceive complex structures including sentences with prepositional phrases (e.g., "Pat is sitting on the chair") (Baltaxe, 1984) and discourse (Fujiki et al., 2008). These differences in stimuli may be implicated in the mixed reports on intonation processing in children with LI.

Another factor that may account for the discrepant findings is difference in the severity of language impairment of participants. Most studies do not report severity levels of their participants. It may therefore be that children who perform poorly on tasks have more severe language impairment compared to those who perform comparably with age-matched typically developing peers. The present study sought to determine whether the discrepancy in findings on intonation processing in children with LI are related to the severity of the disorder. The following research question will be explored:

(1) Are the discrepant findings on intonation processing in children with language impairments attributable to severity of the disorder?

If the discrepant findings are due to severity of language impairment, then there may be differential outcomes on the production and perception of intonation. Children with milder levels of impairment may perform comparably with controls but those with more severe impairment may perform abnormally. On the other hand, if the discrepancy is unrelated to severity, then these children might perform comparably with age-matched peers on production and perception of intonation regardless of severity.

CHAPTER II

LITERATURE REVIEW

Grammatical difficulties are considered to be the hallmark of children with language impairment (LI) and have been the focus of many studies (Hsu & Bishop, 2010; Leonard, 2014). Although intonation is an essential component of grammar, intonation studies on children with LI are limited. In this chapter, studies on its production and perception in children with LI are reviewed.

Intonation Production in Children with Language Impairment (LI)

Recall that focus is an aspect of grammar that contributes to information packaging in sentences. It has to do with indicating prominence on a particular part of a message. Focus is marked by intonation and cleft constructions (Delin, 1990; Gussenhoven, 2008) as shown below in responses 1 and 2 respectively to the question, "Did she mail books".

(1) No, she mailed **letters** (focus on "letter" marked by intonation).

(2) No, it was **letters** that she mailed (focus on "letters" marked by cleft construction involving fronting of the object of the sentence).

Focus is often used to indicate that a portion or a whole utterance is new information. For example, the speaker in response 3 uses intonation to focus ***dad*** as indication that ***dad*** is new to the discourse. This type of focus, which involves a part of a sentence, is called narrow focus. In narrow focus, emphasis is placed on the stressable syllable in the new word. On the other hand, in response 4, the speaker focuses the whole utterance to indicate that everything said in the sentence is new to the discourse. This type of focus is known as broad focus. In broad focus, emphasis usually falls on the last stressable syllable (Cruttenden, 1997; Ladd, 1980). .

(3) Narrow: Did her mom mail the books? No, her ***dad*** mailed the books.

(4) Broad: Did anything newsworthy happen today? ***Her dad mailed the books***.

Children with language impairment have been reported to have deficit in the production of intonation (Fujiki, Spackman, Brinton & Illig, 2008; Highnam & Morris, 1987; Marshall, Harcourt-Brown, Ramus & van der Lely, 2009). Although there are few exceptions (e.g., Wells & Peppe, 2003), the findings of many studies suggest that the ability to use intonation to mark focus is especially difficult for these children. Children with LI are reported to misassign narrow focus in spontaneous speech (Hargrove & Sheran, 1989) and in answering sentences elicited with yes/no questions (Baltaxe, 1984). Baltaxe (1984) introduced children with LI, those with autism and typically developing children to a play situation (e.g., a doll called Pat sitting on a chair). They asked the children a question that was counterfactual to the situation they had been shown (e.g., Is *Mike* sitting on the chair?). A response was considered correct if subjects used a subject-verb-object (SVO) construction and focused the word that was in contrast with the question. Two listeners judged whether the children used narrow focus in their responses or not. They found that the children with autism performed the poorest followed by the children with LI and age-matched peers. However, all children provided responses only 60% of the time, likely due to the artificiality of the task.

In a sister study conducted on the same children, Baltaxe and Guthrie (1987) found that their subjects with LI (aged 3 years 8 months to 10 years 8 months) erroneously assigned broad focus to the first stressable syllable instead of the last one when describing an action performed by a toy. The findings of this study did not seem to be due to task artificiality. In this study, an examiner manipulated toys while asking ‘What’s happening?’ to elicit broad focus. The findings of this study suggests that the children’s poor performance might have been due to difficulty producing focus itself rather than methodological limitations (e.g., task artificiality).

An interpretation for these children’s poor ability to produce intonation is difficult. Focus is influenced by aspects of language such as phonology (Xu & X, 2005), syntax (Buring, 2012; Cormack & Smith, 2000; Kiss, 1998), pragmatics (Buring, 2012; Cormack & Smith, 2000; Zimmerman & Onea, 2011) and semantics (Buring, 2012; Kiss, 1998; Rooth, 1992). Performance of tasks involving its production and perception can be affected by primary impairment in any of these components of grammar. Each of these grammatical components has been found to be abnormal in children with LI (for phonology see, Briscoe, Bishop & Norbury, 2001; Estes, Evans, & Else-Quest, 2007; for syntax, see Deevy & Leonard, 2004; de Villiers, de Villiers & Roeper, 2011; for pragmatics see, Norbury, 2005a; Norbury, 2005b; for morphology see, Bishop, 1994; Leonard, 2014; Oetting & Rice, 1993; Rice, Wexler, & Cleave, 1995 for semantics, see Kan & Windsor, 2010). Thus, the poor performance might be as a result of deficits in any of the other aspects of language.

Such an interpretation would be consistent with Hargrove and Sheran (1989)’s findings that suggest that underling syntactic and/or pragmatic deficit may play a role in the children's performance on focus production. These authors sampled 5 children with LI over a period of about a year (age at first sample was 2 years 9 months to 3 years 10 months). They described syllables that they perceived as prominent (i.e., as given vs. new information, initial vs. final position, semantic category). The data were compared to outcomes for typically developing (TD) children in an earlier study by Wieman's (1976). The researchers reported that three of the children with LI consistently focused the final word regardless of whether it was new or given information. This error shows that the children did not have the ability to understand contextual meaning in order to focus the right constituent. One of the children tended to rotate between position (initial vs. final) and informativeness (given vs. new) suggesting difficulty with both syntactic position and pragmatic meaning. Only one subject focused new information similar to what Wieman (1976) observed in normal children.

While attributing the problem to deficit in other aspects of language has some evidentiary support, the findings of some studies suggest that the problem for these children may have to do with producing intonation itself. Some studies reported that intonation contours produced by children with LI differ from those of TD children. Ringeval et al. (2011) showed that intonation contours produced by children with LI differed from those of their TD counterparts. These researchers investigated ability to imitate different intonation patterns (e.g., descending and rising contours) in children with LI, those with autism, those with pervasive developmental disorder-not otherwise specified (PDD-NOS) and age/gender matched peers. Productions were compared with pre-recorded contours based on a recognition score. The experimental groups' intonation recognition scores were compared with those of TD controls and found to be significantly different. Similarly, Baker (2013) investigated the ability of 17 children with LI to use intonation to indicate turn-taking. Subjects (mean age 6 years 5 months) were interviewed and their productions analysed for rising and falling contours. Falling contours at utterance syntactic boundaries were considered to be an indication of turn-taking. The authors found that children with LI used less falling intonation contours to indicate turn-taking compared to age-matched peers.

In contrast to the reports of abnormal intonation contours, Snow (1998; 2001; 2015) measured some features of intonation contours produced by children with LI and found that these features are comparable to those of age-matched peers. Four-year olds with LI were reported to perform comparably with age-matched controls on imitation (Snow, 2001) and spontaneous production (Snow, 1998; 2015) of falling and rising intonation contours in statements, yes/no questions and list constructions (pig, dog, horse, puppy).

The source of the discrepancy in these production data is unclear. However, methodological shortcomings such as small sample sizes characterize many studies on intonation in this population. For example, Hargrove and Sheran, (1989) tested only 5 children. Both Baltaxe (1984) and Baltaxe and Guthrie (1987) recruited 7, and Highnam and Morris (1987) as well as Snow (1998; 2001; 2015) recruited 10 children with LI.

Another weakness in previous studies has to do with lack of or limited information on the severity of language impairment in children with LI. For instance, Ringeval et al. (2011) did not report the level of language impairment of their participants. Baker (2013) reported a combined expressive (66.2) and receptive (81.79) score which makes it difficult to determine whether majority of the participants had severe impairment or not. Snow (2001) reported z-scores for only a few of his participants whereas Snow (2015) showed different scores for different participants- for some of the participants he reported z-scores, percentile scores and/or standardized scores. Due to these inconsistencies in report of severity, it is unclear whether severity of impairment in participants affected performance on intonation production.

In the same vein, complexity of stimuli analysed in the different studies vary. It seems like stimuli analysed in studies that report abnormality are more complex compared to those that report normal intonation contours. In Baker (2013)'s study, the children's responses in an interview (e.g., "and and I don't know what to name him j- j- just he looks like like have the gear like he look like like him Cobramander") were analysed. On the other hand, the stimuli analysed in Snow's studies were simple. Snow (1998) analysed single words or short phrases (e.g., cat, a book) produced by their participants. Participants in Snow (2001)'s study repeated simple sentences (e.g., This is the pig) and those in Snow (2015) spontaneously produced a list of 3-5 simple words. While the choice of these stimuli might have been influenced participants' age, overall simplicity might still have influenced study outcomes.

Taken together, the difference in severity levels of participants coupled with differences in stimuli analysed makes it difficult to account for the source of the discrepancy. To better understand this issue, studies that account for stimulus complexity as well as severity of impairment are needed.

Intonation Perception in Children with LI

A large number of the studies that have investigated intonation perception in children with LI have focused on emotions. Similar to findings on production, most of these studies found that children with LI performed poorly compared to age-matched peers. Courtright and Courtright (1983) examined children with LI's ability to perceive emotional meanings conveyed by intonation. They tested 25 children (3 years 1 month to 7 years 3 months) with language impairment and 24 typically-developing controls (3 years 2 months to 6 years 11 months). A phrase was recorded in four (happiness, anger, loving and sadness) different emotions by 3 speakers (total of 12 stimuli). These utterances were presented to subjects who were required to point to one of four pictures depicting the emotions being tested. The researchers found that the experimental group were less accurate in identifying emotions conveyed by intonation.

It is worth mentioning that Courtright and Courtright (1983)'s study is limited in that only 3 sentences per emotion were tested. However, studies that have used a larger number of stimuli and different research approaches have also reported that children with LI perform poorly on perceiving emotions conveyed by intonation. For example, Berk, Doehring and Bryans (1983) tested 19 children (5 to 11 years) who had LI. Subjects were presented 30 phrases: 10 conveyed sad, 10 conveyed happy and 10 conveyed angry emotions. They were asked to indicate the emotion conveyed by pointing to a picture. The children with LI performed significantly below normal controls.

The difficulty exhibited by children with LI on processing intonation in emotional contexts is not limited to simple sentences but extends to narrative discourse. Fujiki et al., (2008) examined the ability of children with LI to understand emotion conveyed by intonation in a narrative passage. Subjects were 19 children with LI and their chronological age-matched peers. They were sampled from the age range of 8 years to 10 years 10 months. These children were asked to listen to a seven-sentence narrative read by actors (happiness, anger, sadness, and fear) and indicate what emotion the speaker expressed. The children with language impairment performed poorer compared to their age-matched TD peers in identifying the emotions. The outcomes suggest the possibility that underlying primary emotion processing deficit may be a culprit in the problem exhibited by these children. This possibility is consistent with studies that have reported that children with LI have co-morbid emotional and social difficulties (Conti-Ramsden & Botting, 2008; St. Clair, Pickles, Durkin & Conti-Ramsden, 2011).

The possibility that the poor performance on intonation in emotional context is attributable to an underlying primary emotional processing deficit is corroborated by studies that examined children with LI's ability to perceive emotions in both speech and facial expression. Taylor et al. (2015) tested 18 children with LI, 29 children with autism and 66 typically developing subjects (5 years - 9 years 6 months). In one condition, the participants saw photographs of people expressing one of six emotions (happy, sad, scared, angry, surprised, disgusted) on the face. In another condition, the participants heard a sentence that conveyed one of the six emotional expressions vocally. They were required to indicate emotions presented on the computer screen. Taylor and colleagues reported that all clinical groups including the children with LI were less accurate than the TD children in their identification of emotions on the face and in the voice. This finding suggests that basic emotions such as happy, sad and angry are difficult for these children regardless of modality.

Similar findings were reported by Creusere, Alt and Plante (2004). These researchers examined the ability of children with LI (4 and 6 years 5 months) and age-matched typically developing peers to judge vocal affect and facial cues using four types of stimuli. They videotaped speakers as they produced utterances in a manner that indicated happiness, sadness, anger and surprise. Two- to 4-second long segments, selected from the videos, were presented to subjects in four different conditions. In one condition, participants were presented a portion of the face and unaltered speech video recording. This condition served as the control. In another condition, subjects were shown face only. In a third condition, they were presented low-pass filtered (masking of lexical content so that the stimuli sound like muffled speech) speech only. A fourth condition involved low-pass filtered speech and facial expressions. Subjects were presented these stimuli and asked to identify the emotion conveyed in each segment. All groups performed comparably on filtered (non-speech) and face-only conditions. However, the experimental group differed from controls on the task involving the unaltered speech and face stimuli, with children with LI performing poorly compared to controls.

Boucher, Lewis, and Collis (2000)'s findings also support the possibility of a primary emotional processing deficit in children with LI. The authors compared performance of children with LI (mean age was 9 years) on a test of vocal–facial affect matching with those of children with autism. Participants were presented audio recordings of phrases conveyed in one of six emotions (happy, sad, scared, angry, surprised or disgusted). They were required to label the emotion that they heard and select a photograph that conveyed the same emotion. The children with LI performed significantly worse than the children with autism and the TD children on both the naming and matching components of the tasks.

By contrast, findings of some studies fail to support an underlying primary emotional processing deficit. Trauner et al. (1993) found that children with LI performed poorly on perceiving intonation in emotional contexts but not in the visual domain. This suggests that the problem may not be solely related to underlying primary emotion processing deficit. Furthermore, the difficulties exhibited by children with LI in perception go beyond emotion. Highnam and Morris (1987) studied focus perception in 10 LI children (9; 9-12; 11) and 10 age- and gender-matched peers. Subjects were presented with question-answer pairs and asked to judge whether an answer was appropriate to a question. Children with LI performed poorly on this task.

Perhaps the poor intonation perception ability exhibited by these children is attributable to poor phonetic perception in children with LI. As indicated in Chapter I, the acoustic correlates of intonation are fundamental frequency (F0), intensity and duration. Studies have shown that children with LI have low sensitivity to these acoustic features (Corriveau, Pasquini & Goswami, 2007; Hill, Hogben & Bishop, 2005; McArthur & Bishop, 2004; Mengler, Hogben, Michie & Bishop, 2005; Richards & Goswami, 2015). Thus, these researchers suggest the problem for these children may have to do with lower-level phonetic processing.

One of such studies that indicate a link between lower-level phonetic processing and prosodic problems is Richards and Goswami (2015)'s study. These authors investigated the relationship between the perception of acoustic properties such as F0 and amplitude and perception of linguistic stress. In one task, the researchers examined their subjects' ability to perceive F0 and amplitude. In another task, the subjects were presented a word produced with "deedee". They were expected to identify the name of the character they heard based on the stress pattern of the utterance. Participants were 12 children with LI (8 years 9 months to 12 years 1 month) and 10 typical controls (9 years 7 months to11 years 6 months). The researchers reported that the LI group scored significantly below the typically developing controls on stress perception. As well, performance on the stress task correlated with subjects' performance on amplitude and frequency identification threshold. While this finding showed a relationship between perception of nonlinguistic acoustic properties and linguistic stimuli, it is difficult to establish a causal relationship between these two types of perception.

An alternate interpretation for the poor performance of children with LI is difficulty processing linguistically relevant components of the F0 contour. Data indicate that specific portions of the F0 contour are important for the perception of meaning (D' Imperio, 2000; t'Hart, Collier & Cohen, 1990). For example, D' Imperio (2000) reported that timing of portions of the F0 contour with segments is among the cues that listeners depend on to perceive grammatical distinctions (such as statements and yes/no questions). It may therefore be that the difficulty experienced by children with LI may have to do with the processing of these linguistically-relevant components that convey meaning.

The above possibility is challenged by studies that have investigated multiple functions of intonation in comprehension and production modalities. Studies that have investigated both intonation production and perception in the same participants have reported mixed findings. Van der Meulen and Janssen (1997) failed to find evidence of deficit in emotion perception in a study in which they compared the receptive and expressive prosodic abilities of children with LI to those of a matched normal controls.

Subjects (4- to 6-year olds) were presented two types of stimuli. In one, they were required to imitate sentences conveying grammatical and emotional meanings. In the second stimuli, subjects were required to identify emotions conveyed in neutral content sentences. The LI subjects performed poorly on the imitation task but did not differ from controls on the emotion identification task. If the performance of these children had been due to difficulty producing and/or perceiving linguistically-relevant aspects of intonation alone, these children would have been expected to perform poorly also on emotion identification tasks.

Two studies (Marshall, Harcourt, Ramus and Van der Lely, 2009; Wells & Peppe, 2003) that used the Profiling Elements of Prosodic Systems-Child version (PEPS-C) (Peppe´ & McCann, 2003) also reported mixed findings. The PEPS-C assesses receptive and expressive skills, and targets four different functions of intonation. It investigates grouping of words to delimit speech into ‘chunks’, focus processing, emotion or attitude conveyed by intonation. It also assesses aspects of intonations such as requesting for repetition or an understanding of what a speaker has said. Using this test, Wells and Peppe, (2003) tested 18 8-year old children with speech and/or developmental language disorders (LI), 28 chronological age (CA) matched typically developing controls and 18 children matched for language comprehension (LC). The children with LI scored significantly lower on 5 of 16 tasks compared to CA controls. The experimental group had difficulty discriminating between stimuli that had no segmental information, interpreting meaning conveyed using focus constructions. They also had difficulty perceiving pragmatic meanings such as requesting, affirming and questioning.

Marshall, Harcourt, Ramus and Van der Lely (2009) who tested older children (10–14-year-olds) with LI and dyslexia, only LI, and only dyslexia. These subjects were compared with an age-matched control group and two younger control groups matched for various aspects of language and reading. They found that majority of children with LI and/or dyslexia performed well on the tasks that tested auditory discrimination and imitation of prosodic forms. The subjects with LI and/or dyslexia performed poorly on the tasks that had segmental information but comparable with controls on the task that did not have segmental information (low-pass filtered stimuli). The authors concluded that since the children performed poorly on low-pass filtered stimuli but not on stimuli that involved perceiving pragmatic meanings, intonation itself does not appear to be core impairment in children with LI. Such a conclusion is inconsistent with the nature of intonation as it suggests that intonation of an utterance constitutes an independent communication channel. As already discussed, intonation production interacts with other components of language. Thus, low-pass filtering stimuli render them unnatural.

Perhaps the discrepancy in findings is influenced by non-linguistic deficits which may affect performance on intonation tasks. Children with LI have sustained attention (Ebert & Kohnert, 2011; Jongman, Roelofs, Scheper & Meyer, 2017; Lum, Conti-Ramsden, & Lindell, 2007) and phonological working memory (Alt, 2011; Hutchinson, Bavin, Efron & Sciberras, 2012; Vugs, Hendriks, Cuperus & Verhoeven, 2014) deficit which may contribute in part to their poor performance on tasks. Sustained attention (SA) refers to the ability to maintain alertness for a prolonged period of time (Posner, 2012). Phonological working memory (PWM), on the other hand, refers to the ability to maintain a limited amount of verbal information during a brief period, in order to organize, differentiate, and use this information (Baddeley, 2003; Baddeley & Hitch 1974). Some tasks may rely more on these cognitive faculties than others. It may therefore be that these children's performances were influenced by their PWM and SA. However, since most studies do not directly measure these cognitive abilities in their studies, the validity of this possibility is unclear.

Further, the differential performance of children with LI on different tasks suggest the possibility that the participants within a study may vary in their language abilities. As with any disorder, LI varies in severity. Thus, children with a mild form of the disorder may perform better than those with a severe form of it.

Summary

Overall, findings on intonation production and perception in children with LI are mixed. Methodological limitations such as small sample sizes and stimulus complexity may contribute to this discrepancy in findings in studies. Another limitation of previous studies is that many studies provide no information on severity of LI for their experimental subjects. Differences related to this aspect of the disorder could reflect as differential outcomes. If the group of people recruited to participate in a study generally have severe impairment, they may perform poorly on intonation tasks whereas a group of children who have predominately mild language impairment may exhibit subtle difficulty processing intonation in these tasks.

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CHAPTER III

RESEARCH METHOD

Experiment 1: Production

Participants

Sixty-nine children, aged 7 years 6 months to 11 years 11 months, participated in the study. There were 33 children with developmental language disorder (LI) and 36 age-matched typically developing controls. All participants:

1) Were growing up in monolingual English-speaking homes.

2) Had normal hearing as determined by standard audiometric screening (American National Standards Institute, 1991) conducted in their schools.

3) Had normal overall development as determined by parent reports.

4) Had mothers who had at least a high school education.

The children with LI were made up of 20 boys and 13 girls. Their ages ranged from 7 years 6 months to 10 years 11 months. They were all elementary students in public schools in the states of North Dakota and Minnesota in the United States. Seven of these children were in their first year in elementary school, 8 were in their second year, 7 in their third year, 8 in their fourth year and 3 in their fifth year. Each was diagnosed with language impairment by a certified speech language pathologist. The diagnosis was based on results of formal and informal assessments. The formal assessment was conducted using standardized language batteries (e.g., *Clinical Evaluation of Language*

Fundamentals-fifth Edition (CELF-5*;* Wiig, Semel & Secord, 2013). The informal assessments included language sample analysis, teacher and parent reports.

All children in the experimental group were receiving treatment at the time of recruitment. The period they had been in treatment ranged from 2 to 6 years. Additionally, three of the students, Exp. 15, 24 and 32 (shown with an asterisk in Appendix C) had received treatment for speech sound disorders. Children who had language impairment with comorbid conditions such as attention deficit hyperactive disorder and autism spectrum disorders were excluded from the study.

The control group was made up of 20 boys and 16 girls. Their ages ranged from 7 years 7 months to 10 years 11 months. They were all elementary students in public schools in North Dakota. Eight of them were in their first year in elementary school, 10 were in their second year, 7 were in their third year, 9 in their four year and 2 in their fifth year. All children had normal speech and language abilities as determined by a case history interview with the parents.

Formal Psychometric Assessments

In order to determine the current language status of the participants, the core language composite of the *Clinical Evaluation of Language Fundamentals-Fifth Edition* (CELF-5; Wiig, Semel & Secord, 2013) was administered. This composite has a normative mean of 100 and a standard deviation of 15. Participants' scores on this battery and all other formal psychometric assessments are reported in Appendix C. In order to determine severity levels of the children with LI, children who scored between 78-85 (within -1 and -1.5 SD below the mean) were classified as indicating mild language impairment; those who scored 71-77 (-1.5 to -2 *SD* within the mean) were classified as having moderate language impairment and those who scored 70 and below (-2 *SD* and below) were classified as having severe language impairment. Altogether, 13 children scored within the mild range, 10 in the moderate range and 10 in the severe range. Performance on the CELF was also used to determine eligibility for the control group. Children in the control group were required to score above 100.

Cognitive abilities such as phonological working memory, henceforth phonological memory, non-verbal intelligent quotient (IQ) and sustained attention (SA) were also measured to determine participants' current level of cognitive processing. Phonological Memory was assessed using the Phonological Memory Composite of the *Comprehensive Test of Phonological Processing-Second Edition* (CTOPP-2; Wagner, Torgesen, Rashotte & Pearson, 2013). This composite has a normative mean of 100 and a standard deviation of 15. Non-verbal IQ levels of all participants were assessed using the Brief IQ Composite of the *Leiter International Performance Scale-Revised* (Leiter-R; Roid & Miller, 1997) which also has a normative mean of 100 and standard deviation of 15. Finally, sustained attention, which is the ability to maintain alertness over an extended period of time, was assessed using Attention Sustained subtest of the *Leiter International Performance Scale-Revised* (Leiter-R; Roid & Miller, 1997).

Stimuli

Stimuli were made up of forty names of common objects (e.g., door, dog) written on a 2.5" X 2.5" picture cards. The cards were selected from Mini Apraxia Photo Flash Cards (Webber & Super Duper Publications, 2014). Each card showed a picture and a name of an object written underneath. The names were one- or two- syllables long. They were made up of voiced sounds (mostly sonorants). The names were made up of voiced sounds to ensure that the fundamental frequency (F0) contour is easily identifiable on a spectrograph. Henceforth, these names are referred to as the target words. In addition to the target word, twenty cards that also had pictures and names of everyday objects were used as foils. Thus, a total of 60 stimuli were used in this experiment. A full list is shown in Appendix B. Target words and foils were inserted in the carrier phrase "_______ made the lemonade" was used.

Procedure

The experiment was conducted in a quiet well-lit room that was free from distractions. All participants performed two tasks. In one task, they were required to produce broad focus and in the other narrow focus. Recall from Chapters I and II that focus is an aspect of grammar that has to do with placing emphasis on a whole sentence (broad focus) or a part of it (narrow focus).

Both the broad and narrow focus tasks began with a familiarization phase during which the picture cards were introduced to participants. In this phase, participants were asked to label each card to make sure they could produce the words. For the broad focus elicitation task, the experimenter exemplified the task by inserting a word on one of the cards into the frame, "_____ made the lemonade". In producing this type of construction, the children were expected to focus the entire syntactic frame and not only the target word. Test stimuli were presented after successful completion of the practice phase.

For the narrow focus task, the children were informed that they were going to play a game in which the experimenter would ask questions about someone or something making lemonade. In their response, they were required to determine whether the name on the card they were shown was congruent with the name mentioned by the researcher.

For example, they were shown a picture of a dog and asked “Was it *cat* that made the lemonade? Participants were expected to respond “No, *dog* made the lemonade”. Responding in the negative required subjects to emphasize the contrasting word, *dog*. On the other hand, when they were shown a picture of a cat and asked the same question, the children were expected to answer in the affirmative using broad focus. When they exhibited ability to respond in the negative and affirmative when shown target words and foils respectively, the test stimuli were administered. The cards were presented one at a time. For each subject, the foils and target words were randomized. All 60 cards were administered in one session.

Recording Procedure

Sentence productions were recorded on to a WavePad Sound Editor 4.52 program using an Audio-Technica cardioid condenser (AT2020 USB) microphone mounted on a tripod stand. The mic was connected to a Dell computer via a universal serial bus (USB) port and placed about 5 inches away from the mouths of subjects. The WavePad Sound Editor program made it possible to digitize and store the signal on the computer.

Acoustic Analysis

Files saved on the WavePad program were imported to Praat (Boersma & Weenink, 2016) for acoustic analysis. Praat made it possible to display the F0 contour, intensity, spectrogram, and waveform of each sentence. An example is shown in Figure 1. The target words and their onsets and offsets labelled ON and OFF, respectively, were identified. High and low turning points of the F0 contour associated with the target word were identified and labelled H and L, respectively.

Measures

Several studies have demonstrated that narrowly focused elements are more acoustically prominent than broadly focused elements (Breen, Fedorenko, Wagner & Gibson. 2010; Cooper, Eady & Mueller, 1985; Couper-Kuhlen 1984, Katz & Selkirk, 2011, Krahmer & Swerts 2001). Some features that have been proposed to be associated with prominence include pitch (i.e. F0) (Cooper et al. 1985; Eady and Cooper, 1986), duration (Fry, 1955), loudness (i.e. intensity) (Kochanski, Grabe, Coleman, & Rosner, 2005; Turk and Sawusch, 1996). These features are explained below:

F0 range. Pitch range was calculated as the arithmetic difference between the maximum and minimum points on the portion of the F0 contour associated with the target word. The maximum and the minimum points represented the highest (H) and lowest (L) turning points, respectively, of the F0 contour expressed in hertz.

F0 alignment. Alignment refers to the timing of specific portions of the F0 contour to occur with stressed syllables with which they are associated. To measure alignment, F0 peak associated with the target word was identified. Next, the end of the target word was identified (B in Figure 1). The time from the beginning of the contour (A) to the peak (H) was measured. The time from the beginning of the contour (A) to the end of the target word (B) was also measured. To determine the alignment of the peak (H) with the end of the target word (B), the timing of H was subtracted from B (B-H).

Target word duration. The length of target words in both broad and narrow focus was measured as the distance from the onset of the target word (A) to the end of the same word (B).

Intensity. Intensity, perceived as loudness, was also measured in both broad and narrow focus constructions. The highest point of the intensity contour (yellow line in Figure 1) associated with the target word was measured.

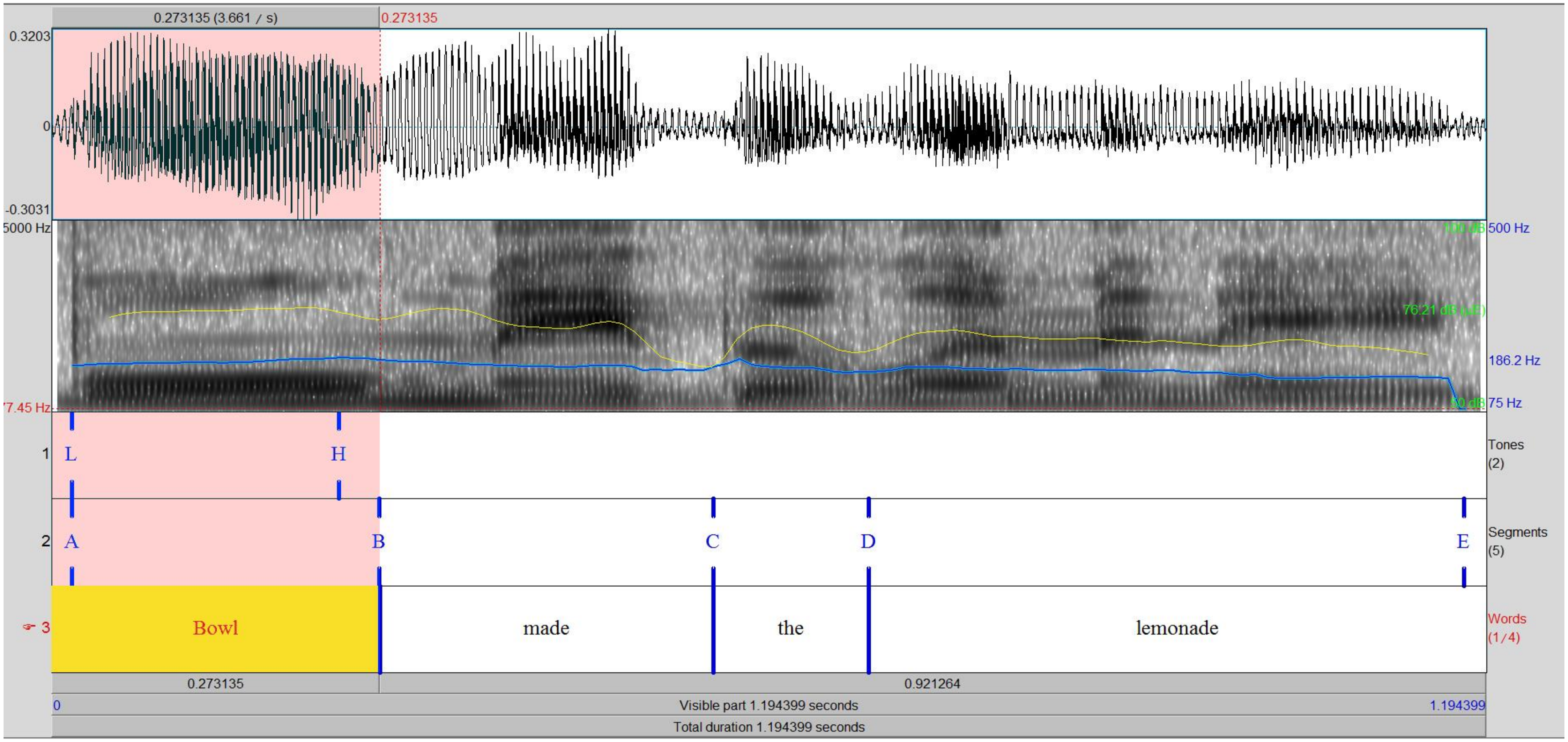

Figure 1**.** Waveform (first upper panel) and spectrogram (second upper panel) showing F0 (blue line/first line from the bottom) and intensity contours (yellow line/second line from the bottom) of the utterance "*Dog made the lemonade*" produced with broad focus by a 50-year old female native speaker of English*;* L=F0 valley; H= F0 peak; A= onset of target word; B=offset of target word; C =offset of verb; D=onset of final word; E=offset of final word.

Statistical Analysis

To determine whether children in the three LI groups differed from the controls in distinguishing between broad and narrow focus, a mixed design multivariate analysis of variance (MANOVA) was conducted. The between-subject variables were Group (mild, moderate, severe, control) and the within-subject variable was Focus (broad, narrow). The dependent variables were pitch range, tonal alignment, target word duration and intensity.

Experiment 2: Perception

This experiment was conducted to determine whether the performance of the children in the production experiment will be similar in perception.

Participants

Participants were the same subjects who participated in experiment 1.

Stimuli and Their Preparation

Stimuli for this experiment were 40 pairs of sentences. Half of the sentences conveyed broad focus and the other half conveyed narrow focus. All sentences were produced by a 50-year old female native speaker of English. The productions were elicited using the 40 target cards that were used in experiment 1. The list of sentences can be found in Appendix B.

The speaker was instructed to produce each sentence as naturally as possible. In the narrow focus set, she produced the sentences in response to a question that was counterfactual to the word presented to her. For example, she was shown a picture of a "moon", and was asked "Was it star that made the lemonade?" She was required to say "No, *moon* made the lemonade" (with emphasis on "moon"). In the broad focus set, she was asked a question to which she had to reply in the affirmative and therefore would not have to emphasize the target word. For example, when she was shown a card of a “moon”, she was asked “Was it moon that made the lemonade?” The expected response was “Yes, moon made the lemonade”.

Recording

The stimuli were recorded using the same procedure outlined for experiment 1. They were edited to identify and remove artefacts such as clicks and pops using WavePad program. Each narrow focus construction (e.g., *Dog* made the lemonade) was paired with its broad focus counterpart (e.g., Dog made the lemonade). To counterbalance for order effects, the stimuli were randomized and duplicated to create two different sets.

Reliability

In order to determine whether the edited stimuli were age appropriate, they were presented to 6 typically developing children between ages 7 and 11 years (mean age = 8 years 1 month) to judge. These children were native speakers of English. None of these children participated in the experiment. Three sentences were removed and replaced because 5 of the judges indicated that they were unclear.

Procedure

The stimuli were presented to participants auditorily by playing them from a computer through loudspeakers. The presentation was done in a quiet setting at a pace and volume comfortable for subjects.

Before presentation of the stimuli, the children were informed that they were going to play a “listening” game. As part of the game, they would listen attentively to what the speaker would say and answer some questions. They were told that the lady they would hear was responding to questions. Some of her sentences were meant to correct her conversation partner (interlocutor) who had asked a question (e.g., Was it *cat* that made the lemonade?). Others were just meant to inform her interlocutor. When she was correcting her interlocutor, she answered by paying attention to the right word (narrow focus) so the person asking the question could know the correct answer. When she was informing, she did not pay specific attention to any word. Subjects were also told that they had to listen to each pair of sentences and determine which sentence indicated that the lady was correcting the person asking the questions.

Three examples with exaggerated intonation were played after the experiment had been explained. The exaggerated intonation examples were meant to highlight the difference between the pairs so that the children could readily understand the requirements of the task. After this, six practice examples were played. Three of the practice examples had exaggerated intonation and 3 were normal intonation. All children demonstrated understanding of the task by responding correctly to at least the 3 sentences with exaggerated intonation. The stimuli were administered after the practice examples.

Scoring

For each sentence pair that was played, subjects had to indicate whether the first or the second indicated narrow focus. They also had the option of indicating that they did not know the answer. They verbally indicated their response to each stimulus. This response was marked on a sheet by the researcher. A copy of the response sheet can be found in Appendix C. After the experiment, the number of correct responses was calculated. In cases where children indicated that they did not know the answer, their responses were scored as incorrect.

Statistical Analysis

To determine whether children with LI differed from age-matched typically developing peers on ability to perceive a distinction between broad and narrow focus, a one-way analysis of covariance (ANCOVA) was conducted. Group (Mild, Moderate, Severe, Control) was the independent variable and Score (percent correct on the perceptual task) was the dependent variable. The task required participants to pay attention to the stimuli in order to respond appropriately. Thus, scores on the sustained attention subtest of the LEITER-R was used as a covariate variable. Another covariate variable was mean score on the Phonological Memory subtest of the CTOPP-2. It was important to control for this variable because the task required children with LI to listen to verbal information and make judgements on them. This involves phonological memory, which has been shown to be impaired in children with LI (Alt, 2011; Hutchinson, Bavin, Efron & Sciberras, 2012; Vugs, Hendriks, Cuperus & Verhoeven, 2014).

CHAPTER IV

RESULTS

Psychometric Assessment Results

Data on participants' performance on the psychometric assessment tests were explored for outliers. There were two outlying scores of Phonological Memory and one outlying score of Brief IQ. One of the outlying variables in the Phonological Memory data set belonged to the mild group and another belonged to the control group. The outlining variable in the Brief IQ data set was in the control group. These data points were therefore transformed by replacing them with the adjacent values from a box plot. An adjacent value is the highest or lowest measure (winsorizing) that is not declared as an outlier (Howell, 2013).

Core Language Composite of the CELF-5 Battery

Means and standard deviations for group performance on the core language composite (CLC) of the CELF are displayed in Table 1 below.

Table 1

Group means and standard deviations for scores on the Core Language Composite (CLC) of the CELF-5 Battery

Group	***M***	***SD***
Mild	81.62	2.53
Moderate	75	1.41
Severe	64	9.08
Controls	122.69	9.58

A one-way between-group analysis of variance (ANOVA) with Group (Mild, Moderate, Severe, Control) as the independent variable and Core Language Composite scores as the dependent variable was conducted. There was a significant difference between the groups, F (3, 65) = 225.46, $p < .001$, $\eta_p^2 = .912$. Post hoc comparisons using Tukey HSD indicated that the performance for participants in the mild ($p < .001$), moderate ($p < .001$) and severe ($p < .001$) groups was significantly lower than that for the control group. The performance of the children in the severe group was significantly lower than that for those in the mild ($p < .001$) and moderate ($p < .001$) groups. Scores for children in the mild and moderate groups did not differ from each other ($p = .201$).

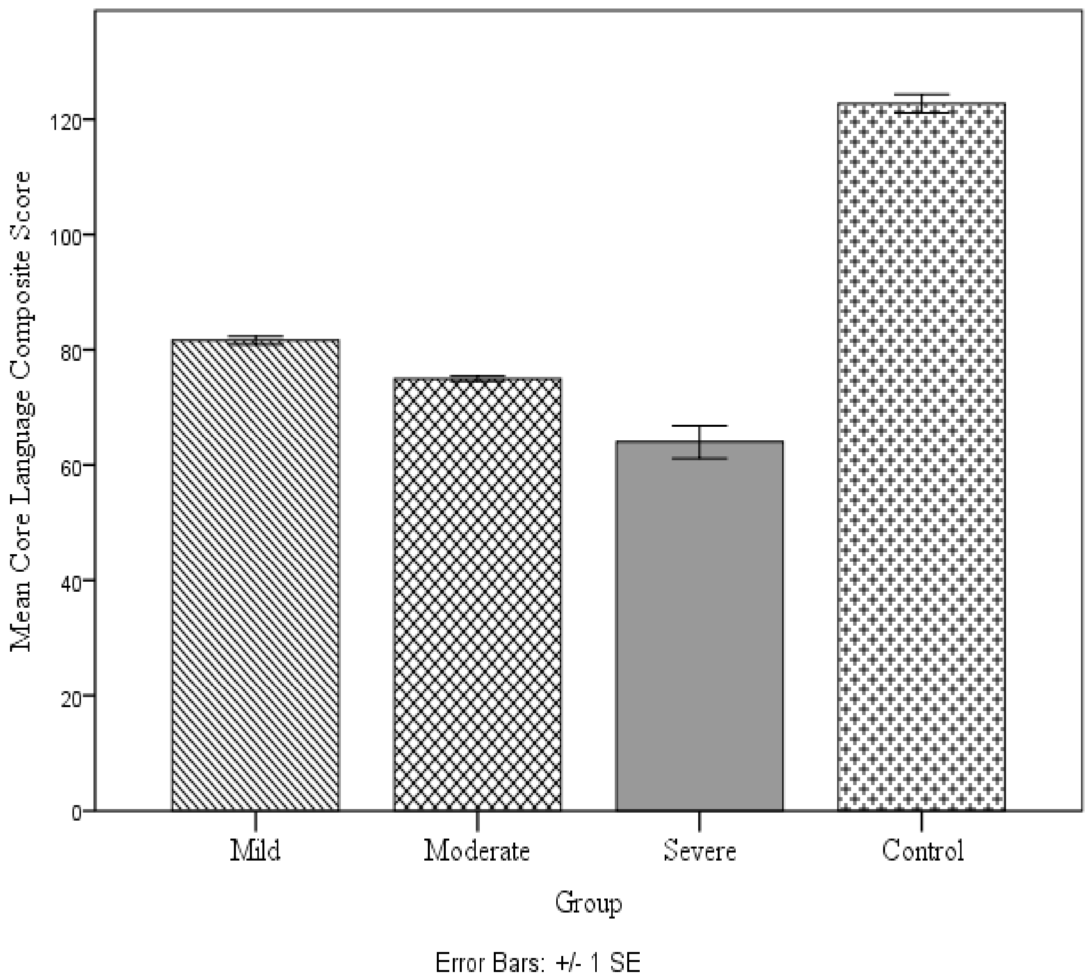

Figure 2. Group means for scores on the Core Language Composite of the CELF-5 Battery

Phonological Memory Composite of the CTOPP-2 Battery

Means and standard deviations for performance of the groups on the Phonological Memory Composite of the CTOPP are displayed in Table 2 below.

Table 2

Group means and standard deviations for scores on the Phonological Memory Composite of the CTOPP-2 Battery.

Group	***M***	***SD***
Mild	83.15	10.46
Moderate	83.10	9.48
Severe	67.60	7.32
Controls	113.92	10.46

Similar to results for the Core Language Composite, the groups differed significantly on this measure, F (3, 65) = 81.12, p <. 001, η_p^2 = .789. Post hoc comparisons showed that the mild (p<.001), moderate (p<.001), and severe (p <.001) groups performed significantly below the level of the control group. The performance of children in the severe group fell significantly below those for the mild (p = .002) and the moderate (p =.004) groups. However, the performance of the children in the mild and moderate groups did not differ significantly (p = 1.0).

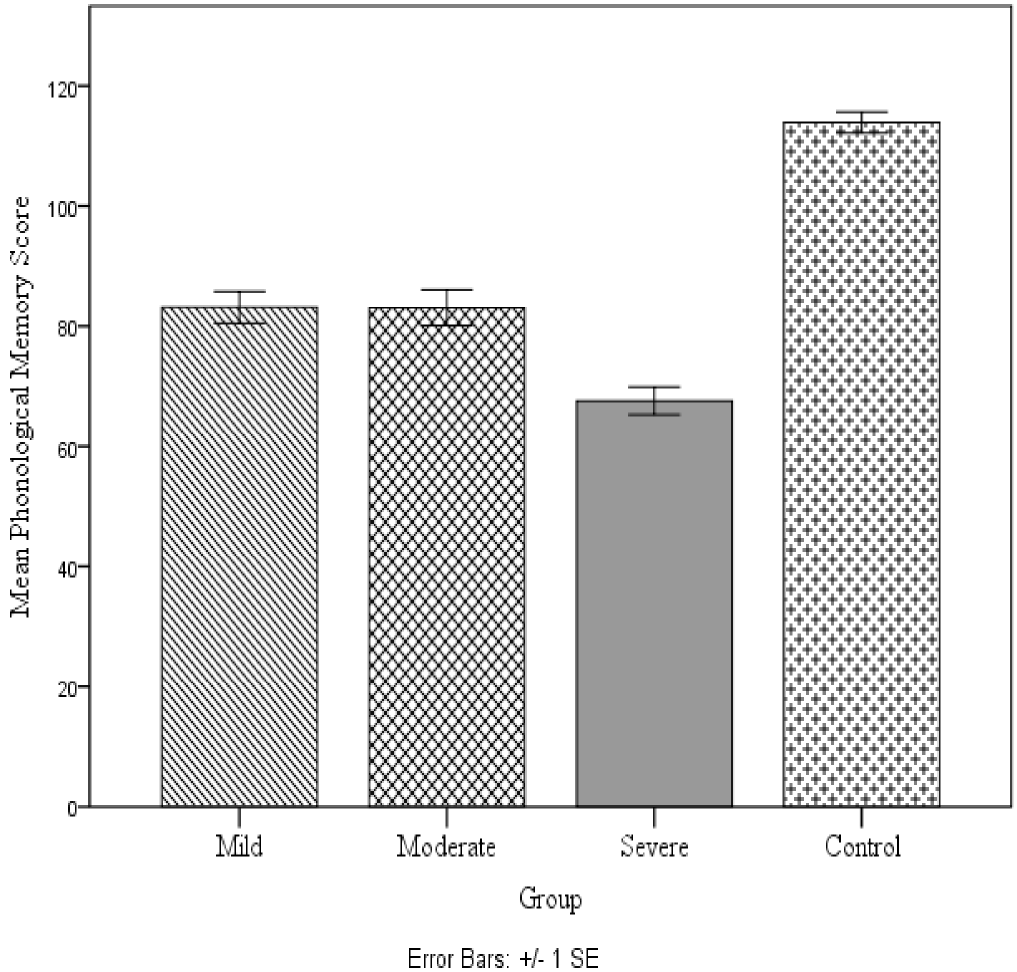

Figure 3. Group means for scores on the Phonological Memory Composite of the CTOPP-2 Battery

Brief IQ Subtest of the Leiter-R Battery

Means and standard deviations for the groups on the Brief IQ Subtest are displayed in Table 3 below.

Table 3

Group means and standard deviations for scores on the Brief IQ Composite of the Leiter-R Battery.

Group	***M***	***SD***
Mild	87.62	13.28
Moderate	77.8	14.13
Severe	69.4	16.9
Controls	109.89	13.52

There was a significant difference between the groups, F (3, 65) = 30.6, p <. 001, η_p^2= .585. Post hoc analysis revealed that the mild (p <.001), moderate (p <.001) and severe (p <.001) groups had lower IQ scores compared to the control group. The performance of the children in the severe group was significantly lower than that for the mild (p = .016) but not the moderate (p = .545) group. The difference between the mild and moderate groups was nonsignificant (p = .354).

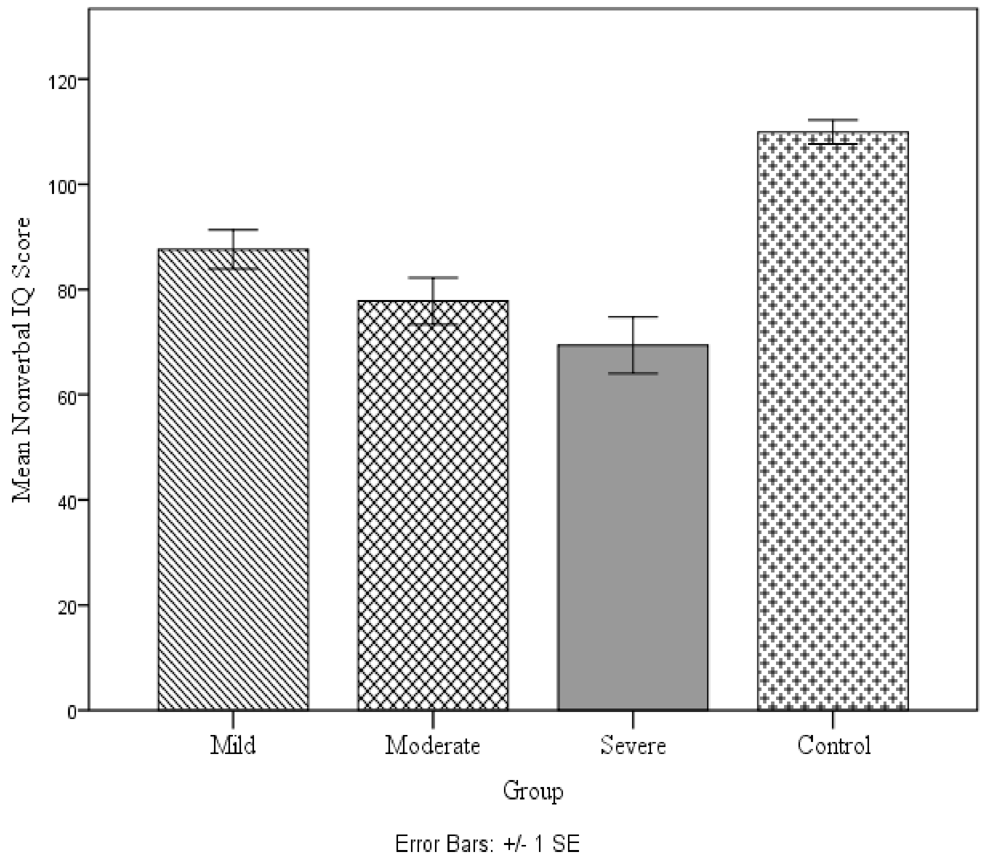

Figure 4. Group means for scores on the Brief IQ Composite of the Leiter-R Battery.

Attention Sustained Subtest of the Leiter-R

Means and standard deviations for group performance on Attention Sustained subtest of the LEITER are displayed in Table 4.

Table 4

Group means and standard deviations for scores on the Attention Sustained Subtest of the Leiter-R Battery.

Group	***M***	***SD***
Mild	9.69	3.3
Moderate	7.40	2.41
Severe	6.7	3.02
Controls	10.72	2.53

There was a significant difference between the groups, F (3, 65) = 7.84, p <.001, η_p^2= .266. Post hoc analysis using Tukey HSD showed that the moderate (p = .006) and severe (p = .001) groups performed significantly below the level of the control group. The mild and control groups did not differ (p = .653). Similarly, the mild group did not differ significantly from the moderate (p = .203) and severe (p = .055) groups. The severe and moderate groups (p = .940) also did not differ from each other.

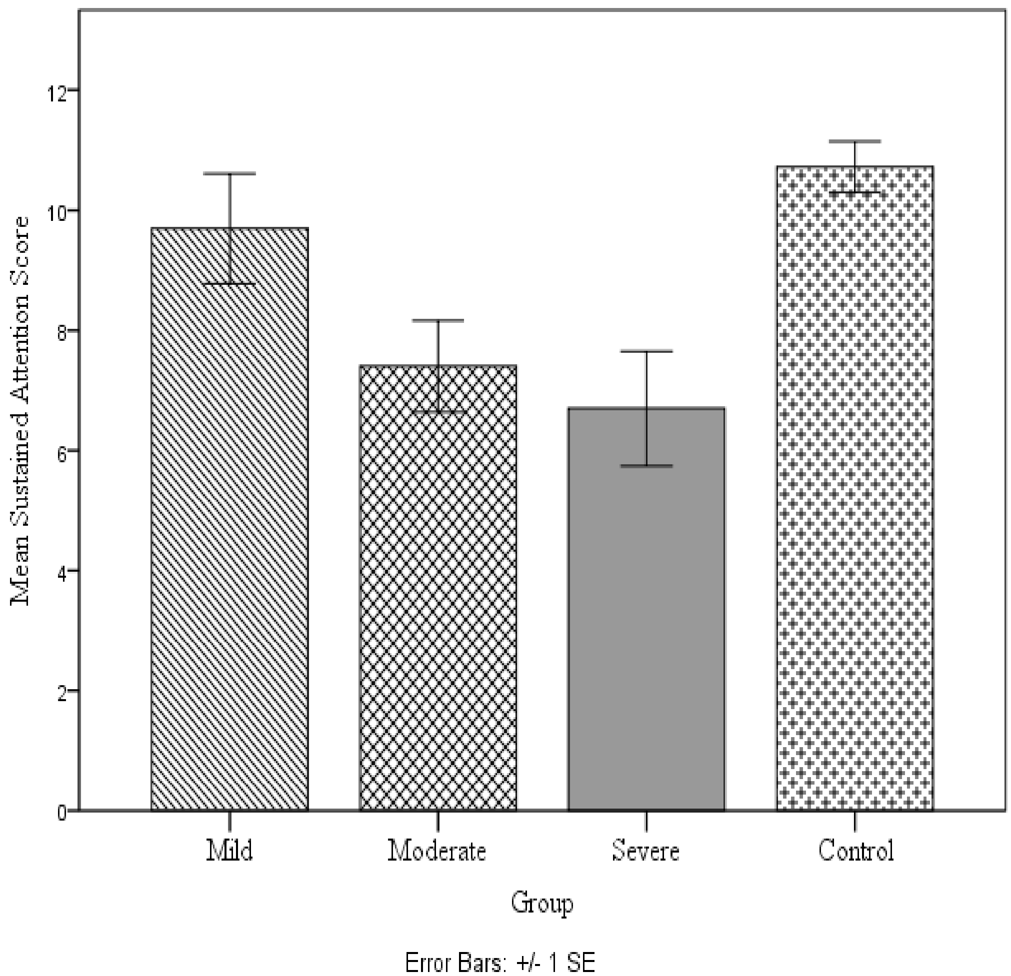

Figure 5. Group means for scores on the Attention Sustained Subtest of the Leiter-R Battery.

Production

A mixed design with two-way multivariate analyses of variance (MANOVA) was used to understand the groups' use of pitch range, tonal alignment, target word duration and intensity to distinguish between broad and narrow focus. The between-subject factor was Group (mild, moderate, severe, control) and the within-subject factor was Focus type (broad, narrow). The dependent variables were pitch range, tonal alignment, target word duration and intensity.

The data set was subjected to tests to determine if it met the assumptions for MANOVA. An exploration of the data showed that there were a few outliers. These data points were therefore transformed by replacing them with the adjacent values from a box plot. An adjacent value is the highest or lowest measure (winsorizing) that is not declared as an outlier (Howell, 2013). Shapiro-Wilk statistic was also found to be significant for some variables for some of the groups, indicating non-normality for those cells. Levene's Test also indicated that the assumption of equality of variance for all the dependent variables except intensity in broad focus stimuli was violated. Non-normality and unequal variances were compensated for by using a more conservative alpha level of .025 in the analyses to reduce the chance of a Type 1 error (Tabachnick & Fidell, 2007).

There was a significant multivariate effect of the between-subject factor, Group, on the combined dependent measures, $F = (4, 164.33) = 10.211$, $p < .001$; Wilks' $\lambda = 0.23$, partial $\eta^2 = .39$. There was also a significant multivariate effect of the within-subjects factor, Focus, on the combined measures, $F = (4, 62) = 84.48$, $p < .001$; Wilks' $\lambda = 0.16$, $\eta_p^2 = .85$. The interaction between Group and Focus was significant, $F = (12, 164.33) = 6.42$, $p < .001$; Wilks' $\lambda = 0.362$, $\eta_p^2 = .29$. To explore the nature of the interaction, four separate Group x Focus Type mixed analyses of variance (ANOVA) were conducted, with Group as the between-subject factor, Focus as the within-subject factor. The dependent measures were pitch range, tonal alignment, target duration and intensity.

Pitch Range

Group means and standard deviations are presented in Table 5 below.

Table 5

Group means and standard deviations for measures of pitch range in broad and narrow stimulus constructions.

Measure	**Focus**	**Group**	***M***	***SD***
Pitch range (Hertz)	Broad	Mild	31.52	6.99
		Moderate	28.92	9.33
		Severe	32.27	4.18
		Control	35.78	12.61
	Narrow	Mild	45.71	20.46
		Moderate	44.0	4.77
		Severe	46.26	14.11
		Control	55.04	11.58

There was a main effect of Focus Type, F (1, 65) = 75.798, p = .001, η_p^2= .538. Pitch range was higher in narrow than broad focus constructions. There was also a main effect of Group, F (3, 65) = 3.293, p = .026, η_p^2= .132. Subsequent tests using Tukey indicated that the means for the mild (p = .035) and the moderate (p = .013) groups were significantly lower than that for the control group. However, the severe and control groups did not differ (p = .082). The mild group did not differ from the moderate (p = .613) and severe (p = .878) groups. The severe and moderate groups also did not differ from each other (p = .536). *Figure 6* shows the differences in performance for the groups.There was no significant interaction between focus type and group F (3, 65) = .957, p = .418, η_p^2= .042.

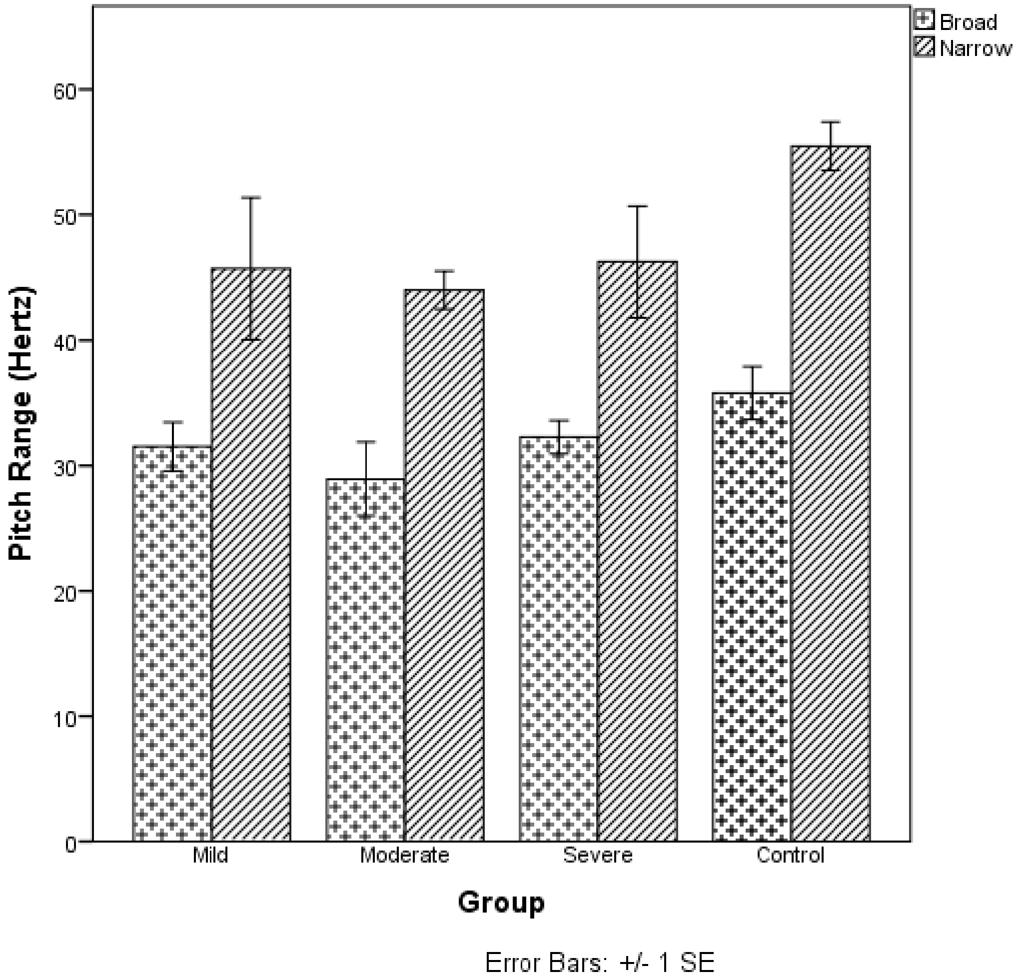

*Figure 6***.** Mean pitch range for the mild, moderate and severe groups in broad and narrow focus stimulus constructions

Tonal Alignment

Group means and standard deviations are presented in Table 6 below.

Table 6

Group means and standard deviations for measures of tonal alignment in broad and narrow focus constructions produced by the mild, moderate and severe groups.

Measure	**Focus**	**Group**	***M (ms)***	***SD***
Tonal Alignment (Milliseconds)	Broad	Mild	.14	.05
		Moderate	.13	.05
		Severe	.21	.10
		Control	.11	.01
	Narrow	Mild	.16	.05
		Moderate	.17	.03
		Severe	.16	.08
		Control	.24	.06

There was a main effect of Focus Type, F (1, 65) = 20.378, p <.001, η_p^2= .239, with tonal alignment occurring closer to syllable offset in broad than narrow focus constructions. There was also a main effect of Group, F (3, 65) = 14.623, p < .001, η_p^2 =.403. Post hoc Tukey HSD tests showed that the mean for the severe group (p <.001) was significantly higher than that for the mild (p < .001), moderate (p < .001) and control (p < .001) groups. None of the other comparisons was different from the other: the moderate group did not differ from the mild (p = 1.0) or the control (p = .541) groups.

Similarly, the means for the mild and the control groups did not differ (p = .518). These group differences are showed in *Figure 7*. There was no significant interaction between Focus Type and Group, F (3, 65) = .769, p = .515, η_p^2= .034.

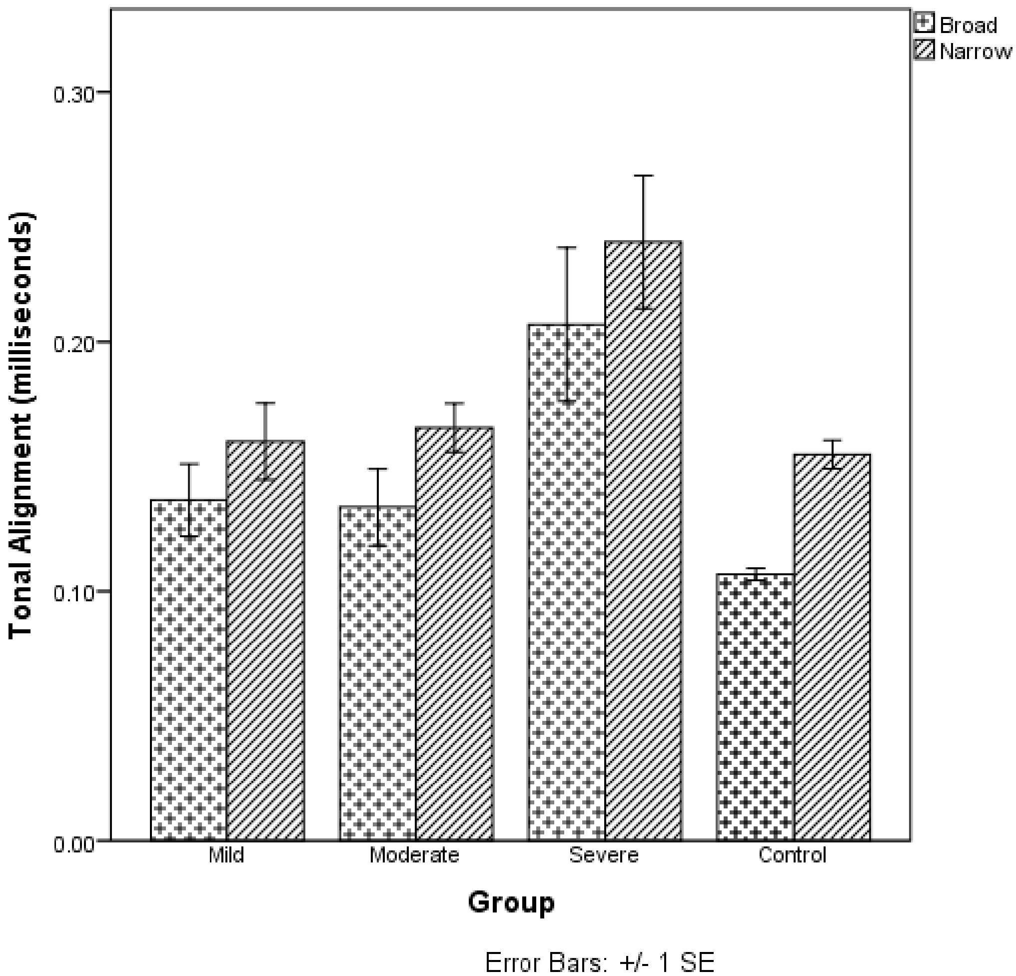

Figure 7. Mean tonal alignment for the mild, moderate and severe groups in broad and narrow focus stimulus construction.

Target Word duration

Mean target word durations and standard deviations are displayed in Table 7 below.

Table 7

Group means and standard deviations for measures of target duration in broad and narrow focus constructions produced by the mild, moderate and severe groups.

Measure	**Focus**	**Group**	***M (ms)***	***SD***
Target word duration (Milliseconds)	Broad	Mild	.41	.07
		Moderate	.41	.06
		Severe	.54	.10
		Control	.35	.04
	Narrow	Mild	.45	.09
		Moderate	.47	.07
		Severe	.74	.10
		Control	.39	.05

There were main effects of Focus Type, F (1, 65) = 104.676, $p < .001$, $\eta_p^2 = .617$, and Group F (3, 65) = 50.281, $p < .001$, $\eta_p^2 = .699$, which were subserved by a significant interaction, F (3, 65) = 14.405, $p < .001$, $\eta_p^2 = .399$. Follow-up Tukey tests were conducted using a harmonized sample size to control for the unequal sample sizes of the groups. The post hoc test showed that for the mild, severe and control groups, target durations in broad and narrow focus productions differed significantly. Durations increased from.41 ± .07, .54 ± .01 and .35 ± .04 in broad focus to .45 ± .09, .74 ± .10 and

.39 ± .05 in the narrow focus productions for the mild, severe and control groups, respectively. The moderate group showed no distinction between broad and narrow focus in terms of duration. *Figure 8* shows these differences.

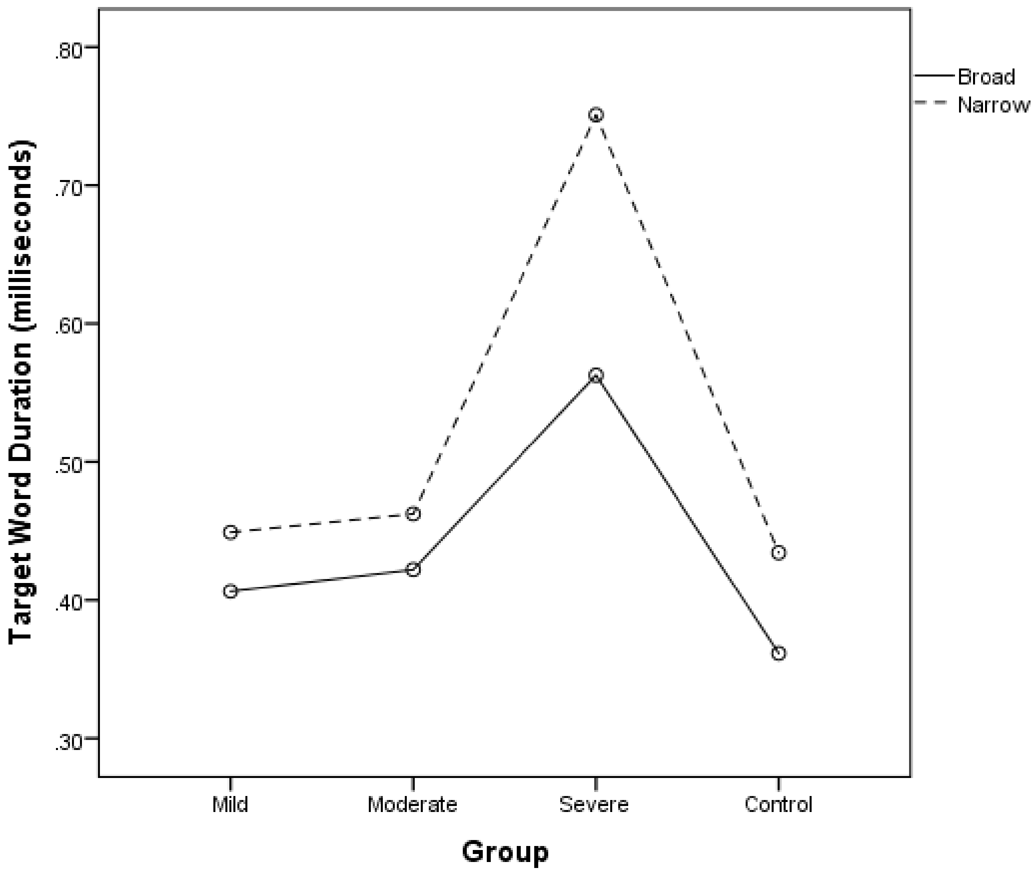

*Figure 8***.** A line graph of measures of target duration for each combination of group and focus type.

Intensity

Group means and standard deviations are presented in Table 8 below.

Table 8

Group means and standard deviations for measures of intensity in broad and narrow focus constructions produced by the mild, moderate and severe groups.

Measure	**Focus**	**Group**	***M (decibels)***	***SD***
Intensity (Decibels)	Broad	Mild	73.28	3.63
		Moderate	73.91	6.40
		Severe	76.17	4.40
		Control	69.55	5.53
	Narrow	Mild	79.20	5.68
		Moderate	76.53	6.40
		Severe	77.98	3.92
		Control	79.62	7.77

There was a main effect of Focus Type, F (1, 65) = 45.782, p <.001, η_p^2 = .413. For all groups, intensity was higher in narrow than in broad focus stimuli. There was a significant interaction between Focus Type and Group, F (3, 65) = 7.971, p < .001, η_p^2 = .269. Follow-up Tukey tests were conducted using a harmonized sample size to control for the unequal sample sizes of the groups. The post hoc test revealed that for the control group intensity increased from 69.45 ± .86 in the broad focus stimuli to 79.62 ± 1.30 dB in the narrow focus stimuli. Similarly, for the mild group, intensity was lower (73.28 ± 1.008 dB) in the broad than narrow (79.67 ± 1.10 dB) focus productions. However, there was no difference in intensity for broad and narrow focus productions for the moderate and severe groups. *Figure 9* displays group performances on the two types of focus constructions.

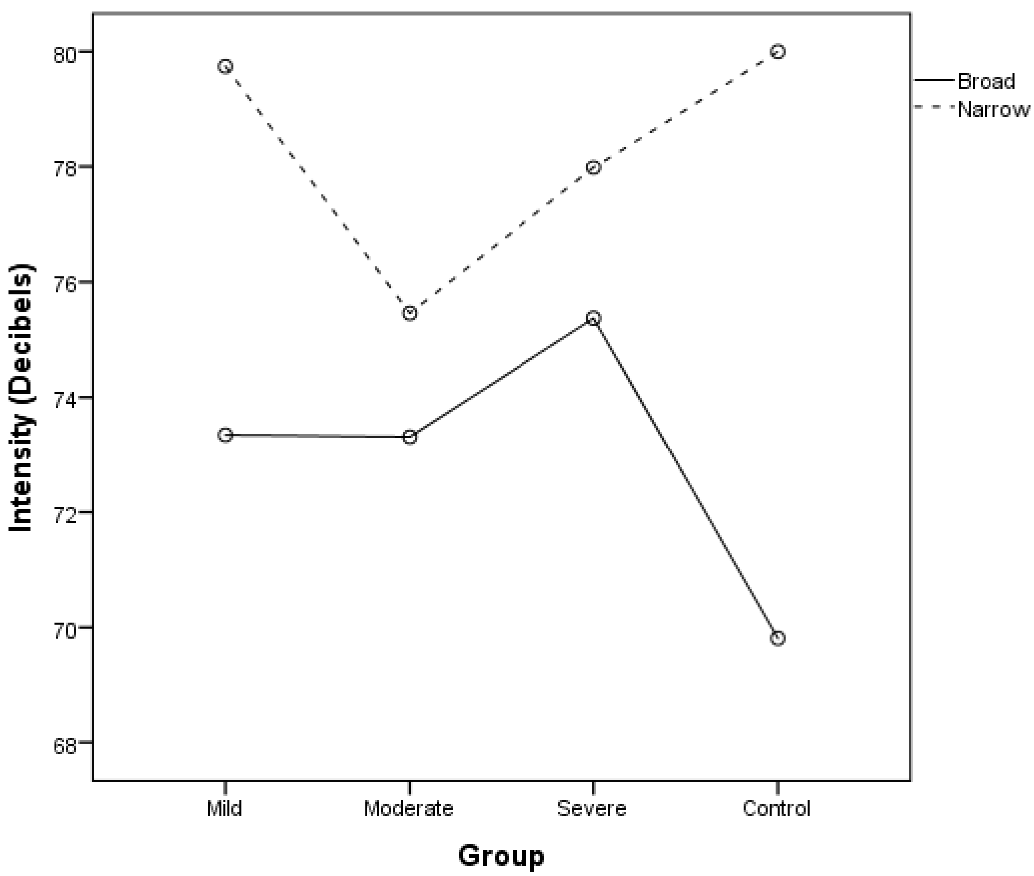

Figure 9. A line graph of the mean measure of intensity for each combination of group and focus type.

Perception

Means and standard deviations for scores on the perceptual experiment are displayed in Table 9 below.

Table 9.

Percent correct identification of broad and narrow focus constructions by the mild, moderate, severe and control groups

Group	***M (percent correct)***	***SD***
Mild	70.38	14.17
Moderate	70.75	13.44
Severe	51.75	10.87
Control	93.96	6.72

A Pearson product-moment correlation coefficient was computed to assess the relationship between scores on the perception task and scores on the attention sustained subtest of the LEITER. There was a high positive correlation between the two variables, r = .855, $p < .001$. A Pearson product-moment correlation coefficient was also computed to assess the relationship between scores on the perception task and on phonological memory of the CTOPP. There was also positive correlation between the two variables, $r = .474$, $p < .001$. Thus, scores on the attention sustained and phonological memory subtests were used as covariates in this analysis.

A one-way analysis of covariance (ANCOVA) was conducted. Group (Mild, Moderate, Severe, Control) was the independent variable and Score (percent correct on the perceptual task) was the dependent variable. Scores on the attention sustained subtest of the LEITER and phonological memory of the CTOPP were the covariate variables. There was a significant difference between the groups, F (3, 63) = 8.317, p <.001, η_p^2 = .284. Post hoc using Tukey HSD comparisons indicated that performances of children in the mild (p = .001), moderate (p = .002) and severe (p < .001) groups were significantly poorer compared to that for controls. Children in the severe group performed significantly poorer than those in the mild (p = .002) and moderate groups (p = .001). Children in the mild and moderate groups did not differ from each other (p = .752). These group differences are displayed in *Figure 10* below.

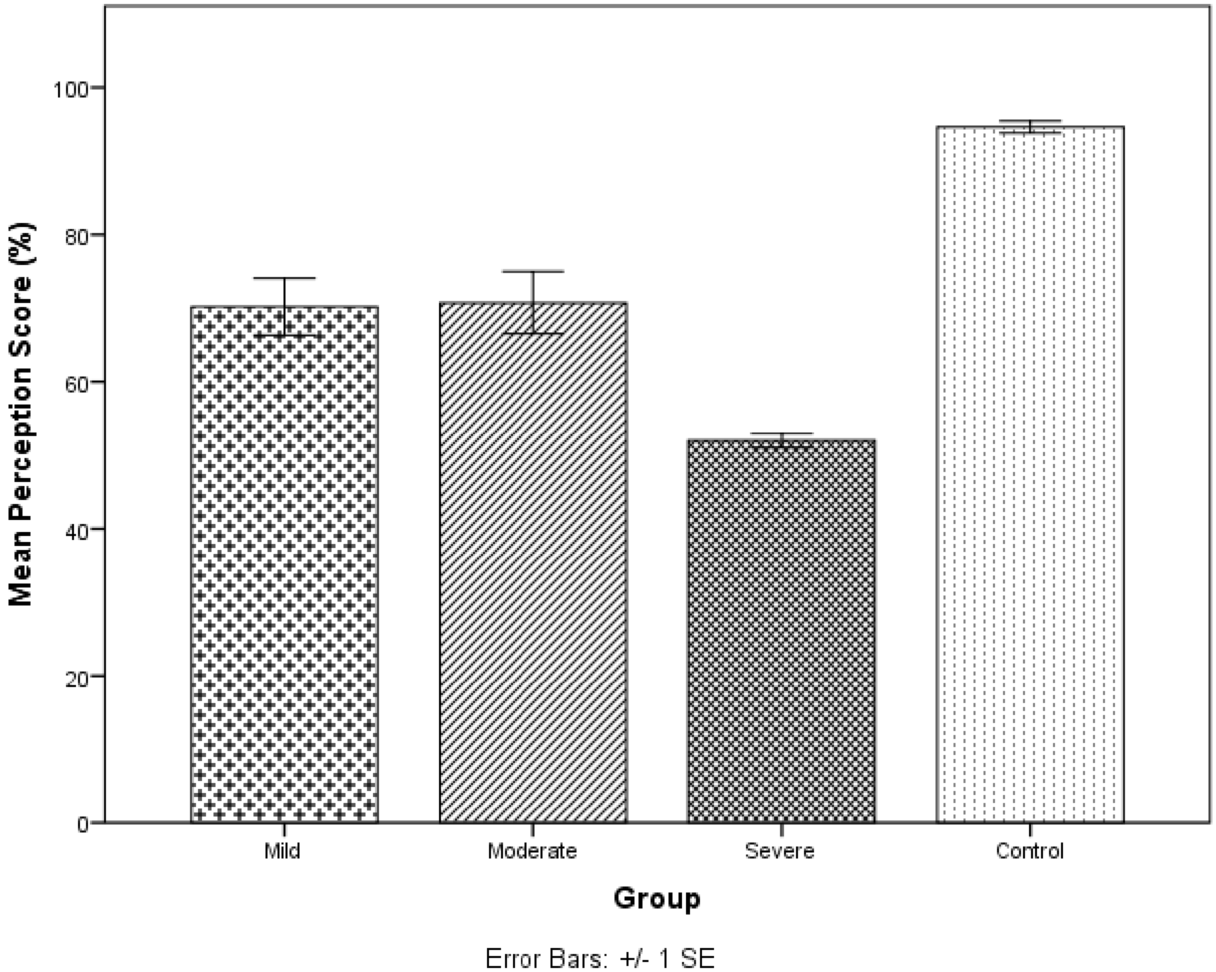

Figure 10. Percent correct identification of broad and narrow focus constructions by the mild, moderate, severe and control groups

CHAPTER V

DISCUSSION

The present study was aimed at determining whether discrepancy in findings on intonation processing in children with language impairment (LI) is attributable to the severity of the disorder. To achieve this goal, children with developmental language impairment (LI) (mild, moderate, and severe severity levels) and age-matched typically developing controls were compared on an intonation production and perception task.

Production

The mild, moderate and severe groups performed comparably with their typically developing counterparts on ability to use pitch range and tonal alignment to distinguish between broad and narrow focus. However, there were group differences in the use of target word duration and intensity to distinguish between the two types of focus. There were also some marked phonetic differences in the productions of the severe group. These findings are discussed in detail below.

Pitch Range

The groups performed similarly in their ability to distinguish between broad and narrow focus using pitch range. It was found that for all the groups, pitch range was higher for narrowly focused constructions than for broadly focused ones. These outcomes are consistent with findings on English-speaking adults (Xu & Xu, 2005; Dilley, 2010).

The findings suggest that the children were able to manipulate fundamental frequency (F0) to convey meaning as reported in Snow's studies (1998; 2001; 2015).

In spite of their ability to use pitch range to distinguish between the types of focus, overall pitch range in the productions of children in the experimental groups was smaller compared to those for the control group. Specifically, those for the mild and moderate groups were statistically significantly different from those of their typically-developing peers. Recall that pitch range was measured as the difference between peaks and valleys (F0 maximum and minimum) associated with a target word. Thus, this finding suggests that children in the experimental group (especially those in the mild and moderate groups) had less variation in their F0 productions compared to typically-developing peers. The pitch range difference between children with mild and moderate LI on the one hand and age-matched controls on the other hand, is also consistent with Snow (1998)'s findings for nonfinal syllables. Snow reported that the 4-year old children with LI in his study had smaller pitch range compared to their typically-developing counterparts.

The impact of this small pitch range difference in meaning perception is unclear. In particular, it is unclear whether this phonetic difference is perceptually salient to listeners in determining intended meaning. Pitch range has been shown to be a gradient phonetic dimension in English conveying semantic contrast, similar to the formant space for vowels (Dilley, 2010). This suggests the possibility that the difference observed in the productions of the children may impact their ability to convey meaning to their listeners.

This may in part be responsible for the intonational abnormality perceived by some researchers in the speech of these children. Further experiments in which these children's productions are presented to adult listeners are warranted to determine if such phonetic details affect meaning interpretation.

Tonal Alignment

All groups were able to distinguish between broad and narrow focus using this measure. For all groups, the F0 peak was closer to the offset of the target word in broad than in narrow focus constructions.

The overall alignment of the severe group was significantly farther way from syllable offset compared to those of the other groups. The basis of this difference is not entirely clear. However, it has been noted that longer syllable duration impacts tonal alignment (Astruc, Payne, Post, Vanrell, & Prieto, 2013; Beckman & Pierrehumbert, 1986). For example, Beckman and Pierrehumbert (1986) showed that alignment of F0 maximum in lengthened syllables appears to be father away from syllable offset (toward syllable onset) compared to unlengthened syllables. As discussed below, in the present study, children in the severe group had the longest target word durations. Thus, it is possible that the alignment difficulty exhibited by these children stems from their difficulty in target word duration. Given the relationship between alignment and duration, the outcomes of these two parameters are explained in the next section.

Target Word Duration

All children in the experimental group produced longer durations in narrow focus constructions compared to broad focus constructions as reported for healthy adults (Cooper et al., 1985; Eady & Cooper, 1986). The moderate group failed to use this parameter to distinguish between broad and narrow focus. Even though the severe group successfully used this parameter to distinguish between the two types of focus, their productions were longer than those for controls. The difference in duration is not surprising as previous studies have reported similar outcomes. Smith, Hall, Tan and Farrell (2011) found that syllable durations of the children with LI they studied were longer compared to those of typically-developing controls.

What remains unclear is whether these phonetic differences impact perception of meaning conveyed by these children. Some studies have shown that duration is a better predictor of perceived prominence than F0 (pitch) (Turk & Sawusch, 1996). Thus, although the difference in target word duration for the severe group did not reach statistical significance in distinguishing between broad and narrow focus, it may be one of the reasons why previous researchers perceive a difference in the productions of children with LI and age-matched typically developing peers.

Intensity

Intensity was the most problematic parameter for the experimental group. Particularly, the moderate and severe groups had difficulty using intensity to distinguish between broad and narrow focus. Both of these groups used high intensity in both focus types.

Studies of intensity production in these children are limited. Intensity has been argued by some researchers to be the strongest cue to indicate prominence (perceived as loudness) (e.g., Beckman, 1986; Kochanski et al., 2005; Turk & Sawusch, 1996). This suggests that difficulty in indicating focus (which required marking prominence) may be more evident in intensity than the other parameters.

While the basis of the poor performance of these children remains elusive, the outcome that children in the severe group performed poorly compared to those in the mild and moderate groups might be significant in understanding the mixed findings on intonation reported in previous studies. As indicated above, intensity is a strong indicator of prominence (Beckman, 1986; Kochanski et al., 2005; Turk & Sawusch, 1996) and its absence greatly impacts intelligibility (Tjaden, & Wilding, 2004). Thus, perhaps studies that reported intact intonation production ability recruited children with mild and/or moderate impairment whereas those who reported impaired ability recruited children with severe impairment.

Production Experiment Summary

Overall, the findings of this experiment show that severity of language impairment plays a significant role in intonation production. This difference is seen in intensity and duration rather than F0 (pitch) manipulation. As indicated above, recent studies on prominence highlight the importance of intensity and duration (e.g., Greenberg, Carvey, Hitchcock, & Chang, 2003; Kochanski, Grabe, Coleman, & Rosner, 2005; Silipo & Greenberg, 2000). Silipo and Greenberg (2000) reported that fundamental frequency turns out to be relatively unimportant in distinguishing between the presence and absence of prosodic prominence. Other researchers have also reached similar conclusions in their study of different stimuli including a large corpus of natural speech covering seven English dialects (Kochanski et al., 2005) and the Boston University Radio Speech Corpus (Choi, Hasegawa-Johnson & Cole, 2005).

The poor ability of children with LI to produce intensity and duration also has implications for the discrepant findings in previous studies. Most previous studies that reported poor intonation production in children with LI studied these children's ability to indicate focus (prominence) and perceptually judged these children's productions (e.g., Baltaxe, 1984; Baltaxe & Guthrie, 1987; Highnam & Morris, 1987; Hargrove & Sheran, 1989). On the other hand, the studies that have consistently reported intact intonation production ability (e.g., Snow, 1998; 2001; 2015) have been instrumental studies that have focused on F0 (pitch). It may therefore be that poor production of intensity and durational cues account for the discrepancy in findings on intonation processing in children with LI. Such an interpretation would reconcile the findings of studies that failed to find intonation production deficit in children with LI and those who found deficit.

Perception

In the perceptual experiment, participants were presented sentences and asked to distinguish between broad and narrow focus constructions. Children with LI demonstrated difficulty distinguishing between these two types of focus constructions in perception, with children in the severe group performing the poorest. These findings are consistent with findings of studies that suggest that intonation perception ability is impaired in these children (e.g., Berk, Doehring & Bryans, 1983; Fujiki et al., 2008).

The outcomes of this experiment highlight the performance differences noted in the intensity measure in the production task. It shows that intonation processing is problematic for children with LI but its manifestation varies based on severity. That is, intonation deficit may be more pronounced in children with severe than those with mild and moderate impairment.

In spite of the finding that children with severe LI perform poorer than those with mild and moderate impairment, the source of the perception problem for these children remains unclear. Poor perception abilities in these children have been attributed to factors such as poor attention and phonological memory as well as complex stimulus structure. In the present study, all these factors were controlled. Sustained attention and phonological memory were assessed and used as covariates in the statistical analysis. Also, the stimuli used in the current study had one simple syntactic structure (subject-verb-object "_______ made the lemonade") which participants repeated over and over. Thus, the outcomes of this study do not seem to have been impacted by these factors.

The difficulties experienced by these children may have been due to poor lower-level phonetic and/or auditory perception abilities. This possibility is supported by Ziegler, Pech-Georgel, George, Alario and Lorenzi (2005)'s data which showed that children with LI have auditory perception difficulties particularly in the perception of voicing. If the difficulty exhibited by these children is rooted in phonetic processing, then it may be that only some features of the intonation signal are difficult for these children. It has been shown that language production and comprehension are interwoven (Pickering & Garrod, 2013). It is therefore possible that difficulty perceiving intensity and duration, as was found in the production task, would be the culprit for the difficulty exhibited by these children in the perception task. However, due to paucity of data, studies aimed at understanding these children's ability to perceive the individual acoustic correlates of intonation are warranted.

One implication of a lower-level perceptual explanation has to do with criticisms that have been made against the importance of auditory deficits in LI. It has been argued that auditory deficits only affect a small group of children with LI (for review, see Rosen, 2003). Thus, if the findings of the present study are attributable to poor auditory perception, then it suggests that auditory processing deficits in children with LI may be present across severity of the disorder. The severity effect showed that children with severe language impairment demonstrated more difficulty perceiving a distinction between broad and narrow focus. The performance of the mild and moderate groups did not differ significantly from each other.

An alternative and more plausible interpretation for these children's poor intonation perception abilities is that the problem may be rooted in the linguistic system. The main problem for children with developmental language impairment is linguistic (for phonology see, Briscoe, Bishop & Norbury, 2001; Estes, Evans, & Else-Quest, 2007; for syntax, see Deevy & Leonard, 2004; de Villiers, de Villiers & Roeper, 2011; for pragmatics see, Norbury, 2005a; Norbury, 2005b; for morphology see, Bishop, 1994; Leonard, 2014; Oetting & Rice, 1993; Rice, Wexler, & Cleave, 1995 for semantics, see Kan & Windsor, 2010). Intonation is a part of the linguistic system of language. Thus, it is possible that suprasegmental aspects of language, including intonation, are also impaired in these children. Furthermore, the difficulty for these children was not limited to perception but was also exhibited in the production domain. This suggests that the problem for these individuals has to do with processing of the intonation contour itself.

In sum, the findings of the perceptual task show that severity of language impairment plays a significant role in intonation processing. It may therefore be responsible for the discrepant findings reported in previous studies. They also show that the poor intonation perception ability reported by previous studies are not solely attributable to cognitive factors such as poor attention and phonological working memory abilities.

General Discussion

My hypothesis that the discrepancy in the literature may be due to severity of language impairment is partially supported in the production and perception data. The pattern of results in the production experiment showed that this may be so in the processing of duration and intensity but not fundamental frequency. In the perception data, all children in the experimental groups performed poorly. However, the severe group performed the poorest followed by the moderate and mild groups, in that order.

Contrary to Snow (2015)'s hypothesis that LI is fundamentally a disorder of segmental representations, the findings of the present study suggest that children with LI have intonation (suprasegmental) processing difficulties. These difficulties, which manifest both in production and perception, are more evident in children with severe language impairment compared to those with mild impairments. The difference in manifestation of the difficulty may account for the discrepancy in findings in the literature. Most studies fail to include information on severity. It may therefore be that studies that reported intact intonation production and/or perception ability might have recruited children with mild LI whereas those that reported abnormal ability recruited children with moderate to severe LI.

Another significant finding of the present study that is useful in understanding the discrepancy in the findings has to do with the acoustic correlates that were measured. The difficulty exhibited by children with LI had to do specifically with manipulation of intensity and duration. Studies have shown that these two acoustic correlates are particularly important for indicating prominence (Silipo & Greenberg, 2000; Greenberg, Carvey, Hitchcock, & Chang, 2003; Kochanski, Grabe, Coleman, & Rosner, 2005).

Although most studies on intonation production in children with LI have investigated production of prominence (focus to be specific), duration and intensity have received limited attention. It has been shown that in general, children with LI have difficulty with duration (Smith, Hall, Tan, & Farrell, 2011), but studies on intensity are limited. Most instrumental studies on intonation address these children's ability to process F0 (pitch). Thus, the findings of the present study suggest that difficulty processing intensity and duration may be implicated in the perceived abnormality in the intonation productions of these children.

If difficulty producing and processing intensity and duration is confirmed in future studies, then the data provided might be helpful to speech-language pathologists in providing help to children with LI in the ability to process intonation. However, it is possible that outcomes of this study were influenced by the limited number of subjects. Another limitation of the present study is that the productions of the children were not presented to others to be judged perceptually by listeners. Listener judgement has the benefit of ascertaining whether the phonetic differences identified in the productions of these children are perceptually relevant to meaning detection. Furthermore, the stimuli employed in this study were limited to one function of intonation. The discrepancies identified in previous studies of intonation are based on these children's performance on several functions of intonation. The present study is a preliminary study. Thus, further studies on other functions of intonation are warranted to corroborate findings of the present study.

The limitations discussed above and the paucity of data on the effect of language severity on intonation processing make it impossible to reach a definitive conclusion on the impact of severity on intonation production and perception. Studies that improve on the methodology employed in this study are warranted to understand these issues.

APPENDICES

Appendix A
Consent Forms

THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH

TITLE:	Prosody in children with communication disorders
PROJECT DIRECTOR:	Afua Blay
PHONE #:	(701) 885-1847; (701) 777-0719
DEPARTMENT:	Communication Sciences and Disorders

STATEMENT OF RESEARCH
Children with communication disorders have problems with speech timing and tone of voice (pitch) variation. However, the underlying basis of this problem has not been determined. One possibility is that these children have impaired ability to target important components and temporal aspects of language when they speak. The present study seeks to investigate these possibilities by examining the speech of children with communication disorders.

WHAT IS THE PURPOSE OF THIS STUDY?
The purpose of this research study is to investigate the nature and basis of the timing and pitch variation problems in children with communication disorders.

HOW MANY PEOPLE WILL PARTICIPATE?
Approximately 50 people will take part in this study.

HOW LONG WILL I BE IN THIS STUDY?
Your child will be in the study for about three hours. This length of time includes assessments, participating in experiments and break times (rest, snack and bathroom breaks).

WHAT WILL HAPPEN DURING THIS STUDY?
Your child's speech, language, hearing and reasoning abilities will be assessed. He/she will also be asked to repeat sentences such as "The girl made lemonade" for recording and to make judgments about sentences played from a computer to them.

WHAT ARE THE RISKS OF THE STUDY?
Participants might be bored by the simplicity and length of the tasks. If that happens, they will be encouraged to take a break and try again later. If the problem persists, they will be encouraged to withdraw from the study.

WHAT ARE THE BENEFITS OF THIS STUDY?

Participation in this study will not benefit children directly. However, outcomes of the study may contribute to a better understanding of pitch variation and speech timing problems for children with communication disorders. These findings may be useful in designing speech/language therapy for these children.

WILL I BE PAID FOR PARTICIPATING?
Yes. Each participant will be given $30 and a toy as a token of our appreciation.

WHO IS FUNDING THE STUDY?
The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY
The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, participants will not be identified. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, the University of North Dakota Institutional Review Board and the Altru Health Systems Institutional Review Board**.**

Any information that is obtained in this study and that can be identified with you/your child will remain confidential and will be disclosed only with your permission or as required by law. You should know, however, that there are some circumstances in which we may have to show your child's information to other people. For example, the law may require us to show children's information to a court or to tell authorities if we believe they have been abused, or they pose a danger to themselves or someone else. Confidentiality will be maintained by storing consent forms and data sheets in separate locked file cabinets in my supervisor's office. Data sheets will be linked to consent/assent forms and assessment records by assigning them numbers and/or letters.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified.

As part of this project, an audio recording will be made during your participation in the study. In any use of the audio recording, participants' name will not be identified. You or your child may request to stop the recording at any time or to erase any portion of the recording.

IS THIS STUDY VOLUNTARY?
Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with Little Miracles Child Care Center, Grand Forks public schools, University Children's Center, North Dakota Autism,Center, Fargo, the University of North Dakota or Altru Health Systems.

CONTACTS AND QUESTIONS?
The researcher conducting this study is Afua Blay. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Afua Blay at 701-317-3471 or Dr. Seddoh at 701-777-6402.

If you have questions regarding your rights as a research subject, you may contact the University of North Dakota Institutional Review Board at **(701) 777-4279** or the Altru Health Systems Institutional Review Board at (**701) 780-6161**.

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.
- General information about being a research subject can be found by clicking "Information for Research Participants" on the web site: http://und.edu/research/resources/human-subjects/research-participants.cfm

I give consent for my child to be audiotaped during this study.

Please initial: ____ Yes ____ No

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree for your child to take part in this study. You will receive a copy of this form.

____
Name of legally authorized representative of subject:

____ ____________________
Signature of legally authorized representative of subject Date

I have discussed the above points with the subject or, where appropriate, with the subject's.

___________________________________ ____________________
Signature of Person Who Obtained Consent Date

INFORMATION FOR CHILDREN AND ASSENT CERTIFICATION

PROJECT TITLE: Prosody in children with communication disorders

PRINCIPAL INVESTIGATOR: Afua Blay

I am studying how children change their voice when they speak. If you want to be part of this study, we will play some pointing games and you will say sentences for me to record. You will also listen to some sentences and tell me what you think about them. If your hearing has not already been checked, I will do so before we start our games.

When you do these things, you might feel tired and bored. If you have these feelings, you can take a break and continue later or stop being part of the study.

You will not benefit from being part of this study. But I hope to use what I learn from the study to help people who have problem speaking.

When I am done with the study, I will write a report about what I found out. I will not use your name in the report.

If you take part in the study, I will say thank you by giving you $30 and a toy. I will also have snacks for you. But you do not have to be in the study if you do not want to do so.

You can ask questions about the study any time. You or your parents can contact me at (701) 885 1847.

If you decide you want to be part of this study, please sign your name.

I, ____, want to be part of this study.

______________________________ ______________________________

(sign your name here) (Date)

Appendix B
Stimuli and Response Sheet
(1) Production Experiment Stimuli


16/m/ cvc
moon
#PRAXM-560 • ©2014 Super Duper® Publications
8/j/ cvcv
yo-yo
#PRAXM-560 • ©2014 Super Duper® Publications
6/d/ cvcv
daddy
#PRAXM-560 • ©2014 Super Duper® Publications
7/n/ cvc
nail
#PRAXM-560 • ©2014 Super Duper® Publications
19/w/ cvcvc
wagon
#PRAXM-560 • ©2014 Super Duper® Publications
20/g/ cvc
gum
#PRAXM-560 • ©2014 Super Duper® Publications
9/g/ cvc
game
#PRAXM-560 • ©2014 Super Duper® Publications
11/r/ cvc
red
#PRAXM-560 • ©2014 Super Duper® Publications
19/b/ cvc
bug
#PRAXM-560 • ©2014 Super Duper® Publications
25
bell
4B
lion
41
balloon


9/k/ cvc
cake
#PRAXM-560 • ©2014 Super Duper® Publications
20/t/ cvcvc
table
#PRAXM-560 • ©2014 Super Duper® Publications
2/p/ cv
pie
#PRAXM-560 • ©2014 Super Duper® Publications
19/t/ cvc
toys
#PRAXM-560 • ©2014 Super Duper® Publications
12/f/ cvc
feet
#PRAXM-560 • ©2014 Super Duper® Publications
5/p/ cvcv
pillow
#PRAXM-560 • ©2014 Super Duper® Publications
17/s/ cvc
sock
#PRAXM-560 • ©2014 Super Duper® Publications
14/f/ cvc
fish
#PRAXM-560 • ©2014 Super Duper® Publications
20/f/ cvc
phone
#PRAXM-560 • ©2014 Super Duper® Publications
3/t/ cv
two
#PRAXM-560 • ©2014 Super Duper® Publications
4/t/ cvcv
taco
#PRAXM-560 • ©2014 Super Duper® Publications
11/p/ cvc
pen
#PRAXM-560 • ©2014 Super Duper® Publications


4/d/ cv
door
#PRAXM-560 • ©2014 Super Duper® Publications
6/m/ cvcv
money
#PRAXM-560 • ©2014 Super Duper® Publications
7/r/ cvc
rag
#PRAXM-560 • ©2014 Super Duper® Publications
10/l/ cvc
leg
#PRAXM-560 • ©2014 Super Duper® Publications
17/d/ cvc
dog
#PRAXM-560 • ©2014 Super Duper® Publications
2/l/ cvcv
lady
#PRAXM-560 • ©2014 Super Duper® Publications
18/d/ cvc
doll
#PRAXM-560 • ©2014 Super Duper® Publications
6/b/ cvcv
bunny
#PRAXM-560 • ©2014 Super Duper® Publications
2/m/ cv
mow
#PRAXM-560 • ©2014 Super Duper® Publications
8/b/ cvc
ball
#PRAXM-560 • ©2014 Super Duper® Publications
11/m/ cvc
man
#PRAXM-560 • ©2014 Super Duper® Publications
4/l/ cvcv
llama
#PRAXM-560 • ©2014 Super Duper® Publications


9B
ring
34
whale
36
wheel
9/m/ cvc
maid
#PRAXM-560 • ©2014 Super Duper® Publications
16/p/ cvc
pool
#PRAXM-560 • ©2014 Super Duper® Publications
13/t/ cvc
teeth
#PRAXM-560 • ©2014 Super Duper® Publications
17/f/ cvc
fork
#PRAXM-560 • ©2014 Super Duper® Publications
5/t/ cvcv
teddy
#PRAXM-560 • ©2014 Super Duper® Publications
6/t/ cvcv
tiger
#PRAXM-560 • ©2014 Super Duper® Publications
2/t/ cv
toe
#PRAXM-560 • ©2014 Super Duper® Publications
8/t/ cvcv
turkey
#PRAXM-560 • ©2014 Super Duper® Publications
14/p/ cvc
pig
#PRAXM-560 • ©2014 Super Duper® Publications


9/k/ cvc
cake
#PRAXM-560 • ©2014 Super Duper® Publications
20/t/ cvcvc
table
#PRAXM-560 • ©2014 Super Duper® Publications
2/p/ cv
pie
#PRAXM-560 • ©2014 Super Duper® Publications
19/t/ cvc
toys
#PRAXM-560 • ©2014 Super Duper® Publications
12/f/ cvc
feet
#PRAXM-560 • ©2014 Super Duper® Publications
5/p/ cvcv
pillow
#PRAXM-560 • ©2014 Super Duper® Publications
17/s/ cvc
sock
#PRAXM-560 • ©2014 Super Duper® Publications
14/f/ cvc
fish
#PRAXM-560 • ©2014 Super Duper® Publications
20/f/ cvc
phone
#PRAXM-560 • ©2014 Super Duper® Publications
3/t/ cv
two
#PRAXM-560 • ©2014 Super Duper® Publications
4/t/ cvcv
taco
#PRAXM-560 • ©2014 Super Duper® Publications
11/p/ cvc
pen
#PRAXM-560 • ©2014 Super Duper® Publications

(2) Perceptual Experiment Stimuli

*Words in italics and bold indicate narrow focus.

1.Rain made the lemonade	15. Leg made the lemonade
Rain made the lemonade	***Leg*** made the lemonade
2. B***oy*** made the lemonade	16. Rag made the lemonade
Boy made the lemonade	***Rag*** made the lemonade
3. ***Bowl*** made the lemonade	17. ***Ball*** made the lemonade
Bowl made the lemonade	Ball made the lemonade
4. Baby made the lemonade	18. ***Money*** made the lemonade
Baby made the lemonade	Money made the lemonade
5. ***Eyes*** made the lemonade	19. Rug made the lemonade
Eyes made the lemonade	***Rug*** made the lemonade
6. Lime made the lemonade	20. ***Moon*** made the lemonade
Lime made the lemonade	Moon made the lemonade
7. ***Bunny*** made the lemonade	21. ***Yellow*** made the lemonade
Bunny made the lemonade	The yellow made the lemonade
8. ***Llama*** made the lemonade	22. Bell made the lemonade
Llama made the lemonade	***Bell*** made the lemonade
9. ***Dog*** made the lemonade	23. Goalie made the lemonade
Dog made the lemonade	***Goalie*** made the lemonade
10. Man made the lemonade	24. ***Yarn*** made the lemonade
Man made the lemonade	Yarn made the lemonade
11. Maid made the lemonade	25. Balloon made the lemonade
Maid made the lemonade	***Balloon*** made the lemonade
12. Mower made the lemonade	26. Jelly made the lemonade
Mower made the lemonade	***Jelly*** made the lemonade
13. Doll made the lemonade	27. ***Bug*** made the lemonade
Doll made the lemonade	Bug made the lemonade
14. ***Lady*** made the lemonade	28. ***Red*** made the lemonade
Lady made the lemonade	Red made the lemonade

29. Game made the lemonade	
Game made the lemonade	
30. ***Wagon*** made the lemonade	
Wagon made the lemonade	
31. Gum made the lemonade	
Gum made the lemonade	
32. ***Nail*** made the lemonade	
Nail made the lemonade	
33. Daddy made the lemonade	
Daddy made the lemonade	
34. ***Yo-yo*** made the lemonade	
Yo-yo made the lemonade	
35. ***Whale*** made the lemonade	
Whale made the lemonade	
36. ***Wheel*** made the lemonade	
Wheel made the lemonade	
37. ***Door*** made the lemonade	
Door made the lemonade	
38. Mommy made the lemonade	
Mommy made the lemonade	
39. ***Lion*** made the lemonade	
Lion made the lemonade	
40. Ring made the lemonade	
Ring made the lemonade	

Response Sheet for Perceptual Experiment

Name:

Age:

1. 1^{st}	2^{nd}	I don’t know
2. 1^{st}	2^{nd}	I don’t know
3. 1^{st}	2^{nd}	I don’t know
4. 1^{st}	2^{nd}	I don’t know
5. 1^{st}	2^{nd}	I don’t know
6. 1^{st}	2^{nd}	I don’t know
7. 1^{st}	2^{nd}	I don’t know
8. 1^{st}	2^{nd}	I don’t know
9. 1^{st}	2^{nd}	I don’t know
10. 1^{st}	2^{nd}	I don’t know
11. 1^{st}	2^{nd}	I don’t know
12. 1^{st}	2^{nd}	I don’t know
13. 1^{st}	2^{nd}	I don’t know
14. 1^{st}	2^{nd}	I don’t know
15. 1^{st}	2^{nd}	I don’t know
16. 1^{st}	2^{nd}	I don’t know
17. 1^{st}	2^{nd}	I don’t know
18. 1^{st}	2^{nd}	I don’t know
19. 1^{st}	2^{nd}	I don’t know
20. 1^{st}	2^{nd}	I don’t know

21. 1^{st}	2^{nd}	I don't know
22. 1^{st}	2^{nd}	I don't know
23. 1^{st}	2^{nd}	I don't know
24. 1^{st}	2^{nd}	I don't know
25. 1^{st}	2^{nd}	I don't know
26. 1^{st}	2^{nd}	I don't know
27. 1^{st}	2^{nd}	I don't know
28. 1^{st}	2^{nd}	I don't know
29. 1^{st}	2^{nd}	I don't know
30. 1^{st}	2^{nd}	I don't know
31. 1^{st}	2^{nd}	I don't know
32. 1^{st}	2^{nd}	I don't know
33. 1^{st}	2^{nd}	I don't know
34. 1^{st}	2^{nd}	I don't know
35. 1^{st}	2^{nd}	I don't know
36. 1^{st}	2^{nd}	I don't know
37. 1^{st}	2^{nd}	I don't know
38. 1^{st}	2^{nd}	I don't know
39. 1^{st}	2^{nd}	I don't know
40. 1^{st}	2^{nd}	I don't know

Appendix C

Language and cognitive assessment characteristics of the participants

Participants	Age (Years; months)	Sex	CELF	Phonological Memory	Nonverbal IQ	Sustained Attention
Mild						
1. Exp. 1	7; 6	F	78	73	87	10
2. Exp. 2	8; 4	M	82	95	93	12
3. Exp. 3	9; 11	M	84	67	62	6
4. Exp. 4	7; 6	M	82	104	93	13
5. Exp. 5	7; 6	M	84	67	109	6
6. Exp. 6	7; 11	M	85	85	103	12
7. Exp. 7	7; 11	M	85	79	91	6
8. Exp. 8	8; 1	F	82	95	67	10
9. Exp. 9	8; 7	F	78	85	97	8
10. Exp. 10	8; 0	M	78	82	77	7
11. Exp. 11	8; 3	F	82	88	80	13

12. Exp. 12	8; 0	F	81	88	89	16
13. Exp. 13	9; 6	M	80	82	91	7
Moderate						
14. Exp. 14	10; 0	F	77	85	97	11
15. Exp. 15*	11; 5	M	75	82	77	8
16. Exp. 16	10; 5	F	75	101	82	8
17. Exp. 17	8; 6	M	74	79	68	5
18. Exp. 18	9; 6	M	75	92	67	4
19. Exp. 19	10;10	F	75	82	95	7
20. Exp. 20	9; 2	F	76	73	77	5
21. Exp. 21	7; 3	F	73	67	76	10
22. Exp. 22	10; 5	M	77	82	50	6
23. Exp. 23	7; 6	M	73	88	89	10
Severe						
24. Exp. 24*	11; 11	M	68	58	44	5
25. Exp. 25	11; 11	F	66	70	50	8

26. Exp. 26	10; 7	M	67	70	48	12
27. Exp. 27	10; 6	M	70	61	74	9
28. Exp. 28	8; 11	F	48	67	77	2
29. Exp. 29	9; 2	M	70	58	71	6
30. Exp. 30	9; 5	M	46	73	67	9
31. Exp. 31	9; 0	F	70	82	89	4
32. Exp. 32*	10; 0	M	67	70	87	8
33. Exp. 33	10; 7	M	68	87	67	4
Control						
1. Cont. 1	10; 6	M	109	110	85	8
2. Cont. 2	10; 2	F	113	107	102	9
3. Cont. 3	7; 7	M	134	125	127	12
4. Cont. 4	9; 2	F	102	101	111	7
5. Cont. 5	9; 3	F	133	122	137	13
6. Cont. 6	9;2	M	113	119	82	10
7. Cont. 7	8; 2	F	107	104	107	12

8. Cont.8	9;2	M	120	119	97	6
9. Cont. 9	8; 9	F	125	146	102	14
10. Cont. 10	8; 1	F	125	101	127	8
11. Cont. 11	7;8	F	137	119	107	10
12. Cont. 12	8; 11	M	131	116	109	9
13. Cont. 13	10;2	F	113	98	100	7
14. Cont. 14	10; 5	M	135	116	113	9
15. Cont. 15	10; 3	M	114	113	113	8
16. Cont. 16	10;11	M	118	110	115	11
17. Cont. 17	11; 1	M	113	113	107	15
18. Cont. 18	10; 0	M	133	104	107	10
19. Cont. 19	7;8	M	136	131	103	9
20. Cont. 20	10; 0	M	121	116	111	11
21. Cont. 21	8; 0	M	122	113	113	11
22. Cont. 22	8; 2	F	120	98	97	13
23. Cont. 23	7; 5	F	131	119	121	17

24. Cont. 24	9; 4	M	107	110	93	8
25. Cont. 25	8; 4	F	120	107	109	12
26. Cont. 26	10;2	M	122	107	90	9
27. Cont. 27	8;4	M	123	98	105	12
28. Cont. 28	8; 10	M	118	113	102	14
29. Cont. 29	9; 8	F	120	113	100	12
30. Cont. 30	7; 9	F	131	134	117	13
31. Cont. 31	7; 9	F	117	101	109	13
32. Cont. 32	7; 8	F	122	122	127	9
33. Cont. 33	9; 9	F	129	113	113	12
34. Cont. 34	7; 0	M	134	110	136	13
35. Cont. 35	8; 10	M	136	131	141	8
36. Cont. 36	11; 3	F	133	134	125	12

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