

A Preliminary study of speech discrimination in youth with Down syndrome

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Abstract

Few studies have examined the ability of individuals with learning disabilities, in general, or with Down syndrome, specifically, to discriminate speech. The purpose of this study was compare the speech discrimination abilities of eight children with Down syndrome (aged 5.7 to 12.8 years) to seven nonverbal mental-age matched controls (aged 4.0 to 5.3 years). A computer program presented the speech discrimination task using a two-cued alternative forced choice procedure. On each trial, the participants heard four successive synthesized speech syllables, with the first and last stimuli being the same and serving as the cue. The results indicated children with Down syndrome differed from their nonverbal mental-age matched peers in their ability to discriminate two of the five pairs, but not in the manner predicted. The relationship between speech discrimination, phonological memory, and speech-language development is also discussed.

Keywords: *Speech discrimination, Down syndrome, phonological memory, speech-language development.*

Introduction

Individuals with Down syndrome (DS) exhibit an array of deficits in speech and language skills, including poor hearing and articulation, short mean length of utterances, and difficulty producing grammatical morphemes (Abbeduto et al., 2001; Chapman, Seung, Schwartz, & Bird, 1998; Kumin, 2001). However, little is known about other aspects of development, such as speech perception. Speech perception ability has been a focus of researchers examining children with language impairment (Leonard, McGregor, & Allen, 1992; Manis & Keating, 2005; Stark & Heinz, 1996a), articulation and phonological disorders (Rvachew & Jamieson, 1989; Rvachew, 1994; Edwards, Fox, & Rogers, 2002), and children with reading disabilities (Chiappe, Chiappe, & Gottardo, 2004; Maassen, Groenen, Crul, Assman-Hulsmans, & Gabreëls 2001; Manis & Keating, 2005; Studdert-Kennedy, 2002). While individuals with DS have difficulties in learning language and exhibit phonological impairment, which may put them at risk for reduced speech perception skills, there has been little research in this area. The present investigation

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addresses this issue by examining the speech perception abilities of youth with DS in a discrimination task.

Speech perception in children with language and phonological disorders

There has been much discussion in the literature as to the nature of speech perception deficits in children with language impairment. Several investigators have reported that children with language impairment have a general processing delay that affects their ability to perceive all types of acoustic information (Merzenich et al., 1996; Tallal, Stark, Kallman, & Mellits, 1980). Others have suggested that children with language impairment have a speech specific problem, that is, difficulty processing specific acoustic features of speech (Gillam, Hoffman, Verhoeven, & van Balkom, 2004; Mody, Studdert-Kennedy, & Brady, 1997; Stark & Heinz, 1996b; Sussman, 1993).

Leonard et al. (1992) compared children with language impairments with children matched for chronological age on a speech perception identification task. The study reported that children with language impairments have greater difficulty with unstressed syllable contrasts and syllable-final consonants. Specifically, these morphemes are more difficult to discriminate because of their short duration relative to adjacent material and that they seldom occur in sentence positions where lengthening may occur, such as phonological phrase-final syllables or utterance final position (Leonard, Eyer, Bedore, & Grell, 1997; Leonard et al., 1992). It is also the case when vowels in unstressed syllables often become reduced and/or centralized which might reduce their saliency and decrease spectral differences between vowels.

Stark and Heinz (1996b) examined the discrimination, identification, and serial ordering of synthesized vowels in typically developing and language-impaired children. The pairs consisted of highly similar and highly dissimilar vowels. The study found that the language-impaired group was less accurate in identifying dissimilar vowels, and required a greater number of prompts and repetitions to identify similar vowels when compared to the typical language learners. Stark and Heinz (1996b) argued that the children with SLI might need more exposure, experience, or training in order to complete auditory processing tasks.

Similarly, there is evidence to suggest that children with phonological disorders have greater difficulty discriminating acoustic information. For example, Edwards et al. (2002) used a backward gating paradigm to examine the discrimination of final consonants in consonant-vowel-consonant words. They found that preschool aged children with phonological disorders performed worse than chronologically age matched peers. Other studies have found that children with phonological disorders have difficulty discriminating sounds they cannot produce. Rvachew (1994) examined whether speech perception training could improve the articulation of children with phonological disorders. Children who received speech perception training on the target error sound significantly improved their ability to produce the sound at the end of treatment. This raises the question of whether this relationship exists in other populations, such as those with Down syndrome, who also exhibit delays in their articulation and intelligibility.

Researchers are beginning to explore the relationship between speech perception and other aspects of language such as vocabulary. Edwards et al. (2002) reported that performance of preschoolers with phonological disorders on a speech discrimination task was significantly correlated with receptive vocabulary. Performance on the Peabody Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997) accounted for 31% of the variance in performance on a speech discrimination task with additional 8% of the variance

accounted for by scores on the Goldman-Fristoe Test of Articulation (GFTA-2; Goldman & Fristoe, 2000). These results suggest a relationship between word learning and speech perception skills (Edwards et al., 2002).

Speech perception in individuals with learning disabilities

There is a dearth of information about the relationship between speech perception, articulation/phonological skills, and language abilities in individuals with DS or other populations with learning disabilities. Eilers and Kimbrough (1980) examined the ability of young children with learning disabilities to discriminate minimal pair contrasts using the Visually Reinforced Infant Speech Discrimination paradigm. The results indicated that the children with learning disabilities had greater difficulty discriminating contrasts that differed in consonants than those that differed in vowels. Others have investigated the pattern of cerebral specialization, specifically, an atypical left ear-right hemisphere dominance for speech perception (Elliott & Weeks, 1993; Heath & Elliott, 1999; Weeks & Elliott, 1992). However, there is evidence that type of task or context effects could contribute to this laterality (Heath et al., 2005; Welsh, Elliott, & Simon, 2003)

Various factors could affect speech discrimination in individuals with DS such as hearing loss, phonological ability and speech intelligibility. Individuals with DS are at an increased risk of hearing loss due to physical malformations of the ear and an increased incidence of respiratory infections (Pueschel, Tingey, Rynders, Crocker, & Crutcher, 1987). In evoked potential studies, Yung-Chung and Peng-Cheng (2005) found that infants with DS exhibited sensory impairments in the peripheral and central nervous system.

Several investigations have found that individuals with DS have a slower rate of phonological development and poor speech intelligibility (Stoel-Gammon, 1997). Stoel-Gammon suggests that difficulty understanding, storing, and retrieving phonological information may contribute to the phonological impairments observed in individuals with DS.

A deficit in verbal short-term memory could also contribute to difficulty in speech perception. Individuals with DS have significantly poorer verbal than visual short-term memory which may affect their ability to perceive acoustic information (Chapman & Hesketh, 2001; Kay-Raining Bird & Chapman, 1994). Laws (1998) reported that the individuals with DS had more difficulty repeating nonwords than real words and that nonword repetition was significantly correlated with reading, receptive vocabulary, and language comprehension. In a later study, Laws (2004) examined the relationship between nonword repetition, hearing status, language comprehension, and expressive language in individuals with DS. Expressive language, measured by mean length of utterance and sentence recall, was significantly correlated with nonword repetition but not hearing status.

Cairns and Jarrold (2005) expanded on this work by comparing the performance of individuals with DS and typically developing peers matched for receptive vocabulary on a speech discrimination task. The McCormick Toy Test (McCormick, 1977), was modified where seven pairs of familiar objects with acoustically similar labels were presented. As an object label was presented via an audio-recording and the participants identified the correct item. The two groups did not differ significantly on the speech discrimination task, although the group with DS tended to perform poorer than the typically developing peers. The groups did differ, however, when the authors examined the correlations between nonword repetition and other measures (Cairns & Jarrold, 1995). In the group with DS, nonword repetition was significantly correlated with receptive vocabulary but not verbal

short-term memory performance. There was a significant association between nonword repetition and verbal short-term memory in the typically developing group, but not with receptive vocabulary. Cairns and Jarrold (1995) suggested that this confirms previous research, individuals with DS have poor verbal short-term memory and further suggests that individuals with DS do not rely upon verbal short-term memory in repetition tasks to the same extent as typically developing children.

The purpose of this study was to examine if children with DS performed differently on speech discrimination tasks than typically developing peers matched for nonverbal cognitive ability. The study also examined the relationship between speech discrimination ability, phonological memory, speech, and language ability.

Methods

Participants

Eight Caucasian participants with DS were recruited from several states in the Midwest, three females and five males (see Table I). According to parental report, each was diagnosed with Trisomy 21, used speech as the primary mode of communication, and were native speakers of English. There were no physical impairments that would prevent performance of the tasks. Participants had pure-tone thresholds equal to or better than 25db HL at 500, 1000, 2000, and 4000Hz. One participant with DS had pure tone

Table I. Means and standard deviations for age, mental -age, and linguistic ability by group.

Characteristics	DS (n = 8)	MA-Matches (n=7)
Chronological Age (years)	9.40	4.94
Standard Deviation	29.40	5.28
Range	5.67–12.75	4.0–5.33
Maternal Education Level (years)	15.13	16.0
Standard Deviation	1.64	1.16
Range	12.0–17.0	14.0–18.0
Nonverbal Mental Standard Score ^a	63.63	100.29
Standard Deviation	8.91	11.72
Range	52.0–78.0	87.0–118.0
Nonverbal Mental Age ^b	4.65	4.64
Standard Deviation	6.76	8.78
Range	3.71–5.21	3.71–5.71
MLU ^c	3.25	7.02
Standard Deviation	1.88	1.26
Range	1.29–7.22	5.51–8.93
PPVT-III ^d Standard Score	58.0	113.86
Standard Deviation	14.14	18.24
Range	40.0–89.0	88.0–145.0
GFTA-2 ^e Standard Score	57.63	114.71
Standard Deviation	22.63	4.50
Range	35.0–97.0	109.0–123.0
EVT ^f Standard Score	49.13	105.00
Standard Deviation	13.93	16.71
Range	40.0–77.0	84.0–127.0

Notes: ^a Mean standard scores from Columbia Mental Maturity Scale. ^b Mean age-equivalency in years from Columbia Mental Maturity Scale. ^c Mean Length of Utterance in morphemes. ^d Peabody Picture Vocabulary Test-III. ^e Goldman-Fristoe Test of Articulation-2. ^f Expressive Vocabulary Test.

thresholds of 30db at 500Hz in one ear, but was retained for the study as there was no evidence that this would impact performance on the speech discrimination task presented at approximately 70dB HL.

A total of seven children, five females and two males, served as mental-age (MA) matches. Six of the eight were Caucasian and two were African-American. Each was at least 4 years of age in order to ensure they were able to comprehend and complete the speech perception tasks. The chronological ages ranged from 4–5.3 years of age. The participants had an age deviation score of at least 84 on the Columbia Mental Maturity Scale (CMMS) (Burgemeister, Blum, & Lorge, 1972) and no history of special education services. The children in the MA-group were individually matched to the DS group plus or minus two standard error of measurements for age-equivalent scores on the CMMS (Burgemeister et al., 1972), resulting in a matching participants plus or minus six months in age-equivalent scores. An independent-samples t-test revealed no significant between group difference ($p > .05$) in mean mental ages and maternal education level of the two groups.

Language and cognitive tasks

Nonverbal Mental Ability. The CMMS (Burgemeister et al., 1972) was used to measure nonverbal cognitive ability. Raw scores were converted to standard scores (age deviation scores) and to an age-equivalent score (mental maturity index, MMI). Since the MMI represents a range, the midpoint of this range was used as the age-equivalent score (see Table I).

Expressive language and articulation. Narrative and conversational tasks were used to collect a 15-minute language sample. According to Abbeduto, Benson, Short, and Dolish (1995) individuals with learning disabilities produce more syntactically complex samples in narrative contexts than in conversation, but produce a greater number of utterances in conversation than in a narrative task. Thus, both contexts were used to evaluate expressive language in individuals with learning disabilities.

An interview protocol was used in accordance with Evans and Craig (1992). Three questions were asked: “What can you tell me about your family?”, “Are you in school? Tell me about it” and “What do you like to do when you’re not in school?”. In the narrative task, each participant was shown a wordless picture book, *Frog Goes to Dinner*, by Mercer Mayer (1977). New York: Puffin Books. Each participant reviewed the book twice. During the first presentation, the child was instructed to simply review each page. In the second presentation, the participant was asked to describe the story in its entirety. Participants were given general prompts, i.e. “What’s happening here?” and were encouraged to complete the story.

The language samples from both the interview and narrative contexts were audio recorded and transcribed orthographically. As shown in Table I, mean length of utterance (MLU) was calculated to provide an estimate of sentence length produced by the participants. (Miller, 1981) To measure reliability, 10% of audiotapes from each group were randomly selected and transcribed by an independent listener.

Additional speech and language measures. In order to provide a broader picture of group functioning, three additional measures were administered. The PPVT-III (Dunn & Dunn, 1997) was used to evaluate receptive vocabulary and the Expressive Vocabulary Test (Williams, 1997) was used to examine expressive vocabulary development. The GFTA-2 (Goldman & Fristoe, 2000) was used to assess phonological development.

Nonword repetition task. A nonword repetition task was used as a measure of phonological memory. The task was developed by Dollaghan and Campbell (1998) and consists of 16 nonwords varying in length from one to four syllables. The nonword stimuli were spoken by a male doctoral student into a microphone and recorded directly onto an IBM compatible computer. The nonwords were then digitized at 20kHz with a 16-bit resolution using the Computerized Speech Research Environment. Finally, the stimuli were recorded onto a compact disc (CD), with a sampling rate of 22,050Hz and a 16-bit resolution. The nonword stimuli include phonemes that are acquired in early developmental stages and minimize the predictability of individual phonemes within the nonwords. Additionally, neither the nonwords nor their constituent syllables resemble lexical items.

The four nonwords at each syllable length were randomly presented, moving from one-syllable nonwords to four-syllable nonwords. Each participant was administered the nonword repetition task using headphones and a portable CD player in a quiet location. The following instructions were given using live voice: "Now you will hear some made-up words. Say them exactly the way that you heard them". Each nonword was presented one time and the responses were audio recorded by an external microphone onto a cassette recorder for broad transcription.

Each phoneme in the nonword was scored as correct or incorrect. Phoneme distortions were counted as correct while phoneme substitutions and omissions were errors. As in Dollaghan and Campbell (1998), phoneme additions were not considered errors. If a participant added or omitted one or more syllables, the repeated vowels served as syllable anchors. For example, if the target was /tævatʃinaig/ and the child produced /vatnaig/; the child would be credited for having attempted the second and fourth syllables and then the response was scored phoneme by phoneme.

The percentage of phonemes correct was obtained by dividing the number of correct phonemes by the total number of phoneme targets at each nonword length and for the entire set of stimuli. In order to measure reliability, a second listener transcribed 10% of the audiotapes from each participant group.

Speech perception task

Stimuli. Five stimulus pairs were created using a cascade parallel software synthesizer (Klatt, 1980). The five contrastive pairs were: [i]-[u], [ba]-[da]; [dab]-[dæb], [das]-[daʃ]; and [dab-i-ba]-[dab-u-ba]. These speech stimuli were generated from the speech specifications used in Leonard et al. (1992) with some minor modifications to increase the naturalness of the syllables. With the exception of [i] versus [u], F4 and F5 were included and were steady state at 3600Hz, and 4500Hz, respectively, for the other four stimulus pairs. For the stimulus pair [i]-[u], a steady state fourth formant was added at 4500Hz from onset. The amplitude of voicing was increased to 60dB for all five-stimulus pairs.

Procedures. In comparison to an identification task where participants are required to retain a target stimulus, a discrimination task was used to minimize the cognitive and memory demands of the task. A two-cued alternative forced choice procedure (2Q AFC) was used and presented binaurally through headphones via a Windows-based laptop computer. Four squares outlined in white were displayed in the centre of the screen against a black background. On each trial, the child was presented with four successive syllables, each of which was signalled by the illumination of one of the four boxes. The first and last stimuli

presented were always the same and served as the cue. One of the two remaining stimuli was identical to the cues, i.e. the same as the first and last stimuli presented, while the other was different from the other three. Thus, on any given trial, the target stimulus was randomly assigned to the second or third interval.

Each child was tested individually in a quiet room with a playback level judged as comfortable by the subject, approximately 70dB HL. Instructions were given via live voice: "We're going to play a listening game. You are going to hear some funny sounds. Each time you hear a sound one of the boxes is going to light-up. I want you to show me which sound was different. Point to the box of the different sound. If you're not sure, it is okay to guess". The children were frequently encouraged to listen carefully.

The stimuli were presented with an interstimulus interval (ISI) of 500msec. After the four stimuli were presented the participants were required to touch the box corresponding to the interval that contained the target stimulus. The adult then indicated the child's response via the keyboard. Depending upon the child's familiarity with computers, several participants were allowed to use the keyboard under the supervision of the examiner to ensure consistency between their response via the screen and the keyboard. The correct interval was illuminated in a green box to provide feedback to the individual participants. Additionally, after each response, a piece of a puzzle was displayed on the monitor and after the block of trials was completed the entire picture was displayed.

Two training sessions were employed to insure that the participants understood the task. The participants received corrective feedback and constant encouragement and praise throughout both training sessions. In the first training task, each child was presented with a 100Hz tone and sawtooth noise, each 250msec in length in the 2Q AFC paradigm in 16 trials. In the second session, a 100Hz tone and a 305Hz tone, each 250msec in length were presented. If the subjects performed below 75% (12 of 16) on the second training phase, both training phases were repeated again. After the training sessions were completed, the children began testing with one of the five stimulus pairs. Each stimulus pair was presented in 16 randomly presented trials, for a total of 80 trials.

Scoring. Signal detection measures have been used to assess performance on perceptual discrimination tasks (Macmillan & Creelman, 2005). The discrimination scores (hit and false-alarm rates) were converted into a sensitivity measure of proportion correct adjusted for response bias, $p(c)_{max, 2 AFC}$.

Results

Nonword repetition task

A mixed model, repeated measures analysis of variance (ANOVA) was used with the group as a between-subjects factor, arc-sine transformations of percentage of phonemes correct, and the within-subject factor was syllable length.

The results revealed a significant main effect for group, ($F(1,13)=63.43, p < .01, \eta^2=.83$), but no significant interaction between Group and Nonword repetition using Wilks' lambda criterion ($F(4,10)=1.65, p > .05$). The results revealed significant main effect for group indicating that the group with DS produced 29% of the total number of phonemes correctly compared to 71% for the MA-matches. As seen in Figure 1, the group with DS produced fewer phonemes correctly at each syllable length than the MA-matches.

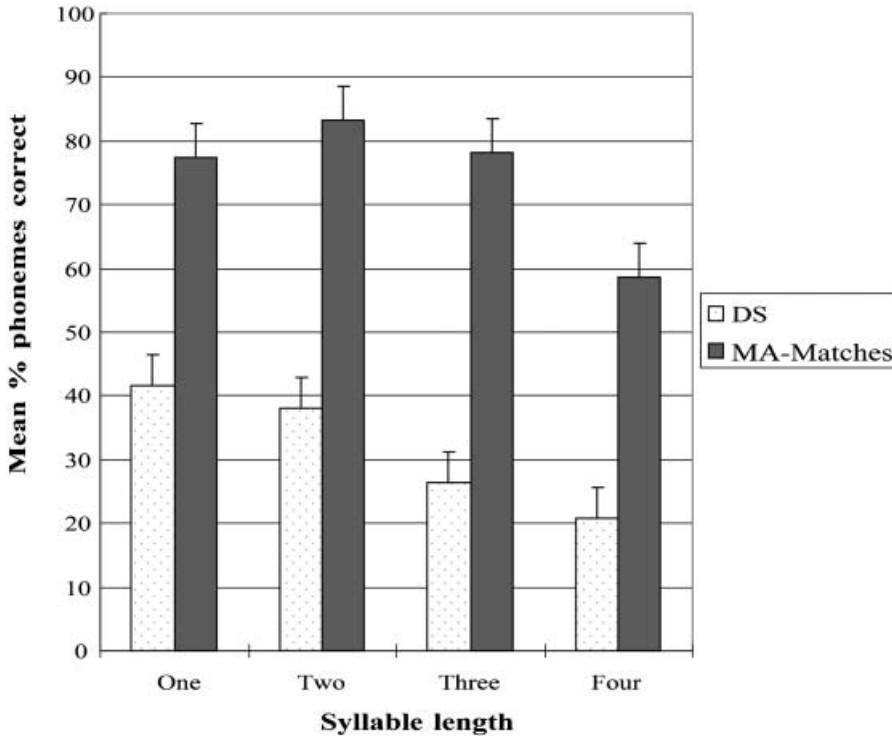


Figure 1. Mean per cent of phonemes correct on nonword repetition task for youth with Down syndrome compared to mental-age matched peers.

The main effect of nonword repetition was significant ($F(4,10)=7.12$, $p<.01$, $\eta^2=.74$). As expected, both groups produced four-syllable nonwords more poorly than one-, two-, and three-syllable nonwords.

Speech discrimination

A series of ANOVAs was performed with group (MA-matches and DS) as the independent variable and the different stimulus pairs as the dependent variables. The tests were significant for the [i]-[u] contrast, ($F(1,13)=11.04$, $p<.01$, $\eta^2=.46$), and for the [dab-i-ba]-[dab-u-ba] contrast, ($F(1,13)=15.86$, $p<.01$, $\eta^2=.55$). As shown in Figure 2, the participants with DS performed more poorly than the MA-matched controls. For the [i]-[u] contrast, the group with DS had a mean $p(c)_{max, 2 AFC}$ of .43 (SD=.15) compared to .74 (SD=.15) for the MA-controls. Similarly, for the [dab-i-ba]-[dab-u-ba] contrast, the MA-controls had a mean $p(c)_{max, 2 AFC}$ of .66 (SD=.15) compared to .44 (SD=.06) for the group with DS. There was no significant difference in the performance of the groups for the [ba]-[da], ($F(1,13)=1.4$, $p<.05$), [dab]-[dæb] ($F(1,13)=2.71$, $p<.05$), and [das]-[da.] contrasts, ($F(1,13)>.01$, $p<.05$).

Relationship between speech discrimination and nonword repetition

A Spearman correlation analysis was conducted to evaluate the relationship between performance on the speech discrimination tasks and on the nonword repetition task. Each

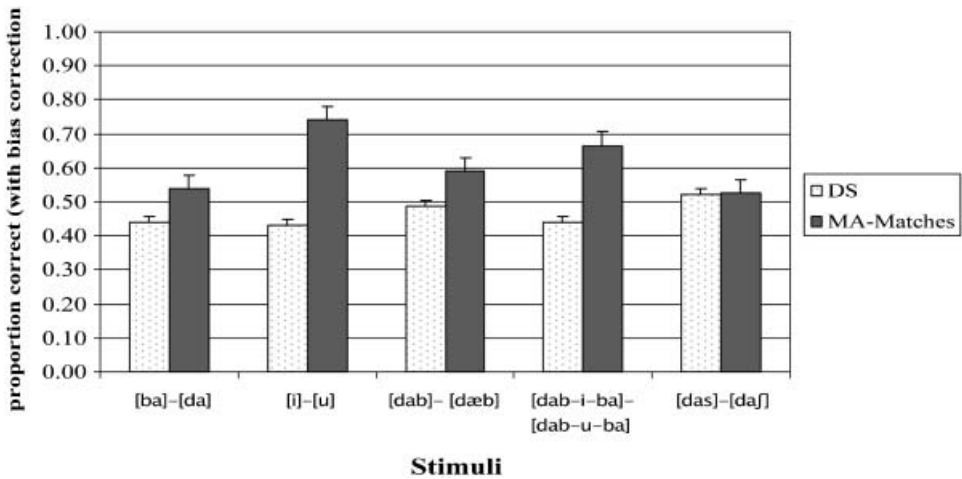


Figure 2. Mean speech discrimination scores for stimulus pairs presented to youth with Down syndrome and mental-age matched peers.

group was examined separately for each of the two stimulus contrasts on which their performance differed significantly. There were significant Spearman correlation between the $p(c)_{max, 2 AFC}$ values for the [i]-[u] contrast, $\rho = .62, p < .05$, and for the [dab-i-ba]-[dab-u-ba] contrast, $\rho = .76, p < .01$ for the entire participant sample.

Relationship between speech discrimination and speech-language measures

The EVT and PPVT-III standard scores were averaged to obtain a vocabulary composite score. Using the Bonferroni approach to control for Type 1 Error, a p value of less than .013 (.05 divided by 4) was required for significance. As shown in Tables II and III, there were significant Spearman correlations between the $p(c)_{max}$ value for the [i]-[u] contrast and the following measures: vocabulary composite score, MLU, and articulation ability when both groups were combined. Similar results were obtained for the [dab-i-ba]-[dab-u-ba] contrast with the exception of MLU, which did not reach significance.

Table II. Spearman correlations between [i]-[u] contrast, vocabulary, and phonological memory for all participants.

Variable	[i]-[u]	MLU	GFTA	Vocabulary Composite
[i]-[u]	1.00	.71*	.69*	.73*
MLU ^a		1.00	.83*	.79*
GFTA-2 ^b			1.00	.92*
Vocabulary Composite ^c				1.00

Notes: * significant at the .013 level (2-tailed). ^a Mean Length of Utterance in morphemes ^b Goldman-Fristoe Test of Articulation-2. ^c Average standard scores on the Peabody Picture Vocabulary Test-III and the Expressive Vocabulary Test.

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Table III. Spearman correlations between [dab-i-ba]-[dab-u-ba] contrast, vocabulary, and phonological memory for all participants.

Variable	[dab-i-ba]-[dab-u-ba]	MLU	GFTA	Vocabulary Composite
[dab-i-ba]-[dab-u-ba]	1.00	.60	.73*	.64*
MLU ^a		1.00	.83*	.79*
GFTA-2 ^b			1.00	.92*
Vocabulary Composite ^c				1.00

Notes: * significant at the .013 level (2-tailed). ^a Mean Length of Utterance in morphemes ^b Goldman-Fristoe Test of Articulation-2. ^c Average standard scores on the Peabody Picture Vocabulary Test-III and the Expressive Vocabulary Test.

Discussion

The primary aim of this study was to examine the speech discrimination abilities of youth with DS. The results of this experiment revealed that the group with DS performed similarly to the MA-matched control group on most of discrimination tasks, except for the [i]-[u] and [dab-i-ba]-[dab-u-ba] contrasts. Leonard et al. (1992) reported that children with specific language impairment (SLI) had more difficulty than typically developing peers identifying stimuli where the contrastive portions were shorter than the adjacent syllables, such as [dab-i-ba]-[dab-u-ba] and [das]-[daʃ], but not perceptual contrasts such as [i]-[u].

These results do not follow the same pattern as reported by Leonard et al. (1992) but do indicate that individuals with DS have more difficulty discriminating some types of perceptual contrasts than MA-matched peers. However, due to the fact that the two groups differed significantly on only two perceptual contrasts, it is unclear if this was due to a general limitation in processing as proposed by Leonard et al. or a specific deficit in auditory processing as suggested by Tallal et al. (1989).

This investigation also examined the relationship between speech discrimination and other aspects of linguistic processing. Participants with better phonological memory, lexical development, and articulation ability performed better on the speech discrimination task. These results support prior research which suggests a relationship between speech perception, language, and articulation. While correlational analyses indicate a relationship, it is still unclear if there is a causal relationship between these factors.

One question raised by the data is why there were not greater differences between the groups. There are several factors that may explain these results, including type task, the use of synthetic speech, and motivation. The participants may have had difficulty using the two cue alternate forced-choice paradigm. A discrimination task was used instead of an identification task such as the one used by Leonard et al. (1992) and Evans, Viele, Kass, and Tang (2002) to reduce the cognitive and memory demands of the task. In an identification task, the participant is given a stimulus target and has to remember what the target is and indicate when that target is presented. Given the difficulties individuals with DS have with phonological memory, an identification task was considered too difficult. Further, the additional cues should have maximized the performance of the children with DS.

The performance of the participants could have been influenced by the use of synthetic speech, suppressing the degree of difference between groups. Previous studies have found that the perception of synthetic speech stimuli requires greater processing demands on typically developing children and children with SLI (Luce, Feutstel, & Pisoni, 1983). Evans

et al. (2002) extended the Leonard et al. (1992) study by comparing the performance of children with SLI to typically developing peers on perceptual contrast created using natural and synthetic speech. The children with SLI were comparable to the typically developing children in the natural speech condition but were significantly different in the synthetic speech condition. Future studies are needed to examine the speech perception abilities of youth with DS with natural and synthetic speech stimuli.

Finally, motivation could also explain the pattern of performance seen in this study. The participants with Down syndrome could have experienced fatigue due to the number of trials in the speech perception task. Niccols, Atkinson, and Pepler (2003) found that preschoolers with DS achieved lower scores on measures of mastery motivation. Thus, while the participants were given frequent breaks and various forms of reinforcement throughout the speech perception task, it may have been difficult for the participants to maintain their motivation to complete the task.

In conclusion, these preliminary results are consistent with the findings of Eilers and Kimbrough (1980) in that the individuals with DS had greater difficulty discriminating certain types of perceptual contrasts. These data suggest a relationship between speech discrimination ability and other measures of linguistic processing that have been found in other populations. Additional studies are needed to examine the ability of individuals with DS to discriminate other types of perceptual contrasts.

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