

PROSODIC CHARACTERISTICS IN CHILDREN WITH STUTTERING OR AUTISM DURING READING AND IMITATION

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ABSTRACT

This study investigates intonation and timing characteristics of autistic and stuttering children's speech in English. Twelve children ranging from 7 to 14 years of age (four subjects from three groups, autistic, stuttering, control) participated in this study. They were asked to read sentences and then to repeat them after the experimenter. Results show that stuttering subjects differed only slightly from normal control subjects in most measurements, though they show more variation. For both reading and imitation data, autistic children's speech was the most deviant from the control data in terms of intonational properties. Results also show that autistic children produced more pitch accents and phrase boundaries than control children, and often could not produce High boundary tone though they were able to produce High pitch accents. This implies that the two high tones may be produced with different articulatory and respiratory effort, supporting their distinct categorical status in the theory of intonational phonology.

1. INTRODUCTION

Prosody is considered a key element in acquiring and producing meaningful language. Studies on children's prosody have focused on infant perception and early production of small speech units such as syllable or word. But a few studies include children with prosodic disturbance in a larger speech unit such as intonational and phonological phrases, and only a few of these include instrumental data [2, 3, 5].

Stuttering is a prosodic disorder observed in most languages in which the speaker knows precisely what to say but for a brief period of time cannot express the thought [15]. Researchers posit that stuttering occurs when there is a mistiming between phonation, articulation, and respiration resulting in repetitions, cessations, or prolongations of sound [10].

Autism has been described in traditional terms as a qualitative impairment in social interaction, language and communication, and play [1, 16]. Currently, autism is viewed as a spectrum disorder (described as a biologically-based, neuroimmunological, and developmental disability) involving physiologic dysfunction of one or more unidentified brain systems [14].

Children with autism also are considered deficient in prosodic skills [9, 14], and having a developmental speech and language impairment both in understanding and expressing communication. They are known to be fluent speakers but their utterances consist of unintelligible jargon that has little communicative intent, i.e., echolalia. Their speech has been known to have a sing-song, atypical voice quality, and also described as being deviant in terms of voice volume (i.e. monotonous, too loud or soft), and 'atonal, arhythmic, and hollow' [4]. A similar claim was made in [13] based on impressionistic data. They claim that the echoed

speech of autistic children did not imitate the rhythm or intonation of the adult stimuli, but rather tended to be monotonous in pitch, rhythm, and intensity. On the other hand, other studies claim that autistic children imitate perfectly the tone of voice and rhythm of other speakers [8].

Several observations on acoustic data have been made regarding the intonation of children with autism in terms of the description of surface tonal patterns. For example, Fletcher [7] showed that the autistic children were not able to imitate adults' intonation contours as well as normal children. Bagshaw [2], on the other hand, found that there is not much difference between these groups in declaratives, though autistic children show more variation in f_0 and duration. Baltaxe [3] examined prosodic characteristics of yes/no questions, wh-questions, and commands, and found that the autistic children had greater durations and greater variability than normal children. She further found that autistic children did not change the word duration whether it is produced in isolation or within a sentence, suggesting that autistic children may differ from normal children in their temporal organization and rhythmic structure of speech. She also found that normal children used f_0 and intensity to express differences in sentence types but autistic children used intensity only. She interpreted this a modality-specific overselectivity. That is, they overselect one modality when competing with several modalities such as f_0 , intensity, and duration.

In a later study [5], f_0 and intensity of autistic, normal, and aphasic children's speech of younger age were examined. They found that autistic children either show a highly exaggerated pitch range, thus similar to normal children's range, or a very narrow pitch range, thus similar to aphasic children's pitch range. Based on the results of sentence final fall, stress marking, and declination, Baltaxe and her colleagues claimed that some of the prosodic characteristics are more stable and consistent than others, and some prosodic markers are produced more differently among the subjects. They suggested that the covariance of frequency and intensity may develop earlier, but still be the result of maturational factors and learned behavior.

In this study, we investigate, based on the phonetic experiments, intonation and timing characteristics of autistic and stuttering children's speech, adopting the phonological model of English intonation [12]. The prosodic characteristics of these groups will be compared with those of normal control children both quantitatively (in terms of pitch range and duration) and qualitatively (in terms of the type of pitch accents, boundary tones, and a phrasing).

2. METHOD

2.1. Subjects

Twelve subjects, three groups (Autistic, Stuttering, and Control) of four subjects, were selected to participate in the

experiment. Subjects were all males, and their age ranged from 7 to 14 years. Control and Stuttering subjects were considered average to above average in terms of academic placement. Stuttering subjects have been treated for at least two years. Autistic children met the diagnostic criteria for autism following DSM-III guidelines. They were sight-word readers and were in special education classes for autism.

2.2. Procedures

There was a total of 32 test sentences -- declarative and question sentences that varied in length and syntactic complexity as well as a word type. There were two types of test sentences: 'rhino' and 'hippo', but only 'rhino' type data will be discussed in this paper. Sentences of 'rhino' type are shown below.

- | | |
|----------------------------|-----------------------------|
| (1) It's a rhino. | (2) It's a rhino? |
| (3) It's not a rhino. | (4) It's not a rhino? |
| (5) It's a rhinoceros. | (6) It's a rhinoceros? |
| (7) It's not a rhinoceros. | (8) It's not a rhinoceros?. |

Each sentence was written on a card, and was randomized. In Session I (Reading), children were asked to read each sentence three times in a row. Utterances were recorded either in children's home or at a private office suite depending on parents' schedules. A Pressure Zone Microphone (PZM) was situated in the middle of the table to enhance the audio quality of the child's responses.

In Session II (Imitation), held a week later, the experiment was repeated for children from autistic and stuttering group. This time each child was asked to repeat sentences after the examiner, the first author. Reading and imitation data from the normal control children were collected on the same day.

Acoustic analysis of utterances was done using *PCquirer*, a speech analysis program. Pitch range (the difference between the maximum f_0 and the minimum f_0) and duration were measured for each utterance. As a phonological analysis of intonation, the existence and the type of pitch accent, and the location and type of boundary tones were labeled by two authors who are both trained in ToBI labeling convention [6].

3. RESULTS

Stuttering subjects differed only slightly from normal control subjects in most measurements, though they show more variation. Autistic children's speech was the most deviant from the control group data in terms of duration, pitch range, and intonational properties. This was true for both reading and imitation data.

Duration results are shown in Figure 1. Here, a mean duration (ms) of both declaratives and questions for three groups in Reading data is shown (the error bar is a standard error) The mean duration in both declaratives and questions was significantly ($<.05$) longer for autistic children than the stuttering group which was slightly longer than the control group. Autistic children often put a pause between a word, i.e. after *It's* or *not*, and prolonged a certain syllable. Autistic children also showed a greater degree of variability in sentence duration, confirming previous findings [2, 3]. The same pattern was found in imitation data. This shows that, as claimed in [13], autistic children were unable to imitate the timing and rhythmic pattern of an adult.

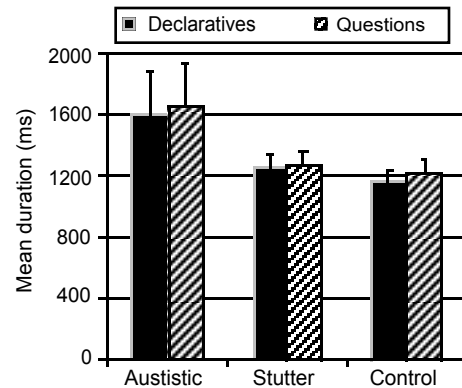


Figure 1. Mean duration (ms) of utterances in declaratives and questions for three groups in Reading data

The pitch range of declaratives were also higher for autistic children than the other two groups in both reading and imitation data. However, in imitation data, both the maximum and the minimum f_0 values were lowered in the autistic group, thus close to the pitch range of other groups. Stuttering and Control groups showed little variation between reading and imitation data. This is shown in Figure 2: the left three bars are from 'reading' data and the right three bars are from 'imitation' data. This result is different from previous studies [11, 3] where normal children showed a wider pitch range than autistic children. This may be due to a different degree and/or type of autism of the subject. As shown in [5], there seems to be a wide variety of responses among autistic children.

In addition to these quantitative differences, we also found qualitative differences between autistic children and other groups. First, they differ in the number of pitch accents and the location of pitch accents. Autistic children produced pitch accents more often than other children, and they tend to put a pitch accent on wrong places (e.g. *rhiNO*, *RHInoceros*) and/or on a function word (i.e. *It*), confirming the results found in [3, 4]. Baltaxe and Simons [4] also found that autistic children did not mark sentence stress in an object position, the last noun in a three-word sentence. In our data, autistic children put stress on the sentence final word most of the time. This may be because this last word in our data is the only content word, and thus somehow focused: some studies mentioned that autistic children are good at using prosody in delivering focus information and other pragmatic information.

Table 1 shows the number of pitch accents in all declaratives (12 sentences) and all interrogatives (12 sentences) averaged across four subjects in each group. In reading data, autistic children show substantially more number of pitch accents than other groups, especially in interrogatives. However, this difference was weakened in Imitation data: all three groups produced a similar number of pitch accents, except for interrogatives in Stutter group. In general, each sentence had one pitch accent on the complement noun, *rhino* or *rhinoceros*, and an additional pitch accent on *not*, if present. It was found that, in imitation data, stuttering children produced all negative sentences with only one accent on *not*. Other than this difference, we could not find any qualitative difference between stuttering and control subjects. We believe that this is due to their weak degree of stuttering and the experiment design in our study. That is, all stuttering children have been treated for more than two years,

and the sentences are all short and produced either in reading or in imitation setting. To investigate prosodic features of stuttering children, more natural and longer utterances should be examined.

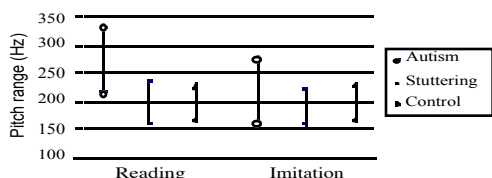


Figure 2. Pitch range (from maximum to minimum f0 value) of autistic, stuttering, and control subjects in Reading (left) and Imitation (right) data.

Subject group	Autism		Stutter		Control	
	Decl.	Inter	Decl.	Inter	Decl.	Inter
Reading	20.5	20.5	16.5	15.0	18	13.7
Imitation	16.7	17.7	18.7	11.3	16.3	15.7

Table 1. The number of pitch accents in all utterances averaged across subjects

The autistic children also differed from others in the number of a phrase boundary. For most cases, each pitch accent was separated by either a phrase boundary tone or a pause. This was the same in imitation data. That is, even though the number of pitch accents decreased in imitation data, the number of phrase boundary in autistic group was higher than that in other groups where two pitch accents in a sentence often belong to one Intonation Phrase.

Another qualitative difference in intonation was found in the boundary tone. It is expected that declaratives are produced with H* followed by a L% boundary tone while interrogatives are produced with L* followed by a H% [12]. Both control and stuttering children produced this pattern except for a very few cases where the declaratives were produced with a list intonation, i.e. L* H%.

Interestingly, autistic children were often unable to produce the High boundary tone for interrogatives, though they were able to produce pitch accents of high f0 (e.g., H* or L+ H*). Instead, they produced H* and L% for interrogative sentences. In this case, interrogatives were not distinguishable from declarative sentences: there was no consistent difference in a pitch range or intensity. Example f0 tracks produced by an autistic subject are shown in Figure 3(a), and those by a control subject are in Figure 3(b), displayed in the same time scale. In each figure, the left panel shows declaratives and the right panel shows interrogatives.

The frequency of boundary tones and their types for both declaratives (total 48 sentences) and interrogatives (total 48 sentences) in Reading data are shown in Table 2(a), and Imitation data are shown in Table 2b (only three subjects in each group, thus total 36 sentences in each sentence type). As shown in Table 2b, autistic children got better in producing a H% tone in interrogatives when they imitate an adult. (In both Reading and Imitation data, autistic children produced a mid plateau boundary (H-L%) for two tokens of interrogatives.)

a) Reading	Autism		Stutter		Control	
	Decl.	Inter	Decl.	Inter	Decl.	Inter
L%	47	31	45	0	43	0
H%	1	15	3	48	5	48
b) Imitation	Autism		Stutter		Control	
	Decl.	Inter	Decl.	Inter	Decl.	Inter
L%	36	6	35	0	36	0
H%	0	28	1	36	0	36

Table 2. Frequency of boundary tones (combined from all subjects in each group) in declaratives and interrogatives in (a) Reading data, and (b) Imitation data

The fact that they can produce H*, but not H%, implies that the high tone produced as a pitch accent is produced differently from that as a boundary tone. That is, these two types of high tones are produced with different articulatory and respiratory efforts: a H* is a high tone accompanied by high intensity, i.e. stressed and pitch accented, but a H% is a high tone not accompanied by intensity. This supports the different phonological status of H* and H% in the theory of intonational phonology. The inability of controlling frequency and intensity independently has been interpreted as a maturational factors [5]. In other words, if autistic children produce a high tone only by means of high intensity, a lack of H% may suggest a lack of linguistic function of pitch, explaining atonal and arrhythmic characteristics of speech by autistic children.

Furthermore, we found that the ability of producing H% in interrogatives was correlated with the severity of autism and the length of a sentence. Shorter sentences were more often produced with H%, and children with less severe autism tend to produce more tokens of H%. Data also show that the child who made a fewer mistakes in the H% tone was better in producing stress on the correct syllable and thus close to the production of control children in terms of the number of pitch accents. This shows that the ability of producing correct prosodic features can be used as a measure of severity of autism.

In sum, autistic children did not imitate the adult's intonation as well as normal or stuttering children, as claimed in [2], and the difference between groups was more apparent in interrogatives than in declaratives due to the different intonation contour, i.e. tonal types of a pitch accent and a boundary tone.

4. CONCLUSIONS

In this paper, we have shown that intonation and timing characteristics of autistic children differ from those of normal control children qualitatively as well as quantitatively. Autistic children used a wider pitch range and a longer duration with greater variability than the control group, both in reading and imitation data. We also showed that autistic children produced more pitch accents and phrase boundaries than control groups, rendering our perception of disconnected and arrhythmic speech. Furthermore, more than half of

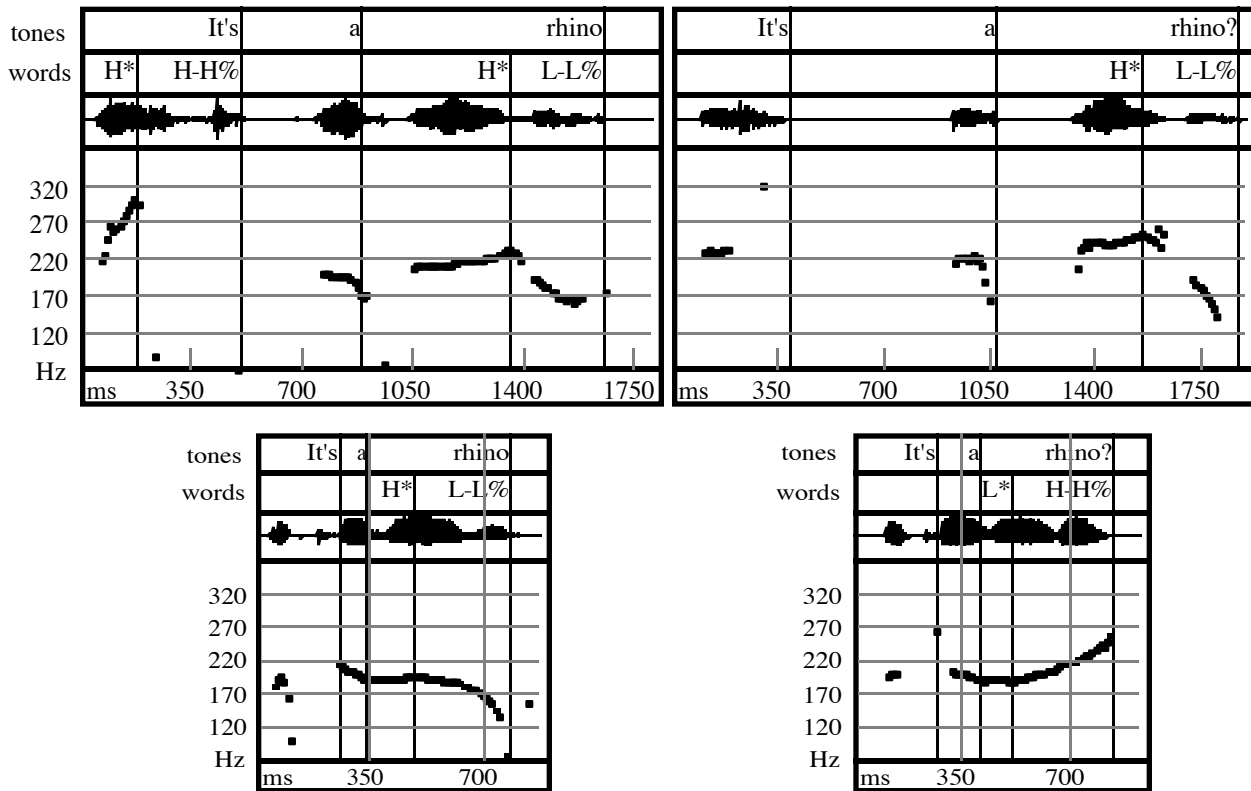


Figure 3. Example pitch tracks of declaratives (left) and interrogatives (right) produced by an autistic child (above) and a normal control child (below).

interrogative sentences were uttered with H* and L% by autistic children, thus prosodically not distinguishable from declarative sentences. This implies that two high tones, H* and H%, are produced with different articulatory and respiratory efforts, supporting their distinct categorical status in the theory of intonational phonology.

We have also shown that stuttering subjects differed only slightly from normal control subjects in most measurements, though they show more variation. More natural and longer utterances should be examined in order to investigate prosodic characteristics of stuttering children.

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