INTONATION AS A POTENTIAL DIAGNOSTIC TOOL IN DEVELOPMENTAL DISORDERS OF SPEECH COMMUNICATION

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ABSTRACT

Speech samples obtained in 4 speech situations from 11 autistic children (7 to 17 years of age) were compared with those from speech/language disordered children and controls matched for age and IQ. The recrdings were analyzed by digital speech processing programs, the parameters assessed being f0, intensity and duration of speech segments. Analyses of variance yielded significant group differences on all three parameters, with the autistic group showing the highest intra- and interindividual variability. Discriminant analyses resulted in a clear separation of the groups. These findings support the hypothesis that intonation can be of key importance in differential diagnosis of children with developmental disorders of speech communication.

INTRODUCTION

Comparisons of morphosyntactic abilities have not resulted in statistically significant differences between verbal autistic children and speech/language disordered children [1]. However, the intonation of autistic children has consistently been described in rather impressionistic and negative terms, for example as odd, mechanical, hollow, devious or monotonous [2,3], whereas, when mentioned at all, the intonation of speech and language disordered children has been judged as normal, adequate or even "compensatory". Monotonous or idiosyncratic patterns of intonation are easily attributed to emotional disturbances because emotional aspects of verbal communication are frequently expressed solely by intonation. But intonation in its wider sense [4,5,6], acoustically a composite of the parameters f0, intensity and duration and their co-variation, serves multiple functions: on the level of the word, of the whole utterance and of the speech situation. To cite Fay and Schuler [2]: "Correct use of non-segmentals thus requires not only grammatical ability but also the ability to attend to and interpret social cues."

Normally the understanding and imitation of intonational contours precedes the acquisition of speech. Ricks [7] found some evidence that in young autistic children "patterns of babble are also impaired or abnormal". It is generally agreed that even quite intelligent older autistic children lack an intuitive understanding of intonational cues. Their literalness and lack of symbolic language might be due to this basic defect [2].

We therefore decided to compare intonational aspects of speech in autistic children, children with specific developmental speech and language disorders [8] and normally developing children. We hypothesized that measurements of f0, of intensity and of duration of speech segments would result in

1. statistically significant group differences between the autistic children on the one hand and the speech/language disordered and control children on the other;
2. Individual differences that would allow identification of each autistic child by discriminant analysis.

METHOD

Subjects

The subjects were 11 autistic children, 11 children with speech/language disorders and 11 normally developing children between 7 and 17 years of age, matched for age and IQ (Raven CPM or SPM). All of the children were of normal intelligence (±SD). They were attending schools for the language disabled or normal primary or secondary schools.

The autistic children had been diagnosed by two different psychiatrists and met Rutter's criteria for infantile autism [9].

The speech/language disordered children (SLD) met Ingram's criteria for specific speech and language disability [8].

Materials

Speech data were obtained in four different speech situations:

1. Repeating sentences (total of 14 syllables)
2. Reading sentences (total of 22 syllables)
3. Telling a story to pictures
4. Answering questions about cars.

In the latter two situations only the first 30 syllables were included in the subsequent analysis.

Procedure

Recordings were made under low noise conditions with a highly directional microphone (Sennheiser Electret Condenser Module Microphone MKE 803) placed one meter from the child's mouth. Speech signals were recorded by a NAGRA 4.2. After appropriate low pass filtering, they were digitized at a sampling rate of 20 kHz. Syllables were then segmented by visual (computer screen) and auditory feedback. F0 was determined by using a refined version of the auto-correlation-pitch-detector suggested by RABINER [10] and visually reexamined with the help of a signal editor to correct any "errors". The data were then transposed into quarter tone steps for better comparison. Intensity was measured (in dB) in relation to the individual maximum amplitude within a given speech situation.

Analyses of variance were performed to assess (a) the homogeneity of group variances (four speech situations) and (b) the homogeneity of variance of individual variances within groups (four speech situations).

Discriminant analyses were made to classify the subjects.

Variables for statistical analysis:

1. MEAN DUR/S (mean duration of syllables in msec)
2. MAX DUR/S (maximum duration of syllables in msec)
3. MIN DUR/S (minimum duration of syllables in msec)
4. MEAN F0/S (mean f0, data in quarter tones above 50 Hz)
5. MAX F0/S (maximum f0, data in quarter tones above 50 Hz)
6. MIN F0/S (minimum f0, data in quarter tones above 50 Hz)
7. MEAN INT/S (relative mean amplitude in dB)
8. MAX INT/S (relative maximum amplitude in dB)
9. MIN INT/S (relative minimum amplitude in dB)

RESULTS AND DISCUSSION

Homogeneity of group variance

For each of the 9 variables studied, the Bartlett test was used to assess the homogeneity of the estimated variance of the three groups (see Table 1).

Table 1: Bartlett test for homogeneity of group variance

Variable	CHI-SQ.	DF	Significance
1. MEAN DUR/S	19.8	2	p<.001
2. MAX DUR/S	31.3	2	p<.001
3. MIN DUR/S	4.7	2	n.s.
4. MEAN F0/S	5.9	2	p<.05
5. MAX F0/S	3.3	2	n.s.
6. MIN F0/S	2.6	2	n.s.
7. MEAN INT/S	8.2	2	p<.05
8. MAX INT/S	3.4	2	n.s.
9. MIN INT/S	0.2	2	n.s.

For variables 1 (MEAN DUR/S) and 2 (MAX DUR/S), the variances of the three groups were significantly heterogeneous (0.1% level) due to the variability in the autistic group. This was the case also for the variables 4 (MEAN F0/S) and 7 (MEAN INT/S) (at the 5% level). There was a significantly greater variability in the autistic group than in either of the other two groups. Although the difference between the control group and the SLD group was not significant for either of these variables (F-test), these two groups could be separated indirectly by comparison with the autistic group: Variable 4 (MEAN F0/S) yielded a statistically significant difference between the autistic children and the control subjects but not between the autistic children and the SLD group.

Homogeneity of variance of individual variances

We then used the Bartlett test to assess the homogeneity of variance of the individual variances within the three groups. We did this because we thought that even in those cases where homogeneous mean group variances could be assumed, homogeneity or heterogeneity of variance of individual variances might enable a clear separation of the groups.

Table 2: Bartlett test for homogeneity of variance of individual variance within the groups

Variable	CHI-SQ.	DF	Significance
1. MEAN DUR S	[illegible]	[illegible]	[illegible]
2. MAX DUR S	[illegible]	[illegible]	[illegible]
3. MIN DUR S	[illegible]	[illegible]	[illegible]
4. MEAN F0 S	[illegible]	[illegible]	n.s.
5. MAX F0 S	[illegible]	[illegible]	[illegible]
6. MIN F0 S	[illegible]	[illegible]	n.s.
7. MEAN INT S	[illegible]	[illegible]	[illegible]
8. MAX INT S	[illegible]	[illegible]	[illegible]
9. MIN INT S	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

and intensity but also the standard deviations of means, resulted in a very good separation of groups (see Table 3).

Table 3: Classification of subjects

Situation	Correct Classification (%) TOTAL	ATT	CON	SLD
1 Repeating sentences	94	100	91	91
2 Reading	94	100	91	9[illegible]
3 Telling a story to pictures	88	91	100	64
4 Answering questions	94	89	100	91

ATT = Autistic children
CON = Control children
SLD = Speech lang. disordered children

[illegible]

Thus speech situations 1 and 2 allowed correct classification of all autistic subjects, and situations 3 and 4 of all control children. No child was classified incorrectly more than once, so that if the predominant category for a given child was used this always led to a correct assignment.

Whether this procedure will generally produce such good results must still be established by testing the model with other children meeting the same criteria.

SUMMARY

Measurements of fundamental frequency, intensity and duration of syllables in four different speech situations resulted in statistically significant differences between autistic, speech/-language disordered and normal control children (analyses of variance). Moreover, discriminant analyses allowed the assignment of each child to the correct diagnostic group.

It is noteworthy that this clear classification was possible without considering age, IQ or verbal proficiency, i.e. even with very intelligent, highly trained and/or older subjects. It appears that not only autistic children but also SLD children fail to achieve the level of proficiency that normal children do.

If analyses of other subjects meeting the same criteria yield similar results, we anticipate that in the future such evaluations of intonation with the help of digital speech processing programs may become a useful tool in differential diagnosis, even in the preverbal stage.

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