Acoustic analysis of speech intonation pattern of individuals with Autism Spectrum Disorders

Análise acústica do padrão entoacional da fala de indivíduos com Transtorno do Espectro Autista

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ABSTRACT

Purpose: This study aimed to analyze prosodic elements of speech segments of students with Autism Spectrum Disorders (ASD) and compare with the control group, using an acoustic analysis. **Methods:** Speech recordings were performed with a sample of individuals with ASD (n = 19) and with typical development (n = 19) of the male gender, age range: 8-33 years. The prosody questionnaire ALIB (Brazilian Linguistic Atlas) was used as script, which contains interrogative, affirmative and imperative sentences. Data were analyzed using the PRAAT software and forwarded to statistical analysis in order to verify possible significant differences between the two groups studied in each prosodic parameter evaluated (fundamental frequency, intensity and duration) and its respective variables. **Results:** There were significant differences for the variables *tessitura*, melodic amplitude of tonic vowel, melodic amplitude of pretonic vowel, maximum intensity, minimum intensity, tonic vowel duration, pretonic vowel duration and phrase duration. **Conclusion:** Individuals with ASD present significant differences in prosody compared to those with typical development. It is noteworthy, however, the necessity of additional studies on the characterization of prosodic aspects of speech of individuals with ASD with a larger sample and a more restricted age group.

RESUMO

Objetivo: Analisar elementos prosódicos de segmentos da fala de escolares com transtorno do espectro autista (TEA) e comparar com grupo controle, por meio de uma análise acústica. **Método:** Foram realizadas gravações da fala de uma amostra de indivíduos com TEA (n=19) e com desenvolvimento típico (n=19) do gênero masculino, intervalo: 8-33 anos. Para coleta de dados, utilizou-se como roteiro o questionário de prosódia do ALiB (Atlas Linguístico Brasileiro), que contém frases interrogativas, afirmativas e imperativas. Os dados obtidos foram analisados por meio do *software* PRAAT e encaminhados para tratamento estatístico com o intuito de verificar possíveis diferenças estatisticamente significantes entre os dois grupos estudados em cada parâmetro prosódico avaliado (frequência fundamental, intensidade e duração) e suas respectivas variáveis. **Resultados:** Verificou-se que houve diferenças significantes para as variáveis tessitura, amplitude melódica de vogal tônica, amplitude melódica de vogal pretônica, intensidade máxima, intensidade mínima, duração de vogal tônica, duração de vogal pretônica e duração de enunciado. **Conclusão:** Indivíduos com TEA apresentam diferenças marcantes na prosódia em comparação aos com desenvolvimento típico. Ressalta-se, no entanto, a necessidade de mais estudos sobre a caracterização de aspectos prosódicos da fala de indivíduos com TEA com uma amostragem maior e faixa etária mais restrita.

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INTRODUCTION

The Autistic Spectrum Disorder (ASD) has been described by DSM-5 to encompass four previously separate disorders (autistic disorder, Asperger's Disorder, Childhood Disintegrative Disorder and Invasive Developmental Disorders not otherwise specified) in a single condition with varying degrees of severity and symptomatology[1].

Thus, with the publication of DSM-5[1], the Autism Spectrum Disorders received a marker of "severity" based on the degree of impairment. Therefore, in the DSM-5 diagnostic criteria, three severity ratings are observed: Level 1 (requiring support), Level 2 (requiring substantial support), and Level 3 (requiring very substantial support). These classifications are divided into two areas: Social Communication (SC) and Restricted and Repetitive Behaviors (RRB), characterizing the main symptoms of ASD[2].

Prosody changes in the speech of people with Autism Spectrum Disorders have been reported in the literature since the initial description of this condition[3]. However, to date, little is known about the prosody's perception of these individuals or about the specific aspects of their prosodic productions which result into perception of strangeness by the interlocutor[4].

The prosodic aspects observed and described since the beginning of ASD classification, include: monotonic or robotic speech, deficits in the use of pitch (frequency) or volume control (intensity), deficiencies in vocal quality and use of peculiar stress patterns[4]. Especially speakers with Asperger's Syndrome or High-functioning Autism are reported to present such difficulties[5,6]. It should be mentioned that these prosodic differences are persistent and present little change over time, even when other aspects of language are improved[4].

Literature reports some inconsistency regarding the specific prosody mechanisms of ASD individuals as well as some uncertainty concerning its possibility of assisting on the diagnostic criteria, which are currently uncertain[7]. Only the abnormal timbre, intonation, velocity, and rhythm or emphasis (eg, tone of voice may be monotonous or may be raised interrogatively at the end of affirmative phrases) are mentioned as characteristics in the DSM-IV diagnostic criteria[8].

Some studies also refer to poor prosody and monotony in intonation as qualitative aspects of production and marked characteristics in the speech of individuals with ASD, based on the diagnostic criteria previously mentioned[9,10].

Klin (2006), in turn, adds that individuals with ASD generally exhibit a restricted spectrum of intonation patterns, presenting little relation in the communicative functioning of the statement (e.g., assertions of fact, humorous comments)[11].

In this sense, prosody can be seen as a suprasegment spanning two aspects: production, characterized by three classic parameters: duration (difference between two events), fundamental frequency and intensity; and perception, characterized by notions of perceived duration, height and volume[12].

In view of the above, the objective of the present study was to analyze prosodic elements of speech segments of individuals with autism spectrum disorder (ASD) and to compare with the control group, through an acoustic analysis.

METHODS

Ethical aspects

All aspects of this study were approved by the Research Ethics Committee of the Universidade Estadual Paulista (n°. 0763/2013). Data collection continued by acceptance in participating in the research and signature of the consent term, according to resolution of the National Health Council CNS 466/12.

Casuistic

Two groups participated in this study: EG = Experimental Group composed of children, adolescents and adults with ASD (n = 19, male gender, age between eight and 33 years) and CG = Control Group composed of individuals with typical development (n = 19, matched by gender and age).

All participants were selected in regular and special schools in a municipality located in the interior of São Paulo - Brazil, according to a list of students with ASD provided by the Municipal Department of Education. Participants in the control group were selected in the same schools, following the inclusion criteria. Chart 1 summarizes the information of the individuals in the experimental group.

Inclusion criteria

The inclusion criteria of the experimental group were: medical report of Autism Spectrum Disorder (previous diagnosis of Asperger's Syndrome) and adequate linguistic performance for recording the speech samples. As inclusion criterion, absence of speech-language complaint was the requirement for the control group.

Materials

Identification form

Parents or guardians of all participants were questioned regarding personal identification data, according to a questionnaire specifically designed for this research. This questionnaire included questions, such as: name, date of birth, age, gender, schooling / school grades and period of therapy (exclusively for participants in the experimental group).

Scale of Autistic Traits (SAT)

Considering that the SAT is not considered a diagnostic interview, but rather a standardized test that gives the behavioral profile, based on the different diagnostic aspects[13], this instrument was used in the present study in order to characterize the symptomatology presented by the participants with ASD. It is important to mention that the SAT is administered after

Chart 1. Characteristics of the participants of the ASD group

INDIVIDUAL	AGE	DIAGNOSIS	SCHOOL GRADE	PERIOD OF TERAPHY	SAT
1	8 years	AS	3rd grade	5 years	29
2	8 years	ASD	2nd grade	4 years	35
3	8 years	HFA	2nd grade	None	31
4	10 years	AS	4th grade	5 years	36
5	10 years	AS	5th grade	3 years	27
6	10 years	AS	4th grade	6 years	37
7	11 years	ASD	4th grade	6 years	40
8	11 years	ASD	Special Ed.	6 years	32
9	11 years	AS	5th grade	10 years	27
10	12 years	AS	5th grade	6 years	33
11	13 years	ASD	8th grade	None	33
12	13 years	AS	8th grade	None	32
13	14 years	AS	9th grade	10 years	31
14	17 years	ASD	9th grade	1 year	30
15	18 years	ASD	Special Ed.	Over 10 years	39
16	19 years	AS	Special Ed.	None	39
17	19 years	ASD	6th grade	10 years	32
18	21 years	AS	Special Ed.	5 years	38
19	33 years	ASD	Special Ed.	2 years	33

Caption: SA = Asperger Syndrome; TEA = Autistic Spectrum Disorder; HFA = High-functioning Autism; SAT = Scale of Autistic Traits; Ed = Education

detailed information of the clinical data and can be applied since two years of age.

The scale is composed by 23 subscales, each one is divided into different items. Its scoring is based on the following criteria: each subscale of the test provides a value of 0 to 2; it is scored zero if no item is present, 1 if there is only one item, and 2 if there is more than one item. Then, the arithmetic sum is obtained, with a cut-off value of 23, which indicates that the person may present some degree of Autism Spectrum Disorder.

Prosody Questionnaire - Brazilian Linguistic Atlas (ALiB)

For data collection of the speech samples, the prosody questionnaire of the ALiB (Annex A), which is composed of 11 questions related to interrogative, affirmative and imperative phrases, was applied. This questionnaire enables the collection of a semi-directed speech sample, since, through instructions given to the inquirer, it becomes possible to obtain certain answers.

The questionnaire is succinct and objective, focusing on the two sentence modalities with distinctive value in Portuguese (assertive and interrogative patterns) and three basic patterns of expressive intonation: dislike, contentment and order.

Data collection procedure

Initially, the parents and the participants were interviewed in a room previously reserved specifically for this purpose, at the institution where the study was conducted. Subsequently, the SAT was applied to the responsible ones, and the speech-language pathology screening to the participants.

From the application of SAT with the responsible for the participants, it was possible to verify that all the participants obtained a cut above 23, as expected, indicative of Autism Spectrum Disorder, with a mean score of 33, with the lowest score being 27 and the highest equal to 40. The procedures were performed with the supervision of a psychiatrist, a speech therapist and a psychologist, and diagnoses had already been established by a specialized multidisciplinary team.

In relation to the speech-language pathology screening, it is pertinent to highlight that were evaluated skills such as: speech chain, comprehension of simple and complex orders and vocal quality. To identify the presence of linked speech ability, participants were initially asked about their hobbies and activities during the week; to evaluate the ability to understand simple and complex orders, participants were asked to perform two or more actions. Finally, to verify the presence or absence of vocal alterations, the participants were asked to pronounce the vowels a, i and u on a long-term basis. All participants presented adequate skills for participating in the study.

Thus, from the initial results compatible with those mentioned in the inclusion criteria, the participants were referred to the acoustic booth for the speech samples recording procedure. It becomes important to note that prior to the completion of all procedures, the research was thoroughly explained to the responsible ones, and they expressed their consent to participate by signing of the free and informed consent form, according to the resolution CNS 466/12.

In reference to the acoustic booth, where the recordings were realized, it becomes important to mention that such a booth is installed in the institution and acoustically isolated, providing

high fidelity equipment inside: digital recorder MARANTZ, model PMD 660 coupled to a Sennheiser dynamic cardioid microphone model e815s.

For the recordings, the participants were seated comfortably at a distance of approximately six centimeters from the microphone. Thus, they were instructed to remain attentive to the elicitations of speech provided by the researcher, who followed the ALiB prosody questionnaire as script, in order to produce the target phrases appropriately according to the interrogative, affirmative or imperative pattern.

For elicitation of the target phrases contained in the ALiB questionnaire in its item "Expected response", the researcher read the questions contained in the questionnaire itself (Annex A). Regarding this aspect, it is pertinent to detail that, considering the final objective is a sample of speech close to spontaneous, on the part of the participants, we opted for neutral reading of the statements (without facial expression or prosodic variations) performed by the researcher. Thus, although it is not characterized as an objective form of elicitation, the situation was as close as possible to a dialogue with the participants, constituting, in this way, a modality of semi-directed discourse.

It should be mentioned that, in some cases, a pre-training was necessary, in order to understand the task. For this training, a question of the questionnaire was randomly selected, as an example for what should be done during the recording, for clarifying doubts. This way, the collection was not biased and the instructions became evident to all the participating individuals.

Data obtained with the recordings were saved on a computer for acoustic analysis using PRAAT *software*.

Data analysis procedure

The 11 sentences (expected responses) obtained with the recordings were analyzed through the *software*. To do so, the audio files were extracted from the recorder, organized into a database and analyzed using PRAAT *software* version 5.3.60. All the sentences were analyzed through 3 parameters offered by the *software*: fundamental frequency, intensity and duration.

In relation to the **fundamental frequency** parameter (F0), the following measures were analyzed:

- Initial F0 and final F0 of the utterances: extracted from the center of the first vowel (initial F0) and last vowel (final F0) of the sentences.

- Maximum F0 and minimum F0 of the utterances: extracted the maximum and minimum values of F0 of sentences.

- Tessitura of the utterances: difference between the maximum F0 and minimum F0 of the sentences.

- Melodic amplitude (MA) of the salient and pretonic tonic vowel separately: difference between the maximum and minimum values of F0 in the tonic and pretonic syllables.

- Melodic variation velocity rate (MVVR) of the salient and pretonic tonic vowel: difference between the maximum

and minimum values of the tonic, divided by the duration of the tonic vowel. The same procedure was adopted for measurement of the pretonic.

Regarding the **intensity** parameter, the measures were analyzed as specified below:

- Maximum and minimum intensity of the utterances.

- Difference between the maximum and minimum intensity values of the utterances.

Finally, in relation to the **duration** parameter, the following measures were analyzed:

- Duration of the salient tonic vowels.

- Duration of the pretonic vowels.

- Duration of the sentences.

For analyzing the recordings, were initially extracted the values of each of the 15 variables analyzed in the 11 sentences produced by the participants. From these values, the average value of the variables for each participant was calculated. These values were submitted to statistical analysis to verify possible statistically significant differences.

Statistical analysis

For the statistical analysis, the *Mann-Whitney Test* was used, in order to verify possible statistically significant differences between the two groups studied in each prosodic parameter evaluated (fundamental frequency, intensity and duration) and their respective variables. The statistical package IBM SPSS (Statistical Package for Social Sciences), version 21.0, was used to obtain the results.

The significance level of 5% (0.050) was used for the statistical test, that is, when the value of the calculated significance (p) was lower than 5% (0.050), there was a 'statistically significant difference', that is, there was an 'effective difference'. When the calculated significance (p) value was equal to or higher than 5% (0.050), a 'statistically non-significant difference' was found, that is, there was 'similarity'.

RESULTS

From the analysis of the speech samples performed using the PRAAT *software*, it was possible to obtain the absolute values of each of the three parameters studied (fundamental frequency (F0), intensity and duration) and their specific variables, namely: initial F0 and final F0 of the utterance; maximum F0 and minimum F0 of the utterance; Tessitura of the utterance (T); Melodic amplitude (MA) of the salient tonic vowel and pretonic separately; Melodic variation velocity rate (MVVR) of the salient and pretonic tonic vowel; Maximum and minimum intensity of the utterance; Difference between the values of maximum and minimum intensity of the utterance; Duration of the protruding tonic vowels, the pre-tonic vowels and the utterance.

For better visualization of the results, the average values obtained with the production of the 11 utterances of the ALiB questionnaire were extracted, as shown in Tables 1, 2 and 3.

Figures 1, 2 and 3 show the mean values of the three acoustic parameters studied and their respective variables for the experimental and control groups.

Using the *Mann-Whitney Test*, it was possible to verify statistically significant differences in the comparison of values between the groups studied, for the variables: Tessitura, Tonic vowel melodic amplitude, pretonic vowel melodic amplitude, Maximum intensity, Minimum intensity, Duration of the tonic vowel, duration of the pretonic vowel and Duration of the utterance.

Table 1. Mean values of the utterances for the acoustic parameter "fundamental frequency"

| Individuals | Fundamental Frequency | | | | | | | | |
| | IF0 | FF0 | F0 Ma | F0 Mi | T | MA | | MVVR | |
						TV	PTV	TV	PTV
E1	298	193	377	179	198	57	31	451	418
C1	291	215	342	170	172	27	22	293	329
E2	257	194	354	161	193	50	26	349	309
C2	249	202	303	174	130	23	20	282	303
E3	274	204	343	187	157	27	18	247	283
C3	278	208	356	200	155	27	20	288	315
E4	241	196	313	188	125	40	16	334	217
C4	224	193	275	175	100	30	15	265	231
E5	271	221	348	195	153	56	41	362	552
C5	253	192	328	182	146	34	18	401	283
E6	293	224	364	209	155	62	29	512	350
C6	280	246	351	182	167	48	31	443	404
E7	168	160	216	134	82	39	25	252	211
C7	239	195	322	188	134	40	24	416	359
E8	261	220	366	195	172	55	42	545	614
C8	303	277	367	255	112	36	25	477	400
E9	343	247	428	181	247	79	47	485	450
C9	235	190	293	174	119	32	22	251	310
E10	246	203	334	166	168	35	36	297	541
C10	229	200	312	172	140	36	17	320	269
E11	144	132	274	100	173	29	36	136	261
C11	117	110	139	97	42	8,8	11	140	216
E12	227	177	315	137	178	30	17	236	203
C12	222	199	308	179	128	23	16	233	222
E13	164	153	207	109	97	21	14	257	251
C13	125	123	153	100	53	7	10	86	147
E14	213	186	304	123	181	34	57	332	685
C14	142	124	234	97	136	28	11	426	188
E15	172	133	246	94	152	54	41	388	318
C15	161	129	236	106	130	29	17	359	265
E16	157	132	237	105	133	19	23	172	299
C16	131	119	237	96	141	16	7	275	162
E17	122	96	145	90	55	17	21	110	177
C17	102	112	143	81	62	13	13	152	299
E18	155	145	267	136	131	9	25	73	382
C18	145	114	180	104	77	23	13	293	221
E19	132	106	152	84	68	24	18	130	216
C19	138	118	247	102	145	23	18	202	267

Caption: IF0 = Initial fundamental frequency; FF0 = Final fundamental frequency; F0Ma = Maximum fundamental frequency; F0Mi = Minimum fundamental frequency; T = Tessitura; MA = Melodic amplitude; TV = Tonic vowel; PTV = Pretonic vowel; MVVR = Melodic variation velocity rate; E = Experimental; C = Control

Table 2. Mean values of the utterances for the acoustic parameter "intensity"

Individuals	Intensity		
	Maximum	Minimum	Diference
E1	72	38	33
C1	65	35	30
E2	80	40	40
C2	74	38	36
E3	72	38	33
C3	66	36	30
E4	80	38	42
C4	73	38	35
E5	80	40	40
C5	62	34	28
E6	85	42	43
C6	76	36	40
E7	62	31	30
C7	75	36	39
E8	78	42	36
C8	70	37	32
E9	78	41	37
C9	77	41	36
E10	83	46	37
C10	67	37	30
E11	61	32	29
C11	63	34	29
E12	83	44	39
C12	63	34	30
E13	72	36	37
C13	71	35	35
E14	64	37	27
C14	69	37	32
E15	85	49	36
C15	74	41	33
E16	79	48	31
C16	66	35	31
E17	85	49	36
C17	66	36	29
E18	74	49	25
C18	62	34	28
E19	61	36	25
C19	68	37	31

Caption: E = Experimental; C = Control

Table 3. Mean values of the utterances for the acoustic parameter "duration"

| Individuals	Duration		
	TV	PTV	Utterance
E1	0.12	0.07	1.5
C1	0.1	0.07	1.4
E2	0.13	0.08	1.9
C2	0.09	0.07	1.4
E3	0.11	0.06	1.5
C3	0.1	0.06	1.4
E4	0.13	0.07	1.7
C4	0.12	0.06	1.6
E5	0.1	0.08	1.7
C5	0.09	0.07	1.4
E6	0.1	0.08	1.5
C6	0.1	0.07	1.5
E7	0.17	0.12	1.7
C7	0.09	0.07	1.5
E8	0.09	0.07	1.5
C8	0.08	0.07	1.2
E9	0.17	0.11	1.9
C9	0.12	0.07	1.4
E10	0.14	0.08	1.7
C10	0.12	0.07	1.6
E11	0.2	0.15	2.4
C11	0.06	0.05	1
E12	0.15	0.08	2.15
C12	0.10	0.07	1.6
E13	0.09	0.06	1.4
C13	0.08	0.07	1.4
E14	0.1	0.08	1.4
C14	0.09	0.05	1.4
E15	0.15	0.1	1.7
C15	0.1	0.06	1.6
E16	0.13	0.07	1.4
C16	0.06	0.05	1.1
E17	0.14	0.1	1.6
C17	0.09	0.05	1.4
E18	0.11	0.07	1.3
C18	0.09	0.06	1.3
E19	0.18	0.08	1.6
C19	0.1	0.06	1.6

Caption: TV = Tonic Vowel; PTV = Pretonic Vowel; E = Experimental; C = Control
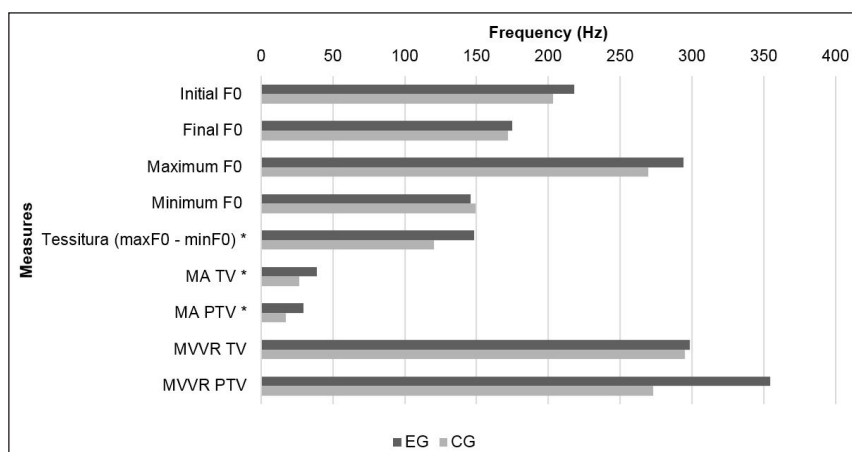
Significant value ($p < 0.05$) - Mann-Whitney test
Caption: *Refers to the significant difference in $p < 0.05$; F0 = fundamental frequency; MA = melodic amplitude; TV = tonic vowel; PTV = pre-tonic vowel; MVVR = Melodic variation velocity rate; EG = experimental group; CG = control group
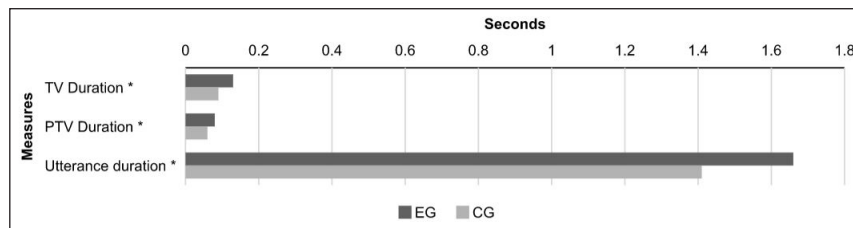**Figure 1.** Mean values of the groups for the acoustic parameter "fundamental frequency"
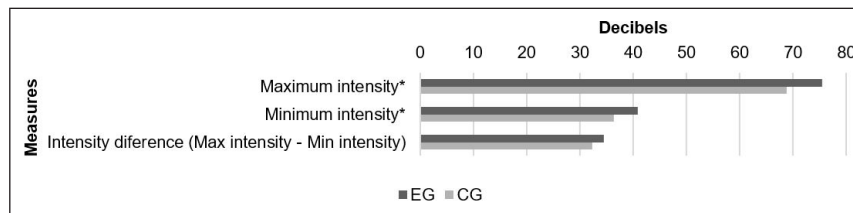
Significant value (p <0.05) - Mann-Whitney test
Caption: *Refers to the significant difference in p <0.05; EG = experimental group; CG = control group
Figure 2. Mean values of the groups for the acoustic parameter "intensity"

Significant value (p <0.05) - Mann-Whitney test
Caption: *Refers to the significant difference in p <0.05; TV = tonic vowel; PTV = pre-tonic vowel; EG = experimental group; CG = control group
Figure 3. Mean values of the groups for the acoustic parameter "duration"

DISCUSSION

The accomplishment of this research enabled to reach the intended objective of analyzing prosodic elements of speech segments of individuals diagnosed with Autism Spectrum Disorder (ASD) and to compare with individuals of the control group, through an acoustic analysis. It is important to mention, however, that the study sample includes participants with a wide age group (from eight to 33 years), characterizing a limitation in the study, not allowing to present, in this way, a generalization of the data found. It is pertinent to highlight that this situation is originated from the difficulty in locating people diagnosed with ASD in the region of this study. Regarding the analyzed variable "period of therapy", it should be noted that three individuals (9, 15 and 17) who mentioned to have been attending therapy for a period equal to, or greater than 10 years, did not present large differences in the values analyzed when compared to the other participants with ASD. This fact should be indicative that such aspects might not be adequately addressed in the therapeutic context. Regarding the symptomatological characteristics obtained through SAT scores, no differences were observed which could indicate that the degree of the characteristics presented by the individuals might be related to the prosody changes presented in the speech.

In relation to the fundamental frequency prosodic parameter, statistically significant differences were observed for the variables tessitura of the utterance, melodic amplitude of the salient and pretonic tonic vowel, melodic variation velocity rate of the salient tonic and pretonic vowel. These data do not confirm statements of the literature regarding a monotonous speech without melodic variation, considering the higher values of these variables in relation to the control group[4,10,11].

No studies were found which evaluated the variable tessitura of individuals with ASD. It is known that tessitura variations can shift the fundamental frequency patterns to more serious or more acute levels, without changing the typical shape of the melody curve. Considering that changes in the tessitura play an expressive function, linked to the discursive intentions of the speaker; (focalization, introduction, prolongation and closure) also enable extra linguistic information, such as: identity, gender, age, psychic aspect, personality, geographic and cultural origins of the individual, the higher values of tessitura of the experimental group in relation to the control group may be a peculiar characteristic of the speech of the individuals with ASD[14].

Also regarding the fundamental frequency parameter, no statistically significant differences were observed for the variables initial fundamental frequency, final fundamental frequency, maximum fundamental frequency and minimum fundamental frequency of the utterance, although it is possible to verify that these values are predominantly higher in the experimental group, in relation to those obtained with the control group. This information partially corroborates a study which mentions that there is no statistically significant difference in the fundamental frequency parameter for the preschool group, but mentions a significant difference in the school-age group[15].

A possible explanation for greater variability observed in the fundamental frequency parameter of the experimental group in relation to the control group, may be the deficit presented by individuals with ASD in the mechanisms controlling the *pitch*. This deficit can be derived from a problem at the reception level, at the production level, or at the relationship between the two, which leads to inadequate production, in relation to what is expected from the discourse[16].

Regarding the prosodic intensity parameter, statistically significant differences were observed in the group with ASD, concerning the values of the control group for the variables maximum intensity and minimum intensity of the utterance. These data corroborate with statements in the literature, pointing out that people with ASD appear to have poor voice volume control (e.g., the voice is very loud, despite the physical proximity of the conversation partner)[4,11].

The intensity of speech of the individual should vary according to factors of linguistic relevance: form of communication (speech, crying, shouting, moaning, etc.); paralinguistic factors: voice tone; and extra linguistic factors: distance of the participants and the physical and social site where the conversation is taking place. Thus, the deficits presented by individuals with ASD in the perception of these factors may explain the greater variability of intensity, in relation to the individuals in the control group[14].

Regarding the duration parameter, statistically significant differences were observed for the three measures studied: duration of tonic vowel, duration of pretonic vowel and duration of utterance. Therefore, a slowed speech pattern of the ASD group was verified, characterized by a longer duration in seconds of the same utterance produced by the control group individuals. These findings corroborate the study by Diehl and Paul (2013), stating that individuals with ASD present a longer term speech, in relation to individuals with typical development[17].

The longer duration in seconds observed in the production of the utterances and also of the tonic and pretonic vowels, already observed in other studies, can be explained by the motor deficit frequently presented by individuals with ASD. Another hypothesis also considered, constitutes of an erroneous perception of that prosody parameter, which could lead to deviant production[17,18].

Two main types of prosody are mentioned in the literature: affective and linguistic. The first involves non-verbal aspects of the language, which are necessary to transmit and recognize the emotions in communication, enabling differences in expression and comprehension of happiness, sadness, anger, etc. In this way, the intonation pattern that accompanies the statement suggests the speaker's emotional state[19].

Yet, the linguistic prosody acts at the phonological and syntactic levels and enables individuals to express the specific meaning of a statement, giving emphasis to parts of words and phrases, thus transmitting an affirmative, interrogative or affirmative message. Thus, individuals with processing alterations may present important difficulties in the production of vocal chants, indicative of emotions, as well as understanding them, which causes an important impairment of social interaction through communication[20].

FINAL CONSIDERATIONS

It was possible to observe that the participants of the present study diagnosed with Autism Spectrum Disorder presented a speech characterized by greater variation in the parameter of fundamental frequency (tessitura) throughout the utterance, greater melodic amplitude of tonic and pretonic vowel, greater intensity variation, so speech was louder and lower than individuals with typical development, and slower speech regarding the duration of the utterance and the tonic and pre-vowel vowels.

Based on the data and discussions presented here, the relevance of speech-language pathology in the assessment and intervention process related to the linguistic and communicative skills of individuals diagnosed with Autism Spectrum Disorder, especially in the suprasegmental aspects of speech (prosody) and its variations, in relation to normality. Thus, in view of the fact that prosody is an important aspect in the pragmatic use of language, it should be emphasized that, either for the evaluation process as for the intervention, the variables interfering in this aspect must be carefully observed.

Therefore, this research reiterates the importance of studies on the characterization of the prosodic aspects of speech of individuals with Autism Spectrum Disorder, considering the necessity of analyzing a sample with a more restricted age group and with larger amount of participants, in order to guarantee more reliability on the results found.

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Author contributions

Annex A. Prosody Questionnaire - Brazilian Linguistic Atlas (ALiB)

1. Modal intonation (phrasal modalities with oppositional function)
   1.1. Interrogative phrases
      1.1.1. Disjunctive or alternative question

(1) "If you want to offer a drink to a friend, and wonder if he prefers wine or beer, how do you ask?" Expected answer: "Do you prefer wine or beer?" (2) "If you want to offer a drink to a friend, and want to know if he drinks milk or coffee, how do you ask?" Expected answer: "Do you prefer milk or coffee?"
1.1.2. Total question
(3) "If you want to know if someone is leaving today, how do you ask?" Expected response: "Are you leaving today?" (4) "A person is hospitalized and wants to know if the doctor is going to leave that day. How do you ask? " Expected response: "Am I leaving today, Doctor?"
1.2. Affirmative phrases   **1.2.1. Neutral Pattern**
(5) "And the doctor, how do you respond?" Expected response: "You're leaving today." 1.2.2. Expression of dislike, harshness (6) "You want to tell some people who are present that you are very upset about what happened. How do you say? " Expected response: "I'm very upset about what happened."
1.2.3. Expression of contentment, politeness
(7) "You mean to some people who are present that you are very happy with the result of the work. How do you say? " Expected response: "I am very happy with the result of the work."

2. Illocutionary Acts
   2.1. Imperative Phrases
      2.1.1. Expression of order, request, suggestion or advice (not explicit in instruction)

(8) "How does a mother tell her son to come out of the rain?" Expected response: "Oh, my son, come out of the rain!" (9) "If a boy is stirring something and someone wants to tell him not to touch it, how do you say it?" Expected response: "Do not mess with it, boy!" (10) "If you want to call many boys who are gathered to come and have lunch, how do you say?" Expected answer: "Boys, come and have lunch!"
2.1.2. Order Pattern (Explicit in instruction)
(11) "Your child / a person wants to stay home, but you want him to leave today. How do you give that order? " Expected response: "You're leaving today!"