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Original articles

Pre-verbal and verbal pattern as predictors for the implementation of the Picture Exchange Communication System (PECS) in autistic children

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ABSTRACT

Purpose: to investigate the preverbal and verbal patterns in autism spectrum disorder, to more easily predict the need for implementation of the Picture Exchange Communication System in autistic children who are about to start speech language therapy.

Methods: a cross-sectional study with a sample consisted of 62 children aged 2 to 10 years, presented with autism spectrum disorder. The Vocal Behavior Assessment which analyzes the preverbal and verbal patterns through three parameters, that is, Mean Extension (mean verbal emission), Speech Characterization (number of atypical emissions) and Language Range (typical emissions of child development), was used. Sociodemographic data, intellectual quotient and non-adaptive behaviors were also analyzed, by using the logistic regression model.

Results: there was a high sensitivity (0.915) and specificity (0.867) for the variables Speech Characterization (p=0,000) and Mean Extension (p=0,001). The other numerical variables, such as age, time of schooling, non-adaptive behaviors and intellectual quotient of children were tested but were not identified as potential predictors for the outcome of interest of the study.

Conclusion: the indices of Speech Characterization and Mean Extension were identified as predictors for the indication of the Picture Exchange Communication System in children who are about to start speech language therapy.

Keywords: Autism Spectrum Disorder; Communication; Language; Communication Aids for Disabled; Speech, Language and Hearing Science

INTRODUCTION

Impairments in non-verbal and verbal communication have always been considered fundamental aspects for the diagnosis of autism spectrum disorder (ASD). Current clinical evidence of ASD shows inabilities to initiate as well as to sustain and respond to the social and communicative demands of the environment[1-5].

The precursors of language and communication points out, since an early age, to a deviant and atypical path. In other words, non-verbal signals such as directing the gaze, sharing attention and using gestures suffer a strong impact and follow a different course in terms of time, speed of acquisition and functional use. The inability to integrate information, with context and meaning, the lack of harmony and synchrony in interpersonal relationships and the absence of empathy greatly compromise the communicative performance and social reciprocity in ASD[1-5].

Added to these losses is the fact that about a third of individuals with ASD are not able to use speech to communicate. Therefore, these individuals can benefit from an alternative communicative resource that allows them to initiate, sustain and expand the dialogic situation and that, in a complementary way, considers the inabilities of shared attention, gaze direction and the lack of communicative intentionality [6-8].

The great demand for intervention, especially in the Brazilian public health network, calls for the need for agile and effective approaches that boost the development and adaptation of individuals with ASD. In Brazil, there are important barriers imposed by the health system, ranging from limited access to assessment, diagnosis and treatment services in public sectors, to a very high cost of quality in private services. These barriers will strongly impact the prognosis of people with ASD [9].

The Picture Exchange Communication System (PECS) is currently one of the most used communication programs worldwide for autistic children. This system is composed of pictures/photographs selected according to the lexical repertoire of each subject and involves not only the replacement of speech by a picture, but also encourages the expression of needs and desires.

The use of PECS seems to contribute to improving verbal comprehension, as it adds visual and contextual clues to verbal information and, in some cases, allows for an increase in verbal production. However, its implementation must be individually assessed, and the involvement of all stakeholders is guaranteed [4-8].

And although it is widely used in countries in North America and Europe, the experience in a clinical school inserted in the Public Health System (SUS – Sistema Único de Saúde), has shown great difficulty in decision making regarding the use of PECS. This is probably due to the lack of definition of indicators of the child's communicative pattern, which can guide the clinical practice of Brazilian speech-language pathologists and help them define the right moment to implement the system.

This study aimed at investigating pre-verbal and verbal behavior patterns in ASD, to predict the need to implement PECS in autistic children undergoing a process of speech-language therapy intervention. It also aimed at specific objectives to evaluate the variables: age, schooling time, non-adaptive behaviors and intellectual quotient of children as well as categorical variables: maternal education and socioeconomic level as potential predictors for the outcome of interest to the study. The hypothesis was that the pre-verbal and verbal behavior patterns would be potential predictors for the speech-language pathologist's decision-making about PECS implementation.

METHODS

Research design: This is a cross-sectional study.

All parents or guardians were aware of the study's methodological procedures and signed the Informed Consent Form (ICF) as suggested by the Research Ethics Committee of the Federal University of São Paulo, Brazil, (Report ICF Nr. 0896/2020, CAAE 5007.2721.80000.5505)).

Participants: The convenience sample consisted of 62 children, 55 (88.7%) males and 7 (11.3%) females; in the age group between 2 and 10 years (mean = 5 years), diagnosed with ASD by a specialized multidisciplinary team, according to DSM 5 diagnostic criteria. All children were regularly enrolled in regular schools due to the Brazilian policy of school inclusion, on average for 65 (SD=21.9) months.

The mothers were in average 41 years and 5 months old (SD=7.9). Nineteen of them (30.6%) had completed higher education; one (1.6%) had incomplete higher education. Twenty-seven (43.5%) completed high school, while four (6.5%) mentioned incomplete high school. Six (9.7%) had completed elementary school, four (6.5%) had incomplete elementary school and one (1.6%) reported only kindergarten schooling.

Regarding the socioeconomic level of the families, only one (1.6%) belonged to class A; four (6.5%), to

class B, fifty-five (88.7%) belong to class C, and two (3.2%) to class D, according to the Brazilian Association of Population Studies (*Associação Brasileira de Estudos Populacionais* - ABEP) socioeconomic classification[10].

As inclusion criteria, ASD diagnosis and age group were considered. Exclusion criteria were: known genetic malformations and/or syndromes, physical, auditory/visual and/or motor impairments.

Materials: To assess the children's cognitive and adaptive performance, the following instruments were applied:

- SON-R 2 1⁄2-7 [a]: non-verbal intelligence test that measures spatial, visual-motor and abstract and concrete reasoning skills in children aged 2 years and six months to 7 years, regardless of the child's verbal skill level[11].
- Weschler Intelligence Scale – WISC III: estimated intelligence test was applied to children over 7 years old[12].
- Autism Behavior Checklist: is a list of 57 maladaptive behaviors divided into five areas: Sensory, Relating, Body and Object Use, Language and Social and Self Help, which measures the probability of ASD diagnosis. It was applied in the form of an interview with parents or caregivers[13].

To assess the children's pre-verbal and verbal behavior, the following was applied:

- Sample of Vocal Behavior Record Form: this instrument is an integral part of the ASIEP-2 (Autism Screening Instrument for Educational Planning – 2[14]. During a speech-language evaluation session with the presence of a familiar adult, the child was offered toys and games were shared with the evaluator. The session was recorded and later on, 50 spontaneous emissions produced by the child were transcribed, during 45 minutes, on average.

Emissions are classified according to variety (spontaneous or repeated emissions), function (communicative or non-communicative); articulation (intelligible or unintelligible) and length (vocalization, babble or words).

From this analysis, it is possible to trace three analysis parameters:

- Average Length (AL): obtained by balancing the number of babbles and the total number of words produced by the child. The higher the value obtained, the greater the communicative performance.
- Autistic Speech Characteristics (ASC): measures the amount of repeated, non-communicative, unintelligible and babbling emissions, which are criteria described by several studies as typical of children with ASD.
- Interpreted Language Age Raw Score (ILARS): measures the amount of spontaneous, communicative and intelligible speech and may be compared to a normality standard.

Procedures: For the transcripts of the sessions applying the Sample of Vocal Behavior, the ELAN software[15,16] was used. This tool was developed by psycholinguists from the Max Planck Institute and has resources for temporal and spatial synchronization and coordination of different types of modalities: verbal and non-verbal. It facilitates the visualization and annotation of interactional resources triggered in dialoguing situations. The average time for analyzing each video was about two hours, totaling 135 hours of work. About 55% of the digital collection was transcribed by ELAN. Videos that could not be inserted due to poor audio and/or image quality were transcribed manually.

The tracks used for recording and analyzing the transcripts by ELAN and those produced manually followed the parameters proposed by Sample Vocal Behavior: initial variety or repetition variety; communicative function or non-communicative function; intelligible articulation or unintelligible articulation; and length by vocalization, babble or word.

Transcriptions were performed by two researchers and subsequently part of the Average Length indexes obtained were statistically treated to analyze the agreement of responses between evaluators.

After testing the variables of interest for PECS outcome, children were divided into two groups: PECS and Non-PECS, according to the Average Length index (AE = 2.46). This index considered the emission of at least two words, one of them being a verb.

Statistical Method

The first step was to univariately assess the variables that supposedly are predictors of PECS outcome (PECS x Non-PECS), by applying the Kolmogorv-Smirnov Normality Test. Descriptive analyzes of all variables of interest to the study were performed. For categorical measures, comparisons were made using the Chi-square or Fisher's exact tests. For numerical variables, comparisons were made using the Mann-Whitney test.

To estimate the probability of a child's use of PECS, the variables of interest were entered into a logistic regression model with forward selection. Thus, it was

possible to assess the individual contribution of each variable and, subsequently, identify the patterns with a higher risk of non-PECS. The criterion for entering the variable in the model was p<=0.05 and for exiting the model, p>0.10.

The evaluation of the goodness-of-fit was done using Receiver Operating Characteristic (ROC) curve. All analyses were performed in R 3.4.1 and type I error was set at 5%.

The Intraclass Correlation Coefficient (ICC) was used to analyze the agreement of the Average Length responses between the evaluators.

RESULTS

Table 1 shows the comparisons between the outcomes of the groups: No PECS x PECS, as for the numerical variables from the application of the Mann-Whitney Test.

Table 1. Comparative analysis of numerical variables for the groups: Non-PECS and PECS

Variables		PECS		Mann-Whitney	Result
		Non- PECS	PECS	Test (p)	
Child Age (Months)	Average	78.13	55.30	0.006*	Non-PECS > PECS
	Median	77.00	49.00		
	SD	29.01	22.793		
	N	15	47		
Child Education (Months)	Average	49.53	29.04	0.016*	Non-PECS > PECS
	Median	48.00	24.00		
	SD	28.21	23.26		
	N	15	47		
ABC Total	Average	92.60	84.45	0.494	Non-PECS = PECS
	Median	83.00	81.00		
	SD	30.02	18.78		
	N	15	47		
Autistic Speech Characteristics	Average	40.47	60.36	0.042*	Non-PECS < PECS
	Median	33.00	60.00		
	SD	39.09	35.31		
	N	15	47		
Language Age Raw Score	Average	118.93	46.72	<0.001*	Non-PECS > PECS
	Median	122.00	45.00		
	SD	27.72	31.39		
	N	15	47		
Average Length	Average	1.93	0.50	<0.001*	Non-PECS > PECS
	Median	2.18	0.21		
	SD	0.8	0.84		
	N	15	47		
IQ	Average	65.53	67.51	0.741	Non-PECS = PECS
	Median	65.00	67.00		
	SD	8.47	15.04		
		15	47		

Captions: SD = Standard deviation. N= number of children. IQ = intelligent quotient. ABC= Autism Behavior Checklist. PECS = Picture Exchange Communication System

Regarding the categorical variables: maternal education and socioeconomic level, no differences were observed between the groups.

Following, a multivariate analysis was carried out to assess the dependent variable PECS (Non-PECS x PECS) as a function of the independent predictor variables selected in the univariate analysis step: Child's Age, Child's Education, Autistic Speech Characteristics, Interpreted Language Age Raw Score and Average Length.

The first variable to enter the model was Autistic Speech Characteristics, as it was initially the most significant one.

Below are shown details of the input process of the five predictor variables.

Table 2. Entry into the logistic regression model of the five predictor variables

Variables			Score	DF	Sig.
Step 0	Variables	Child Age (Months)	7.511	1	0.006
		Child Education (Months)	3.440	1	0.064
		Autistic Speech Characteristics	18.112	1	0.000
		Interpreted Language Age	0.458	1	0.499
		Average Length	0.278	1	0.598
	General Statistics		39.535	5	0.000

Captions: Sig = Significance. DF = degrees of freedom

This is the significance of variables in each step, and the selection by significance indexes.

Table 3. Step 1

Variables		B	S.E.	Wald	DF	Sig.	Exp (B)
Step 1	Autistic Speech Characteristics	0.021	0.006	13.835	1	0.000	1.022
		Variables			**Score**	**Df**	**Sig.**
Step 1	Variables	Child Age			0.781	1	0.377
		Child Education			1.783	1	0.182
		Interpreted Language Age			11.844	1	0.001
		Average Length			**15.486**	**1**	**0.000**
	General Statistics				26.329	4	0.000

Captions: Sig = significance. DF= degrees of freedom. B= probability. SE= statistic. Wald = Wald statistics. Exp = Exponential function of B.

Table 4. Step 2

Variables		B	S.E.	Wald	DF	Sig.	Exp(B)
Step 2	Autistic Speech Characteristics	0.045	0.012	15.183	1	0.000	1.046
	Average Length	-1.344	0.405	11.017	1	0.001	0.261
		Variables			**Score**	**DF**	**Sig.**
Step 2	Variables	Child Age (Months)			1.883	1	0.170
		Child Education			0.312	1	0.577
		ILARS			2.016	1	0.156
	General Statistics				13.293	3	0.004

Captions: Sig = significance. DF= degrees of freedom. B= probability. SE= statistic. Wald = Wald statistics. Exp = Exponential function of B.

The model represented below comprised the following variables: Interpreted Language Age Raw Score and Average Length:

Table 5. Final model with variables: Interpreted Language Age Raw Score and Average Length

Variables		B	S.E.	Wald	DF	Sig.	Exp (B)
Step 2	Autistic Speech Characteristics	**0.045**	0.012	15.183	1	**0.000**	1.046
	Average Length	**-1.344**	0.405	11.017	1	**0.001**	0.261

Captions: Sig = significance. DF= degrees of freedom. B= probability. SE= statistic. Wald = Wald statistics. Exp = Exponential function of B.

The Autistic Speech Characteristics variable has a coefficient with a positive sign (0.045), that is, the higher the function value, the greater the chance of being PECS. The Average Length variable acts negatively (-1.344) on the value of the function, that is, the higher the value, the lower the chance of being PECS.

Therefore, the function that defines the probability of being PECS is as follows:

A = 0.045 x Autistic Speech Characterization + -1.344 x Average Length.

Probability = 1 / (1+exp(-A).

The resulting value from this calculation is the probability of being a PECS or Non-PECS case. In the worksheet below ones sees the calculation of this probability for each of the cases in the database. Thus, a person may have a PECS x Non-PECS classification according to this regression model.

To assess the cutoff points for probability regarding PECS, the ROC curve analysis was applied. See Figure 1 for ROC curve graphical representation. In the ROC curve, to obtain a sensitivity of 0.915 and a specificity of 0.867, the cutoff point of 0.55 was used.

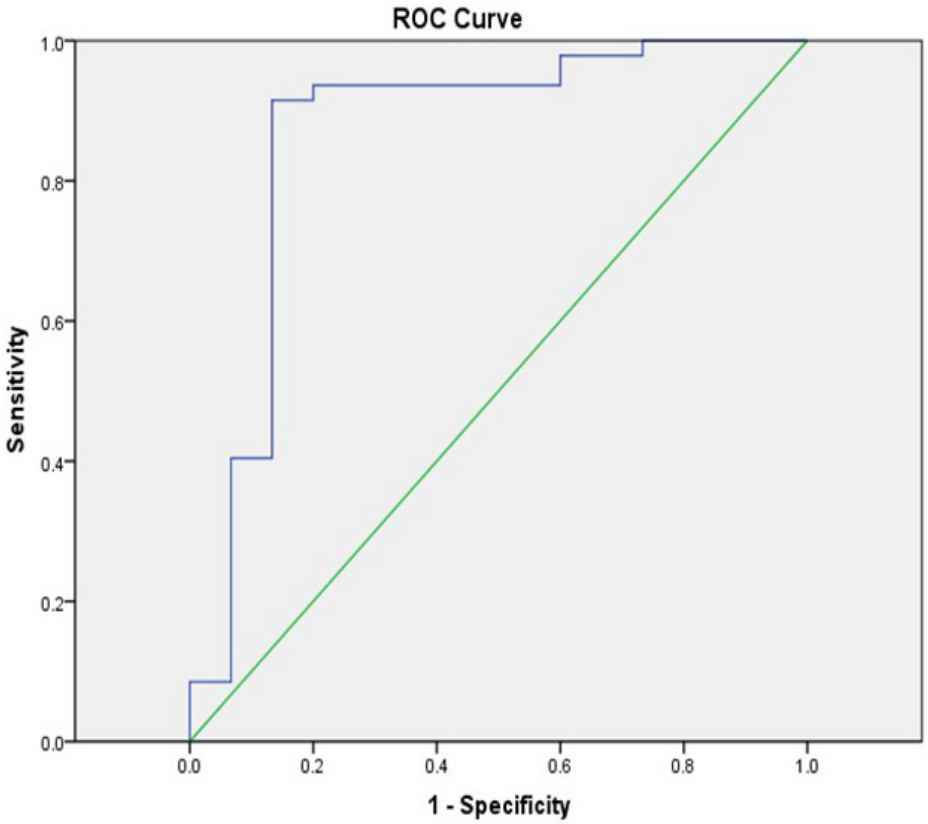

Figure 1. Graphical representation of the ROC curve

Using the cutoff point, the following diagnostic parameters are seen:

Table 6. Diagnostic parameters from the cut-off point

Regression	Group		
	PECS	Non-PECS	Total
prob > 0.55	43	2	45
prob =< 0.55	4	13	17
Total	47	15	62
Prevalence rate:		0.7581	
False negative rate:		0.0851	
False positive rate:		0.1333	
Sensitivity: (s)		**0.9149**	
Specificity: (sp)		**0.8667**	
Positive predictive value:		0.9556	
Negative predictive value:		0.7647	

Captions: Prob = probability. PECS = Picture Exchange Communication System.

The agreement analysis of the Average Length responses between the evaluators was of ICC = 0.998, indicating an excellent correlation.

DISCUSSION

This study aimed at investigating the pre-verbal and verbal behavior patterns in Autistic Spectrum Disorder (ASD), in order to more easily predict the need to implement Picture Exchange Communication System (PECS) in children undergoing therapeutic intervention Speech-Language Therapy.

Regarding the mean age of the groups, there was a statistically significant difference between the groups with higher rates in the Non-PECS Group (mean of 78 months) compared to the PECS Group (mean of 55 months). This finding points to a possible effect that the absence of speech or minimal verbalization may have in the search for diagnosis and treatment. In other words, confronted with a non-verbal child may mobilize the family to seek health services earlier, and this fact could explain the statistically significant difference found between the age groups of the groups evaluated in this study[1-4].

This same difference between the mean age of the groups also impacted the analysis of the children's schooling period. There was statistical significance with greater exposure to the school environment of children in the Non-PECS Group, who were chronologically older, as previously explained.

Regarding the non-adaptive behaviors observed through the application of the Autism Behavior Checklist[13], it was observed that the total values of both groups did not differ significantly; showing that despite the children's different communication profiles, and in the perspective of the families, the severity of other symptoms that make up the clinical picture of the ASD remained evident[4,7,8,13].

As for the Intelligence Quotient (IQ), indexes in the deficient range, with an average score of 65.5 for the non-PECS and o 67.5 for PECS groups, were found. There was no significant difference between groups. Although some studies demonstrated differences in IQ[12] between minimally verbal and verbal groups with ASD, in this study the difference had no statistical significance.

Regarding the variables that made up the assessment of the sample's pre-verbal and verbal patterns, it was found that, as to Autistic Speech Characteristics, which measured the pragmatic, semantic and morphosyntactic language deviations commonly described in the ASD, as it quantifies echolalic emissions, non-communicative (decontextualized), unintelligible and babble; it was noticed that there was a statistically significant difference with a greater presence of these atypical speech characteristics in the PECS Group. These results corroborate the descriptions of the clinical language manifestations that make up the basis of the diagnosis from the first descriptions to the current diagnostic criteria[1-5;17-30].

In the Interpreted Language Age Raw Score variable analysis, which aimed to measure the amount of spontaneous, functional, and contextualized speech, a better performance was noticed in the Non-PECS Group. The same occurred in the analysis of Average Length, which was obtained by balancing the number of babbling and total words produced by the children, that is, children in the Non-PECS Group once again showed a better performance. These results highlight the importance of keeping a close eye on the language and communication skills and inabilities of children with ASD[1-5;17-30].

Regarding maternal education and socioeconomic level, no differences between groups were observed. The middle class was the most mentioned by the families of the two groups: PECS and Non-PECS. Although maternal education and the socioeconomic level of families are considered protective factors for child development, as mothers with a lowered education and worse financial conditions may have less access to health and education information[4,9], such influence on the results was not observed in this study.

Finally, the multivariate analysis to evaluate the dependent variable was conducted: PECS (Not PECS x PECS). The predictor variables were those considered with statistical significance: Child's age, Child's education, Autistic Speech Characteristics, Interpreted Language Age Raw Score and Average Length.

The first variable to be included in the Logistic Regression model was Autistic Speech Characterization, as it was initially the most significant variable. Next, the variables Average Length and Autistic Speech Characteristics were tested.

To assess the cutoff points for the probability of PECS outcome (recommendation for its implementation), the ROC curve analysis was applied. On the ROC curve, a sensitivity of 0.915 and a specificity of 0.867 were obtained. Importantly, from a statistical point of view, a good cutoff point reports sensitivity and specificity greater than 0.80, as obtained in this study. This means that the predictor variables considered in this analysis model, Autistic Speech Characteristics and Average Length, became potential predictors for the indication of the use of PECS in children with ASD undergoing a process of Speech-Language Therapy intervention[5,17-30].

Limitations

Differently from our initial hypothesis, child's age was not identified as a predictor for the study outcome. This was probably due to the wide distribution of the age group, which in this study ranged from 2 to 10 years. Therefore, more studies with larger samples, and with a greater delimitation by age group, are recommended.

CONCLUSION

Autistic Speech Characteristics and Average Length indexes could be identified as predictors for the indication of PECS in children in the initial process of Speech-Language Therapy. This study is of great relevance to indicate parameters for the Speech-Language Therapy process.

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SC: data collection, tabulation and preparation of the manuscript;

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ACT: supervision of data collection, data analysis, study design, and general orientation of the stages of execution and final preparation of the manuscript.