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The perception of emotional prosody between children with high-functioning autism spectrum disorder and typically developing children

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Abstract

In this study, we compared the ability of children with high- functioning autism spectrum disorder and typically developing children to recognize emotions using recorded words and sentences, while they had to choose the image displaying the emotion and indicate the correct answer verbally. A descriptive analysis was performed and the results demonstrated that typically developing children had similar performance in recognizing the emotional state through image selection and in recognizing the emotional state and expressing it through verbal production. Also, these children performed better compared to children with autism. Children with high- functioning autism showed a reduced ability to recognize emotions as expressed by changes in the recordings compared to typically developing children. Children with high - functioning autism scored low scores on both tests, but performed better on the test where a response with an image selection was required. Therefore, the expression of the recognition of the emotional state of the speaker seemed to be assisted by some visual stimuli.

Keywords: high-functioning autism spectrum disorder, emotional prosody, typically developing children, perceptual evaluation.

Introduction

Autism spectrum disorder (ASD) belongs to pervasive developmental disorders, which are characterized by developmental difficulties in various areas of development (American Psychiatric Association, 2013). Autism is a neurological disorder that affects the wider functioning of the brain and the various areas of development and communication. It often coexists with other syndromes and diseases. People with autism face serious deficits in their social communication and social interaction. Some children may not develop speech, or they may use single words or phrases to communicate. It should also be noted that in those cases where speech is poorly developed, it is mainly used to express basic needs and not as a means of communication. According to the American Psychiatric Association (2013), the term ASD describes a wide range of neurodevelopmental disorders with three common characteristics: impaired verbal and nonverbal social interaction, limited interests, and repetitive patterns of behavior.

Prosody consists of the suprasegmental elements of speech (Xu, 2011), which include stress, intonation, intensity, rhythm, and speed. These characteristics are very important both for the production of spoken language and for its understanding (Arvaniti, 2020). The suprasegmental elements are divided into perceptual ones, which are loudness, pitch, duration, and voice quality. Prosody generally provides cues about attitude or emotional state, as well as providing context, giving meaning to words, and keeping listeners engaged

(Hubbard et al., 2017). Studies that have been conducted on language development identify early sensitivity to prosodic properties, suggesting that infants are equipped with an input processing mechanism that is primarily attuned to prosodic information. In addition, from very early on, through the reflex reaction of crying, babies express their biological needs, which are characterized by different intensities or durations (Massicotte - Laforge & She, 2015).

The development of prosody features takes place until puberty. Findings from studies of the prosody of children with high-functioning autism and children of typical development demonstrate that prosodic skills are highly related to the receptive and expressive vocabulary levels of these children. According to Pell and Kotz (2021), there are five stages of mastering prosody, of which the last two are considered particularly important:

1st stage (birth - 6 months): pre-linguistic prosodic features, which are usually referred to as infant vocalization and serve to express basic needs (through crying) or pleasure.

2nd stage (2 – 4 months): awareness of prosodic contrasts in the expressions of adults addressed to the child.

3rd stage (6 months): children's speech is characterized by a range of non-segmental features that resemble the native language.

4th stage: Learned prosodic features are observed in the child's utterances during the second half of the first year.

5th stage: tonal contrast occurs and pauses decrease as sentences become more grammatically complex.

Infants are exposed to the prosodic characteristics of speech during the gestation period, which results in the recognition of the mother's voice and its prosodic characteristics. Studies show that they can recognize their native language by prosody and prefer it over others, while an interest in higher speech frequencies is also observed in 4-month-old infants, which gradually decreases (Wermke, Robb, & Schluter, 2021). Finally, it was shown that through the prosodic elements, syntactic terms of the sentence can be recognized, but the flow of speech can also be segmented (de Carvalho et.al., 2019). The development of emotional prosody occurs during the first six months of infant development. From the age of 7 months, babies can distinguish hostile from friendly voices (Liu, et al., 2022) and recognize negative emotions. Furthermore, around 5 years old, children can recognize the emotion of joy with the help of prosodic features (Weiyi, 2022). These data show that even with the help of a visual stimulus, there is difficulty in recognizing the emotional state of the speaker through a single word.

Purpose of the study

Several studies have shown that individuals with high - functioning ASD have difficulties in both the perception and production of emotional prosody, which is related to and directly affects their performance in social interaction. Since the findings regarding the perception of emotional prosody by people with high - functioning ASD are unstable and the studies that have been carried out in the Greek-speaking population are few, in the present study, qualitative research will be conducted to examine the ability to recognize angry, happy, sad, and scared feelings. This evaluation will be done through recorded audio clips of words and phrases. The entire population participating in the research are children aged 4 - 6 years old. The sample consists of a control group and an experimental group. Specifically, the control group includes 2 boys and 2 girls of typical development, while the experimental group includes 2 boys and 2 girls with high - functioning ASD.

The main aim of this study is to investigate the ability of typically developing children and those with high - functioning ASD to perceive emotions (i.e., anger, joy, sadness, and fear) through emotional prosody when presented with auditory stimuli and to determine the difference between the two groups in the given area. In addition, this research aims to spark the interest of the scientific community for further study in order to help fill the knowledge

gap that exists in the Greek literature and, through a global picture, support this population group in order to improve their social skills.

Research Questions

The research question that will be investigated in this study is "If children with high - functioning ASD have the same ability to recognize emotions through changes in their interlocutor's voice, relative to typically developing children". More specifically, through this research, it is sought to give an answer to the question, "If the recognition of the emotional state of the interlocutor, aided by some visual stimulus (i.e., facial expressions)".

Question 1:

Null hypothesis H0: Children with high - functioning ASD have the same ability to recognize emotions through changes in the voice of their interlocutor, compared to typically developing children.

Alternative hypothesis H1: Children with high - functioning ASD have a different ability to recognize emotions through changes in the voice of their interlocutor compared to typically developing children.

Question 2:

Null hypothesis H0: The recognition of the emotional state of the interlocutor is aided by some visual stimuli (i.e., facial expressions).

Alternative hypothesis H1: The recognition of the emotional state of the interlocutor is not aided by some visual stimuli (i.e., facial expressions).

Participants

In the research conducted, two groups of people participated. In the first, four people with autism took part, which were 2 girls and 2 boys aged from 4;9 to 5;9. The boy, aged 5;3 is on the autism spectrum, without an official diagnosis at the time the sample was collected (diagnosis came after 6 months), and is high functioning. The remaining three children who participated in the research had a formal diagnosis and are high functioning. In the second, 2 girls and 2 boys of typical development (TD), with ages ranging from 4;0 to 6;1 years, participated (Table 1).

Table 1: Participants with diagnosis of high - functioning ASD

Gender	Age	Level of Autism
Boy	5;9	With official diagnosis (high functioning)
Boy	5;3	With official diagnosis (high functioning)
Girl	5;1	Without official diagnosis (high functioning)
Girl	4;9	With official diagnosis (high functioning)

In the research conducted, two groups of people participated. In the first, four people with autism took part, which were 2 girls and 2 boys aged from 4;9 to 5;9. The boy, aged 5:3, is on the autism spectrum, without an official diagnosis at the time the sample was collected (diagnosis came after 6 months), and is high functioning. The second boy with autism, aged 5;9, who participated in the research had a formal diagnosis and is high functioning. In the second, 2 girls and 2 boys of typical development (TD), with ages ranging from 4;0 to 6;1 years, participated (Table 2).

Table 2: Typically developing participants

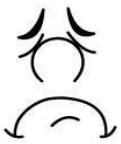
Gender	Age
Girl	4;0
Girl	4;0
Boy	5;0
Boy	6;1

The selection criteria for the participants were the ability to recognize the four emotions (i.e., joy, sadness, fear, and anger) and the ability to distinguish sounds. The assessment of the control group was carried out in a familiar environment (at each child's home), while those of the experimental group were in a speech therapy center, where they attended a therapeutic program. Two sessions were devoted to the evaluation of the two groups, in particular informal materials and tests from three weighted tests [i.e., Diagnostic Verbal IQ Test – Preschool (DVIQ), RAVEN'S EDUCATIONAL Colored Progressive Matrices (CPM) / Crichton Vocabulary Scales (CVS), Diagnostic Evaluation of Language Variation (DELV)], and additionally one session to carry out the experimental procedure. The environment was quiet, free from noises, for the smooth running of the activities. The administration of the tests was carried out by the researchers. Materials used included a game to assess the ability to recognize emotions "The Emotional". In this game, the child had to stick to the "emotional" face depending on whether it fit the condition described by the clinician. For example, see below:

«Emotional Face»

«Angry Face»

«Happy Face»



«Sad Face»

«Scared Face»

At the same time, recorded sound clips were used to evaluate the auditory discrimination of the groups, as well as the weighted tests of DVIQ preschool, RAVEN'S EDUCATIONAL CPM/CVS and DELV. During the experimental procedure, the children were given audio-recorded verbal stimuli that should be matched with the appropriate emotion. The recordings were made by a professional actress using the PRAAT program version 6.0.4.9. For example,

from words the word /ðinaˈta/ was given and from phrases, the phrase /vjes ˈekso/ and the pseudo-phrase /ˈila ˈcema/.

Methodology

For the needs of the research process, three sessions were needed for both the children with autism and the children of typical development for the administration of all informal and formal tests. Specifically, in the first visit, auditory discrimination was assessed through 30 auditory stimuli, of which 10 were non-verbal stimuli (e.g., cat sound, door slam), and the remaining 20 included 10 minimal pairs of nonsense words (e.g., / faˈropi/ - /θaˈropi/ , /ˈkufe/ - /ˈgufe/) and 10 minimal real word pairs (e.g., /ˈpino/ - /ˈdino/ , /ˈfaros/ - /ˈvaros/). The nonsense words were chosen in this research in order to assess whether the children use semantics in the answers they give. The presentation of the auditory stimuli was made through the laptop computer speaker at maximum volume. To assess the auditory discrimination of non-verbal sounds, each child was given two pictures and depending on the sound they heard each time, they had to choose the one that corresponded to the sound they heard. Whereas, for the pairs of nonsense words and real words, he would have to judge whether they sound the same or different. In order for the child's performance to be successful, he would have to score 28/30.

At the same time, the recognition of 4 emotions (i.e., joy, sadness, anger, and fear) was assessed by giving the child 8 images, 2 for each emotion, through the game "the emotional one". In order for his performance to be considered successful, he would have to recognize the set of emotions (4/4), otherwise, he would be automatically excluded from the survey. In addition, the (DVIQ preschool) was granted at the first visit. This specific test is aimed at ages 3.5 – 6.5 years and assesses the development of various language dimensions, such as expressive vocabulary, production and understanding of morphosyntax, repetition of sentences, and understanding of meta-linguistic concepts. It has been weighted by the Greek population. Only two subscales were administered to the sample in this study: the vocabulary production subscale and the metalanguage comprehension subscale. This was done because only the discourse dimensions that would be necessary in the experimental procedure had to be assessed.

In detail, for the vocabulary production subscale, 27 pictures were given, and depending on their content, the child had to name them or say the action depicted. Whereas, for the subscale of understanding meta-linguistic concepts, a total of 25 commands and from 1 to 3 pictures were given for each of them, so that the child could carry out each command that was given to him. The attempt would be considered successful when the child collected a score that corresponded to his age group, as shown in table 3 below:

Table 3: Scores on vocabulary production and on meta-linguistic concepts based on age groups

Age Groups	3;5-4;11	5-5;11	6-6;5
Vocabulary Production [27]	12,3	14,2	15,3
Understanding meta-linguistics concepts [25]	13	15,5	17

Finally, at the first visit, the parents of the typically developing children and the clinicians of the children with autism were given an early age play observation from the University of Patras. The observation form contained general questions about the child, about his behavior during play, about his preferences, and about the types of play he has mastered. This particular observation form was given in order to obtain information about the child's levels of concentration and cooperation. At the second visit, the RAVEN'S EDUCATIONAL CPM/CVS Color Progressive Matrices (CPMs), which measure the individual's non-verbal ability to make inferences in a visuospatial context, were administered. In other words, it examines the

person's inductive ability (that is, the person can think clearly and draw conclusions from complexity) as well as being the only psychometric tool that allows a Speech Therapist to measure a child's general intelligence. According to this test, each child is given colored shapes from which a piece is missing and asked to choose the appropriate piece from six options. In addition, the children's linguistic and pragmatic abilities were assessed with the DELV evaluation. This particular test is a valid and reliable tool that assesses the pragmatic abilities of children aged 4 to 9 years.

In Part 1 of the DELV, the clinician showed a picture to the child, and the child had to think about what one person might say to another. In the second part, a short story should be told through a series of six pictures. Finally, in the third part, the child was given pictures from which something was missing, and he was asked to formulate appropriate questions in order for the clinician to reveal to him what was missing. On the third visit, the experimental procedure took place. More specifically, the children's ability to extract information about the emotional state of the speaker was assessed through 20 auditory verbal stimuli that were recorded by a professional actor. The presentation of the auditory stimuli was made through the laptop computer speaker at maximum volume.

During the reproduction of the stimuli, the participants with high - functioning ASD faced the researcher and saw the back of the computer and the table where it was placed in the speech therapy room. Whereas, two of the TD children looked at their mother, and the rest looked at the wall or the white desktop of the computer. More specifically, an activity was provided that was divided into two parts. In the first part, 5 words and 5 phrases were used, and the child had to match each word and each phrase with the picture that expressed the specific emotion. For the purpose of this test, the game was used "The emotional one." First, the activity was described to the child, where he would have to listen carefully to the sound stimuli and then choose among 4 pictures the one that showed the correct emotion (i.e., joy, sadness, fear, and anger), in order to show “What does the girl feel?”.

In the second part of the experimental procedure, 5 words and 5 phrases were also used. Each child should verbally produce the corresponding emotion. Similarly, in the first part, the activity was described to the child, where he should listen carefully to the sound stimuli and then say “How does he think the girl feels?”. Both TD children and children on the autism spectrum could perceive the purpose of the experimental procedure and understand the questions asked. It should be noted that in the design of the experimental procedure, verbs, nouns, adverbs, and adjectives were used as words. In addition, both real and nonsense sentences were included in the sentence recording to see whether children's performance was better, the same, or worse on the real ones because of the help they received from the semantics. Finally, during the data collection, the answer booklets of the weighted tools were used to record the performance of the children, as well as an informal recording of the successful or unsuccessful response of the children to the non-weighted tests. For the analysis and evaluation of the results, the scales of the weighted tools were taken into account, and the children will be categorized according to the score they have scored.

Results

In the assessment of the four basic emotions, both typically developing children and children with autism scored 4/4 on the test given to them. All children responded successfully to emotion recognition (Table 4).

Table 4: Assessment of the four basic emotions across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	4/4
TD	4/4
TD	4/4
TD	4/4
High - functioning ASD	4/4
High - functioning ASD	4/4
High - functioning ASD	4/4
High - functioning ASD	4/4

In the assessment of auditory discrimination through recorded sound clips, there was a discrepancy between typically developing individuals and individuals with autism. The success criterion that was set at 28/30 was achieved only by children of typical development. Individuals with autism scored below the successful performance criterion. It should be noted that only one child with typical development failed to score 28/30. Underachievement was observed in both groups, with the difference that all children with autism failed. Therefore, children with high - functioning ASD scored worse than typically developing children (Table 5).

Table 5: Assessment of auditory discrimination across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	28/30
TD	28/30
TD	27/30
TD	28/30
High - functioning ASD	27/30
High - functioning ASD	27/30
High - functioning ASD	25/30
High - functioning ASD	26/30

According to DVIQ norms, the group of typically developing children scored well on tests of vocabulary production and comprehension of metalanguage concepts. In contrast to the group of children with high - functioning ASD, on the vocabulary production test, the boys scored below the passing criterion, and on the metalanguage comprehension test, one child failed to answer all questions successfully. More specifically, children with high - functioning ASD failed to score their chronological age for TA children (Table 6).

Table 6: Scores on DVIQ test across children with high - functioning ASD and TD accordingly

Diagnosis	Score DVIQ (Production)	Score DVIQ (Comprehension)
TD	26/27	22/25
TD	27/27	25/25
TD	25/27	25/25
TD	26/27	24/25
High - functioning ASD	14/27	15/25
High - functioning ASD	13/27	17/25
High - functioning ASD	17/27	13/25
High - functioning ASD	15/27	17/25

According to the table above, both the performance of children with autism and the performance of children with high - functioning ASD are almost the same. Low scores were observed in both groups. The lowest was found in the group of children with high - functioning ASD, where the child scored 11 (age 5;1), and the highest score was found in the group of typically developing children, where the subject scored 22 (age 6;1). Strong difficulty was observed in both groups, with children with high - functioning ASD performing worse (Table 7).

Table 7: Scores on DELV test across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	12
TD	22
TD	16
TD	15
High - functioning ASD	17
High - functioning ASD	11
High - functioning ASD	12
High - functioning ASD	15

According to the table above, TD children scored higher on RAVEN'S. The answers they gave were equivalent to their respective ages. Of the group of children with high - functioning ASD, ¾ of the subjects scored within the normal range and were considered successful, but one subject scored low with a clinically significant difference. While his age is 5;9, based on his performance, he is ranked under 4 years old (Table 8).

Table 8: Scores on RAVEN'S test across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	33/36
TD	36/36
TD	34/36
TD	32/36
High - functioning ASD	10/36
High - functioning ASD	18/36
High - functioning ASD	19/36
High - functioning ASD	15/36

In this test, where the children were asked to identify the emotion by selecting the appropriate picture, the group of typically developing children scored higher compared to the children with autism. The highest score was noted in the group of children with typical development and the lowest in the group of children with high - functioning autism (Table 9).

Table 9: Scores on recognition of emotional state (by selecting picture) across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	7/10
TD	9/10
TD	8/10
TD	8/10
High - functioning ASD	6/10
High - functioning ASD	6/10
High - functioning ASD	6/10
High - functioning ASD	7/10

According to table 10, the performance of TD children was better than those with ASD. The lowest score was found in the group of children with high - functioning ASD and was only 2/10. Comparing Tables 9 and 8, it was observed that children with typical development had approximately the same performance in both tests (both in the recognition of emotional state by picture selection and in the recognition of emotional state by verbal production). Children with high - functioning autism, however, scored better scores on the emotional state recognition test with picture selection in relation to verbal production.

Table 10: Scores on recognition of emotional state (verbal production) across children with high - functioning ASD and TD accordingly

Diagnosis	Score
TD	6/10
TD	9/10
TD	8/10
TD	9/10
High - functioning ASD	2/10
High - functioning ASD	5/10
High - functioning ASD	5/10
High - functioning ASD	6/10

Comparing the two groups, the children with typical development scored higher in both tests than the children with autism. This observation leads to the conclusion that children on the autism spectrum have a reduced ability to recognize emotions through changes in the voice of their interlocutor, compared to typically developing children. Also, the recognition of the emotional state of the interlocutor is aided by some visual stimuli (facial expressions).

Conclusion

According to the results of the present study, although all children recognized the four basic emotions, children with autism, compared to typically developing children, show a reduced ability to recognize emotions through changes in the voice of their interlocutor. Furthermore, typically developing children performed approximately equally well in picture-selected emotional state recognition and verbally expressed emotional state recognition. In contrast, children on the autism spectrum performed better in the picture selection test, which indicates that the recognition of the emotional state of the interlocutor is aided by some visual stimulus. However, no significant difference in performance was observed between children of different genders belonging to the same group. The above results are consistent with previous research findings in which it is argued that individuals with high - functioning autism spectrum disorders face difficulties in both the perception and production of emotional prosody.

Discussion

Considering that the studied sample was collected by non-random sampling and is also very small, the results of the study cannot be generalized to the entire population of children with high - functioning ASD. Furthermore, only high-functioning children were studied, as no low-functioning individuals were found during the sampling. Nevertheless, it is possible that the conclusions obtained are valid for a wider group beyond the studied sample. More specifically, it was found that children with high - functioning ASD show a reduced ability to recognize the emotional state of their interlocutor through prosodic changes. However, it was observed that the recognition of the emotional state of the interlocutor is aided by some visual stimuli, since they scored better in the test with picture selection compared to verbal production. Therefore, it is considered appropriate to carry out a more extensive investigation with a larger sample size in order to ascertain the validity of the findings.

This is an area that needs to be studied because if people with high - functioning ASD have difficulties in the perception and recognition of emotions, this will have an impact on their difficulty in understanding the meaning of the linguistic message, the attitude of the speaker, and his emotional state, during during a discussion. By extension, it will result in difficulties in the communication and successful social reconciliation of these individuals. Finally, it would be important to investigate the effect of visual stimuli, such as facial expressions, on the recognition of the emotional state of the interlocutor among children on the autism spectrum, who differ in terms of their level of functioning.

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