A new decade for social changes
Emotional intelligence and autism spectrum disorder

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Abstract. In recent years there has been a growing interest in people on the autism spectrum emotional intelligence, an area in which people with Autism Spectrum Disorder (ASD) show a deficit. The aim of this work is through a literature review of the research a) to illustrate the emotional development and education of individuals on the spectrum and b) to present the findings of eye-tracking, neuro-imaging, and electro-physiological studies in individuals with ASD because they allow researchers, among other things, to discover the mechanisms and how they affect emotion. c) Raise questions about the development of educational methods aimed at enhancing the emotional development of individuals on the autism spectrum and subsequently the development of social skills.

Keywords. Autism Spectrum Disorder, Emotional intelligence, eye-tracking, Electrophysiological Studies

1. Introduction

[1] In describing autism, he emphasized the social and emotional features of autism disorder and argued that these features are an "innate" inability of children to develop emotional contact with other people. More than 60 years later, scientists continue to highlight social and emotional deficits and the role of emotions in autism is still under debate. The classification systems of the World [2], [3], [4] in the criteria for the diagnosis of autistic spectrum state note the deficiencies of autistic individuals in the use of facial expressions, body postures, and gestures to regulate social interaction, as well as lack of reciprocity of feelings, reduced or deviant response to other people's feelings, and lack of spontaneity to share pleasure, among other symptoms. These difficulties in using and responding to emotions correspond to two components of emotion processing [5], [6], [7], the production of an emotional state, and its regulation [8].

2. Autism and Emotion

2.1. Expression - Perception - Understanding of Emotion in ASD

[9] Emotions are the first way children communicate, as from the very first weeks of their life they can express their basic emotions: joy, sadness, anger, disgust, and surprise [10].

The ability to distinguish a person's emotion from their facial expressions is a key element for development and successful social interaction, as well as the opposite i.e. social
interaction, through experience in facial expression, is essential for normal development of facial emotion recognition (Facial Emotion Recognition) [11]. Research has shown that many people with ASD with severe difficulties in social interaction show impairments in FER. First [1] described autism as a "disorder of emotional contact", and as pointed out by [12]; [9] is characterized by (a) significant difficulties in the development of the social-emotional and communication skills of the individual with his social environment characteristics which are highlighted and [2], [3], [4] a person is diagnosed with ASD when behaviors listed in above diagnostic manuals and the revised DSM-V, defined by 2 groups-criteria: a) social communication and b) stereotyped, repetitive behaviors, activities, and interests.

[8] Accept that in typically developing children, recognition of emotional facial expressions is an early development of social skills. [13] Found that 4-month-old infants were able to discriminate between expressions of anger, fear, sadness, happiness, and surprise when these expressions were presented in a familiar context and that their responses were specific to the particular emotional expressions. Also, between 8 and 10 months, infants begin to use emotional expressions for social reference [14]. In typically developing children, emotional decoding improves throughout much of childhood [15] and adolescence [16]. The typical developmental path of facial emotion recognition is emotion-dependent: among the six basic emotions (happiness, sadness, anger, fear, surprise, disgust), happiness tends to be recognized first, while surprise and fear tend to be recognized last [6]. Emotional expressions are a key source of information about the sender's current emotional state [17], intentions [18], and about important objects and events taking place in the environment [19], [20]. The failure of these basic emotion recognition skills will have serious consequences for the child's social development, removing the child from learning about other people's feelings and reactions [8].

Scientists argue that children with ASD can express their emotions, their emotional expressions however differ from the emotional expressions of typically developing children [21]. The people with ASDs present a disturbance in emotion while not having a lack of emotion, they have difficulty reading the emotions of others and reflecting on their own, and they present a disturbance in the connection of emotion with perception and thought as a result of which individuals have difficulties in understanding, managing of emotions and attribution of personal meaning to what they perceive.

Research on emotional intelligence, especially in the last decade, is booming, but findings on facial emotion recognition in autism are inconsistent: some studies find no deficits in ASD, while others find profound deficits [22] resulting in despite numerous studies, there is still no general agreement whether or not emotion recognition is a fundamental difficulty for people with autism. Several of these studies have shown that autistic individuals have difficulties with labelling facial expressions [23], [24], [25], [26], some other studies have found no deficits in identifying basic emotional expressions [27], [28], [29], [30], [31], [32] while other research has found deficits limited to specific emotions, most often negatively valenced emotions such as fear [33], [34], disgust, sadness and anger [35], [36] [37], one of the first researchers, argues that the cause of autism is the inability of individuals with autism to create emotional bonds with other individuals as these individuals lack the intersubjectivity that concerns the recognition of emotions. The absence of intersubjectivity is the individual's inability to perceive emotional states and understand the minds of others [38], [37], [39].

[40] argue that autistic individuals have difficulty in perceiving emotional expressions and this is found when reading the emotions on the faces of others, this hypothesis was strengthened by the research findings where [40] involved autistic children and a control group.
of typical children with the same linguistic mental age in which the autistic children found it difficult to recognize the emotions of individuals when they were not shown the whole face and some of its features were hidden from them, in relative to the control group. Also, in another study by the same researchers in 1989, the findings showed that autistic individuals had difficulty naming the emotions displayed on the faces of some people, but also recognizing the emotions expressed by the tone of a person's voice.

Another finding from an experiment [40] showed that autistic individuals do not understand the emotional expressions on others' faces. Images of upside-down faces were presented and participants with ASD and two control groups were asked a) to create groups of faces expressing the same emotion and b) to group the different emotional expressions of the same face, the ASD group had no difficulty answering and this led the researchers to the conclusion that autistic children do not see the face as a single form (Gestalt) but as a set of elements connected in a certain way and thus can locate them in the rotation stages of the experiment.

The researchers [41] videotaped the interactions of individuals with ASD, individuals with Mental Retardation, and typically developing children with an unfamiliar adult and studying their reactions concluded that autistic children express themselves in unusual or idiosyncratic ways than control group children.

Also, researchers [42] in their study recording the emotional expressions of autistic and typically developing children, aged 2 to 6 years, during face-to-face ten-minute structured interaction with their mothers observed that the autistic children were less likely to combine smiling with eye gaze contact and rarely smiled at their mother's smile, unlike the control group. The result of the research reveals the inability of autistic children to affect others and to express their feelings with non-verbal expressions.[21]. The same conclusion was reached by [43], as in their research they found that autistic children find it difficult to express their feelings when interacting with an adult.

[44] prompted by the results of the research of Hobson and his colleagues studied the difficulty of autistic children to understand emotions, raising the question of whether the difficulty of autistics in understanding emotions is a primary abnormality [38] or a secondary consequence of the difficulties of understanding of the mind. [45]. Using the work of [46] asked children with autism to describe the emotional state of the heroine, Jane, and the children's responses showed that they understand the situations and events that cause emotions. This undermined the claims of researchers Hobson and colleagues.

Also, another study [44] found that children with autism understand something about the relationship between desire and emotion. Again using the work of [46] children were asked to respond to Jane's emotional state. However, in an experimental condition where there was a false belief condition, autistic children faced difficulties in understanding emotions. This led Baron-Coen to conclude that autistic children's difficulty in understanding beliefs is a primary deficit, but difficulty in understanding emotions is a secondary consequence. From the research findings, new evidence emerges that autistic children understand certain situations or events that cause specific emotions.

Recent researches [47], [48], [49], [34], [50] argue that the difficulty in perceiving emotions is probably due to the difficulties that children with ASD have in the more general processing of faces. Indicatively, it is mentioned that in the research of [34] a sample of high-functioning autistic individuals and a control group of non-autistic adults were asked to express one of six basic emotions (joy, sadness, fear, anger, surprise, and disgust) in photographs of a man and a woman on their face, recording with an optical scanning machine the points on the
face the research subjects fixed their gaze on. Autistic adults focused their attention on places such as the chin and forehead, while adults in the control group focused on places such as the eyes, mouth, and nose. The findings showed that the autistics focused their gaze on parts of the face where the emotion is not expressed, in contrast to the control group. He has reached similar findings in his research [48], [21].

In addition to the research concerning the understanding and expression of basic emotions, research was also carried out into the ability to perceive, understand and express complex emotions of autistic individuals.

The researchers [51] in their research studied the basic social behaviors of children with autism, aged about 4 years, and control groups of children of typical development and children with mental retardation are independent of the individual's motor activity. The conclusion from the research showed that autistic individuals show deficits in the ability to develop emotional bonds with others, an ability that in typically developing individuals appears in the first year. This finding reinforces the argument that socialization is one of the three deficits in autism [52] and their inability to connect emotionally with others leaves them deprived of social experiences.

[53] in their research with the same mental age: children with ASD, children with mental retardation, and typical preschool children studied who expressed the feeling of pride after being praised by an adult for completing a puzzle. It was observed that the autistic children smiled as much as other control groups, did not look at the adults, and many children after the praise turned away from the adult. [21]. Research findings reinforce the view that autistic children have not developed intersubjectivity, the ability to perceive emotional states, and an understanding of the minds of others [38].

As reported by [21], the research findings of [53] are also supported by other researchers such as [28], [54], [55], [56], [57].

Specifically, in the research of [55] on children with high-functioning autism and typical children about the feeling of guilt, children with autism felt guilty in cases of violation of rules or actions, while typical children felt guilt towards events that had an interpersonal nature and involved events that their behavior had an impact on others.

Other research suggests that children with autism show a deficit in understanding the mental states of others, i.e. the "theory of mind" necessary for the development of complex emotions since complex emotions are usually manifested when other people are present rather than when the individual is alone. Alone, so that they have difficulty understanding the beliefs, desires, intentions, and emotions and consequently have difficulty interpreting the behavior of others [58], views supported by [59], [60].

A study by [61] investigated emotion recognition in typically developing individuals and individuals with ASD with 2 experiments that showed: in the 1st experiment children (5-7 years old, n = 37) were presented on video screens with short facial expressions that differed in subtlety, and children with autism performed worse than children in the control group. In the 2nd experiment 3 age groups (8-12 years old, n = 49? 13-17 years old, n = 49? and adults n = 45 ) were examined in the same stimuli and showed that the performance of the control subjects was better in the adult group, the performance of individuals with autism was similar across age groups. The researchers found that although young children with autism did not recognize expressions of emotion like typically developing control children, these group differences were not observed with older children. The research found that until adulthood, the performance of people with autism was worse than typically developing ones and that while young children...
with ASD can perceive original facial expressions, adults with ASD do not sufficiently develop the ability to recognize compared to typically developing adults.

[22] the review collected the studies that refer to the emotional intelligence of autistic individuals and represent conflicting research findings and also suggest suggestions for future research to address the disagreements. The researchers identified three factors as responsible for much of the discordant findings on emotion recognition in autistic disorder: a) the demographic characteristics of the participant group, b) the demands of the tasks used, and c) which demanding variables were measured. a) Demographic Factors: The study of the research results showed that the demographic factors that influence the ability to recognize emotions in autism spectrum disorder are: a) the age and IQ of the sample. b) age and level of functioning, pointing out however that to separate the roles of these two factors, higher cognitive ability, in addition to age, may contribute to FER [62], [63]. Scholars [22] and suggest three directions for future research that could help address these issues: 1) groups or individuals with verbal and non-verbal IQ, when possible, or include a verbal IQ and non-verbal IQ control group, and 2) to carefully document any known ID etiology in control groups paired with low-functioning individuals with ASD, and 3) to investigate its developmental course and age-related changes in emotion recognition in individuals with ASD and include larger sample sizes to better detect group differences due to the heterogeneity of autistic disorders. b) Demand tasks: The choice of tasks seems to be a more important factor in emotion recognition as studies with low-functioning young people use tasks with simpler demands, while for high-functioning people the tasks are more complex. Individuals with ASD and emotional intelligence deficits have been found in a wide range of experimental tasks, including matching photographs of facial expressions [64], matching videotaped facial expressions with photographs and schematics [24], matching dynamic expressions with photographs [65], even recognizing human and animal faces depicting various emotions [26]. Low-functioning individuals have been controlled according to the developmental level or verbal cognitive age of the participants in the dynamic stimulus projects [66] and mixed static emotions and original expressions projects [29].

Research results showed that projects with more dynamic, complex, and valid stimuli yielded more motivating results and were more informative in addressing real-life difficulties faced by individuals with ASD than the static, prototype faces used in the original studies. In addition, studies that use morphing sequences of facial expressions [67], [68], [69], [70], [71], [72] to examine FER emotion recognition are unusual, but will be important in investigating more subtle differences in the recognition of emotional facial expressions between individuals with ASD and individuals typically developing individuals.

Also, in the literature review, [22] refer to the results of Eye-Tracking and Brain-Based Studies, which they consider to be an important complement to behavioral studies, because they allow researchers to investigate not only how quickly and accurately participants can recognize emotions but also the mechanisms that underpin their emotion decoding. In stark contrast to behavioral studies that measure subjects' ability to match or label facial expressions, almost all eye tracking studies, neuroimaging, and electrophysiological studies report that individuals with autistic disorder show abnormalities in recognizing emotional facial expressions. (Detailed reference is made in subsection 2.3)

[73] Investigated recognition of emotional facial expressions and perceptual sensitivity (from neutral to full expression) between high-functioning autistic adolescents and typically developing adolescents (matched for age, IQ, and gender ratio) on six basic emotions and examined the links between recognition of emotional facial expressions and
symptomatology/adaptive functioning of the autistic adolescent group. The findings showed that there are empathic deficits as individuals with high-functioning ASD showed reduced sensitivity to sad facial expressions associated not only with the classification of autistic behavior but also adaptive functioning, they presented difficulty in processing emotional facial expressions, especially regarding perceptual sensitivity and sad facial expressions than individuals of typical development.

In their research, [74] to assess the expression process of participants with autistic disorders designed and used the computer project “Let’s Face It! Emotion Skills Battery”(LFI!) consists of three subscales-tasks measuring verbal and perceptual abilities involved in the recognition of facial emotions. a) Name Game, b) Matchmaker Expression, c) Parts - Wholes. LFI Granted ! in groups of participants with autistic disorders and typically developing individuals of the same chronological age and intelligence (IQ). The results from the research showed that: a) in the project Name Game autistic individuals were equal to typical individuals in their ability to report facial emotions: joy, sadness, disgust, and surprise, and only showed reduced ability to recognize the expression of anger. b) in Matchmaker Expression, which measures the recognition of facial emotions in different facial identities, participants with autism were reliably worse than typical individuals, regarding the emotions: joy, sadness, disgust, fear, and anger. c) in the Parts - Wholes task of perceptual expression strategies, typical participants used holistic encoding for eyes rather than mouths in facial expressions, while participants with autism showed the opposite pattern: holistic recognition for mouths and analytic recognition of the eyes. The above led the researchers to conclude that individuals with ASD were able to label basic facial emotions (other than anger) at the same level as chronologically and intellectually (IQ) age-matched typically developing control individuals but presented reduced ability to generalize facial emotions across identities and demonstrated a tendency to recognize mouths holistically and eyes as isolated regions.

The results of the project: “Let’s Face It! Emotion Skills Battery”(LFI !) formed the basis for designing effective interventions to improve emotion processing skills of ASD children [75], [76], as the findings suggest that treatment programs should promote the generalization of emotion recognition in a variety of people and social activities and should be given information that will guide the child that emotional information is "transferred" to the eyes and is perceptually integrated throughout the face. Finally, the researchers believe that strengthening expression recognition skills in people with ASD should also strengthen skills in social reciprocity, building trust and proficiency in everyday social interactions.

The [8] in a bibliographic meta-analytic approach to the issue of emotion recognition in ASD 48 studies involving emotion recognition and involving 980 individuals with ASD across the age spectrum, IQ, and emotion recognition projects. The criteria of the review of the articles concerned: a) the number of the sample, b) the gender of the autistics and the control group, c) the diagnosis and the diagnostic criteria, the mental age of the participants, the type of the project, the research tools and emotion study category (basic or complex) and focused on the recognition of emotion from visual stimuli, intending to determine whether recognition dysfunction exists across autistic ages, regardless of IQ and at each level in autism, and whether deficits in visual recognition emotions and the difficulties are equivalent in magnitude to all the different emotions. The results showed that there is an objective difficulty in recognizing emotions by people with autism and that the age of the participants, their IQ, and the task used did not affect the performance of the sample.

Also, researchers have noted that there are critical issues that should be taken care of: the sample size, the sample group, and the projects used [22], [77], [78], [79]. Based on these
studies, they suggest: a) that larger sample sizes be used, to increase the reliability and reproducibility of the data, b) that the results (in tables, graphs, and more) and all statistical tests be fully recorded. From the above, concerns arose such as a) the importance of time in the recognition of emotion, people with ASD need more time, b) the greater failure to recognize negative emotions by people with ASD and suggest more research on different emotions with groups of a large number of participants combined with brain neuroimaging and eye tracking methods.

### 2.2. Emotional development and education in ASD

[9] Report that the ability to recognize and understand emotions develops in the first year of a person's life and infants can distinguish different emotions from facial expressions and human voices [80].

Children with ASD present significant difficulties in recognizing, understanding, and expressing emotions [21]. The inability to create emotional relationships is considered primary [1] and modern researchers [81] argue that these difficulties in the emotional domain of development arise as a consequence of the inability to create interpersonal relationships while [82] as a consequence of the inability of autistic individuals to master the "theory of mind".

Individualized psychoeducational intervention programs aimed at teaching emotion understanding skills for children with ASD do not exist and the integrated intervention programs, Lovaas, PECS, TEACCH, etc., aim to improve the behavior of autistic children and train their social-communication skills.

Although there is research interest in the development of social-emotional intelligence, not enough research has been carried out to investigate, based on different intervention models and in a different population of autistic individuals, whether children with autism can be trained to understand and express emotions as well as shown below.

Based on the principles of behavior analysis (ABA), [83], conducted a study with 4 autistic individuals chronologically aged 11-19 years and aimed to: a) teach socially acceptable emotional reactions to autistic individuals using the combination of reinforcement, presentation of a role model and verbal guidance, b) to evaluate the effects of the intervention with new therapists and in new situations after one month, and c) to train autistic individuals in emotional states related to acceptance by their peers. The categories used to train autistic people were: 1) talking about favorite things, 2) laughing at absurdities/nonsense, 3) showing sympathy, 4) showing appreciation, and 5) showing displeasure. As indicative socially acceptable emotional reactions were considered: 1) eye contact, 2) socially acceptable verbal response, and 3) socially acceptable emotional expression. Each participant was trained in 3 or 4 categories and the results of the study showed that all 4 participants benefited from this training, as they showed socially acceptable emotional reactions, not only in the categories they were trained in but also in new situations with new therapists and after a month.

In the context of the "theory of mind", [84], [85] studied whether children with autism aged 4-13 years chronologically and verbally aged 6 years can be taught to understand emotions, beliefs, and pretense. Their research findings showed that autistic children could be taught to understand emotions and beliefs and succeed on tests that assessed understanding emotions and beliefs. While in the evaluation after 2 months it was observed that there was no generalization to non-teaching activities with a different structure from the initial training and that this intervention did not contribute to the improvement of communication in terms of the use of mental states and the ability to expand in discussions.
In another study, [86] used computers to teach individuals with autism or Asperger syndrome to better recognize and predict the emotions of others with the program “Emotional Trainer”. The research involved 2 groups with 11 participants in each group, chronologically aged 12-18 years and with a verbal age of 7 years or older, who had a diagnosis of autism or Asperger’s syndrome. The experimental group used the program for 10 30-minute episodes over a 2-3 week period while the control group subjects attended their class. Participants were assessed before and after the intervention using: 1) photos with facial expressions (happy, sad, angry, scared), 2) photos referring to a person in a specific emotional state that triggers the expression of a specific emotion, 3) photos that show what the protagonist wants, what he ultimately gets and how he ultimately feels, and 4) photos that refer to a person and a specific situation that triggers emotional reactions. The results of the intervention showed that: a) the experimental group showed an improvement in all parameters compared to the control group b) the score on the measures of emotions was not related to age or verbal ability and c) the more they used the program on the computer the more positive results there were. However, it would be useful to test whether these positive effects can be generalized to real life or contribute to better performance on theory of mind measures.

[87] Used the principles of cognitive-behavioral therapy in a sample of 15 autistic individuals with a chronological age of 8-17 years and an IQ of 60-109 on the WISC - R to evaluate the effectiveness of such an intervention concerning social-emotional understanding and social interaction. The intervention lasted 7 months for 3 hours every week in the context of the school by the child’s teacher in collaboration with a peer and his parents. The intervention related to emotional understanding included: 1) teaching simple emotions (happy, sad, afraid, angry) by describing the rules for each emotion, 2) teaching recognition of emotions in oneself and others through the recognition of emotional expressions, gestures, and utterances, and 3) teaching emotion recognition in social situations. Intervention results for emotional understanding showed that autistic individuals: 1) recognized and described more emotions, 2) used more complex emotions and considered the presence of others, and 3) reported personal emotional experiences more often than used common stereotyped responses.

Their [88] study used computers to recognize and learn emotions through the educational software “The Transporters” designed as a means of entertainment for children on the autistic spectrum, aged 4-8 years, and as a tool for teachers for children to learn to recognize emotions [89]. This software is a game that takes place in a child’s bedroom, in a predictable environment. This digital game uses “living” vehicles, eight characters with real human faces to facilitate children’s learning about emotions. The characters come to life when their owner, Jamie, goes to school in the morning. A narrator helps children focus on facial expressions. Episodes and quizzes are about repetition, which is characteristic of children on the autism spectrum and therefore likely helps them learn. Also, this software is based on the view that children with autism are fascinated by spinning wheels and movement, and that vehicles whose motion is determined only by physical rules (such as vehicles that only go forward and backward in a linear fashion) are preferred by many children with autism more than vehicles such as airplanes or cars, whose motion could be highly variable as they move at the will of the human driver [90].

This study evaluated “The Transporters”, the animated series intended to enhance the feeling of understanding in children on the autism spectrum. The sample of 20 children with autism, aged 4-7, attended “The Transporters” daily for 4 weeks. Participants were tested before and after the intervention on emotional vocabulary and emotion recognition at three levels of generalization and were compared with two control groups of children: the first group
was 18 children with ASD and the second group was 18 typically developing children who were also assessed twice without any intervention. The intervention group showed significant improvement more than the clinical control group at all levels of the assessment project, the performance of the projects compared to the control group of typically developing children during the second examination. The researchers concluded that using the software “The Transporters” improves emotion recognition in children with autism. [88].

The researchers [91] in their research used the program "FaceSay", a computer program that uses an interactive, realistic assistant avatar and was designed and created specifically for this specific research to teach social skills to improve the social interactions of children with ASD in natural environments using previous computer-based approaches to teach the person emotion and static recognition skills based on the software's response. [92]. The game "FaceSay", uses an interactive approach as the computer animates the avatars, people, and animals, and creates a more realistic software program to teach facial emotion recognition skills, also includes attractive predictability [93] and a limited field of focus [94] with the use of computer technology using interactive videos and realistic avatars through the three games and one of the main goals was to increase their ability to observe globally when interpreting facial expressions of emotion.

The study by [91] evaluated the effectiveness of FaceSay activities involving 49 low- and high-functioning ASD children and had the opportunity to practice eye gaze, discrimination of facial expressions, and recognizing faces and emotions in the structured environment of FaceSay with assistants in the interactive, realistic to improve their abilities in social skills. Low-functioning children showed improvements in two intervention domains: emotion recognition and social interactions. High-functioning children showed improvements in three areas: face recognition, emotion recognition, and social interactions. These findings, particularly the measured improvements in social interaction in a natural setting, are encouraging.

Also, in a review of research concerning the use of serious games [95], in training people with ASD to improve social and emotional skills, reviewed 31 articles on serious games between January 2001 and April 2014: 16 targeting the recognition or production of emotions and 15 targeting social skills. The results showed that serious games are a promising tool in education for the development and improvement of socio-emotional skills. Nevertheless, the conclusions from the specific games highlighted some parameters: (i) most of them are aimed at high-functioning individuals; (ii) their clinical validation hardly meets the standards of evidence-based medicine; (iii) there is no description of its design, and, (iv) in many cases, the clinical validation and reproducibility/playability of the design is not compatible.

Although the social skills required in real life include rich combinations of perspective taking, emotional regulation, cognitive flexibility, appropriate use of language, and so on, the literature reviewed here emphasized that a significant portion of the effort devoted to game design has focused on the core skill of emotion recognition, which maintains these more complex forms of social skills and it is suggested that further studies include (i) in terms of training methodology and game effectiveness: large samples, control groups, longer treatment periods, monitoring for evaluation, etc.) (ii) collaboration between clinical scientists (doctors, therapists) and computer/game design experts; and (iii) more serious games to appeal to all people with ASD (High and Low Functioning) [95], [9]

In recent years, thanks to the leaps and bounds of artificial intelligence, the usefulness of robotics in the diagnosis, treatment, and education of individuals with ASD has begun to be explored and the notion of helping this particular group of individuals prevails [96].
Computation in social robots is considered very important especially when social robots are designed for children with autism spectrum disorder (ASD). The operation of social robots is based on cognitive-emotional models, which allow them to communicate with people with social behaviors and rules. However, interactions between a child and a robot are different than those between an adult or a child with emotional deficits. Robotics interventions for people with autism target the following behaviors: (a) imitation, (b) joint attention, (c) turn-taking, (d) recognition of emotions and expressions, (e) initiation of interaction, and (f) triad interaction [97].

Many educational materials are designed to help people with ASD develop some basic skills. The researchers argue that people with ASD have positive attitudes toward robots and often prefer interacting with a robot over a person as they observed that there was a long time of children’s eye contact with a robot compared to a human face, [98]. One such is the Nao robot, which helps with eye contact to develop communication skills but this particular educational tool also helps to generalize the skill.

Also, the researchers linked the repetitive and stereotyped behaviors of individuals with autism to the typical stereotyped movements of a robot. So robots have been built to understand emotions through imitation. They are robots with a screen where emotions and expressions are represented and the child imitates the movements and expressions of the robot watching them on the screen, resulting in the understanding of emotions [99].

Another robot, iromec, helps children on the autistic spectrum to understand some basic social skills, such as expressing emotions and representing them [100].

In this study [101] systematically reviewed 46 studies related to computational models of emotion for children with ASD, to answer various research questions related to the definition, interaction and design of computational models supported by theoretical psychology and only 12 studies focus on children with/without ASD, where three studies involve children with ASD. The Moxie was the only robot to integrate applied behavior analysis (ABA) and cognitive behavioral therapy (CBT) into the STAR framework. Moxie acts as a companion robot, which increases the interest of the child because he feels that he is not alone.

2.3. Eye-tracking and brain studies

As mentioned above, [22] in their literature review talk about the importance of Eye-tracking and Brain Studies, with the help of magnetic resonance imaging (fMRI), positron emission tomography (PET), and event-related potentials (ERP), because they allow researchers, among others, to discover the mechanisms and how they affect emotion. To date all research: eye-tracking, neuro-imaging, and electro-physiological studies in autistic individuals have reported abnormalities in facial and emotional expression.

2.3.1. Eye-tracking

A dysfunction in autism is the processing of faces and information received from the eyes. Many studies show that high-functioning individuals with autism look less in the area around the emotional facial expression than the control group [34], [102] or do not use information from higher facial features effectively during emotion recognition [103], [104], [105] and b), others find that individuals with autism rely more on evidence from lower parts of the face (eg, mouth) [106], [105], and others show that these subjects look into the eyes in the rest of the emotional facial expressions as much as the control group.

Another finding in the tracking eye is that individuals with ASD look more toward regions outside of the salient features of the face when decoding emotions [72], [107].
studies using eye-tracking find abnormalities in ASD. [106] using computational modeling observed that gaze modulation was top-down rather than bottom-up. eg the mouth did not show more interest than the eyes. In general, eye-tracking studies show that individuals with autism show process differences in the emotional expressions of faces from the control group. [22]

[108] a meta-analysis of 38 articles that used eye-tracking methods to compare ASD and TD controls evaluated the influence of eight factors on the effect size for the difference in social attention between these two groups: age, non-verbal matching IQ, verbal matching IQ, movement, social content, ecological validity, audio input, and attentional bids. Results show that individuals with ASD spend less time attending to social stimuli than typically developing (TD) controls. Social attention in ASD was more affected when the stimuli had high social content.

The [109] in a total of 1,458 papers showed that the abnormal attention pattern of autistic patients is mainly related to the activation of the amygdala, occipital temporal lobe, and fusiform gyrus. Further research on autism-related biomarkers is needed to provide objective markers for early diagnosis and intervention of autistic patients.

2.3.2 Amygdaloid nucleus: its role in the emotional disorder

In addition to eye-tracking, neuroimaging studies can provide information about the neural correlates associated with decoding emotions. A dysfunction of emotional ability has been observed in autism and recently it is discussed that the dysfunction of the amygdala nucleus is responsible for this disorder.

The amygdala is one of the brain structures that make up the sickle system and consists of a cluster of at least 13 nuclei connected to other brain structures such as the thalamus, hippocampus, and brainstem [110].

The amygdala plays a role in associative learning as shown by studies in patients with amygdala damage. The amygdala plays a key role in emotional learning whereby cues acquire meaning through association with rewarding or aversive events, but it also regulates cognitive processes such as memory or attention. [111].

Also, stimulation of the amygdala nucleus causes negative emotions (fear, sadness, anxiety) or positive emotions (happiness)[112].

Researchers [113], [114] in necropsy studies studying the cytoarchitecture of the sickle tissue of autistic individuals showed that there were abnormalities in the size, density, and dendritic branches of the neurons of the sickle system and the amygdala nucleus and considered these findings as evidence for abnormal development of the amygdala nucleus in autistics. [21]

The above hypothesis is also supported by research done on animals, such as the research by [115] done on rhesus monkeys which showed that any damage or bilateral removal of the amygdala nucleus can lead to a dysfunction of the emotional ability and behaviors of the autistic spectrum. But the experiment showed that removing the amygdala nucleus caused a decline in emotional competence and other autistic behaviors in juvenile monkeys but not in adults. This led her[116] to argue that abnormalities of the sickle system are the cause of autistic affective disorder [21].

In recent research by [117] and [118] with monkeys, ibotenic acid-induced localized damage to the amygdala nucleus, something that previous research lacked, and it was shown that macaque monkeys in the experimental group compared to a control group of monkeys without amygdala damage showed a lack of fear to stimuli that typically evoke this emotion. [21].
Neuroimaging studies to demonstrate the role of the amygdala in autistic disorder have used magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) techniques, or using simple images (see Table 1).

The findings of these studies show reduced activation of the amygdala nucleus of the participants during the experimental study in tasks that required recognition of emotional facial expressions.

<table>
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<tr>
<th>RESEARCH</th>
<th>TECHNIQUE</th>
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<td>Baron-Coen, Ring, Wheelwright, Bullmore, Brammer, Simmons &amp; Williams (1999)</td>
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<td>Recognition of emotional states in eye photographs</td>
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<td>Critchey, Daly, Bullmore, Williams, Van Amelsvoort, Robertson, Rowe, Phillips, McAlonan &amp; Murphy (2000)</td>
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<td>The left one amygdala nucleus of autistic participants was not activated during unconscious processing of stimuli.</td>
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<td>Wang, Dapretto, Hariri, Sigman &amp; Bookheimer (2004)</td>
<td>fMRI</td>
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<td>The activation of the amygdala nucleus of autistic children did not differ according to the type of task</td>
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<td>Dalton, Nacewicz, Johnstore, Schaefer, Gernsbacher, Gildsmith, Alexander, &amp; Davidson (2005)</td>
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<td>Dapretto, Davies, Pfeifer, Scott, Sigman, Bookheimer &amp; Iacoboni (2005)</td>
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Table 1: Neuroimaging studies that studied the activation of the amygdala nucleus of autistic individuals during the processing of emotionally charged stimuli Source: Misailidi & Papoudi, 2009

Brain imaging studies, when conducted with careful controls and analyses, can help clarify whether and how individuals with autism using compensatory mechanisms can be helped to recognize facial emotions.
2.3.3 Electrophysiological studies

Another way to examine neuronal processes is through the measurement of electrophysiology, event-related potentials (ERP), which provides better temporal resolution of neuronal activity than fMRI, but at the expense of spatial resolution and can measure only cortical activity, and not subcortical activity such as that of the amygdala. Studies have found that individuals with autism show dysfunction in the context of the recognition of emotional facial expressions, such as [119] in a study of children and adults with Asperger's syndrome, delayed components of face processing were found during the recognition of emotion compared to the group age-matched controls only with adults, and lower performance only in adults but not in children and [120], who report normal ERP in children with high-functioning autism, but in the bipolar source analysis, a weaker and slower response from the frontal, fusiform, and visual cortices was found, along with a slower and larger response in the somatosensory parietal cortex. This latter finding may be more relevant to facial emotion processing in autism [120].

2.3.4 Autonomic correlates of FER

Another type of measurement involves measuring autonomic arousal. Only two FER studies have used physiological measures of arousal. [121] measuring skin conductance responses, and found a reduced response to emotional facial expressions in an adult with autism, indicating a lack of autonomic nervous system stimulation in this condition. The researcher [72], measuring respiratory sinus arrhythmia and heart rate, found higher than threshold levels of arousal in children with autism. Possibly, individuals with autism have both higher levels at the onset of arousal and more problems shaping this arousal than typical individuals, which may play a role in their social-emotional deficits [22].

Conclusions

Scientific and research interest in recent years in researching the emotional intelligence of individuals with ASD has increased but findings on facial emotion recognition in autism are inconclusive: some studies find no deficits in autism, others report profound deficits [22], and despite numerous research studies, researchers have not been led to a general acceptance of whether or not emotion recognition is a fundamental difficulty for people with autism. Several of the studies have identified difficulties in recognizing facial expressions in individuals with ASD [32] while other studies present findings showing a deficit in specific negative emotions, such as fear [33] [34] disgust, sadness, and anger [35] Ashwin, C., Chapman, E., Colle, L., & Baron-Cohen, S. (2006). The bibliographic review of [8] refers to the research that focused on the recognition of emotion through visual stimuli and the results of the bibliographic review showed that: a) people with ASD present objective difficulty in identifying emotions and b) age, IQ, and participant performance did not affect sample performance. Finally, they pointed out that factors such as the sample size, the sample group, and the projects used [22] should be clarified in the next research studies; [77], [78], [79].

Based on the above, it is clear that there is an increased interest of both medical and educational researchers in the socio-emotional deficits of people with autism, the causes that cause them as well as how to deal with and improve them. The use of information communication technologies (ICTs) in therapy offers new perspectives for the treatment of
many domains in people with autism spectrum disorders (ASD) because they can be used in many different ways and settings and are attractive to patients.

The incorporation of digital technologies in the education domain is very productive and successful, facilitates and improves the educational procedures via Mobiles [126-135], various ICTs applications [136-168], AI & STEM [169-180], and games [181-186]. Additionally, the combination of ICTs with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation [187-210] as well as with environmental factors and nutrition [122-125], accelerates and improves more over the educational practices and results.

References


