Analysis of softwares for emotion recognition in children and teenagers with autism spectrum disorder

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ABSTRACT

Purpose: to investigate the use of softwares for emotion recognition in children and teenagers with Autism Spectrum Disorders (ASD).

Methods: an integrative review of the literature with scientific papers published from 2012 to 2017 indexed in Periódico Capes, Science Direct, and PubMed; combined descriptors: autism AND emotion AND software; autism AND emotion recognition AND software. Inclusion criterion was the use of software related to emotion recognition in children and teenagers with ASD, up to 18 years old. Review papers and those using robots were excluded.

Results: ten international papers were reviewed. The most used emotional expressions were “happiness”, “fear”, “anger”, “disgust”, “sadness”, and “surprise”. Ten software programs were described: Emotion Recognition Task (1), Cambridge Mindreading Face-Voice Battery for Children (3), Mind Reading (2), Mood Maker (1), Virtual-Reality Emotion Sensitivity Test (1), FaceSay (1), Penn Emotion Recognition (1), FaceMaze Game (1), Computer Emotion Recognition Toolbox (CERT) (1), and Emotiplay (1).

Conclusion: studies with software programs focused on ASD intervention allow future research efforts in the diagnosis and intervention of this disorder.

Keywords: Autism; Emotions; Software
INTRODUCTION

Autism Spectrum Disorders (ASD) are neurodevelopmental disorders characterized by restricted and repetitive behavioral patterns, impairment of social interaction and verbal and nonverbal communication such as facial expressions, gestures, and eye contact, as well as socio-emotional reciprocity deficits present since the beginning of childhood. Other possible traits are echolalia, impairment of functional language use, aversion to physical contact, and stereotypies, among others. Thus, impairments in social interaction and nonverbal communication, as well as facial expressions of emotions, have been included among ASD diagnostic criteria and they are often described as critical for the social difficulties of individuals with ASD.

Ever since Leo Kanner described autism as a biological disorder in 1943, many more cases have been observed and a multitude of theories have been proposed to explain the various manifestations of ASD. One of such is the Theory of Mind, which is used to describe individuals with ASD who are unable to recognize mental and emotional states in others and themselves and therefore struggle to assign meaning, emotions, desires, and intentions with the interlocutors.

Several studies have shown the ability to recognize emotion is compromised in individuals with ASD and this refers to the ability to identify and recognize the different types of emotions as presented in multiple modalities (i.e., face, body, and voice). This ability is essential for interpersonal relations and is an important element for developing empathy and, consequently, communication and social interaction skills.

In this perspective, studies have been proposed for individuals with ASD to recognize their mental states, more specifically in the development and application of computational tools that involve emotion recognition through facial and vocal expressions.

Additionally, computers are created to analyze, build systems, and assist in understanding and preventing unexpected behaviors, since they may be designed according to each person’s specific interests and may be used routinely. Hence, this tool has become an ideal way to support individuals with ASD in both high and low functioning cases.

In the United States, one in every 59 individuals has ASD. In South Korea, 2.64% of school-age individuals have ASD, which amounts to one in every 38 children. In Brazil, despite the scarcity of epidemiological studies, 1.5 million individuals are estimated to have ASD, although diagnosing them is still difficult due to several factors such as the complexity of the Brazilian public health service, which does not have specialized care centers to meet the demand for referrals of children at risk, thus, generating late identification at around five or six years of age.

Given that emotional reciprocity is one of the criteria employed by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) for diagnosing ASD, emotion recognition is one of the elements in the Theory of Mind deemed essential for communication and social interaction and may be explored as a way of identifying signs of ASD.

Studies on tools for evaluation and/or intervention of emotion recognition in children with ASD are still rare in Brazil, there is a need for a review study to identify the world panorama on the subject, so this article is of scientific relevance, since it aims to investigate, in the Brazilian and international literature market, the use of software programs for the recognition of emotions in children and adolescents with autism spectrum disorders.

METHODS

This integrative literature review was carried out by researching Brazilian and international scientific papers indexed in Periódico Capes, Science Direct, and PubMed using combined keywords “autism” AND “emotion” AND “software”, as well as “autism” AND “emotion recognition” AND “software”. Descriptors were based on the DeCS database of health sciences descriptors and the search was performed from July 2016 to October 2017.

The inclusion criteria were: (a) papers published in the last six years (2012-2017) involving the development and application of software programs related to emotion recognition in children and teenagers with ASD; and (b) studies with individuals at most 18 years old. Papers were excluded from the review if they (a) used robots as technology, (b) were systematic or integrative reviews, or (c) were not available in full text.

The paper search criteria were initially employed by reading titles and abstracts. Once included, the full text was read to verify the criteria set out in the review. The analysis was performed using an Excel spreadsheet, with the data being tabulated regarding the goals, methods, ASD tests and diagnostic protocols, as well as software programs employed in each study.
LITERATURE REVIEW

Given the descriptor-based selection, 1,074 papers were found, of which 1,053 did not meet the inclusion criteria and were, hence, excluded in the title and abstract reading phase. Of the 21 papers selected to be read in full, only ten met all criteria and were analyzed. Figure 1 illustrates how the paper selection was carried out.

![Figure 1. Flow chart of articles analyzed](image-url)

Table 1 lists paper titles, publication dates, authors, journals of publication, the databases in which they were found, and the software programs used in the studies.

Table 2 shows the ASD diagnosis criteria used in the studies, as well as sample sizes and age ranges. Six papers performed studies with a typical development control group and an ASD-diagnosed experimental group, four papers only considered individuals with ASD, while one paper connected ASD to another disorder, namely social phobia.

Figure 2 shows the number of software programs and their proposed uses, either in intervention or evaluation. Figure 3 presents the number of reviewed papers in which each emotion is considered. Figure 4 shows the number of papers each software program is studied in.
Table 1. Summary of articles that investigated softwares in autism spectrum disorders

| TITLE                                                                 | YEAR | AUTHORS                      | JOURNAL                        | DATABASE          | SOFTWARES                                                                 |
|----------------------------------------------------------------------|------|------------------------------|--------------------------------|-------------------|--------------------------------------------------------------------------|
| ‘Emotiplay’: a serious game for learning about emotions in children with autism: results of a cross-cultural evaluation | 2017 | Fridenson-Hayo et al.        | Eur Child Adolesc Psychiatry | Periódicos CAPES  | Emotiplay and Cambridge Mindreading Face-Voice Battery for Children (CAM-C) |
| RCT of mind reading as a component of a psychosocial treatment for high-functioning children with ASD | 2016 | Lopata et al.                | Research in Autism Spectrum Disorders | Science Direct | Mind Reading program and Cambridge Mindreading Face-Voice Battery for Children (CAM-C) |
| The Cambridge Mindreading Face-Voice Battery for Children (CAM-C): complex emotion recognition in children with and without autism spectrum conditions | 2015 | Golan, Sinai-Gavrilov & Baron-Cohen | Molecular Autism | Periódicos CAPES | Cambridge Mindreading Face-Voice Battery for Children (CAM-C) |
| A Virtual Joy-Stick Study of Emotional Responses and Social Motivation in Children with Autism Spectrum Disorder | 2015 | Kim et al.                   | J Autism Dev Disord            | PubMed            | Virtual-reality emotion sensitivity test (V-REST)                       |
| The effect of ICT on emotional education and development of young children with Autism Spectrum Disorder | 2015 | Charitaki                    | Procedia Computer Science      | Science Direct    | Mood Maker                                                               |
| Reduced Recognition of Dynamic Facial Emotional Expressions and Emotion-Specific Response Bias in Children with an Autism Spectrum Disorder | 2015 | Evers et al.                 | Child Psychiatry Hum Dev       | Periódicos CAPES  | Emotion Recognition Task                                                  |
| Computer-Assisted Face Processing Instruction Improves Emotion Recognition, Mentalizing, and Social Skills in Students with ASD Evidence for shared deficits in identifying emotions from faces and from voices in autism spectrum disorders and specific language impairment | 2015 | Rice et al.                  | J Autism Dev Disord            | Periódicos CAPES  | FaceSay Program                                                          |
| Evidence for shared deficits in identifying emotions from faces and from voices in autism spectrum disorders and specific language impairment | 2015 | Taylor et al.                | Int J Lang Commun Disord       | Periódicos CAPES  | Mind Reading Program                                                     |
| Training Facial Expression Production in children on the Autism Spectrum | 2014 | Gordon et al.                | J Autism Dev Disord            | PubMed            | Computer Expression Recognition Emotion Toolbox (CERT) and FaceMaze.     |
| Facial Emotion Recognition in Children with High Functioning Autism and Children with Social Phobia | 2012 | Wong et al.                  | Child Psychiatry Hum Dev       | Periódicos CAPES  | Penn emotion recognition                                                 |
Table 2. Criteria and tools used for the diagnosis of autism spectrum disorders in the studies

| Article                                                                 | Criteria and tools for diagnosis                                                                 | Sample and age range of Autism Spectrum Disorders |
|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|--------------------------------------------------|
| ‘Emotiplay’: a serious game for learning about emotions in children with autism: results of a cross-cultural evaluation | Previous diagnosis of ASD given by a Doctor or Psychologist according to DSM-IV criteria or ICD-10. Diagnosis was confirmed with application of Autism Diagnostic Observation Schedule (ADOS-2). | 15 participants aged between 6 and 9 years          |
| RCT of mind reading as a component of a psychosocial treatment for high-functioning children with ASD | Previous diagnosis of autism, Asperger Syndrome or Invasive developmental disorder, non-specified and confirmed with application of Autism Diagnostic Interview-Revised (ADI-R). | 36 participants aged between 7 and 12 years         |
| The Cambridge Mindreading Face-Voice Battery for Children (CAM-C): complex emotion recognition in children with and without autism spectrum conditions | Diagnosis made for a clinic Psychiatrist or Psychologist using DSM-IV-TR and ICD-10 criteria. | 30 participants aged between 8 and 12 years         |
| A Virtual Joy-Stick Study of Emotional Responses and Social Motivation in Children with Autism Spectrum Disorder | Previous clinic diagnosis of ASD and confirmed the conditions with reports of parents applying the Autism Spectrum Screening Questionnaire (ASSQ), the Social Communication Questionnaire (SCQ) and the Social Responsiveness Scale (SRS). | 19 participants aged between 8 and 16 years         |
| The effect of ICT on emotional education and development of young children with Autism Spectrum Disorder | Diagnosis criteria was not cited in the study. The children with ASD attended special school programs. | 5 participants aged between 9 and 14 years          |
| Reduced Recognition of Dynamic Facial Emotional Expressions and Emotion-Specific Response Bias in Children with an Autism Spectrum Disorder | Diagnosis of multi-professional team or for a child Psychiatrist, according to DSM-IV-TR criteria. Such diagnoses were confirmed using the Autism Diagnostic Observation Scale (ADOS). | 50 participants aged between 6 and 14 years         |
| Computer-Assisted Face Processing Instruction Improves Emotion Recognition, Mentalizing, and Social Skills in Students with ASD | Students from Ventura County School, California, who were chosen by special education services on condition of autism. | 31 participants aged between 5 and 11 years         |
| Evidence for shared deficits in identifying emotions from faces and from voices in autism spectrum disorders and specific language impairment | Previous diagnosis of ASD according to DSM-IV criteria and confirmed using Autism Diagnostic Observation Schedule-General (ADOS-G). | 29 participants aged between 5 and 12 years         |
| Training Facial Expression Production in children on the Autism Spectrum | Diagnosis of ASD with the British Columbia Autism Assessment Network (BCAAN), Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview (ADI). | 30 participants aged between 6 and 18 years         |
| Facial Emotion Recognition in Children with High Functioning Autism and Children with Social Phobia | Previous diagnosis of ASD using the Autism Disorders Interview-Revised (ADI-R) for a licensed clinic Psychologist. | 57 participants aged between 7 and 13 years         |
Figure 2. Relation of softwares and proposal of use

Figure 3. Relation of emotions by article

Figure 4. Relation between the number of articles and softwares used
Using software programs in evaluation and intervention processes among children with ASD is still rare in Brazil, which is noticeable from the absence of Brazilian literature in this review. Most of the reviewed international studies use such tools to aid in the intervention process and only a few use software programs for evaluation. We also identified that software programs are predominantly used in groups of children with high-functioning autism (HFA)\textsuperscript{14,21-29}.

Previous diagnosis with validated protocol application appears as diagnostic and inclusion criteria in most studies\textsuperscript{19,21,22,24-27,28}. Among the protocols considered as diagnostic gold standards, the Autism Diagnostic Observation Schedule (ADOS)\textsuperscript{21,22,25,26} and Autism Diagnostic Interview (ADI)\textsuperscript{22,24} were the most employed. Different versions of the Diagnostic and Statistical Manual of Mental Disorders (DSM) and the International Classification of Diseases (ICD) were employed to aid the processes, seeing they are the most used scientific references for diagnosing the disorder\textsuperscript{1,30}.

We also observed that most studies used a sample size of approximately thirty participants with ASD\textsuperscript{19,22,24,25,27,28} and that only six papers compared the performance with that of groups of typical development individuals\textsuperscript{14,22,25-27,29}. Another relevant aspect is that software programs were used predominantly with individuals in the range of 4 to 18 years of age\textsuperscript{14,21-29}.

Most of the tests in the reviewed papers consider the recognition of six basic emotions, namely happiness, fear, anger, disgust, sadness, and surprise\textsuperscript{14,21,23,24,29}, varying the intensity of the facial stimuli from neutral to more expressive\textsuperscript{27}.

From this review, one may be familiarized with software programs with evaluation purposes such as Emotion Recognition Task, CAM-C, CERT, Penn Emotion Recognition, and V-REST\textsuperscript{14,25,27,28}, as well as programs with intervention purposes such as Mood Maker, FaceMaze, Facesay, Emotiplay, and MindReading\textsuperscript{21-24}. All of the aforementioned software programs are used as aids to the respective processes and have shown good results when applied to individuals with ASD. CAM-C and MindReading are among the most used.

**CONCLUSION**

This literature review allowed identifying which software programs are used for children with ASD, mainly for intervention purposes. Ten software programs were identified in the ten papers reviewed which showed effectiveness in evaluation and intervention in the age range 4 to 18 years old. The software programs showed six basic emotions (happiness, fear, anger, disgust, sadness, and surprise) that support the understanding of facial recognition of emotions in children and teenagers with ASD. Diagnosis varied according to the use of protocols and scales considered of excellence for identifying the condition. No Brazilian study was found in this research field which subsidizes future investments in developing tools that can aid and facilitate the diagnosis and intervention of ASD.

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**ERRATUM**

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