

Web Application for the Learning of Emotions in Children with Autism Spectrum Disorder

Christophe Magalhães¹, João Sena Esteves^{1,2}, Ana Paula Pereira³, Vinícius Silva²,

Filomena Soares^{1,2}

¹ Department of Industrial Electronics, School of Engineering, University of Minho, Guimarães, Portugal

² R&D Centre Algoritmi, Guimarães, Portugal

³ CIEC, Department of Psychology of Education and Special Education, University of Minho, Braga, Portugal

(a73770, a65312)@alunos.uminho.pt, sena@dei.uminho.pt, appereira@ie.uminho.pt, fsoares@dei.uminho.pt

Abstract. Individuals with Autism Spectrum Disorder (ASD) tend to have a difficulty in interpreting and even expressing basic emotions such as joy or sadness, difficulties that can be mitigated with the support of tools that help those children understand and demonstrate emotions. The main goal of the presented work is to promote the learning of emotions in children with ASD, in a playful, didactic and simple way, through the use of a developed web application. Several games with different objectives were developed in order to optimize the acquisition of specific skills. The application gathers these games and makes them accessible in different contexts. A pilot study with seven children aged between six and eight years, three with ASD and four with typical development, was performed to validate the developed games, by analysing their suitability for the target audience. The results obtained allowed to verify that all players, with and without ASD, showed positive evolutions throughout all sessions, as they showed higher levels of interpretation regarding the game requests and completed the game with fewer errors and in less time.

Keywords: Autism Spectrum Disorder (ASD), Children, Emotions, Web Programming.

1 Introduction

Emotion recognition promotes a child's social communication development and learning. However, not all people find it easy to communicate through gestures and emotions. A case in point are individuals with Autism Spectrum Disorder (ASD), who tend to have a difficulty in interpreting and even expressing basic emotions such as joy or sadness. These difficulties can be mitigated with the support of tools that help those children understand and demonstrate emotions. This paper concerns the development

and application of interactive technologies to support and promote new adaptive teaching-learning approaches for children with ASD. Serious games are more intended for educational purposes than entertainment. In this case, the focus is on helping users with ASD in the learning of emotions. They may be a useful tool to help developing social-emotional skills in children with ASD.

1.1 Affective Computing

The ability to recognize and express affection is one of the most important characteristics of the human being. Affective computing addresses the ability of computers to process behavioural cues and to interact with human users in a way that is similar to human interaction. Without the ability to process this information, one cannot expect a computer to be able to interact with humans in a harmonious way. Affective computing concerns multidisciplinary knowledge of areas such as psychology, physiology and computer science [1].

Systems and devices that can recognize, interpret, process and simulate human behavioural cues have been in development for a considerable time. The recognition of emotional information requires extracting meaningful patterns from the obtained data. To perform an automatic analysis of facial expressions, it is pertinent to divide this process into three stages, namely the detection and face tracking, feature extraction (such as AUs), and classification of expressions (usually the six basic expressions described by Paul Ekman) [2].

1.2 Emotions and ASD

ASD is characterized as a neurological disorder associated with impairment of communication and social interaction and restrictive and repetitive behaviour. Individuals with ASD tend to have greater difficulty in interpreting and even expressing basic emotions, such as happiness or sadness. It is difficult to carry out an analysis based on the look, which complicates the interpretation of what the someone else is trying to express. However, it is possible to mitigate these difficulties these obstacles teaching these people to express and interpret emotions [3].

There is a big difference in the social communication development of children with ASD compared to typically developing children. Different approaches, methodologies and tools are needed to help in the intervention process with children with ASD [4]–[6]. More recently, the use of affective computing has been explored in order to facilitate the processes of learning, and this work aims to help in this process, in a didactic way.

1.3 Serious Games and ASD

With the constant technological evolution, new tools and new approaches have been proposed in the teaching-learning process. Serious games are included in the special

category of games, with specific objectives and purposes, in which the player uses his knowledge to solve problems or to know new problems and practice tasks.

Serious games are applied to simulate critical situations that involve some kind of risk, taking decisions or even to develop specific skills, which is the fundamental point of this dissertation, which focuses more specifically on the development of the ability to recognize emotions. For teaching-learning purposes, situations can be simulated in which the use of a knowledge is necessary for the evolution in the game. In some cases, teaching and training may be combined to simulate situations where you learn something to use in everyday life.

The purpose of these games, when aimed at teaching-learning, can be divided into three categories: awareness, knowledge building, and training [7].

With the constant evolution of technology, the gaming area has also gained from this and, in this way, it is possible to explore areas that were previously of little relevance. More and more serious games are used to help with everyday problems, and new methods are explored to optimize learning as can be seen in Fig. 1 [8].

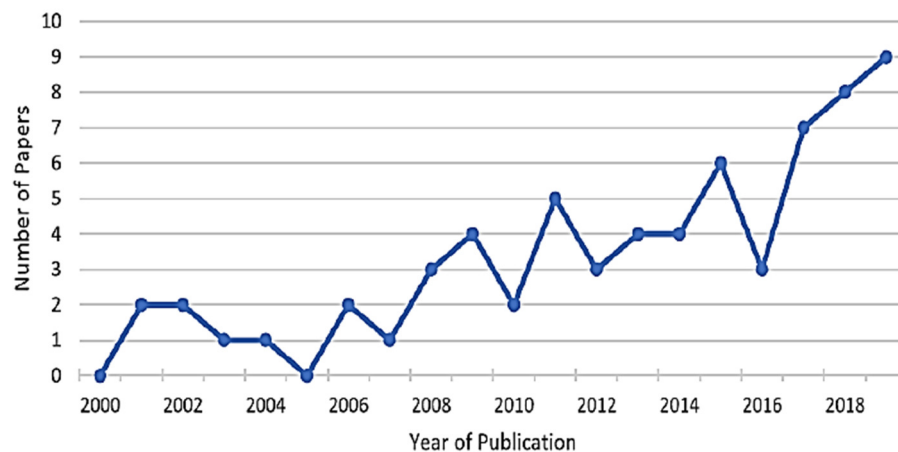


Fig. 1. Total Number of Papers that Presented a Serious Game for PEA, Intervention or Evaluation in Each Year [8].

In the period between 2019 and 2021, 12 articles were published about interventions with serious games and entertainment games in ASD [9].

Madsen [10] developed an interface called Emotion Bubbles, in which each displayed emotion has a particular colour. Positive emotions were assigned colours with a good feeling, such as green, blue and purple, indicating a productive state, and negative emotions were assigned warm colours, such as red, orange and yellow, indicating that the user must be aware of a possible impediment in the course of the conversation. Fig. 2 shows an example of the face analysis system and the bubble interface of the emotion detected [10].

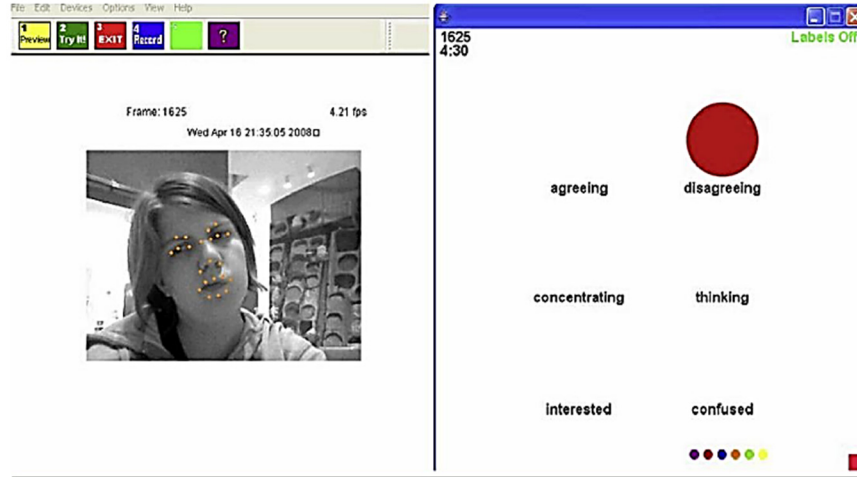


Fig. 2. Example of the face analysis system (on the left) and the developed Emotion Bubbles interface (on the right) [10].

The main goal of the work presented in the following sections is to promote the learning of emotions in children with ASD, in a playful, didactic and simple way, through the use of a web application gathering several games developed with different objectives, aimed at optimizing the acquisition of specific skills. The application makes the games accessible in different contexts.

2 Games and Application Development

The JavaScript programming language was used to develop a web application. It was used in front-end programming, which is responsible for the “visual” part of the application. Two early languages, HTML and CSS, were also used. Furthermore, it was possible to create a complete web application using Node.js along with a library that helps in the task of creating a web server, and through the use of some front-end frameworks and a database.

As the games were developed for children with ASD, special care had to be taken not to make it too difficult or too confusing for the users, simplifying the graphical interface presented. In all games, several images are presented in the Help menu, with the aim of helping a player to assimilate even better the different emotions.

After successfully completing the two developed games, the player will find it easier to interpret and associate different emotions with certain characteristic features of a human face.

It is possible to create an account, consisting of name, age, email and password. It is account will be responsible for containing the information of each player and, mainly, for storing the failed attempts in each game, so that whoever plays or monitors can have

a better perception about what you are doing wrong and reflecting on what to do to rectify your reasoning.

In this work, two serious games were developed. The first one, Emotions Game, aims to build a facial expression through the use of various facial parts such as the eyes, eyebrows, nose and mouth. The second game, Recognition of Facial Expressions, prompts the user to replicate a requested emotion, but the success of the task is verified by means of a camera and a system that validates whether the emotion is correct.

2.1 Emotions Game

The purpose of the Emotions Game is to create a face that represents the requested emotion. This game has four emotions: Happiness, Sadness, Anger and Surprise. It uses various parts that make up a human face, such as the mouth, nose, eyebrows and eyes. As can be observed on the left side of Fig. 3, a set of parts to drag is presented towards the incomplete face to create the emotion of Anger. On the right side, three images make up the Help menu, which presents the most pronounced features of each emotion in order to help the player find the correct face part.

The menu containing the parts of the face is updated with each passing level, and the positions are randomly changed to make the player's task more difficult. The face shown in Fig. 4 was correctly completed. When all emotions are correctly completed, a warning shows the message “Game completed successfully!”. A child has to drag a part of an incomplete face, according to a requested emotion, from the options menu that is on the right side and must interpret which parts correctly correspond to the requested emotion. Fig. 4 shows the emotion of Sadness completed successfully.

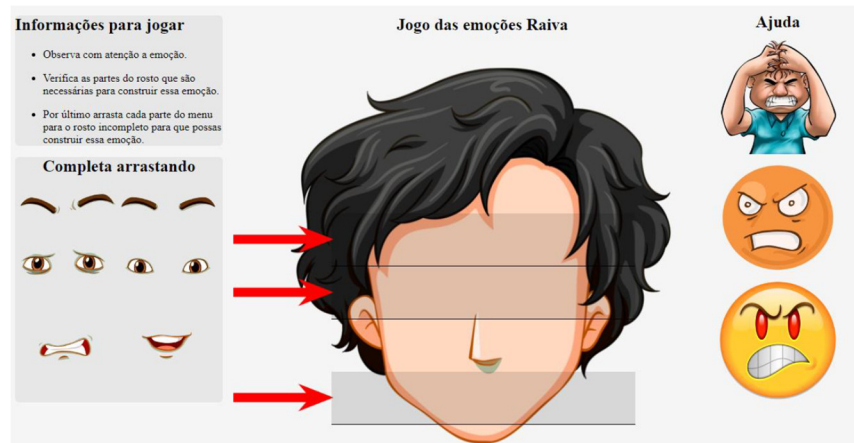


Fig. 3. General aspect of the Emotions Game



Fig. 4. Correctly filled face for the emotion of Sadness

Furthermore, whenever the player hits or misses a constituent part of the face to be completed, a message is displayed on the screen, as can be seen in Fig. 5 and Fig. 6.

In addition to the visual notification, a sound notification is also given through an audio that says: “Good! You got it!” as a positive reinforcement to the player.

The same way that a sound notification is given when a player gets it right, when he makes a mistake, he hears an audio saying: “Oh! Try again”. Thus, the player can realize that he/she was right or wrong.

The colours around and inside the text boxes, green and red, are in accordance with the ideas that people associate with right and wrong, respectively.

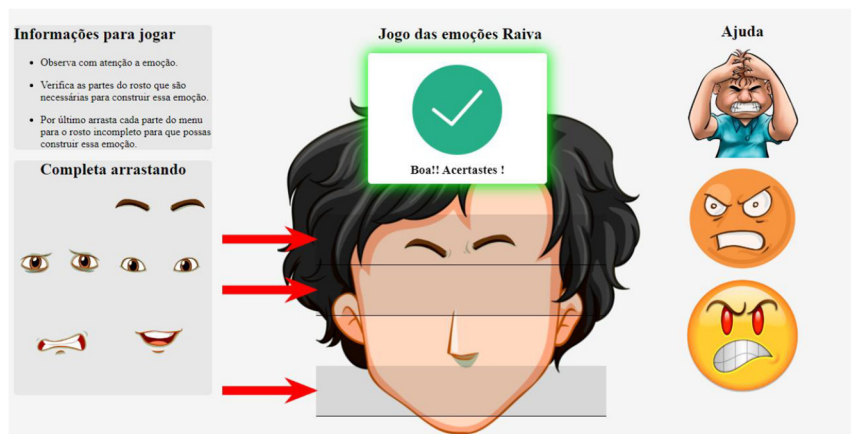


Fig. 5. Visual notification to alert if the face part was chosen correctly

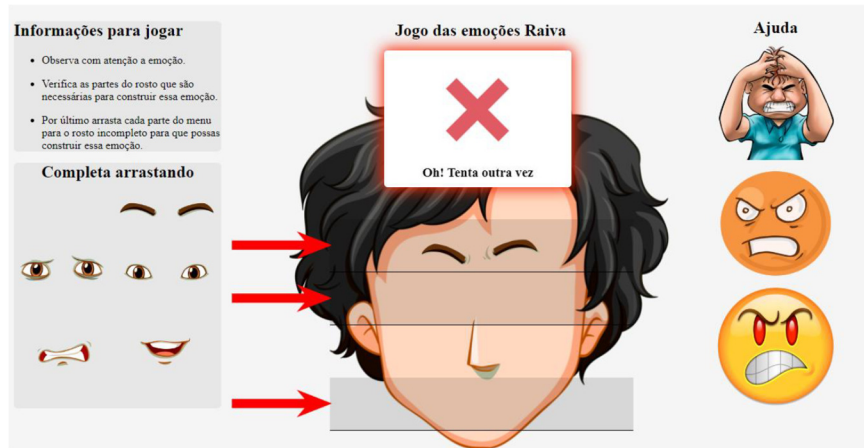


Fig. 6. Visual notification to alert if the face part was chosen incorrectly

2.2 Recognition of Facial Expressions

The second game is called Recognition of Facial Expressions. It prompts the user to replicate a requested emotion, but the success of the task is verified by means of a camera and a system that validates whether the emotion is correct. After successfully completing the two developed games, it is expected that the player will have greater ease in interpreting and associating various emotions with certain characteristic features of a human face.

A detection and facial recognition system was used. It has several functionalities, such as: facial recognition, checking similarities between photos, detecting facial expressions, detection of face reference points and real-time detection of face movements. Only face detection and facial expressions features were used in the developed application. The JavaScript library, Face-API.js, developed by Vincent Müller is an open access library that any user can integrate into their project [11]. Part of the code was integrated into the developed application and some changes were made in order to fulfil the objectives proposed for this second game.

As in the first game, the right side of Fig. 7 shows four images related to the four emotions used in this game: Happiness, Anger, Surprise and Sadness. Key features of each emotion, such as the mouth and the eyebrows, are highlighted. On the left side, with a yellow underline, the emotion to be performed is requested, and the player should imitate this emotion in the best possible way.

Fig. 8 shows the detection of multiple emotions, such as: Sadness, Joy, Surprise and Anger. When the system performs the validation with a probability above 70%, another emotion is asked until the game is completely finished.

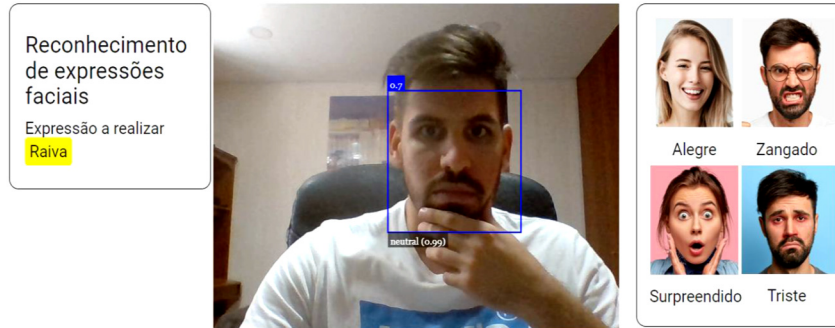


Fig. 7. Neutral state



Fig. 8. Multiple emotion detection: Sadness, Happiness, Surprise and Anger

3 Pilot Study

Five test sessions were carried out with seven children aged between 6 and 8 years old attending the elementary school with the goal to verify the evolution of the game for all of them and, also, whether the application allows responding to the functioning specificities and special needs of children with ASD. Three children have a diagnosis of ASD (Mateus, Josué and Joaquim) and four are children with normative/typical development (Madalena, Ricardo, Miguel and Fernando). To protect the identity and confidentiality of children, fictitious names are used, and the children's parents signed an informed consent in which they were notified about the objectives and methods applied in the research. Fig. 9 illustrates the setup of a test session with a child.

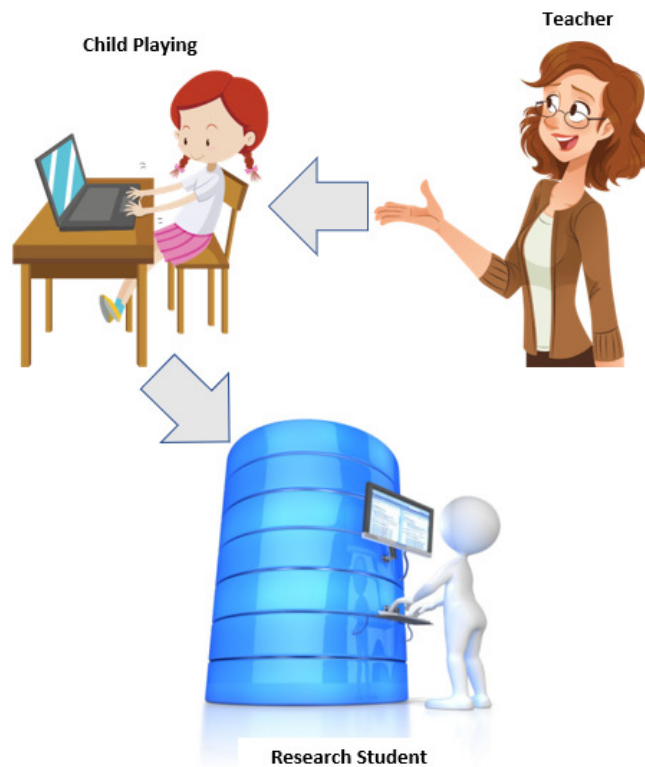


Fig. 9. Setup of a test session with a child

4 Results

In order to analyse the evolution of each player, a comparative analysis of the results obtained in the first and the fifth test sessions was carried out. Table 1 presents the data of the seven children.

Table 1. Percentage of correct answers from the players for each emotion in the 1st session and the 5th session (%)

Percentage of correct answers by emotion of all players between the 1st and 5th session								
Fictitious Name	Happiness		Anger		Surprise		Sadness	
	1st	5th	1st	5th	1st	5th	1st	5th
Mateus *	75	100	75	100	75	100	75	100
Josué *	100	100	75	100	100	100	75	100
Joaquim *	60	100	75	100	100	100	60	75
Madalena	100	100	75	100	100	100	100	100
Ricardo	100	100	10	100	100	100	100	100
Miguel	100	100	75	100	100	100	60	100
Fernando	100	100	75	100	100	100	100	100

*Children with ASD

Using the correct answers from all players in the five sessions, an average of all sessions and standard deviation were computed for each emotion, in order to find which emotions were more difficult for children to interpret and had lower percentages of correct answers. This data is shown in Table 2. It is clear that the emotion of Sadness and, soon after, the emotion of Anger were the most difficult to interpret.

Table 2. Overall average of correct answers and standard deviation for each emotion in the five sessions performed

Emotion	Average of all sessions (%)	Standard Deviation
Sadness	92.29	13.79
Surprise	97.14	8.07
Anger	92.43	12.39
Happiness	96.71	9.54

In the first sessions, most of the children got the eyebrows wrong for the emotion of Sadness, and this lowered the average throughout the sessions, in comparison with the other emotions.

Regarding the emotion of Anger, the most common mistake was getting the eyebrows and eyes wrong. The children mainly confused the eyes of the emotion of Happy with the eyes of the emotion of Anger and, sometimes, the eyebrows, too. So, the average in this emotion is lower in comparison to the other emotions.

In order to carry out a complete analysis of the evolution between sessions, a comparison of the completion time for each emotion was carried out. Table 3 shows which were the emotions in which the players had more difficulties, according to the time they took to complete it.

Table 3. Comparison of completion times for each emotion

Completion time for each emotion in the 1st and 5th session (min)								
Fictitious Name	Happiness		Anger		Surprise		Sadness	
	1st	5th	1st	5th	1st	5th	1st	5th
Mateus*	1:03	0:19	1:52	0:21	1:08	0:17	1:44	0:23
Time Reduction	0:44		1:31		0:51		1:21	
Josué*	0:34	0:14	0:32	0:32	2:43	0:13	0:34	0:50
Time Reduction	0:20		0:00		1:30		- 0:16	
Joaquim*	1:55	0:13	1:59	0:24	1:11	0:38	1:58	0:27
Time Reduction	1:42		1:35		0:33		1:31	
Madalena	0:40	0:10	0:48	0:18	0:28	0:13	0:27	0:18
Time Reduction	0:30		0:30		0:15		0:09	
Ricardo	0:29	0:10	1:05	0:09	0:41	0:14	1:07	0:19
Time Reduction	0:19		0:56		0:27		0:48	
Miguel	0:34	0:17	0:55	0:13	0:40	0:15	1:06	0:13
Time Reduction	0:17		0:42		0:25		0:53	
Fernando	0:50	0:30	0:20	0:15	0:17	0:09	0:18	0:12
Time Reduction	0:20		0:05		0:08		0:06	

*Children with ASD

Comparing times from the first and the last sessions, it is possible to observe a positive evolution in the players with ASD, Mateus, Josué and Joaquim. The emotions of Sadness and Anger have higher completion times than the rest, because they were the emotions in which all players had greater difficulties. Josué's results are different, as he has a longer completion time in the fifth session, compared to the time used in the first session for the emotion of Sadness. He holds a constant time in the emotion of Anger.

However, he presents a positive evolution in the emotion of Surprise, where he managed to reduce the execution time in 1:30 min. It is possible to conclude that the players easily adapted to the game and demonstrated greater levels of confidence and motivation throughout the sessions.

The players without ASD (Madalena, Ricardo, Miguel and Fernando) also showed a positive evolution throughout the sessions, and became faster and faster in the choice of the parts of the human face (eyebrows, eyes and mouth) that characterize each of the emotions, presenting more doubts, namely in the emotions of Sadness and Anger.

All the completion times were recorded and are presented in Table 4. A comparison was made between the completion time of the game in the first and the fifth sessions. To complete the game, it is necessary to successfully complete the four indicated emotions.

Table 4. Time for game conclusion in the 1st and 5th session (min)

	Fictitious Name	Time for game conclusion in the 1st and the 5th session (min)	Time Reduction
Children with ASD	Mateus	5:52 - 1:22	4:30
	Josué	4:43 - 1:49	2:54
	Joaquim	7:05 - 1:55	5:10
Children with Typical Development	Madalena	2:24 - 1:01	1:23
	Ricardo	3:23 - 0:52	2:31
	Miguel	3:21 - 0:58	2:23
	Fernando	1:47 - 0:51	0:56

By analysing the data in Table 4, it is possible to conclude that the players with PEA were the ones who had a better evolution in terms of completion times. These players were not completely comfortable in the first sessions, and took longer to decide which options were correct. Throughout the sessions, they improved in all aspects, and this was later reflected in the total time needed to complete the game.

It is important to emphasize that all players, with or without PEA, showed positive evolutions throughout all sessions, as they showed higher levels of interpretation regarding the requests of the game and completed it with fewer errors and in less time.

5 Conclusions and Future Work

This paper presented a web application gathering several games developed with different objectives, aimed at optimizing the acquisition of specific skills. The application makes the games accessible in different contexts and was developed in order to promote the learning of emotions in children with ASD in a playful, didactic and simple way.

Through all the data recorded in the five sessions carried out in an exploratory study, it was possible to make several comparisons and verify the evolution of each player. The emotions in which the children had more difficulties were Sadness and Anger, with 92.29% and 92.43% of correct answers, respectively. This result can be explained by the fact that these are less frequent emotions in a child's daily life, compared to the emotions of Joy and Surprise. This lesser use of the emotions of Sadness and Anger may have resulted in a greater number of errors in their identification, and in greater confusion with parts of the face of other emotions, namely with regard to the eyebrows and the mouth.

Analysing the results, it is possible to conclude that all children evolved throughout the sessions, and that they all demonstrated the need for a greater amount of time to finish the game in the first and second sessions, potentially due to the novelty factor. From the second session onwards, all children demonstrated greater confidence and speed in executing emotions. The obtained results may constitute important indicators for the promotion and development of this type of games in the context of emotions recognition and imitation skills, in children with or without ASD who attend the first cycle of basic education. The social relevance of the type of application developed for schools in the first cycle of basic education and for families of children with and without ASD is reinforced.

The application offers the possibilities of creating an account with the data of each player and saving the results of each game session in its database, for future studies. As future work, some improvements can be made in terms of the confidence interval and validation of the system, and also at the aesthetic level, in order to reinforce the child's motivation for the game. Emotions such as Fear and Disgust can also be introduced. These two emotions, although more difficult to interpret when compared to the emotions already used in the application, could provide greater complexity in the game and the need for collaborative work between peers. This collaborative work promotes interactions between children, with or without ASD, and the development of problem-solving skills. Finally, an exploratory study could be carried out, with a larger sample, in order to validate the behaviours of children with or without ASD regarding the recognition and imitation of emotions.

Acknowledgments

This work has been supported by national funds through FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020. The authors thank the teachers and students of the Elementary School of Gualtar (EB1/JI Gualtar) in Braga for the participation.

References

1. J. Tao and T. Tan, "Affective Computing: A Review," in *Affective Computing and Intelligent Interaction*, J. Tao, T. Tan, and R. W. Picard, Eds., Berlin, Heidelberg: Springer Berlin Heidelberg, 2005, pp. 981–995.
2. Vaigai College of Engineering, Institute of Electrical and Electronics Engineers. Madras Section, and Institute of Electrical and Electronics Engineers, *Proceedings of the 2017 International Conference on Intelligent Computing and Control Systems (ICICCS)*: June 15–16, 2017.
3. M. Uljarevic and A. Hamilton, "Recognition of Emotions in Autism: A Formal Meta-Analysis," *J Autism Dev Disord*, vol. 43, no. 7, pp. 1517–1526, 2013, doi: 10.1007/s10803-012-1695-5.
4. J. Chen, G. Wang, K. Zhang, G. Wang, and L. Liu, "A pilot study on evaluating children with autism spectrum disorder using computer games," *Comput Human Behav*, vol. 90, pp. 204–214, 2019, doi: <https://doi.org/10.1016/j.chb.2018.08.057>.
5. A. C. Dantas and M. Z. do Nascimento, "Recognition of Emotions for People with Autism: An Approach to Improve Skills," *International Journal of Computer Games Technology*, vol. 2022, p. 6738068, 2022, doi: 10.1155/2022/6738068.
6. P. Mihova, M. Stankova, F. Andonov, and S. Stoyanov, "The Use of Serious Games for Developing Social and Communication Skills in Children with Autism Spectrum Disorders—Review," in *Artificial Intelligence and Machine Learning for Healthcare: Vol. 2: Emerging Methodologies and Trends*, C. P. Lim, A. Vaidya, Y.-W. Chen, V. Jain, and L. C. Jain, Eds., Cham: Springer International Publishing, 2023, pp. 181–196. doi: 10.1007/978-3-031-11170-9_7.
7. L. Dos, S. Machado, I. Ronei, and M. de Moraes, "Serious Games Baseados em Realidade Virtual para Educação Médica Serious Games Based on Virtual Reality in Medical Education," 2011. [Online]. Available: www.abragames.org
8. A. Hassan, N. Pinkwart, and M. Shafi, "Serious games to improve social and emotional intelligence in children with autism," *Entertainment Computing*, vol. 38. Elsevier B.V., May 01, 2021. doi: 10.1016/j.entcom.2021.100417.
9. G. M. Silva, J. J. de S. Souto, T. P. Fernandes, I. Bolis, and N. A. Santos, "Interventions with Serious Games and Entertainment Games in Autism Spectrum Disorder: A Systematic Review," *Developmental Neuropsychology*, vol. 46, no. 7. Routledge, pp. 463–485, 2021. doi: 10.1080/87565641.2021.1981905.
10. M. Madsen, R. el Kaliouby, M. Goodwin, and R. Picard, "Technology for Just-in-Time in-Situ Learning of Facial Affect for Persons Diagnosed with an Autism Spectrum Disorder," in *Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility*, in *Assets '08*. New York, NY, USA: Association for Computing Machinery, 2008, pp. 19–26. doi: 10.1145/1414471.1414477.
11. Mühler Vincent, "<https://itnext.io/face-api-js-javascript-api-for-face-recognition-in-the-browser-with-tensorflow-js-bcc2a6c4cf07>," *face-api.js* — JavaScript API for Face Recognition in the Browser with tensorflow.js, Jun. 25, 2018.