A Web Framework For Configurable Games With Application to Autistic Children

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***Abstract*—We present a configurable web-based mini-game design tool with application to feelings teaching. It is an important type of activity commonly employed to train empathy for autistic children. Specifically, the proposed framework provides four types of configurable mini-games: emotion identification, social stories, pairing, and - as an incentive to the players to perform imitations of expressions - a facial-expression-detection game where the player controls a race car by mimicking feelings in real-time. We present how our framework was designed and how the configurable templates can be used to create different context-based mini-games to teach emotion recognition and empathy for children, especially the ones who need special care such as children with Autism Spectrum Disorder.**

***Index Terms*—game, web-based game framework, autism, emotion teaching**

I. Introduction

Autism is classified as a psychological disorder manifesting in the early stages of childhood. The symptoms range in a spectrum of behaviors affecting the quality and the children's development in areas such as language and social capabilities.

Autistic Spectrum Disorder (ASD) appears in all racial, ethnic, and socioeconomic groups [1], being four times more common among boys. The average prevalence of the number of people with ASD, identified in European, Asian, and North American studies is around 1% to 2% [1]. In the United States, it affects 1 in every 54 North American children, up to eight years old [1], [2]. In Brazil, there is no official measure of prevalence. A study conducted in the city of Atibaia, in the interior of São Paulo, sampled 1,470 children, between seven and 12 years old, founding a prevalence of 0.3% of ASD, which indicates that around 40 thousand children or adolescents (with up to 20 years) may present the disorder [3], [4].

Children in the Autism Spectrum Disorder (ASD) may have a low emotional attachment, non-existent or abnormal speech, or even aggressiveness [5]. Autism does not have a known cause, and does not have a definitive cure; however, some therapies to improve the life quality of people with ASD have been proposed over the years.

The treatments of ASD have different formats. Recently, Medavarapu et al. [6] evidenced the results of the effectiveness by combining the Applied Behavior Analysis (ABA) therapy and specific drugs.

The official health manuals [7], [8] identify characteristics related to neurodevelopment, with deficits in the area of social communication, restricted interests, and stereotyped behaviors. The diagnosis is divided into the following domains:

- Sociability and empathy: Difficulty in dealing with situations of social interaction, little emotional reciprocity, among others;
- Communicative language and imagination: Ability to communicate with delay and absence in the development of oral language, difficulty in maintaining a conversation, difficulties in imaginary (symbolic) representation and social imitation;
- Cognitive and behavioral flexibility: repetitive and stereotyped behaviors, high intensity of focusing on specific activities, routine inflexibility, repetitive motor habits.

Considering the diagnostic criteria of the ASD [7], an alteration that may arise refers to emotional cognition. It means that people with ASD can present distortions in the perception and understanding of emotions [9]. When considering the emotional expressions represented by the human face as a fundamental ability to recognize other people's emotions and thus establish social reciprocity, it is necessary to investigate strategies for teaching emotional expression, as well as recognition [10].

Thus, one of the areas that children with ASD must develop is the recognition of emotion and empathy, which improves the social skills of individuals. Empathy is the ability to share the internal feelings of other people and to recognize emotions. Autistic people suffer from reduced empathy, having concerns for understanding the other's emotions from their facial expressions, and have reduced or unexpected behavior when processing their own and other's emotions [11].

The ability to recognize emotions is developed in the first years of life and continues through childhood and adulthood

[12]. The basic emotions are happiness, sadness, fear, anger, surprise, and disgust. However, people within ASD present difficulties to identify emotions from facial expressions, voice, and context

Muñoz [13] assessed the difficulties of people with ASD in recognizing emotions involved in a daily situation. The thinkers discuss the connection between the amygdala and the emotions, correlating this structure to the Central Nervous System (CNS). Besides, the text exemplifies that, in literature reviews, evidence was found that ASD, amygdala, and gaze are correlated with each other. To carry out the study, an eye-tracker was used to mark the obtained data. Muñoz (2018) reports that some variables influenced the results of his thesis, such as, for example, the age of the participating subjects. According to the study, as age increased, it was possible to notice an improvement in the ability to recognize emotions, however, people without ASD got a better result compared to people with ASD.

Zangrando [14] addressed, from a general perspective, how the recognition of emotions occurs in the CNS. For such action, a review of the existing literature was carried out, in addition to a linear-temporal construction of the existing theses. Zangrando [14] formulated hypotheses as to why the population with ASD has a deficiency in the processing of faces, among which we can highlight the difficulty in integrating information from the different structures of the face.

Thus, considering the persistent deficits in reciprocal social communication and social interaction of people with ASD and how these conditions affect emotional cognition, as well as social skills, it is necessary to guarantee teaching conditions for social skills involving people with ASD, aiming at a life with higher social quality. Among the most elementary social skills is the recognition, naming, and expression of emotions, also known as emotional expressiveness [15].

Emotional expressiveness can be taught through specific tasks, in a computerized way, since according to Barroso & de Souza [16], there is little research regarding the use of digital technologies that aim to teach specific behaviors to children with ASD. Examples of these tasks may involve classes of stimuli, such as the name of the emotions, the representation of the emotions on isolated faces, or even videos with the emotions in a given context, or even in the format of social stories, according to da Silva et al. [17] who used social stories to teach classroom routines.

Therefore, teaching emotional expressiveness to children with ASD can involve different activities. One of the activities is the recognition of emotions through images or videos of expressions. It can be configured in the format of matching tasks with the model, in which three emotional faces are presented, and the child is asked to choose one of them, through oral instruction, for instance, “which person is happy?”.

Another type of activity is to expose the children to a situation and ask him to describe what emotion this situation leads. For instance, the professional tells the child, “ A girl got a gift that she wanted. How did she feel? ” And then the child must inform how the person in the story would feel. In other teachings, the child may be asked to pair similar facial expressions. In these matching tasks, the child must point to two similar expressions or drag one to the other. One may also ask the child to name emotions. An image or video with an expression is displayed and the child must then say what the expression it represents.

Finally, the children can be asked to imitate expressions. An image, video, oral instruction, or text is presented to the child who must make the requested facial expression. Making the teaching of emotional expressiveness more dynamic and interactive, through computerized social stories is what is proposed in this project.

In the ASD treatment, the volume of activities usually has to be high to present better results [5]. The activities, specified by a professional (therapist, speech therapist), are applied by teachers and parents or guardians at school or home. One of the skills to be trained for recognition is emotions and empathy. We present in this article a framework for creating personalized teaching activities, which can be easily used to teach emotion recognition to children with ASD. In addition to the activities described above, we added an activity based on a race, in which, to finish the game, the player must imitate facial expressions. Each hit takes your character closer to the finish line and wins the game. Our tool allows to create custom mini-game without the need to know how to program.

This paper is organized as follow: Section I presents this introduction; Section II presents the studies related to teaching emotion recognition and abilities to autistic children; Section III presents how we designed our framework; Section IV shows some examples using our framework; Section V presents some discussions about the framework, and; Section VI presents our preliminary conclusions and future work.

II. Related Work

The use of games and applications in education has become popular in recent years. Games with specific teaching purposes were designed, such as JECRIPE [18] and JECRIPE 2 [19] aim to assist in the development of players with disabilities, such as children with Down Syndrome. Both have an interactive and enjoyable interface, providing provide several mini-games designed to assist in the children’s development, in a playful way.

The GEIC (Computerized Individualized Education Manager) software allows to create customized interactive activities. The customization is limited to select which images will be used in each activity and selecting rewards. Although the software was released in 2008, it has been widely used in research projects [20] yet.

Artoni et al. [21] present a web-based application for easy programming of Match-To-Sample activities, a type of game frequently employed in the Applied Behavior Analysis Therapy, which is commonly used in the autism treatment.

Those software are not specifically created to teach emotion recognition, but, the professionals can configure mini-games to this end. We can also find some software and studies that aim

to specifically teach emotion recognition. Zirkus Empathico was designed for pre and primary school children with ages ranging from 5 to 10 years. The app has a big database of facial expression images and videos which are used in the activities. The app has 4 modules: 1) recognition of one's own emotions; 2) recognition of other's emotions from video-taped emotions; 3) recognition from a video of what triggered the emotion, and; 4) describe own emotions in reaction to other's emotions. In a quick evaluation, authors noticed that the children liked to use the app and the effectiveness still being investigated [11].

Golan et al. [12] evaluated Mind Reading for it effectiveness in teaching adults with Asperger Syndrome and high-functioning autism to recognize emotions in faces and voices. Mind Reading software has 24 emotions and six developmental levels, from 4 years to adulthood. Each emotion is described with six films of faces, six voice recording and six situations that lead to the emotion. The software allows the student to view the emotions library, learn (through some activities as lessons and quizzes), and games (puzzle).

Silver & Oakes [22] evaluated the software "Emotion Trainer" with two groups of 11 children (age 12-18). In this software, each page presents one face, scene, or object with a short text question and two buttons. The child should then select the correct answer. The questions ask for the child to select the correct emotion presented in the screen and to analyze different situations and respond which emotion these situations trigger. After the training, the children presented a reduction in errors when detecting emotions.

Bolte et al. [23] developed and evaluated a computer application to teach the ability to identify basic facial expressions. They evaluated the application with 10 autistic adults or adolescents. They built a database with 1000 images of women and men showing facial expressions. The players should select what emotion the image represents. If they choose the wrong, an explanation about the feeling is presented along with the image.

Rodrigues et al. [24] presented a game developed to teach emotions. Players (children with ASD) interact with the game through facial expressions. The game was designed in two stages: In the first, the child must imitate faces that are presented (through photos) until filling in a progress bar; in the second stage, the child must imitate the expressions in images, however, a 3D avatar will imitate the expressions made by the children. The authors presented an evaluation with users: 12 children with ASD tested the software and the authors found that with the use of avatars, children reproduced facial expressions more quickly.

The software and studies found usually present limited interaction, in which children must analyze the context and select (using the mouse or touch screen) a correct answer. The software that differs from the others is the one presented by [24], which allows children to interact with the player through facial emotions. However, the mini-games are not customizable. Using our software, parents or educators can configure a complete game-based teaching program without the need of any computer programming skills.

In Section III we present how we designed our software to allow parents or educators to create customized mini-games.

III. Application Design - Activities as Games

For the development of our configurable web-based game, we developed a framework that allows creating customized mini-games without the need to know computer programming. Our framework allows creating customized teaching mini-games that behave like teaching activities. Each mini-game is configured through different screens, already defined in our framework, which can be:

- Stimuli presentation: allows to present stimuli (image, audio, video, text) to the student for a configurable time;
- Stimulus selection: presents images or texts and allows the student to select one of these;
- Drag: allows to drag images and group them;
- Text insertion: allows to display stimuli and a text box so that the student can insert text;
- Behavior analyst evaluation: presents a screen with three buttons so that the behavior analyst enters the evaluation of an activity that has been performed outside the application: the student performed the activity correctly, the student performed the activity correctly with some tip, or, the student performed the activity wrongly;
- Select stimulus for future use (used in the race mini-game), and;
- Race mini-game: This screen allows to configure a game using the webcam for emotion recognition.

Each activity is composed of a set of screens that are presented to the student. The framework has a set of activity templates using the existent screens already defined, however, the professional can create their own activity templates. For example, the MTS template has only one stimulus selection screen on which the student must compare the model stimulus and select one of the comparison stimuli presented. The professional can create a new template where the first screen is a "Stimuli presentation" that presents the model stimulus and, on the second screen, the selection of stimuli; This way, the professional creates a Delayed-MTS activity, which is used to train memorization.

Our framework was developed using Web languages such as HTML5, PHP, Javascript, and the MySQL Database Management System. Each activity is stored as an XML file. The file contains the screens' descriptions such as stimuli used or the time a stimulus will be displayed. In the database the framework stores metadata about the activity, such as its owner, name, category, and difficulty (provided by its owner).

The professional configures activities using a web-based interface, and for that, he/she only needs a Web browser. The applicators (parents or teachers) can run the activities with the students using a Personal Computer, smartphone, or tablet as our framework runs on different devices.

A game has it's own universe, with its rules and conditions for victory or defeat [25]. In our mini-games, the universe is defined in the game configuration, according to the specific theme the game designer (educator or parent) aims to teach.

The rules are also defined in the game configuration: if the player gives the correct answer, one can receive a reward; if the player performs the task incorrectly, he/she will not get the reward.

Using our framework it is possible to create new mini-games with teaching purposes. The mini-game's objectives are defined by who configure it. The victory and defeat rules are also defined using the web interface. The rewards (presented when the player answers correctly) are also configured using the same interface as the mini-games. Fig. 1 shows the edition interface. Each mini-game consists of different screens that can have their characteristics edited.

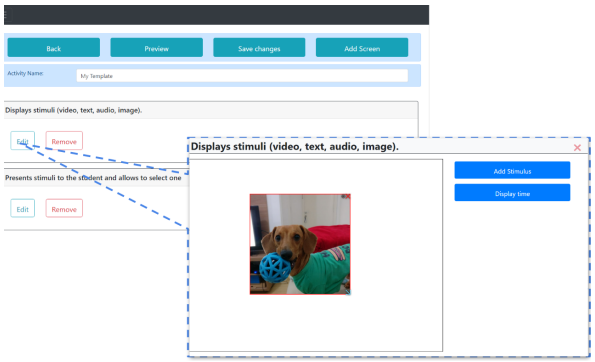

Fig. 1. Each mini-game or reward has one or more screens. Each screen is configurable and the user can set it's properties.

Section IV shows the mini-game templates available in the framework and how these templates can be used to teach emotion recognition to children with ASD. The use of customizable rewards is yet another feature that can help to gather players' attention.

IV. Mini-games for Evaluation and Teaching of Emotions

Our framework allows to configure different mini-games. For that, it is necessary to register each player and set up the mini-games and their rewards. In this section, we present how to create mini-games for Emotion identification, Social stories, Pair Emotions, and a Racing mini-game.

A. Emotion Identification

To configure a mini-game in which the player has to identify an emotion, we need to create two game screens. First, an emoticon, image, or video with an expression is displayed to the player for a certain time. After that, the next screen is made up of a selection screen. In this second screen, the player must select between images or texts displayed. In the example shown in Fig. 2, the first screen shows a happy emoticon, and on the next screen, the player must select from the options shown, being "happy" the correct one.

B. Social stories

A common activity to teach empathy is to expose the player to a scenario where one has to analyze it and decide what

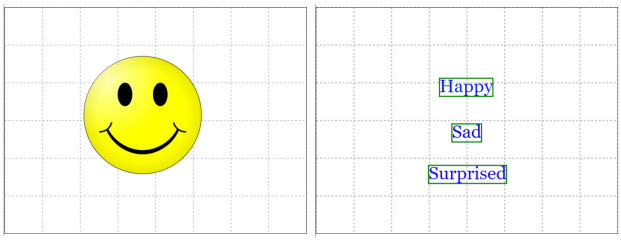

Fig. 2. Naming emotion activity. The professional can use different objects (image or text) as model and ask the player to select the correct name of the emotion.

emotion would be brought up from the situation. For example, we can tell a story saying that a fictional character was rude to a little friend, or, the character received a gift and then asked the player how that character would feel in that situation.

Social stories can be based on the stories elaborated by Silva et al. [15]. The professional presents three cards for children (or adolescents) with a story and at the end of the story narrative, the professional asks how the character of the story is feeling.

To create social stories, the mini-game format is very similar to that shown in the nomination of emotions. A screen presents the situation, through texts, images, audio, or video. The next screen then asks the player what emotion the character would be feeling. Fig. 3 shows the configuration of the mini-game using our framework. The first screen shows a gift along with a text explaining that it was a gift for Johnny. In the second screen, the player must answer how Johnny felt when receiving the gift by clicking/touching on the emoticon that represents the correct emotion.

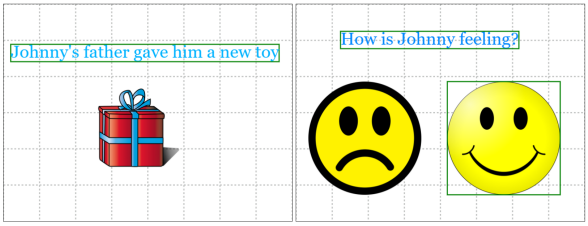

Fig. 3. Situation and Recognition. The first screen shows a message saying that Johnny's father gave him a gift. In the second screen is asked to the player how Johnny should feel about receiving the gift.

C. Pairing Emotions

Our framework has a mini-game model that allows to drag images. In this model, the professional can configure a container, which will receive an image, and add images that can be dragged. When releasing an image that has been dragged into a container, they are associated. This can be used to create different types of mini-games. Fig. 4 shows the configuration of drag mini-game. At first, the user adds the containers and draggable images. Then, configure the correct container for each image - the one to which the player must drag the image.

Fig. 4. Drag mini-game configuration. The draggable images are configurable. The professional can select any image to be draggable and other images to be fixed. The player should then drag and associate the images correctly.

The example shown in Fig. 5 shows that the player must compare the emoticon and the emotion it represents with images of a real person and pair them, dragging the image to the correct emoticon.

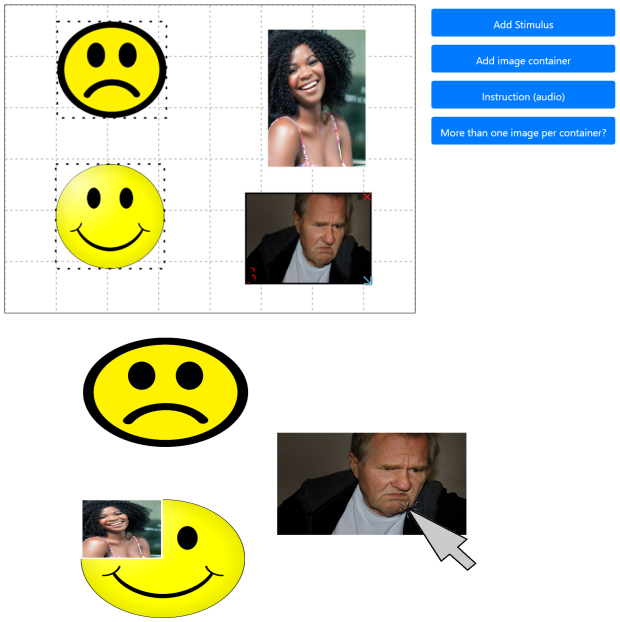

Fig. 5. Drag to match emotions. The player should evaluate the emoticons and the real faces and match the emotions on them.

D. Race mini-game – Facial Expression Detection

As an incentive to the players to perform imitations of expressions, our framework has a template of mini-game that can be used to make stories in different contexts. In the template, the professional defines a background, a set of stimuli that represent emotions (images, audios or texts), an object that moves on the screen as the player gives a correct answer, the initial position of the object, the final position of the object, a sound that is played at each correct answer and a sound to be played for each error. Also, the first screen of the mini-game allows the player to select which will be the movable object, or character.

In the mini-game, the facial expressions are analyzed using Artificial Intelligence. We used the Face-api.js [1] library to detect faces and facial expressions. The library is open-source and free to use, works in web browsers, and is written in the Javascript language. The library is easy to use and returns marks of detected faces and emotions. The library uses computer vision, Machine Learning and already has face training data, so it is ready for use, this way the developer not necessary to collect data and perform training to classify faces.

The movable object can be used to create, e. g., a race car or some kind of progress bar. The moving object could be a car, the background could be a road. With each correct answer, the car (character) moves a little on the track, until it reaches the final line. Fig. 6 shows the configuration screens for character selection and the game screen. Two cars are shown on the selection screen and the player must select one. On the game screen, a background with a road is presented, in addition to the emotions that the player must imitate (emoticons). During the gameplay, at each correct answer, the selected car moves a bit towards the final flag.

The same activity template allows the professional create other kinds of activities that better fits the player's context. The movable object (character) could be a basket ball, the background could be a basketball court and the object could move from a player's hand to the basket. Fig. 7 shows an example where the correct expressions move the ball to the basket.

V. Discussion

In the literature and in app stores we can find different applications to assist in the education of children with ASD. Such applications already have the contexts created for the general public, that is, they do not have a specific configuration for each player, and, as each one has their own demands, this situation is not the best for the player.

Our framework allows professionals to create customized and individual mini-games, thus meeting the difficulties of each player. Our framework presents game templates that can be used to create custom mini-games. It is also possible to create own game templates with the screens already available in the framework without any need of programming skills.

In the literature we can find different studies for teaching the recognition of emotions or empathy; however, these are not customizable [11], [23], [24]. In our framework, the professionals create mini-games and selects the stimuli that will be best for each individual. In the different activities, it is possible to use images, videos, texts, or audios that are best suited for each individual, such as images, videos, or audios of family members.

The face detection API works well as long as the player is situated in a well-illuminated room. Also, even if the player uses glasses the API can identify the facial expressions, as long as the eyes can still be captured by the camera. The

[1] https://github.com/justadudewhohacks/face-api.js

API uses a database of facial expressions to learn and an already trained dataset. This way, its use is very simple. The mini-game design interface is very simple, allows the user to position the camera view, select images, text, or audio clips that represent emotions, and select the game objects in a simple interface.

The developed framework is available in a web interface and works only with a browser on different devices, including mobile. As many users access the internet through smartphones or tablets, the availability to different platforms is a must-have feature. Hosting applications on the internet facilitates access by different users, thus, a greater number of people can be benefited. Furthermore, the remote working model was shown to be necessary during the COVID-19 pandemic.

VI. Conclusions and Future Work

In this work, we presented a framework to configure and create mini-games. The framework comes with game templates that can be used to teach the recognition of emotions and empathy. Using these templates we can create mini-games to teach emotion recognition, emotion naming, social stories, emotion pairing, and a race mini-game with facial recognition.

We presented different mini-games that could be used to teach emotion recognition and empathy for children, especially children with special needs, such as ASD. Our framework was designed by a team of researchers composed by computer scientists and psychologists and the main idea behind the development is that the framework should be easy to use.

In the next works, we want to test the mini-game acceptance by the target public: children with ASD. We also would like to test the framework usability with professionals and check if it is easy to configure the mini-games.

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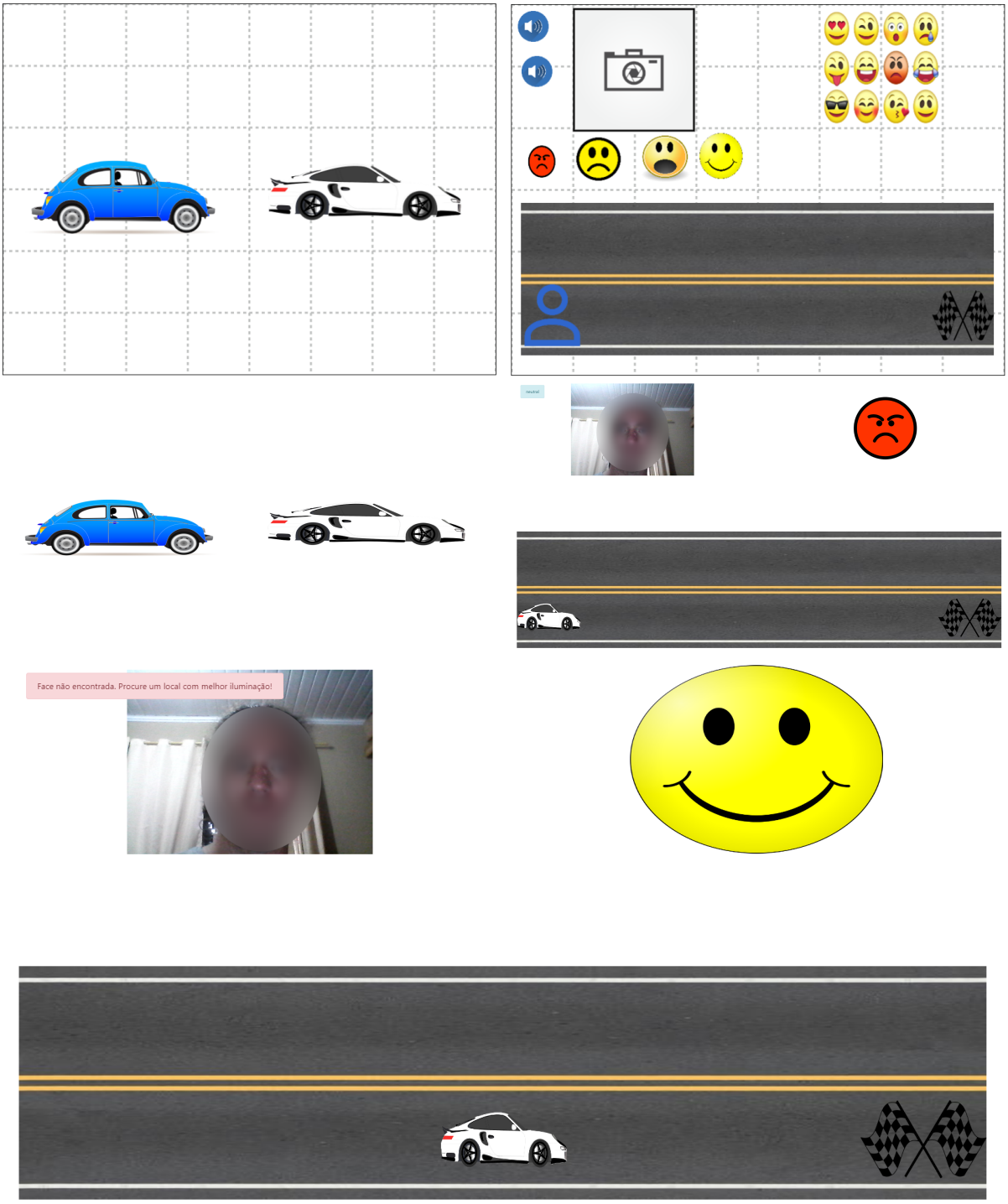

Fig. 6. Race configuration: Using the template the professional can create emotion recognition activities in a race-like style (top images). The other images show the activity being run: the player can see the webcam and the emotion s/he needs to imitate. As the player gives a correct expression the car moves in the direction of the final flag.

Fig. 7. Basketball based on expression imitation. The professional can configure the activity template as a basketball game (top images). As the player imitates correct expressions the ball moves from the basketball player's hands to the basket.