Observed Interaction in Games for Down Syndrome Children

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Abstract

This work proposes a method for evaluating the children's behavioral interactions with a game, more specifically for evaluating playful applications for kids with cognitive disabilities. Our method introduces an evaluation criteria over children's behavioral interaction and game design analysis, adapted from a list of breakdown indication types of the Detailed Video Analysis (DEVAN) that was originally designed for regular applications. We present a case study of the proposed evaluation method with a detailed analysis of the game called JECRIPE, originally developed for stimulating cognitive abilities of children with Down syndrome in preschool age. The proposed method adopts qualitative and quantitative criteria to review the initial developmental factors that have driven JECRIPE's design versus the real behavior observed in a group of children playing the game. As results of this case study, we demonstrate the reliability of the evaluation method and the capacity of this method in discovering usability and fun problems in order to be considered and addressed in future game releases.

1. Introduction

There is a remarkable number of studies highlight the benefits of computer games interaction for children's learning in general [1 and 2] and also for children with disabilities [3, 4, and 5]. Despite the increasing popularity and importance of the relation between human computer interactions and computer games with the use of new technology, still very few works have explored the effectiveness of this interaction paradigm for children with multiple and/or severe disabilities.

Many questions related to the game design aspects when adopting interactive technology emerge during the development process. For instance: how can one increase the amount of relevant information about the selected cognitive abilities correct stimulation in addition to an increase in usability and fun in games? Interaction effectiveness in games is close related to usability factors. In his seminal work, Malone, T. W. [6, 7] suggests heuristics about the creation of effective user interface which can only be provided within an enjoyable game. He divides the proposed heuristics into: challenge, fantasy, curiosity and control. If a game surprises the player by different activities with unmet expectations, there would be a joy. Only under that situation a game can be classified as in the toy category rather than a tool.

The fun factor of a game comes from its playability, which is the interaction of the player with the established mechanics and rules. The human interface has a fundamental role for the execution and interpretation of those mechanics, and its issues are discussed as usability. Usability is considered one of the most significant topics for games analysis. According to Laitinen, S. [8] usability increases efficiency and satisfaction. He supports the idea that playing a game is to have fun and compete against others. If this enjoyment or competition is prevented due to coping with usability problems, they would be a risk for user experience. Thus, usability problems cause the loss of players. In order to control the usability with the real play experiences, he suggests testing the game with target group of players.

In this work we observe that the direct adoption of existent interaction effectiveness and usability measurements over games designed to children with cognitive disabilities is not straightforward. This is an unexplored topic specially when talking about digital games for children with Down syndrome. At this point it is relevant to clarify what are the main challenges that a method for user's interaction evaluation should be aware of and should be able to tackle when talking about children with Down syndrome.

For children with Down syndrome speech and language skills are often significantly delayed, more so than their non-verbal abilities. Specialists have identified a specific profile of speech and language delays and difficulties associated with Down syndrome. It affects those children ability to understand language, to produce and use speech, to sequence thoughts and ideas and to put words together into sentences [9]. Besides, it is often hard to understand what the children are saying. Children with Down syndrome can have difficulties in making speech sounds because of low muscle tone in the tongue and lips making their speech imprecise or slurred. Mouth breathing
due to nasal congestion or enlarged tonsils and adenoids will also affect intelligibility, fluency and resonance. Vocal chords may be swollen, affecting their ability to vibrate, resulting in the hoarse voice typical of many children with Down syndrome [10].

Another challenge that should be considered is related to behavioral problems. Although there are no behavior problems unique to children with Down syndrome, much of their behavior will be related to their development level. So, when problems occur, they are generally similar to those seen in typically developing children of a younger age. The thresholds that trigger behavioral problems may therefore be lower than in their typically developing peers, i.e. they are likely to feel anxious or insecure and become frustrated more easily [10].

For that we can assume that a human-interaction evaluation method cannot be based on their ability of expressing themselves. Moreover, many of the interaction evaluation methods based on inspection and heuristics cannot meet this need since they do not involve the end user. Even among those methods that include the end user (such as thinking aloud protocol and questionnaires), they cannot be suitable to be applied with young children due to ladderling procedures [11].

Looking forward to attend such demand, this article proposes a new coding scheme to detect usability and fun problems in games for children with Down syndrome. It also focus on how to communicate with the game designers by generating practical results about the detected usability problems so that they can be used as new requirements during a following development cycle.

Our contextual case study is the JECRIPE1, a game that aims to stimulate preschool children with Down syndrome. The following cognitive abilities are stimulated by JECRIPE’s design: imitation, perception, fine motor skills and hand-eye coordination and, finally, receptive and expressive verbal language. As a sample result of the application of our evaluation method we intend to identify where JECRIPE’s usability and fun problems are causing losses to the learning interactive process but also to produce directions for game improvements in new releases.

2. Related work

In our previous work [18], the authors have applied the Semiotic Inspection Method (SIM) in order to identify signs (statics, dynamics and metalinguistics) in the JECRIPE’s interface and to analyze its communicability. Since the SIM is an inspection method, i.e., a qualitative method without the presence of the users, now we are interested to investigate the user behavior during the game interaction. Then, a selected literature review of existing evaluation methods for children’s interaction with games is presented. The methods described in Sections 2.1 and 2.2 report interaction evaluation of children without disabilities while the methods described in section 2.3 and 2.4 are involving children with some kind of disability.

2.1 Picture cards

Barendregt and Bekker [15] developed a usability evaluation method for children’s games which combines the traditional thinking aloud method (also known as verbalization) with the picture cards method. Their goal is to help children in expressing digital game fun and usability problems either in a verbal way or by picking tactile picture cards those children can place in a box to express different kinds of problems, verbally or non-verbally.

They point out different types of problems based on fun heuristics, and proposed that each picture card would have an image that represents one of those usability problems. Their list items (and corresponding cards) represent respectively: usability problems on the cognitive level; usability problems on the physical level; inefficiencies; challenge problems; fantasy problems; curiosity problems; and control problems. They also point out concepts that could be expressed by a child behaviour and verbalization when finding one of the listed problems [15]: When a child encounters a usability problem on the cognitive level, he/she may not understand what to do, or what has happened; When a child encounters a usability problem on the physical level, he/she may find it difficult; When a child encounters inefficiency, he/she may think it takes too long; When a child encounters a fantasy that is designed to older children, he/she may think it childish; When a child encounters a fantasy that is congruent with the story or with his/her experiences, he/she may find it silly or strange; When a child experiences a problem related to a too high challenge level, he/she may find it difficult.; When a child experiences a problem related to a too low challenge level, he/she may find it boring; When a child experiences a control problem, he/she may think it takes too long; When a child experiences a curiosity problem, he/she may find it boring. These problems were considered in the next evaluation method.

2.2 DEVAN for children

Barendregt and Bekker [13, 14] proposed to adapt the Detailed Video Analysis (DEVAN) method in order to evaluate usability and fun problems in games targeted at children. Despite the fact that the original DEVAN method was developed toward task-based products, they have chosen not to use explicit tasks. They argue that setting tasks explicitly can interfere with the goals established by the game itself, because children feel obligated to fulfil both the tasks and the goals of the game.
Moreover, their work also observed the need for new breakdown indications that reflect the behaviour observed in children when they indicate problems of fun and usability. In order to include fun analysis, they followed the theory of fun in computer games from Malone and Lepper [6, 7], whose taxonomy consists of four main heuristics: challenge, fantasy, curiosity and control.

In [13, 14], the following relations were pointed: the detection of challenge problems was associated with the presence of stopped, help and bored indications; fantasy problems with the dislike indication; curiosity problems with the doubt, surprise and frustration (DSF) besides bored and stopped indications; and control problems with the impatience indication.

The final set of proposed breakdown indications to detect both usability and fun problems suggested by [13, 14] is the following: wrong action, execution problem, stop, wrong goal, puzzled, random actions, doubt, surprise, frustration, recognition of error or misunderstanding (all previous are indications from the original DEVAN) and the new indications: Impatience, wrong explanation, bored, dislike, help, passive, perception problem.

The method application may be summarized as follows: Evaluators watch the video (in which one or more users interact with the game) looking for problems of interaction. When a problem is observed, the evaluator should note the time stamp in which the problem happened and encode it putting the equivalent breakdown indication corresponding to the problem.

2.3 Scenarios

Garzotto et al. [16] presented an intensive evaluation of the benefits for the child with disabilities of activities oriented by teachers and therapists. Even though this work does not represent a method for a digital game analysis, it presents a mixed scenario with high individual support from the specialists. According to their proposal, using an application framework called “Talking Paper”, teachers and therapists can easily associate conventional paper based elements (e.g., PCS cards, drawings, pictures) to multimedia resources (videos, sounds, animations), and can create playful interactive spaces that are customized to the specific learning needs of each disabled child.

In order to validate the appropriateness of this approach they carried on a pilot evaluation at school, involving two severely disabled children during a period of three months. Both children have a diagnosis of severe spastic diplegia (probably due to cerebral palsy for genetic causes), which strongly affects body movement and coordination, and has impoverished their cognitive development.

The evaluation process adopted was based on the use of scenarios [17]. A scenario was structured with the following components: Child’s profile; Goal (the educational benefits that the child is supposed to achieve by performing a set of tasks); Materials (the tangible and digital resources employed in the activity); Activity (defining the tasks proposed to the child); Context (defining the environment in which the activity takes place). The two children performed the whole set of scenarios defined, over a three months period, with the support of their respective specialized educators. The authors participated as observers and video recorded each activity. At the end of each session, the problems encountered by the child and his/her behavior and reactions were discussed with educators, analyzing the video recordings. At the end of the whole pilot study, the authors performed a series of interviews with each educator, children’s parents, and the language therapist, to evaluate the actual benefits (emotional, cognitive and motor control) gained by children and to identify the issues that needed to be addressed to extend the project to other disabled subjects at school.

2.4 Empirical study with games for Autistic children’s learning

Bartoli et al. [22] developed an empirical study in order to verify if motion-based touchless games actually help children with autism on learning process. Five autistic children with ages between 10 and 12 years old participated in the study, and also a therapist. The study employed five motion-based touchless mini-games that are commercially available for Xbox 360 Kinect. Each child participated in five “gaming meetings”. All meetings were recorded, which generated approximately 19 hours of video. Attention variables were measured using the Bell Test on three occasions: at the beginning of treatment, i.e., at the beginning of the first session, before any exposure to the games; during treatment at the end of the fourth session immediately after the game; and seven days after the end of treatment. The psychologist of study team independently analyzed the video recordings and coded it according to the child's behavior observed. Behavioral variations used to encode the video are:

(i) distress – inappropriate movements, negative emotion, overstimulation, loss of attention and loss of interest; (ii) positive emotion – laughs, smiles, expresses excitement, impatience, exults, jumps, claps, congratulates, chat with the adult; (iii) need for intervention – Adult verbal intervention, adult physical intervention, adult technical intervention, verbal request for help or explanation, verbal expression of incomprehension, confusion; (iv) usability gap – correct movement, prolonged too much, correct movement prematurely done, wrong movement, passive imitation, wrong selection, exit the game, exit the device sensing area, too close to the screen.

To assess the children's attention, two variables were observed: “Selective attention” - the capability to focus on an important stimulus ignoring competing distractions; “Sustained Attention” - the capability to hold the attention for the time needed to conclude an activity. Observing the values obtained for those variables (using the Bell Test)
before and after treatment, it was noted an increase in the retention of short-term learning. It is believed that the high level of positive excitement of children manifested immediately after the game may have increased motivation for a good performance during the test. By encoding the video was possible to observe a progressive decrease in the interaction difficulties (verified with “Need for Intervention” and “Usability Gap”). Accordingly, the “Distress” level also decreased.

From these works we noted most empirical evaluations evolve a small number of subjects, with specific characteristics. In addition, current research offers limited insights on how to perform user studies with Down syndrome children, i.e. on which procedures are appropriate for this user group and why. Methodological evaluation guidelines in this respect are yet to be developed.

3  The evaluation method based on the user’s observation

Our method proposes an adaptation of the observational method described in Section 2.2 in order to face the challenges of an evaluation method designed to analyse children with Down syndrome interaction. In this section we describe the definition of what we are considering to be a breakdown indication followed by the explanation of the adaptations performed.

3.1 Interaction problems definition

A breakdown indication can point out a usability problem or a fun problem. But looking at a wide scope definition a fun problem became an outcome component of a usability problem. According to Lavery et. al [23] an usability problem is an aspect of the system and/or a demand on the user, which makes it unpleasant, inefficient, onerous or impossible for the user to achieve their goals in typical usage situations. For any given usability problem there is a cause, a possible breakdown in the user’s interaction and an outcome. All of which happen in specific context (e.g. of use, of task, of user or of interaction). We can assume within a specific context some cause (e.g. a design fault), may lead to a breakdown in the interaction (e.g. the user performing an inappropriate action, or even doing nothing). This in turn may result in some undesired outcome in terms of behavior and/or performance (e.g. the user’s task fails, the fun quality of the game suffers, the user becomes bored). Besides that we can have knowledge mismatches occurring when the user does not have the correct understanding of a particular aspect of the game or task.

The words unpleasant, inefficient, onerous and impossible in Lavery et al.’s [23] definition refer to the outcome component of a usability problem, they refer to consequences of interaction breakdowns. Analogously, here we can assume that the fun problems (challenge, curiosity, fantasy and control) described in Section 2.2 refer to consequences of interaction breakdowns. Evaluators can observe the existence of such consequences by watching to users (e.g. attending to nonverbal behaviours like frowning) or by logging task performance (e.g. the user selecting a wrong action and then does not know how to proceed). Thus, at different points in time there can be multiple indications for the occurrence of a single breakdown. For example, an evaluator may see that the user erroneously selects an object (first indication), may see the user shaking negatively his head (second indication) and may then see that the user don’t know what to do next (third indication).

3.2 Adaptations in the code scheme

In order to meet the need of evaluating user’s interaction in digital games for children with Down syndrome, it was necessary to remove, add and redefine meanings of some information contained in the list of previous work [14]. To do that, we observed a total of nine children with Down syndrome while interacting with three different interactive environment form the JECRIPE game, as described in Section 4.1. As a result of this phase, a new
list of code indications is proposed as it can be seen in Table 2. Following we describe the adaptations performed.

3.2.1 Removed breakdown indications. Basically, children who have Down syndrome have more difficulty in expressing themselves verbally. In [14] there are breakdown indications which are based only on verbal explanations. In this work, it would be difficult to observe these breakdown indications causing its observed frequency to be probably very low. As a result of these observations, the following breakdown indications were removed: wrong goal, wrong explanation, recognition, doubt, surprise and frustration.

3.2.2 Maintained breakdown indications. Six breakdown indications from [14] were maintained with no changes in their original definition. The indications and reasons for keeping them are presented below.

Wrong action was kept on the list because it can be observed when a child clicks on a no clickable area or performs an action that was not expected at that moment. The difficulty of interacting with a physical game device is characterized by the indication execution problems. If the game responds slowly, or if the user fails to perform some type of command in the game, the indication impatience appears when the user repeatedly click on a button or make more abrupt movements in an attempt to do something work or get a faster response. Games for children with disabilities should also entertain their users and propose challenges. But when the challenge proposed is very easy and does not interest the child to continue playing, the ‘scenario stopped’ indication is noticed. When the game fails to stimulate the user’s curiosity, the child begins to yawn and sigh which are a clear demonstration of the ‘bored’ indication. The game interface should be able to drive the user in a simple and efficient way, if this does not happen, interaction problems can occur and the user can get confused, pointing the indication puzzled.

3.2.3 Modified breakdown indications. Five breakdown indications from [14] were maintained but had their definitions changed.

As previously mentioned, children with Down syndrome have difficulty in verbalizing their feelings and thoughts. For this reason, the need of verbalization was removed from the definition of the perception problem indication and also of the random actions indication. Difficult to achieve goals, hinder the child to proceed without the intervention of a mediator. Mediators often help children with Down syndrome when they realize that the child cannot proceed, i.e. without a verbal request, thereby avoiding serious problems. The help indication also had its definition changed, again precluding the need for verbalization. If the fantasy provided by the game is too childish or too scary the child may express dislike, which can be observed through facial expressions. If the child does not know how to perform some action, he or she tends to be passive just staring at the computer screen. But there are other reasons that could cause the child to have that reaction, for example, he or she did not want to perform an activity because it is too difficult or boring, or even by lack of stimulus.

3.2.4 New breakdown indication. During a user’s interaction session it was observed that one child performed a wrong action just to enjoy the reaction of a character. It is important to cite that the children had experienced the game for 6 months long. Such behaviour did not fit perfectly into ‘Wrong action’ indication, motivating the need to create a new indication of ‘Intentional wrong action’. In this kind of interaction the child knows that he/she is not performing the correct action, but is still doing it only for the purpose of fun. This breakdown indication can be considered as a usability breakdown (e.g. decreasing performance scores) but a good behaviour for the fun analysis of the game interaction.

3.3 Method validation

When validating a method, it is very unlikely that different evaluators will agree exactly by giving identical results for all evaluation sessions. We investigated the aspects of consistency between our method evaluations using two statistical measures (see Table 1). Firsts results about our method validation can be seen in [24].

The any-two agreement method measures the extent of agreement on what problems the system contains for pairs of evaluators [20]. For each comparison the number of agreements, disagreements and single points were recorded, always considering the margin of 4 seconds to be counted as the same observation point. The average score of the

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<th>Table 1. Estimation of agreement level.</th>
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<td><strong>Any-two agreement</strong></td>
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<td>Percentage</td>
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comparisons for each pair of evaluations was 44%, exceeding the average of 38.5% obtained in [14]. Based on the 64% agreement obtained applying the Cohen’s Kappa [21] measurement that included the participation of evaluators with distinct experience levels, we can assume that even inexperienced evaluators will be able to apply the method after receiving an appropriate training. However, both assumptions need to be further investigated.

4 Applying the proposed evaluation method

Based on previous studies and observations, some of the authors of this work had developed JECRIPE, which is designed for children with Down syndrome [19]. JECRIPE is a pool of different scenarios, each one prepared for specific requirements, but all of them unified by a main character who also has Down syndrome (see Figure 1.a). Then our case study is based on the evaluation of the user interaction with each one of these JECRIPE interactive scenarios.

4.1 JECRIPE scenarios

In the music house scenario the game demands the imitation of simple movements of the body, accompanied by singing interactive songs. Starting this scenario, aiming to stimulate fine motor skills and hand-eye coordination ability, the player is induced to click twice on the doorbell, by an instruction voice. Once the task is completed, the player can then see the front of the house with six windows. Each window is associated with a different simple choreography and correspondent song. Next, the user chooses a window using a single click. After that, the window opens and a character appears and starts to dance so that the player is induced to dance with him (Figure 1.a). After the song is played, the window is closed and the user is conducted to his or her original position, in front of the house. The player can dance each song as many times as he/she wishes, until all the dancing windows are visited.

Considering the importance of the exposition of those children during pre-scholar age to auditory and visual stimuli to overcome limitations in perceptual processes, a scenario was created in JECRIPE, named The Bubble House (Figure 1.b) that exercises the well-functioning of visual and auditory modalities, guided by different sounds. During this scenario, the player uses the mouse only by moving it (without clicking). During all stages, the game constantly rewards each accomplished sub-task with positive reinforcement sentences.

The Day Care Centre scenario was designed specifically for the stimulation of fine motor skills and hand eye coordination together with receptive and expressive verbal language (although it is also exercised indirectly in the Bubble House scenario). Playing with the Day Care Centre the child manipulates the mouse to drag-and-drop objects to deliver personal objects to a baby character (Figure 1.c). Inside the Day Care Centre, there are four objects placed on top of the shelves and a baby character. He does not know how to talk, but continuously asks for what he wants by pointing at the desired object. The baby also turns his body and face directly to the object, indicating his wish to catch the desired object. The instructor’s voice speaks reassuring his wish. When a player clicks on an object which is not the one that baby wishes, he manifests dissatisfaction. Then, the instructional voice indicates the desired object and the baby faces that specific object again until the user grants his wish. Once the correct object is clicked, it moves with the mouse cursor while the mouse is being pressed so that the player can drag the object closer to the baby. When the mouse button is released, the position of the dropped object is checked. If the object is released in any other place, but not closer to the baby’s body region, the object is moved back to the original place on top of the shelf. After all the objects have been delivered to the baby, he starts clapping his hands and a success audio clip is played telling about the end of the activity.

4.2 The users’ profile

According to discussed in the Introduction, the range of ability, strengths and weaknesses within this group of children is very wide and it is no possible to establish levels of severities. People with Down syndrome are individuals first and foremost. Due to many variables influencing the

![Figure 2. Users’ interaction sessions. Examples of (a) Help, (b) Passive and (c) Bored indication breakdowns.](image)
children profile it is hard to find individuals, which fit the same profile. Then the users profile was defined as follows: Five children with Down syndrome, aged between 6 and 12 years (mean = 9 years), joined the group of users (Figure 2). None of the children who participated in this study know how to read and write they are all in the process of learning it. They use the computer at least once by week and the most of them always need help from adults. The computer is mainly used for entertainment activities (like games, drawing etc.) and homework. Because their families are low-income some children only interact with computers at school or another place. None of the children had experienced JECRIPE before and (as argued in [15]) was chosen not to define explicit tasks, because it could generate interference with the goal of the game.

4.3 Procedure

From the interaction session we obtained a video of approximately 40 minutes containing interactions of children with the three game scenarios (Figure 1). Ethical procedures regarding the users’ participation in the video were also performed. The video shows users interacting with the game and during the analysis, the evaluators could see clearly the screen, the mouse and hear what the children or teacher spoke. Figure 2 is composed with pictures taken from the video.

To encode the video, we invited three students from the Human Computer Interface class that had some experience in such evaluations. Evaluators were instructed to observe the occurrence of problems and to examine whether these problems characterized some of the indications present in the Table m. Each interaction problem detected and the corresponding code should be noted the instant of its occurrence. The average time for analysis and coding was approximately 80 minutes.

4.4 Evaluation results

A breakdown indication percentage for each interaction scenario of the JECRIPE game was calculated after the video analysis. This score is the sum of times each indication was seen by the all evaluators. Our goal in measuring such indications is to highlighting the key aspects that need further improvement. In all the graphs shown in this section, the indications problems displayed are those with the information score greater than zero.

In Figure 3a, we notice the prevalence of the indication ‘Help’ followed by ‘Execution Problem’, ‘Passive’ and ‘Wrong action’. Basically the high ‘Help’ indication is a consequence of the ‘Execution problem’ and ‘Wrong action’ occurrences. Some children observed interacting with this scenario had an initial difficulty in understanding how to deliver the requested object to the baby character and so he left the object back to the shelf, which featured a ‘Wrong Action’ breakdown indication. Due to this initial difficulty in performing the task, the speech therapist helped the first delivery to the baby, occurring the ‘Help’ breakdown indication. When the baby character requests the last available item, was noted the presence of indications ‘Dislike’ and ‘Impatience’. Another observed child had more difficult to interact demonstrating ‘Puzzled’ indication. Often, the child accidentally clicked the wrong button mouse signaling ‘Wrong Action’ and ‘Execution Problem’. In several cases the children had difficulty in using the mouse, so it was not possible to relate the breakdown indications ‘Help’ to the challenge problems, as it was described in section 2.2. Based on these results, we assume that in this scenario the breakdowns are mainly due to physical problems in manipulating the mouse and to knowledge problems in discovering how to proceed with the mouse.

In the Bubble house scenario we noticed high percentages for ‘Help’, ‘Passive’ and ‘Wrong Action’ indications (Figure 3b). The first observed user interrupted
several times his interaction with the game stating breakdown indications for ‘Passive’ and ‘Scenario Stopped’ and only returned to play after being instigated by the speech therapist. At the third step of this scenario it was observed that the child had some difficulty in placing the objects in the boxes, which caused the emergence of ‘Wrong Action’ and ‘Help’ indications. At the end of the scenario, we noticed a deep sigh indicating that the user was ‘Bored’. Some users also had difficulty in placing objects inside the boxes because they did not understand the correct location where the objects should be placed, which resulted in ‘Wrong Action’, ‘Perception Problem’ and ‘Execution Problem’ breakdown indications.

In the second part of the scenario whose goal is to blow soap bubbles, it was found the ‘Perception Problem’ indication. It was not clear to the user that the goal was to pop the bubbles, because the audio spoke on blowing bubbles, and consequently succeeded the ‘Passive’ indication. Another child, also in this part of the game, indicated a ‘Dislike’ facial expression in watching some toys falling from bubbles. The observation of ‘Dislike’, ‘Bored’ and ‘Scenario Stopped’ indications pointed to fun breakdowns, as discussed in section 2.2. ‘Dislike’ is affecting the fantasy criterion while ‘Bored’ and ‘Scenario Stopped’ indications are mainly involved with the challenge criterion. It is noteworthy that these problems were observed in children aged from 8 and 9 years and the tasks presented to them may have been very easy thus affecting the fun criterion of the game.

The main breakdown observed in the Music house was ‘Passive’ - The user stops playing and does not perform the expected action. As a consequence of that, the ‘Help’ indication was required (see Figure 3c). Scenario starts with the audio saying: "To call Betinho to dance, hit the doorbell twice". At this point was observed that several users pressed only once, what suggested to the ‘Perception Problem’ indication being followed by the ‘Help’ indication in order to help the children to continue with the task. The observed children just watched the dancing character, and at no time tried to imitate any character’s movement (Passive indication). When asked by the speech therapist if she does not mimic the character she answered "No". For some reason not identified, the child was not stimulated enough by the game to mimic the character. Only one child (from 8 children) danced all the time but the speech therapist had commented this child loves to dance. The ‘Dislike’ indication in this house was related to some attempts from the user in stopping the game presentation. Despite not having been observed indications related to the presence of curiosity and challenge problems, it is clear that this house needs to have a mechanism for improving the interactivity in order to encourage all children to dance.

4.5 Discussion

With this evaluation, it was possible to investigate the “observed fun", e.g., the statements of satisfaction or dissatisfaction, given by the user during the interaction with the JECRIPE game. The statements of dissatisfaction were long sighs and yawns to facial expressions of disgust or attempts to interrupt the game sequence, while for satisfaction manifestations had smiles from even kissing. Figure 4 shows the overall percentages for each breakdown indication, as the score sum from the three scenarios. As in previous graphs, it was only shown those indications observed at least once. Due to the large percentage nominations: ‘Passive’, ‘Help’, ‘Wrong Action’, ‘Execution Problem’ and ‘Perception Problem’ (Figure 4), it is difficult to assert that the user understands how to proceed and also that he can operate the system himself. In general, younger users have less skill to use the mouse and thus constantly need help. Moreover, older children can find some scenarios very childish which originated some few observations for ‘Dislike’, ‘Impatience’ and ‘Bored’ breakdowns affecting the fun game criterion. It was observed that the indication: ‘Puzzled’ and ‘Random Actions’ obtained low scores because the game have little complexity and children are always accompanied, which facilitates help interventions. Despite the indication ‘Passive’ not be directly related to fun problems, sometimes the stimulus given by the game is not enough for the user to remain playing. This fact is guiding us to also consider the ‘Passive’ indication as a breakdown for fun analysis besides those already pointed in Section 2.2.

5 Final remarks

The main contribution of our work consists in to provide a method able to systematically evaluate game interaction of children with down syndrome. With the evaluation method proposed in this work we conclude that such adaptations performed in the previous DEVAN method were suitable to evaluate game interaction (in terms of usability and fun) of children with Down syndrome. Although our method was validated using only the JECRIPE we can assume this game contains 3 unrelated mini games. And each sub-game contains different goal and stimulates different abilities. In the game, it is not necessary to finish one mini game to play another; all the sub-games are available since the beginning to play. And there is no global goal that involves the 3 mini games. Because of that, we can say that they are completely independent from each other.

The main advantage of our method is to structure the data analysis process, making it explicit and allowing quickly finding and understanding video fragments from user interaction sessions. Additionally, the results of the evaluation can be communicated to gamers’ designers in an accessible table providing quick access to events that

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2 Betinho is the name of the main character of the JECRIPE game.
indicate the occurrence of a usability or fun problem. Many of the fun problems detected in our case study are due to the fact that the observed children were more aged than the expected target public of the game. It happened mainly because children from the public institution observed in this study have no easy access to technological incentives. Then, the younger children observed didn’t have familiarity with mouse while older children (which knew how to use the mouse) found some activities very easy. However it has validity to show that the proposed method is able to detect such interaction problems.

For future works we intend to investigate how is the acceptability and usability of the results reported to the gamers’ designers. Besides that we hope to apply the proposed evaluation method to other kinds of games as well as to study how this method can be applied to other kinds of cognitive disabilities. Also, as pointed in [22] this method could be applied to observe the user interaction over a long time period in order to investigate how the breakdown indications are changing according to the acquired user experience with the game.

![Figure 4. Percentage and types of breakdown indications pointed by all evaluators at the JECRIPE game.](image)

6 Acknowledgment

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7 References


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<tr>
<th>Code</th>
<th>Description</th>
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<td>ACE</td>
<td>Wrong Action</td>
<td>An action does not belong in the correct sequence of actions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An action is omitted from the sequence.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An action within a sequence is replaced by another action.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actions within the sequence are performed in reversed order.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The user performs a wrong action unintentionally.</td>
</tr>
<tr>
<td>ACP</td>
<td>Intentional Wrong</td>
<td>The user knows that the action is wrong, but still performs this action only to have fun.</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td></td>
</tr>
<tr>
<td>AJU</td>
<td>Help</td>
<td>The user cannot proceed without help or the researcher has to intervene in order to prevent serious problems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The user is helped to do some action.</td>
</tr>
<tr>
<td>ANT</td>
<td>Dislike</td>
<td>The user indicates disliking something.</td>
</tr>
<tr>
<td>CON</td>
<td>Puzzled</td>
<td>The user indicates not knowing how to proceed.</td>
</tr>
<tr>
<td>IMP</td>
<td>Impatience</td>
<td>The user shows impatience by clicking repeatedly on objects that respond slowly, or when it takes too much time to reach the desired goal.</td>
</tr>
<tr>
<td>PAS</td>
<td>Passive</td>
<td>The user stops playing and does not perform the expected action.</td>
</tr>
<tr>
<td>PEX</td>
<td>Execution Problem</td>
<td>The user has physical problems during interaction with the game.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The user has motor skill problem.</td>
</tr>
<tr>
<td>PPR</td>
<td>Perception Problem</td>
<td>The user indicates not being able to hear or see something clearly, not understanding how to proceed.</td>
</tr>
<tr>
<td>RAN</td>
<td>Random Actions</td>
<td>The user performs random actions.</td>
</tr>
<tr>
<td>STP</td>
<td>Scenario Stopped</td>
<td>The user stops the scenario before reaching the goal.</td>
</tr>
<tr>
<td>TED</td>
<td>Bored</td>
<td>The user indicates being bored by sighing or yawning.</td>
</tr>
</tbody>
</table>