Wearable Immersive Storytelling for Disabled Children

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ABSTRACT
Our research aims at supporting existing therapies for children with intellectual and developmental disabilities (IDD) and with autism spectrum disorders (ASD). The personal and social autonomy is the desired end state to be achieved to enable a smooth integration in the real world. We developed and tested a framework for storytelling and learning activities that exploits an immersive virtual reality viewer to interact with target users. Our system uses Google Cardboard platform to enhance existing therapies for IDD and ASD children, enabling caregivers to supervise and personalize single therapeutic sessions. This way curative meetings can be adapted for each child's specific need accordingly to the severity of their disabilities. We co-designed our system with experts from the medical sector, identifying features that allow patients to stay focused on the task to perform. Our approach triggers a learning process for a seamless assimilation of common behavioral skills useful in every day's life. This paper highlights the technologic challenges in healthcare and discusses cutting-edge interaction paradigms. Among those challenges, we try to identify the best solution to support advanced visual interfaces for an interactive storytelling experience. Furthermore, this work reports our preliminary experimental results from a still ongoing evaluation with IDD and ASD children and discusses the benefits and flaws of our approach. On the one hand, we explore children reaction to - and acceptance of - the viewer, on the other hand, therapists' ease of use when interacting with our framework. We conclude this paper with few considerations on our approach.

CCS Concepts
• Human-centered computing~Virtual reality • Social and professional topics~People with disabilities • Software and its engineering~Virtual worlds software

Keywords
Children; intellectual and developmental disorders; autism; virtual reality; touchless interaction.

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1. INTRODUCTION
Intellectual Developmental Disabilities" (IDD for short) as a broad term encompassing any form of disability (e.g., ADHD - Attention Deficit/Hyperactivity Disorder, ASD - Autism Spectrum Disorder, epilepsy, cerebral palsy, learning disability) that begins during the developmental period and is characterized by significant limitations in intellectual functioning (e.g., reasoning, problem solving, communication, and imagination) and adaptive behavior (the collection of basic operational and social skills that are learned and performed by people in their everyday lives). These deficits impact day-to-day functioning, and usually last throughout a person's lifetime with devastating effects on quality of life of the subject and his/her family. The general goal of the current research performed at "L'abilità" in cooperation with experts (therapists and special educators) in the field is to design, implement and test novel interactive technology that can be integrated in the current therapeutic and education practice for IDD children.

Currently a considerable amount of activities performed at the center are focusing on storytelling. Storytelling is a process the children are familiar with: it is present in their life since young age and enables children development, as well as their awareness and cognition of the surrounding world. Existing therapies exploit storytelling benefits and are commonly used in rehabilitation centers, however, reading from a book may result in a frustrating enterprise for a disabled child.

In this work we try to provide an alternative support for storytelling activities other than the classical book. IDD children may present lack of attention, hyperactivity, assimilation problems, struggles in senses perceptions, troubles in verbal expression, difficulties in thoughts abstractions. Because of these shortfalls, viewing a book may result in a difficult activity: for them, it is not straightforward to focus on an image or even understand the page they are watching. To support reading exercises, we developed a set of activities that enable children to experience the same tale they would read in the books, providing a pleasant user experience and allowing them to share their feelings with peers.

One promising technology is virtual reality (VR), as some practical applications in healthcare and medical sectors already exist. We tried to push the research one-step further by adding an immersive component to the virtual world: the immersion triggers a totally different experience because the user is a part of the simulation. Using a special viewer to accomplish such an immersive effect, delimiting what the user can see, the child experiences an "immersive virtual reality" where the engagement in the exercise is ensured through the player's spontaneous participation in the enveloping storytelling. In this context, we have created “Wildcard”, a system to manage the fruition of multimedia interactive stories for IDD children that exploits the aforementioned low-cost wearable viewers as enabling technology. We transposed a storytelling activity into a virtualized scene displayed on small-medium screens such as smartphones’ ones, enabling an interactive multimedia experience. The interaction is guaranteed by a tracking system that traces what the user is looking at, as for the diversity of the simulated world we leverage different forms of media that can be chosen from a predefined set of images and sounds.

Wildcard is integrated with a supervision tool and a web based application that support the creation and personalization of wearable immersive stories: in this way, it can be transformed and adapted to a specific child session. Wildcard has been co-designed with therapists, who have set the main requirements, defined the story contents, explained what kind of personalization was necessary and the preferred parameters to be controlled.

Our system presents a novel form of storytelling: it is an affordable pervasive support tool in the small, i.e. it can be customized at will and can be installed on every smartphone, thus consisting in an effective portable and modular solution for existing therapies.

2. RELATED WORK

A commonly accepted definition of Virtual Reality (VR) is the following:

Virtual Reality is electronic simulations of environments experienced via head mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations [6]

We would like to stress out how an immersive virtual reality device may impact on IDD children compared to a screen projected environment. In fact, our target users are very sensitive to any external stimuli, thus diminishing the efficiency of the therapy. We noticed that children’s attention was easily captured by surrounding objects in the physical world: the creation of a fully immersive environment seems the best solution to avoid interferences during the therapeutic session. The feeling we must be able to re-create should induce the user into sensing the computer generated scene as the real world.

VR has already been used in disabilities treatment with considerable results [1][3][10][12][14]. However, the choices to implement virtual environment differ from a research to another, most of them do not use an immersive VR headset, but prefer to set up some forms of Cave Automatic Virtual Environment [8]. They justify their preferred solution for comfort reasons: not all ASD children tolerate head mounted accessories. Such an argument is acceptable, however, immersion is a key requirement for our system and we would partially loose users’ engagement with projected screen and similar approaches.

Others studies are exploiting VR headsets to enhance existing rehabilitations processes: Stanford researchers are leveraging Google Glass for behavioral home therapies [16]. Microsoft HoloLens forum is acquiring new ideas for autistic children [17], Google Tango project investigates motion tracking, depth perception and area learning to enable mobile devices in detecting their position relative to the world around them without using GPS or other external signals [18].

We distinguish two kinds of VR head mounted displays (HMD):

- Embedded solutions provide a complete VR experience without needing any external integration. They are produced by the same manufacturer avoiding compatibility issues and usually ensure a more precise user interaction but at a much higher cost than their interchangeable counterpart.
- Modular solutions depend on external heterogeneous devices, mostly smartphones, as enabling technology for displaying the simulated world. Even if these solutions are less robust due to the differences in the independent integrated modules, they consist in economic accessible systems.

Figure 1. Google Cardboard viewer

We use Google Cardboard [19]. a product that can transform any smart phone into an interactive wearable virtual reality environment (see Figure 1).

Cardboard was the best fit for our study because it is the lowest cost solution that grants enough personalization for an immersive user experience. In its simplest form Google viewer is composed by a folded cardboard combined with two biconvex lenses, it is even possible to follow a step by step tutorial and create your own goggles at home. Moreover, there are many real-world customizations that ensure every user finds the version that suits him the most. Considering the target users of our study, we decided to use a colored ethylene-vinyl acetate version, for a soft touch and a comfortable wearing.

Another feature is Google Cardboard applications’ portability to any device fitting into the viewer. This enabled us to realize a system that exploits all the advantages of an external module such as a smartphone (e.g. sensors and internet connection).

A similar opportunity is also offered by Samsung Gear VR [20], which has a much higher cost than Google Cardboard and only supports the integration with Samsung Galaxy smartphones. Other interactive VR viewers are also available, such as Facebook Oculus Rift, Microsoft HoloLens, Sony PlayStation VR, but they do not integrate external devices available in the market [21][22][23].

Regarding Oculus technology, we want to emphasize how much this solution is the de facto standard for nowadays VR systems. In particular, it has a massive use in gaming industry [2][4] and has been already explored for storytelling games [5]. However, Oculus is flexible enough to participate in all kinds of applications: medical training, travel experiences et.al. [11][13]. The functional principle is very similar to Google Cardboard viewer, so understanding this tool’s possibilities and noticing existing studies about storytelling activity with this appliance encouraged us to exploit Google viewer for related purposes.

Finally, it is important to notice that VR headsets introduce the so-called “motion-sickness” side effects. Basically this is due to an inconsistency between the movement our brain sees in the simulated world and anticipates with accelerations not physically sensed by our body. This discrepancy forces any application using VR to follow precise guidelines to avoid sickness and provided users with a pleasant simulated experience [9].

3. USERS’ NEEDS AND REQUIREMENTS

Storytelling plays an important role in therapy for autistic children [15]. A book is frequently accompanied with songs and the children are encouraged to imagine the parts of different characters from stories. Storytelling helps them master language skills, improves their listening skills, increases their attention span, develops their curiosity and creativity, and enhances generalization[1].

Keeping a child engaged while telling them a story is not easy though. Children with intellectual disabilities tend to get distracted easily. The teachers from L'abilità, a specialized therapeutic center in Milan, use a lot of props, songs and other activities to keep the children engaged. A therapist from the center described her experience with the Suzy Lee's book "Wave". To explain the concept of the protagonist doing some actions they made the children close their eyes and asked them to imagine the sea and the protagonist doing those actions. Moreover, one of the teacher commented that the students cannot visually see the character moving and thus couldn't understand the action or connect very well with the character where they were teaching up and down movements to the children using the story. Furthermore, many impairments associated to IDD are ascribed to the:

- inability to properly synthesize input stimuli (especially verbal ones);
- lack of social imagination so to understand and predict other people's behavior, make sense of abstract ideas and to imagine situations outside of our immediate daily routine;
- abnormality in the neurological mechanism that controls the capacity to shift attention between different perceived signals. Hence, exposing ID children to too many variable stimuli simultaneously could be counter-productive as the child would easily be overwhelmed and, consequently, become distracted or anxious.

After different pre-study sessions with therapist and children we defined the following set of requirements:

- Attention catalyzer: the product should be able to focus the child's attention and remove all the other stimuli (or at least those not belonging to the story). Additionally, the system should be able to automatically capture if the child is pointing at the right objective according to therapists or story instructions)
- Undemanding social imagination: the child should not be required to imagine a world that does not belong to him.
- Cause-effect: the experience should always be perceived as a cause-effect. When the child does something, something else related should happen.
- Generalization enhancer: the activity should enhance the possibility to abstract and generalize terms and actions from the story
- Controllability: the therapist should always be in control of the session. The system should be developed by bearing in mind that therapists have always the last, personalized and toughest decisions and interventions while providing therapeutic sessions to children.

[1] A generalization is a concept in the inductive sense of that word, or an extension of the concept to less-specific criteria. Generalizations posit the existence of a domain or set of elements, as well as one or more common characteristics shared by those elements (thus creating a conceptual model).

4. STORYTELLING IN WILDCARD

Wildcard storytelling experience has two components hereinafter referred to as children's *storytelling* and *supervision*,

The storytelling component is a mobile application which runs on the smartphone and enables the child to interact with a set of multimedia stories using the Google Cardboard. Stories are inspired, in terms of plot, visual contents, characters and other story elements, by books children are familiar with. The supervision component enables therapists to supervise children's storytelling activities during a therapeutic session.

4.1 Children UX

For each story, we enforce two interaction "modes", hereinafter referred to as *Story360* and *Exploration*.

In the *Story360*, the child will have to follow with his eyes an avatar to proceed in the narration, resulting in an immersive story where the user determines the tale's advancement. If the player stops looking at the main character, the avatar will stop moving and, as a consequence, the storytelling will be paused. Nevertheless, the child can still benefit from the VR experience, by just looking around in the simulated environment, he may find other dynamics elements surrounding the protagonist, thus realizing the space he can scrutinize. After acquiring this new cognition, he shall decide to continue with the story progression.

Figures 2, 3 and 4 exemplify this type of interaction using a Wildcard story based on Suzy Lee's book "Wave", about a little girl who wanders on the seashore, plays with the ocean's waves and discovers shells after a big wave breaks on the beach. A complete representation of the simulated environment is shown in the "unrolled panorama" in Figure 4, showing the exhaustive scene where the story evolves in Figure 2. Figure 3 illustrates what the child will really see when looking inside Google's viewer.

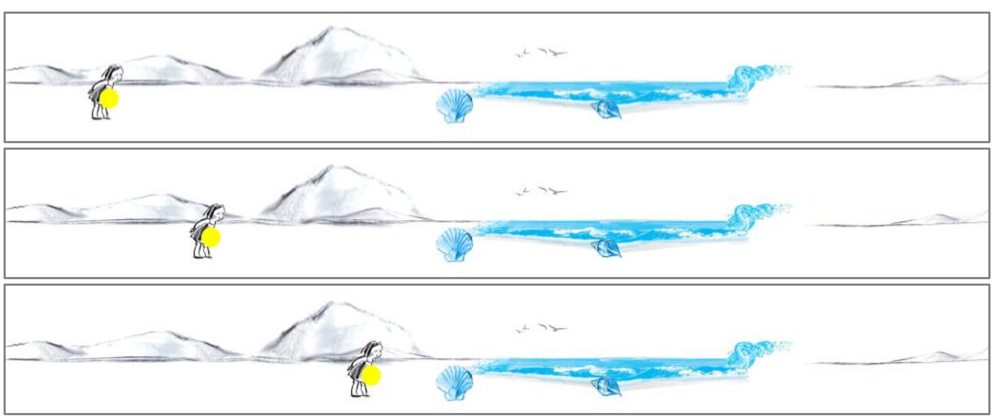

Figure 2. Protagonist progression in the scene

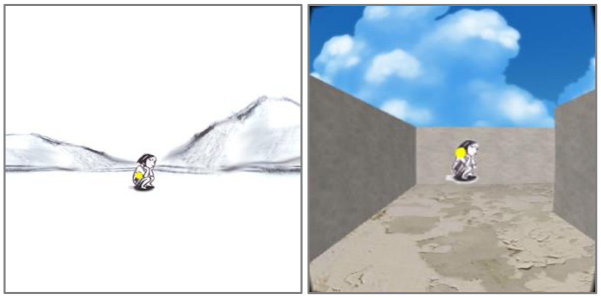

Figure 3. Child's fields of view inside the Google Cardboard

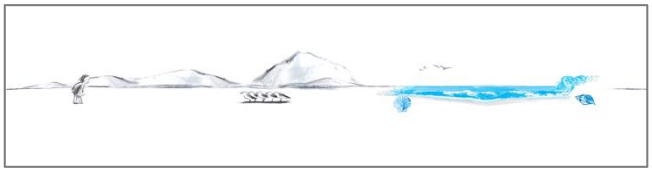

Figure 4. Unfolded Virtual World: 360° flat overview of the Story360 environment

In the *Exploration* mode the child explores a flow of interactive contents arranged along a path that he must follow. Figure 2 shows what the child sees, while Figure 5 represents the track to follow (top-view). The path renders the story's narrative flow by exposing different images at specific points in the walkway that can be interpreted as "checkpoints".

The player can proceed along the path in two ways:

- Looking at the image for a specified time lapse: the protagonist will continue automatically to the next image after a predetermined focus interval on the current illustration.
- Looking at the image to move: if the user looses concentration and stops looking at the interactive representation on the wall, the avatar will stop walking until the focus returns to the image.

The *Exploration* mode is more complex than the *Story360* because the progression is no longer linear (the avatar does not always walk in the same direction), but unexpected turns will require the player to adapt his head's orientation to the irregularity of the path and discover the next narration step.

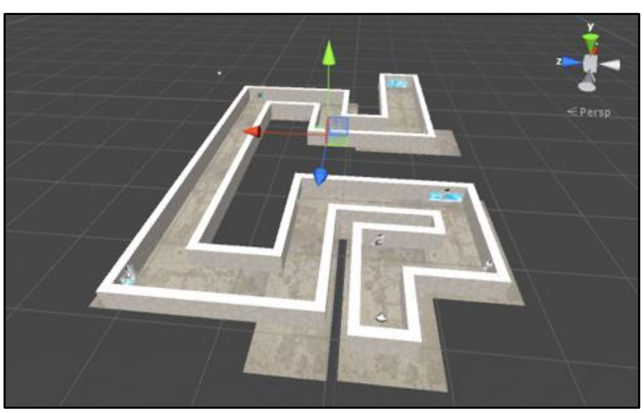

Figure 5. Maze pattern to expose the progression path.

4.2 Therapists UX

Using an external screen, therapists can observe what the child is watching and interacting with on the wearable device. As shown in Figure 6, the therapist's view is an exact replica of what is displayed on the smartphone screen, without the 3D immersive effects created by the wearable viewer.

To duplicate the screen, the mobile app streams the smartphone's display via Wi-Fi using Google Chromecast HDMI plug connected to an external independent monitor.

Figure 6. Therapist UX: Supervision component

In some cases, the presence of an external display turned on in the room at the beginning of the therapy captured the children's attention until they wore the viewer. After wearing Google Cardboard, they completely forgot the secondary screen and could concentrate only on the storytelling experience interacting with the supervisor and proceeding in the story. If the external monitor is a disturbing element the simplest solution would to display the smartphone screen only after the head mounted display has been worn, anyway through the Chromecast, we may project Wildcard on a smallest HDMI-compatible support.

5. AUTOMATIC DATA GATHERING

To make the virtual worlds interactive, the assumptions are:

- the direction of the eye view is defined by the head orientation (not by the real eye view direction);
- the eye view focus is at the center of the screen;
- when an interactive element in the VR space (which can be an interaction object or an area in the virtual space) is in the eye view focus, this is interpreted as a "pointing action", i.e., the willingness to interact with the element, or the user's curiosity/attention for that specific area.

Given those assumptions the supervision is able to track and store the pointed objects during each single session. The data gathering process simply writes timestamps and names of the focused objects to an external file, this can be analyzed afterwards to get a precise insight of the therapeutic session. Timestamps provide a lot of information, in fact, we can extrapolate the duration an object stays focused but also how frequently the user bounces from a simulated world item to another, such data may be further mined and expose some pattern recognition useful for therapeutic examinations.

This tracking was possible by means of the smartphone's accelerometer and gyroscope, allowing to change the user's field of view and as a consequence the center of the screen. The central region is continuously watched by the user because of the VR immersive feature, so we identify in the middle of the display the attention focus origin coordinates. More precisely we cast a ray that intersects objects present in the scene, and derive from ray collisions what item is indeed being watched. The tracking can only intercept what we call "dynamic objects" i.e. objects provided with a special mask that enables collision with our ray-casting system, in particular they consist in the protagonist's avatar and the key elements from the story (e.g. seashells). Fortunately, when the ray stops hitting a dynamic object the system raises a lost focus event with the associated timestamp.

6. PERSONALIZATION

The personalization component is a web application that allows therapists to personalize the storytelling experience to address the specific need for each single child.

To enable therapists to personalize a single session and to tailor it to individual children needs, we developed a web application and gave therapists the possibility to choose the following specific set of features:

- Choice of the theme/story for each interaction mode.
- Selection of predefined avatars to impersonate the main story character of the *Story360* interaction mode.
- Positioning of dynamic objects in the *Story360* scene.
- Insertion of personalized images for each checkpoint of the *Exploration* interaction mode.
- Adjustment of the avatar's speed in the *Story360* interaction mode.
- Adaption of time intervals for story advancement in both interaction modes.

As an example, we easily built another famous story they use at the center: Nicoletta Costa's volumes about "Giulio Coniglio".

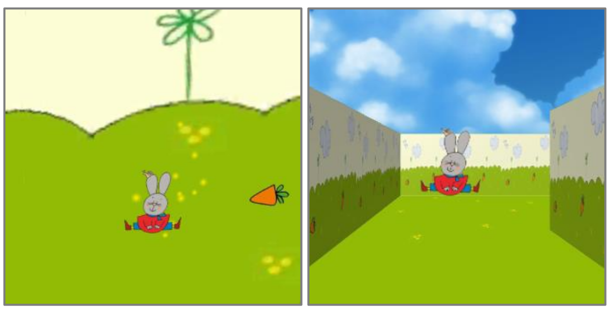

Figure 7. Child's field of view inside the "Giulio Coniglio" story

To augment personalization features, we allow caregivers as well as designers that collaborate with the therapeutic center, to upload their own images. This way the set of themes/stories that can be created are not limited to some framework's static built-in representations, but may cover newly introduced books for children therapies. Caregivers have a standalone tool that is independent from external facilities, they are able to create activities empowering the therapeutic center to define its own themes without relying on external developer interventions.

The autonomy is a key factor when building a product such as Wildcard, in fact what may happen with similar tools is that once the provided set of story has been totally exploited, the children are no longer interested in continuing playing. The game must be an amusing activity, because through a cheerful engagement we trigger a learning process: not loosing this will to play is fundamental and for this reason autonomous personalization is a key feature for us.

Another factor that refines the personalization component is the possibility to set parameters at run-time. In this way, if the therapeutic session does not suit completely the patient's needs, it can be updated pausing both interaction modes, adjusting the desired criteria (e.g. protagonist speed, ray-cast precision). The session can then continue by simply resuming the activity that will now hold the newly inserted parameters. This pause and play logic is a common design pattern in video-games so we decided to embrace this solution for a quick in-game personalization. Figure 8 demonstrates objects insertion from the web platform.

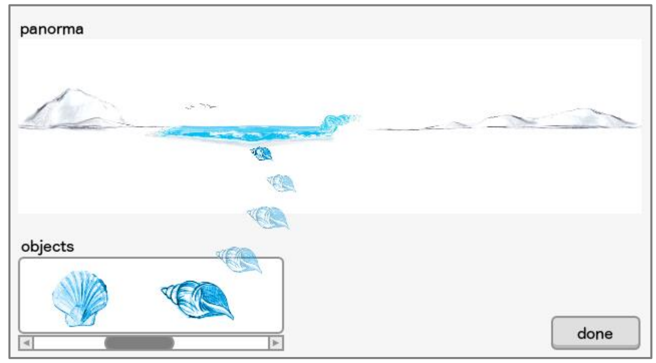

Figure 8. Therapist personalization component

7. EVALUATION

Wildcard is currently being evaluated at a local therapeutic center (Figure 9). The evaluation focuses on the following research questions:

- RQ1) Children's acceptability of the device: do children with (some forms/degree of) disability accept to wear it?
- RQ2) Virtual world usability: can the children interact with the virtual world?
- RQ3) Does this technology help to improve cognitive skills such as attention, concentration, concept understanding?
- RQ4) Can this technology improve socialization and communicative skills?

Figure 9. Children using Wildcard and therapist supervising the sessions

At the moment, the study is in its first stage, involving 5 children for which we report diagnosis and ages:

- 3 Autistic kids, (6,7,8 years old)
- 1 child with learning disability (10 years old).
- 1 child with psychomotor deficit (8 years old).

From November to December 2015 we observed 8 individual therapeutic sessions in which Wildcard was used by these subjects, enabling us to explore issues related to RQ1, RQ2, and RQ3.

Concerning RQ1 and RQ2, two children with autism had problems wearing the device and interacting with Wildcard. The other children were not bothered at all and were rather willing and excited at using it. For one of them the therapeutic session was not possible because he refused to wear the viewer, in later discussions with caregivers we identified a possible reason in a lack of familiarization with the device, the head mounted displays could be accepted after a preliminary training period.

Concerning RQ3 we have so far only qualitative data, based on therapist's observations during the sessions, which pinpoints the cognitive benefits of the approach. For example: "The immersion in a virtual environment culminated in a pleasant experience for every child. Moreover, improvements were verifiable after two consecutive sessions regarding attention capacity, focalization skill and visual contact." (Elisa Rossoni, therapist)

We are still analyzing some more quantitative data, based on tracking the children's focus of attention in the virtual space. An example is reported in Figure 10, which is based on recorded therapeutic sessions measurement of the avatar's tracking in the *Story360* interaction mode. We report the attention levels plotting 1 on the graphic if the player is staring at the protagonist in a given instant, 0 otherwise. The x-axis unit of measure are seconds while the y-axis is a binary value 0 or 1 at the relative time instant. Figure 10 allows the comparison of attentions levels during the first session of the three kinds of pathologies from our target users set. We report data for children with respectively autism, psychomotor retardation and learning disability, but comparable intellectual functioning level.

Figure 10 reports the measured attention levels during the first therapeutic session in which these children initially experienced Wildcard. The session duration is different for each child, depending on the time they needed to process the storytelling activity and depending on therapist intervention asking when they wanted to stop. As we can observe, the three graphics are quite different, which suggests that Wildcard technology can be used not only as a therapeutic tool, but may also be used, with caution, for diagnostic purposes in further studies. Still, those graphs provide a lot of information, at first we observe that the attention level at the beginning of the session varies from case to case. We can spot the attention of the child with learning disability was captured almost immediately by the protagonist and he continued looking at it for a moment, realizing it was a dynamic element of the story. At the opposite, the child psychomotor retardation employed a lot more time to understand which was the main character of the story, still, once the avatar started moving he could remain concentrated on it for a while before scrutinizing the rest of the environment. As for the autistic child, his attention was captured soon enough by the protagonist, but, even if no other important stimuli were present at the beginning of the story, he lost and re-acquired focus repeatedly for most duration of the therapeutic session, a minor stabilization in attention levels was possible only at the end of the experience.

Moreover, we can extrapolate how the understanding about the narration varies from user to user: we traced a linear evolution of the attention level in the single session time lapse (hatched line) and for all of them the attention levels seem to grow inside the individual graphic. This lets us suppose that already in the starting session Wildcard can present some benefits in augmenting IDD-ASD children's attention. Even if the longest attention period was achieved by the kid with learning disabilities, we identify in the child with psychomotor retardation the maximum linear attention growth during a single session. For the autistic child instead, even if linear growth is the lesser, we spot an attenuation of the attention level oscillation over time.

Figure 10 only tracks the focus on the protagonist, we are still gathering more data for a complete detection of all scene elements, in further charts we shall compare attention levels according to different dynamic objects. In the same graphic therapist could be able to identify instants where the child is not watching any of the relevant object from the story point of view, for example when he is looking at the sky or ground for no particular reason. Caregivers will then have a complete summary of every therapeutic session.

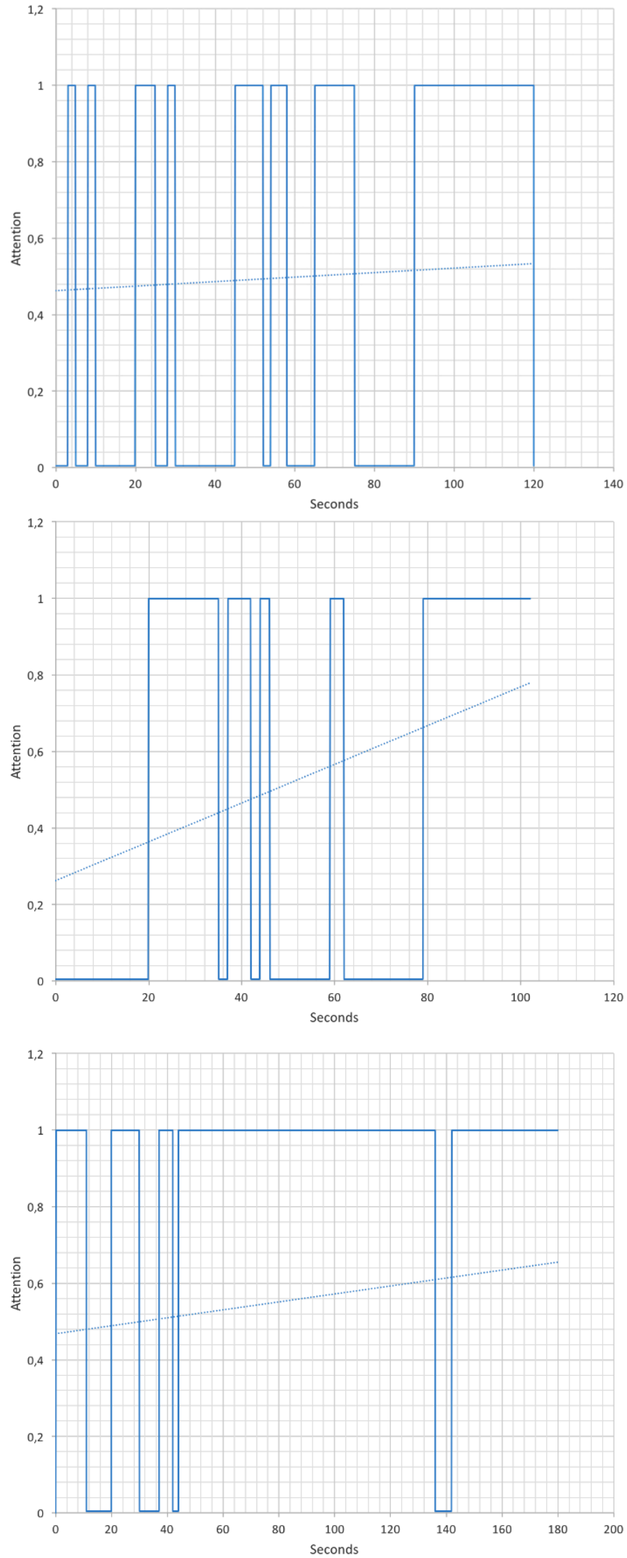

Figure 10. Attention levels for a child with autism (above) compared to a child with psychomotor retardation (middle) and a child with learning disabilities (below).

We now report more in depth session analysis for the psychomotor retardation child, because he was the one with major attention evolution over the first session, and we wanted to investigate the attention levels trend in his second therapeutic meeting: this comparison is reported in Figure 11. The attention during the second session is definitely more linear implying a better comprehension of the storytelling advancement from the patient's point of view. Meaning the child remembers what exercise he performed before and is able to catch up faster with the storytelling activity. We can see that in the second experience there are still some fluctuations in the attention level: discussing those trends with caregivers afterwards we identified the interferences as the dynamic objects that were placed on protagonist's path. Doctors are curious to probe a continuous attention level in future experimentation that will indicate a total comprehension of the narrative activity.

Finally, the difference in these charts stress out how Wildcard not only boosts children attention in one single experience but how it also triggers a long-term memory improvement. The attention level is in fact only a starting point to enhance other children skills (e.g. problem solving capacities, visual-spatial perception, recollection abilities, social and relational readiness).

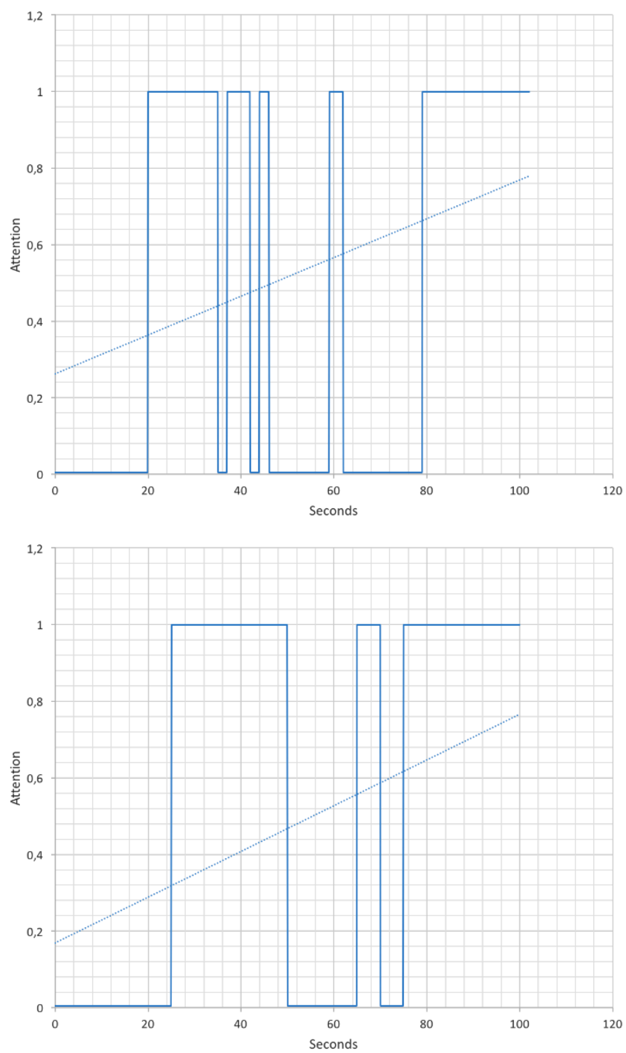

Figure 11. Attention levels of two consecutive therapeutic sessions (first session above – second session below) for the same child with psychomotor retardation

8. CONCLUSIONS

In conclusion Wildcard is a possible support for IDD-ASD children. The experimentation led us to collaborate with healthcare facilities and gave us the opportunity to test our system with very delicate target users, such as impaired children, however, we managed to furnish them with a tool that effectively improves their curative experience. In a case, one child recognized us as "Suzy's friends" enhancing how the simulated world marked their participation and partially boosted their long-term memory. Furthermore, Wildcard has only been superficially explored and already proves its potential, both on patient and caregiver side. Our system was willingly accepted by the children who tried it and allowed them a total engagement in the exercise they were performing. Wildcard was able to track their attention level for a subsequent analysis, but during the therapy it provided continuous feedback to the caregivers, who were indeed able to see the simulated world through the user's eyes. This way therapists supervised seamlessly entire sessions and understood what elements disturbed the most in the narration progression.

The possibility to personalize each single session was a key requirement to maintain a high engagement during the therapy. For children the curative activities are games, and it is indeed through the gaming experience they learn most of the behavioral skills therapies are trying to enforce. Two children were amazed about how they could play the same game with their favorite hero as protagonist. The child with learning disabilities wanted to continue having fun with the viewer and performed several stories by changing first the theme and then the interaction mode. In a single meeting he played four different times, stressing how children commitment is always present when interacting with our framework.

Wildcard is unique in terms of features it can offer: therapeutic centers have now the possibility to customize a curative session and tailor the exercise to each child's needs through the personalization component. Caregivers have now the necessary autonomy for not depending from external developers anymore. They can set up and update therapeutic sessions without incurring in delays that may result from a requirement gathering process. Wildcard empowers therapist with a complete, independent, modular and portable tool to support existing therapies. Caregivers were enthusiast in employing Wildcard not only for the personalization they were granted, but also for the real-time supervision during sessions. They could actively participate to children activities, asking them to accomplish more elaborate tasks than following the protagonist in some cases, or just comforting them discussing what they were experiencing in others. Finally, the possibility to adjust some in-game parameters such as speed and precision in the collision to trigger objects movement, were the add-on that therapists needed to conclude the personalization process.

All the aforementioned features are possible thanks to Wildcard's modular nature. In fact, the usage of an external device such a smartphone enables the installation and update of our framework as an "app" that can be downloaded by masses. Parents are provided with the same identical tool as therapists, due to its low-cost implementation, this means that Wildcard is able to smoothly migrate from therapeutic centers to children's home. Patients can thus exercise on their own devices, after a few supervised sessions, and still benefit from all advantage VR technologies can give.

Our hope is to extend this study and provide caregivers with continuously improving tools. As a matter of facts, we shall add new components to Wildcard framework and explore alternative environment creation, not only inspired by books and exploiting storytelling. Wildcard may be used for education and learning activities simulating real-life situation for which it can furnish a step-by-step guide that demonstrates how to act in such cases.

We conclude our study by wondering how many novel technologies are still under-exploited, and asking ourselves which aspects we are still missing, whishing to inspire the community in order to help those who need and deserve our attention.

9. ACKNOWLEDGEMENTS

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