State of the Art on: Interactive Storytelling for children with Neurodevelopmental Disorders

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1. Introduction to the research topic

Storytelling is the ancient art of creating and communicating narrative structures of words, images, sounds, or actions, as a means to entertain, preserve a culture, or educate.[1]
My research aims at improving necessary skills in the lives of children with neurodevelopmental disorders through the use of an interactive form of storytelling.
More in general this topic focuses on studying how interactive systems and advanced user interfaces may allow us to tackle important issues that children with these kinds of disorders face each and every day. These difficulties span from different kinds of linguistic issues to socialization problems and cognitive impairments.

1.1. Related areas of study

Given the goals, there are many areas of study involved in this kind of research.
Psychology and more precisely developmental psychology and neuropsychology. The former studies physical development, cognitive development, and social emotional development with a particular focus on infants and children; the latter is concerned with how cognitive functions and behavior are related to the brain and the rest of the nervous system.
Delving deeper in the therapy processes we may also find techniques and sub-categories such as Speech-Language therapy or Cognitive behavior therapy that are very relevant in their respective domains. Closer to the Engineering side of things we have the Advanced User Interfaces field and the Interaction Design one, in particular, with a specialization on children and children with neurodevelopmental disorders.[1]
These fields study how we may create a dialogue between a person and a product, system, or service, in particular, with the use of advanced interfaces that may enrich specific interactions given a precise goal or focus. Another aspect of this topic of research could be studies behind the storytelling needed to create a vivid and effective story.
The area of Storytelling and, more specifically, storytelling for children is once again very interdisciplinary and closely related with Psychology and Anthropology.
These are areas that, although different, may effectively come together in creating tools and knowledge that may help the people that each of these topics target.

1.2. Related conferences

The main conferences for this area of research are the ones below: the International Conference on System Sciences in Hawaii, the International Conference on Conversational Data Knowledge Engineering, the International Conference on Human-Computer Interaction, the Conference on Human Factors in Computing Systems and the International Conference on Intelligent User Interfaces: Companion.

1.3. Technological tools

The specific tools that are relevant for this topic are various and brought by the technological progress over the years. The Advanced User Interface field, in particular, is very keen on implementing the new technological trends in a way that can benefit the creation of meaningful interactions and products. Over the last few years there have been amazing breakthrough innovations such as Virtual Reality headsets, complex motion infrared

sensors, conversational agents and more generally software for human-computer interaction like Text-to-speech or Speech-to-Text. The Advanced User Interface area is vast and the technology behind it is one of the key aspect of its research. The more relveant interfaces for our research are Conversational agents, Speech-to-Text and Text-to-Speech and touch interaction. Along with that we should also consider those advanced tools that allow to gather and label data in effective ways such as cameras combined with software that maps face features or recognize movements of the human body.

1.4. Research topic

Creating complex and effective research in such a multidisciplinary environment is certainly a challenge, there are many issues that may arise during the research given the areas of study involved and their differences: the difficulty in assessing the tools that are designed and tested, given how qualitative the gathered data may be and the need of an expert to interpret such data; the time-span for which the data needs to be collected in order to make meaningful observations (during the children therapy that may last years); the small batch of candidates and the poor generalization that a few case studies may cause; the early adoption of new technologies that may not be fully tested or understood.
These are constraints that are inherent to the areas that this topic covers but there are specific ways in which their differences may complement each other in the research process. For example, the availability of computers, and more in general of advanced interfaces, grants us the ability to record and store data in an easier and more effective way compared to traditional therapy.
Where regular therapy doesn't usually involve the use of tools that are capable of recording the sounds or the scene, the use of Advanced Interfaces brings along many possibilities in terms of data collection. This does not solve any intrinsic issues but grants more tools than usual for the gathering of meaningful data that may help in the evaluation of proposed tools and procedures.
Technology development is one of the many reasons for which this topic needs to be sustained and improved upon. The advancing of the tools we use everyday rarely goes hand-in-hand with the needs of people with neurodevelopmental disorders, but it often happens that those same tools find many useful applications in their treatment.
The iPad clearly wasn't invented to retain the focus of Autistic kids for longer periods of time, but this can surely be a nice byproduct. Because of this, researchers that study and cover this topic are very aware of the latest innovations in the Computer and Interfaces industry. A clear example of that is the breakthrough applications that the technology behind the virtual reality headsets brought along. Such tools are having a massive impact over the possibilities for therapy and rehabilitation. There are many examples like this, and it highlights why this topic needs to be studied and researched along with the technological developmental.
Areas such as developmental psychology tend to progress at a slower pace but the on-going collaboration between the fields needs to be explored more, especially when innovative technological approaches are proposed. At the same time, new found techniques for therapy must be taken into consideration as well as their possible implementations with advanced interfaces.
These are all possibilities brought by the multidisciplinarity of the area and by the fact that each of these topics bring their points of strength and weakness. Our duty in researching these topics is to try to be knowledgeable on each of these areas and bring together the benefits each one presents in order to enrich the lives of children with neurodevelopmental disorders.

2. Main related works

2.1. Classification of the main related works

The main dimensions in which we may evaluate and classify the related works are closely tied to the effectiveness of the therapy. The difference between results obtained by classic means of therapy and the ones obtained with interactive approaches, especially with storytelling, reveal the importance of these works.
The difficulty in assessing these kind of topics is given by the amount of time required in order to properly evaluate the state of a child over multiple therapy sessions that may last many months or years. Another issue, as discussed above, is the poor ability to generalize these kind of results to children with slightly different conditions. These starting conditions are fundamental for the evaluation of these works of research and span from a different language to different kinds of disorders or again different ages and cognitive abilities. On top of this given our specific conditions, there doesn't seem an abundance of work with which we may compare our results.
That being said, we will try to gather here some of the main topics that are being actively studied and the ones that have been left behind or somewhat solved already.

Something that seems quite clear is that there is no serious disadvantage in using hypermedia applications and modern digital devices such as iPads or computers during therapies with children. In fact, while 'in terms of strictly promoting spontaneous communication, there does not seem to be an advantage for electronic platforms relative to more traditional picture books', research 'does suggest that digital technology provides one important advantage relative to traditional methods in that it can be easily adapted to accommodate different learning styles and the individual's current knowledge than face-to-face learning: the number of repetitions of material to be learned, the quantity and type of scaffold to aid learning, and the level of difficulty, can all be adjusted automatically based on the learner's response'.[2][3] In general, even broader studies seem optimistic about the possible implementations, although the concerns raised by sensory sensitivity of certain disorders like autism require further experimentation.[4]

Another concern of ours is how effective tools exploiting imaginative skills would be. Studies highlight the importance of a 'flexible tool for eliciting narratives, which responds to the child's interest and knowledge'.[5] Especially when giving the children the possibility to express their passion, this flexibility grants us the possibility to capture the child's attention more effectively.
This clearly highlights the effectiveness of storytelling as an engaging tool, but raises the concern for the amount of freedom and complexity we should grant the children. Especially when dealing with cognitive impairments the many possibilities could contribute in creating a story that is too complex. When discussing with the therapists, they made clear that the story needs to be customized according to the capabilities of every child and that a story that doesn't resonate with the kid is not effective.
In creating an effective interactive experience there are many variables that may influence the results.
From our conversations with the experts, it emerged also that the tasks we wanted to create would be too complex for certain ranges of age. Therefore, we need to consider not only the children's capabilities but also their age. Since we want to target neurodevelopmental disorders as soon as they present themselves, we need to strike a good balance between complexity and effectiveness for younger kids and infants. The therapists suggested to start with kids ranging from 4 to 7 years of age as younger children would struggle with the tasks proposed. Some research highlights how specific interventions may be effective on older children as well, but it seems clear that the sooner the action the better the results.[6]
We also found that some older studies highlight how storytelling is a relevant possibility saying that 'learning episodes should actively engage children in producing utterances with the target form, but only after they have had the chance to hear some utterances with that feature.' And that it is suggested that 'a session plan starts with a structured activity and then incorporates the target form into an embedded activity such as storytelling'.[7][8] But these results were not derived from applications with modern and advanced interfaces.

More in general, although there were various applications that , while different, seemed to share some of our ideas and gave some insights on research methodologies[9][10], we couldn't find something that resembled our idea for this work of research closely enough for the results to be comparable. Because of these, we reviewed papers on the individual aspects of our projects and tried to derive observations from the mixing of these results while also listening carefully to the therapists' feedback. The bases behind the technology implementation seem solid, the possibilities for the engagement of the child also seem like a strong point, while the ability to customize many of our features was the selling point for all the therapists we talked to. From these knowledge we believe that our idea has the potential to be an effective implementation of modern interfaces to tackle important issues for kids with neurodevelopmental issues, in particular language impairments, although we believe that further research is needed to fully comprehend the various aspects of this topic in order to create a meaningful application.

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