Dolphin Sam: A Smart Pet for Children with Intellectual Disability

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ABSTRACT
Our research aims at helping children with intellectual disability (ID) to "learn through play" by interacting with digitally enriched physical toys. Inspired by the practice of Dolphin Therapy (a special form of Pet Therapy) and, specifically, by the activities that ID children perform at Dolphinariums, we have developed a "smart" stuffed dolphin called SAM that engages children in a variety of play tasks. SAM emits different stimuli (sound, vibration, and light) with its body in response to children's manipulation. Its behavior is integrated with lights and multimedia animations or video displayed in the ambient and can be customized by therapists to address the specific needs of each child.

CCS Concepts
- **Social and professional topics~People with disabilities**
- **Human-centered computing~Interaction paradigms**

Keywords
Children; intellectual disability; autism; pet therapy; smart object; Arduino

1. INTRODUCTION AND BACKGROUND
Intellectual Disability (ID) is a neurodevelopmental disorder that affects about 2-3% of the world population and is characterized by severely impaired intellectual and adaptive functioning. ID has an incurable nature, but early interventions and appropriate therapeutic approaches can help ID persons to improve their intellectual and behavioral skills. Pet Therapy (PT) is a treatment that has been proved to work well especially with ID children, leading to improvements in various spheres. According to current research [1], PT helps ID subjects to release their often persistent state of anxiety and improves relaxation, as human-animal bond acts on "stress hormones" production, inducing a reduction of arterial pressure, cardiac and respiratory rates. Some studies have found that 5- and 6-year-olds who were more attached to their pets expressed more empathy toward peers and that 7- to 10-year-olds who had more "intimate talks" with their pets also had more empathy toward their peers (Bryant, 1985). Many beneficial, even if indirect effects arise from the presence of an animal in the ID child's life. To care for pet "virtual" alimentation, for example, leads to care also for one's alimentation.

AVI '16, June 07-10, 2016, Bari, Italy
ACM 978-1-4503-4131-8/16/06.
http://dx.doi.org/10.1145/2909132.2926090

The use of interactive technology to provide alternative, "virtual" forms of Pet Therapy has been explored in research since late nineties. The pioneer in this field is PARO [3], a stuffed robot shaped like a baby harp seal and equipped with five kinds of sensors - tactile, light, audition, temperature, and posture sensors - with which it can perceive people and its environment. PARO can recognize light and dark. He feels being stroked and beaten by tactile sensor, or being held by the posture sensor. PARO can also recognize the direction of voice and words such as its name, greetings, and praise with its audio sensor. By interaction with people, PARO responds as if it is alive, imitating the voice of a real baby harp seal and moving its head and legs [4]. PARO, now a commercial product, has been proved to have psychological, social, and physiological positive effects especially on elderly ID people and has advantages over real animals in PT: there are no infections to worry about, no one is afraid of a stuffed animal, and PARO can be used in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties. In our research, we have extended the PARO approach and developed a "smart" stuffed dolphin called *Sam* that engages ID children in a variety of play tasks. Sam's affordances and behavior has been designed for this specific target group in cooperation with a team of therapists from SAM Foundation, a non-profit institution in The Netherlands that offers dolphin therapy at a local dephinarium to over 800 children with chromosomal deviations and/or autistic disorder per year.

The choice of dolphins for Pet Therapy has been based on a number of factors [3]: positive image of these animals in the general population (big, protective, friendly aquatic mammals, intelligent and communicative); their curiosity; their capability of sustaining complex interaction with humans, accepting physical contact, including hugs, caresses and kisses; their general cooperative and playful attitude. The therapetic programme at SAM Foundation has been proved effective to support relaxation, stimulate and help increase children's emotional, cognitive, social and physical development. Still, dolphin therapy is extremely expensive, requiring over 1.000 euro per therapeutic session. The challenge of our smart dolphin is to offer a cost-affordable tool that enables the replacement of some animals-based activities, so reducing treatment costs while preserving the benefit of dolphin therapy.

2. DOLPHIN SAM

2.1 Technology
Dolphin Sam is a stuffed toy enhanced with complex system made up of several embedded sensors and actuators (Figure 1 a-b) and external components (Figure 1 c-d, Figure 3). Four parts of the body (head, stomach, right and left fins) are integrated with four *touch sensors*. There are *light actuators* on the stomach and a *speaker* and an *RFID reader* into the mouth. *Eyes and mouth movements* are

controlled by two different *motors*. In addition, a low-cost ESP8266 chip is used for Wi-Fi communication. All embedded components are connected and managed by an Arduino module which manages also the communication between the smart dolphin and the external components. The latter consist of commercial *smart lights* (Philips Hue), tagged *RFID cards* and a *web application*. The web component (Figure 2) manages the multimedia contents on digital displays or ambient projections, and the customization functions

2.2 The User Experience

The UX with Sam has been designed to promote and increase some basic skills in the cognitive, emotional and social spheres that are under-developed in ID children's:

- to relax and reach the mental status of relaxation,
- to exercise selective and sustained attention (in particular to audio and visual signals),
- to explore and understand cause-effect relationships,
- to interpret visual contents at different levels of complexity,
- to understand elementary abstract concepts,
- to exercise control and make choices,
- to build affective bonds with objects and with humans.

These goals are intended to be achieved by *orchestrating* the different features of the Sam system into a set of *gaming activities.* Differently from PARO, Sam does not support sophisticated dialogic features but game play goes beyond the interaction with the smart toy: it involves effects in the physical space – through lights and multimedia contents shown on digital displays or immersed in the ambient via projections – potentially enabling an infinite set of play opportunities. A child can interact with Sam by touching or caressing its head, stomach and fins. She can also "feed" the dolphin by inserting a food card (a tagged RFID card with a food image or PCS symbol [2]) into its mouth. In response to these interactions, Sam emits different stimuli (sound, vibration, and lights) with its body, while ambient lights are turned on or change color and intensity, and multimedia animations or videos appear in the ambient or change state, to offer feedbacks, rewards, or suggestions for new tasks to be performed.

Game Example 1: "Wake up!" - Sam is sleeping, his eyes are closed, and he is snoring. A video of a night seascape is shown in the environment while lights are blue (Figure 3). The child is asked to caress dolphin and wake it up it. Sam opens his eyes, emits "wake up" sounds, moves its mouth, while a sunrise on the sea is projected and environment lights turn to a carousel of sunrise colors.

Game Example 2: "I am hungry!" - A screen displays the image of a small fish and Sam asks the child to give him this food. The child must select, among a set of RFID tagged cards, the one showing the image of that fish, and put it into Sam's mouth. If the child performs this task correctly, the dolphin thanks him, moves the mouth like eating, and emits chewing sounds, while visual rewards are displayed in the ambient.

Figure 1. Sam features: a) hardware board; b) body light; c) integration with multimedia animations.

An interactive video can be seen on: *www.i3lab.me*

Game Customization - Sam games are integrated with a web application that provides a set the *customization function.* These enable therapists to *personalize existing* games – customizing Sam's behaviour and multimedia contents to meet the specific needs of each single child, and define *new* combinations of interactions and stimuli on Sam and in the ambient that offer a new games opportunities. Using a simple interface (Figure 2) they can include/replace any video, animation or image in the game, include/replace any behaviour of the smart object using a library of build-in features.

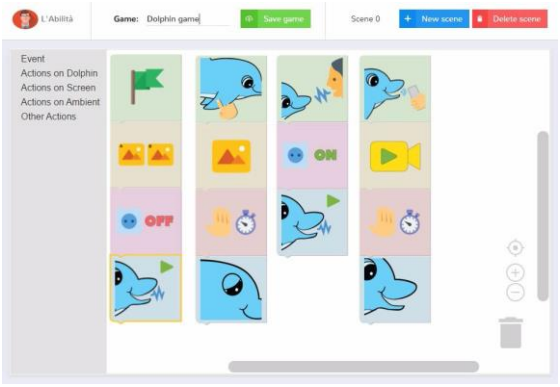

Figure 2. Customization Interface.

Figure 3. Playing with Sam.

3. CONCLUSIONS

Sam extends the capability of the existing smart pets in a number of directions, making it unique: i) it provides multisensory stimuli *both on the object and in the ambient;* ii) its play activities are not restricted to the interaction with the smart toy but also involve the experience of lights and multimedia contents in the physical space; iii) it offers powerful *customization features,* addressing the fundamental need of offering personalized play experiences to each child to address his or her unique need. Sam has been evaluated in an exploratory study at a local therapeutic center. From Summer 2016, it will be integrated with the Dolphin Therapy program at SAM Foundation (NL) for a more systematic testing.

4. REFERENCES

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