Rafigh: A Living Media Interface for Speech Intervention

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ABSTRACT
Digital media can engage children in therapeutic and learning activities. Incorporating living media in these designs can create feelings of empathy and caring in users. We present, Rafigh, a living media interface designed to motivate children with speech disorders to use their speech to care for a living mushroom colony. The mushrooms’ growth is used to communicate how much speech is used during interaction. The main focus of the interface is to motivate children to use their speech as part of interaction.

Author Keywords
Living Media Interfaces; Speech Intervention; Embedded Computing.

ACM Classification Keywords
H.5.2. User Interfaces

INTRODUCTION
Embedded electronics allow for new ways to interact with living beings. A new wave of hybrid biological interfaces sometimes referred to as “moistmedia” [2], explore novel ways to engage users through combining digital and biological elements in design. Additionally, therapeutic digital activities have the potential to motivate users, especially children, to perform repetitive and otherwise boring tasks for long periods of time. We bring together these two ideas in an empathetic living media interface that focuses on caring as interaction goal in an interface to be used in the context of speech intervention and elicitation.

In the face of increasing urbanization and lack of contact with nature, it is important to design systems that facilitate a re-connection or at least dialogue around our interaction with living beings. Many children are naturally fascinated by animals and plants. By developing technology that encourages and builds on this fascination we can support children’s relationship with nature and the environment around them. Additionally, this area provides opportunities to build-in caring and empathy into interaction; elements whose absence have been a cause of concern for the critics of computer games [1].

The need for regularity in the care of living beings corresponds well with therapeutic and intervention applications for repetitive and regular use [17]. In this work, we present a design that requires children to take responsibility for taking care of living beings with regularity and by performing tasks that would benefit them therapeutically and aid with intervention.

Rafigh is an embedded tangible interface that uses a living mushroom colony as part of its display, where the growth rate of the mushrooms corresponds with the amount of speech practiced through the use of the interface. It is designed to motivate small children (ages 4-7) with speech disorders to use their speech to perform a series of digital activities that results in the irrigation of the mushrooms. We have chosen to use mushrooms as the living interface because of their relatively rapid growth rate that is suitable for engaging children (typically 6-10 days). Children who undergo speech intervention typically work with trained Speech-Language Pathologists (SLPs) who assign speech exercises to them and provide corrective feedback [9]. To inform our design we interviewed five SLPs who work with children and also performed a review of extant systems [9]. The results were incorporated into our design. We have used a holistic design method that emphasizes not only the therapeutic use of speech but also the promotion of knowledge about the environment and encouragement of family and community involvement.

In the next section, we review similar research projects that examine human-nature interaction through computational material. We will describe Rafigh next, including a discussion of its design rationale, and results of a series of SLP interviews that informed it.

BACKGROUND
Our fascination with nature is as old as humanity. Recently, digital designs have emerged that explore intimate digital-biological interaction scenarios. While there are relatively few research projects in this area, they cover a wide spectrum of interactions with nature. At the one end of the spectrum are biohacking projects that directly manipulate plant and animal biology, turning them into cyborgs and allowing control or monitoring of their activities (e.g.,
Cyborg Beetle [18]). On the other end of the research spectrum are projects that aim to foster nurturing and less hierarchical relationships with living beings through technology. For example, in the Botanicalls project, embedded sensors communicated information about a plant’s well-being (e.g., moisture level, soil quality) via phone calls and Twitter messages, to plant owners [10].

Previous studies have shown that interacting with living pets can have positive therapeutic and educational benefits. Caring for pets has been shown to increase children’s self-esteem [3]. Many parents admit that interacting with pets gives children valuable lessons about life events [15]. Other positive outcomes have included reduced levels of loneliness [5], stress and anxiety [19].

The Time to Eat project has examined the effectiveness of using virtual pets to promote positive behavior change, specifically health eating, in children [17]. During the period of use, virtual pets request to be fed regularly and encourage the children to eat breakfast with them. In a user study with 53 middle school children, it was observed that children who used the game ate breakfast more frequently. Children also expressed interest in and attachment to their pets in interviews. While having virtual pets can be beneficial in some contexts, we believe there is a qualitative difference between caring for a living being and a virtual one. A review of hybrid biological-digital games has identified several potential benefits, such as enabling care, education and interspecies awareness [14]. While the review focuses on games that interact with animals, the mentioned implications are relevant to this project.

A small number of projects have used living media to communicate information. PlantDisplay uses plant growth to display information about the owner’s amount of daily communication with friends, collected through monitoring of phone call logs [13]. Plant growth is correlated with the amount of communication: the more the owner communicates the more the plant grows.

Babbage Cabbage uses live red cabbage as empathetic biological feedback display [8]. Each head of cabbage is viewed as a single organic pixel that can change color based on the pH level of an administered solution. Social and ecological information are communicated to a viewer of the system through a range of colors that the cabbage head displays. The same research group has developed an ambient empathic interface that uses DNA-transformed E. coli to communicate information through glowing microorganisms [6].

Spore consists of a self-sustaining rubber tree plant watered depending on the stock exchange value of a corporation [7]. Information about the rising or falling price of the company’s stock controlled the amount of water that was given to the plant, thus affecting the health of the plant based on the activity of the company’s finances. The project ended when the plant died of overwatering.

Meet Eater consists of a garden of plants watered based on activity on its Facebook page [12]. Activity on the plants Facebook page (i.e., receiving “likes”) triggered a watering mechanism. The plant garden is used as an ambient display that can communicate about the plant’s online social life via its health and growth. Similar to Spore, the plant got overwatered due to increased activity on its Facebook page.

Our system is different from other previous living media interfaces in several important ways: a) the growth and wellbeing of the mushrooms are mapped to the actions of the child (as opposed to an abstract form of data as in the cases of Spore, Babbage Cabbage and Meet Eater), b) the child is responsible for the well-being of the mushrooms and in this way is empowered and, c) the growth cycle of the mushrooms is short and eventually they are to be harvested (and potentially eaten) after a week of care, thus having a concrete and tangible outcome for the child in the short term that is different from caring for a plant over a long period of time.

RAFIGH: A LIVING MEDIA INTERFACE FOR SPEECH INTERVENTION

We present Rafigh (which translates to “companion” in Farsi), an empathetic living media interface for speech elicitation and intervention for children with speech disorders. Figure 1 shows Rafigh. The interface consists of a box designed to house a mushroom colony (with its growing side exposed), an irrigation system controlled by a wireless microcontroller and housing for an iPad.

Figure 1. Rafigh interface (left): the iPad is mounted on the left and the mushroom colony peers out of an opening on the right. The irrigation system (right) is a water pump activated by a microcontroller.

The child can interact with the digital activity on the iPad at any time but typically we expect them to use it at least once a day. The SLP can specify the number of repetitions and words needed for each child, determining the length of the interaction. The SLP can also input new images and audio for a word or phrase. Other parameters such as how often the activity should be done each day and how many repetitions requested for a word can also be specified. After a period of use, the child’s recorded activities can be reviewed (via segmented and categorized video logs).
The software interface consists of a series of audio and image prompts that require the user to repeat names of familiar animals, fruits and vegetables. The current setup uses a set of words that contain common English phonetic sounds, but the prompts and images are customizable and can be changed by the SLP as needed for each client. Once the user finishes a set of exercises (that currently consists of 10 words but can also be customized), he or she is informed that the mushrooms will be “fed” (i.e., watered). The irrigation mechanism (shown in Figure 1) consists of an Arduino microcontroller and a small water pump originally designed for use in fish tanks. The mushrooms will be irrigated for durations calculated based on the amount of the user’s speech. Once irrigation starts, the mushrooms grow considerably every day (Figure 2).

Figure 2. Rafigh grows every day; after the second or third day, mushroom growth is clearly visible.

We have set three levels for the amount of water to be administered to the mushrooms based on how regularly and thoroughly the child repeats the set of exercise words and phrases: High, Medium and Low. High is activated if all words are repeated, Medium, if half the words are repeated and, Low, if less than half are repeated. Feedback is provided to the child after each repeated word.

The thresholds are set such that the mushroom colony will always live and grow no matter how little speech is used. While this might seem unintuitive as it provides positive feedback to the child even if they don’t practice their speech, we made this decision based on the ethical principle of wanting to avoid the death of the mushrooms at any cost due to over- or under-watering (which can easily happen as is apparent from the case of earlier projects reviewed earlier). Thus, we provide the child with positive feedback through the growth and size of the mushrooms not its life and death.

We use a mushroom colony developed by the Back to the Roots Company and designed for educational purposes [2]. The mushrooms are edible and can be consumed by the child’s family and friends after growth. Therefore, another aspect of the design is that it empowers the child through food production. The idea of incorporating a living being as part of the interface was inspired by our observation of several children who are family and friends and through informal conversations with their parents who told us that the children are generally interested in living beings and nature. While there is merit in including rewards such as badges and scores in games, we wanted to experiment with caring as a mode of interaction and the health of the living component and its growth as a form of alternative (possibly more meaningful) reward.

Rafigh’s design is informed by interviews with five SLPs who work with children [9]. All of the SLPs agreed that developing a digital media toy for speech elicitation would be useful. Three SLPs regularly use props such as dolls and physical toys, as well as, images and flash cards to engage children. They emphasized that for young children (ages 4 to 7) having toys that can be grasped, touched and are durable is recommended. Tangible language intervention games have proven promising for children [11].

A key design idea was to focus on engagement rather than the generation and presentation of automatic feedback. All SLPs indicated that having no or little feedback that is consistent and accurate is preferable to having inconsistent or incorrect feedback, especially in the absence of the SLP who can mediate between the technology and the child. However, they recommended having a measure of progress so that not all speech is rewarded equally. This confirmed the results of a review of extant computational intervention systems that showed that the use of automatic speech recognition to provide corrective feedback to children is technically challenging and might backfire by providing incorrect and inconsistent feedback due to a lack of analysis capabilities of non-standard speech in current systems [14].

On the other hand, projects that focus on motivating and engaging speech rather than analyzing it automatically, have shown promising results [16]. Thus, we decided to use the interface to motivate and engage children to use their speech and record it for future analysis by a qualified SLP.

The recording of speech samples was recommended for other reasons as well: One SLP noted that capturing the child’s natural speech (i.e., speech spoken in the absence of the SLP) would be helpful in assessing intervention needs. Our system is designed such that, once set, it can be used in the absence of the SLP. Another SLP records samples of her clients’ speech during some of her sessions. She uses these samples for future comparison of intervention outcomes and analysis of speech in the absence of the client. In addition to recording speech, all the SLPs suggested that automatic tracking and record keeping of exercises are useful functions that a computational toy could provide, and that we have built into the design.

Another important recommendation by the SLPs was to make the application customizable as each client is unique. Given the multicultural context in which they work (Toronto, Canada), three of the interviewed SLPs recommended support for multilingual contexts. In addition to the customizations mentioned already, support for multiple languages will be incorporated into the future versions of the software.

The use of an iPad as part of the interface was initially motivated by the observation that two of the SLPs already use iPads to play games that engage speech. They believe
the use of tablets will become more prevalent among SLPs and it is important to incorporate these tools into future designs. Surprisingly, they preferred activities that allowed for the engagement of speech through play but were not specifically developed for speech intervention and have simple interfaces (e.g., My PlayHome). One SLP commented that she prefers to use non-computational material during intervention because too much technology can be distracting for the children. We used a simple digital activity on the iPad and decoupled it as much as possible from the living media using modular design, so that, in the future SLPs could use a variety of games and activities of their choice to trigger the irrigation mechanism.

Another factor that led to the inclusion of the iPad was an unsuccessful experience with an earlier prototype that relied on LED lights and a bubble blower that were activated by input speech to engage the user. When one of the SLPs invited us to show it to one of her clients, a 4-year old boy with speech delays, the prototype failed to engage the child. We realized that we needed engaging video and audio components that a tablet such as the iPad can provide.

CONCLUSION AND FUTURE WORK
We have presented Rafih, a living media interface for children with speech disorders that encourages them to use their speech to care for a living mushroom colony.

In future, we plan to conduct user studies with the interface and examine its usefulness and impact, not only in terms of speech intervention, but also in how it affects user satisfaction and experience. Additionally, we plan to explore its use for other applications such as second language learning and adult population speech intervention and speech banking.

REFERENCES