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Inviting Silence: An Ambient Digital Living Media System in the Home

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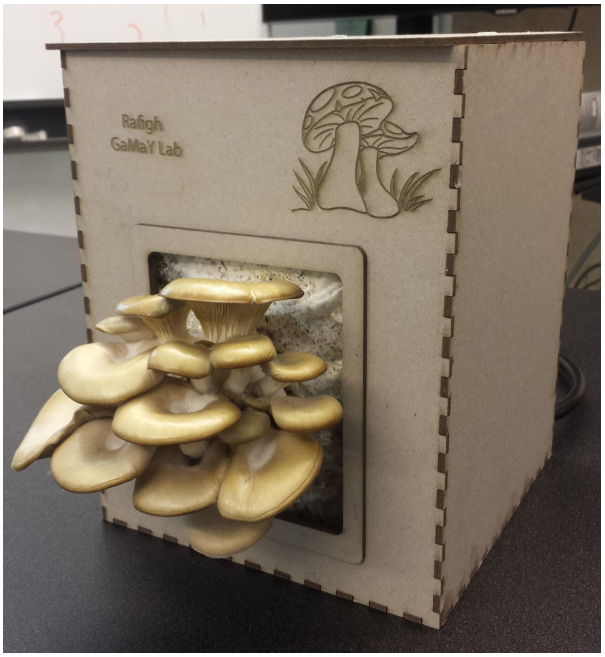
In her seminal book, *Alone Together*, Sherry Turkle drew a sobering picture of the confusion and stress that many young children expressed when interacting with autonomous robot pets, such as AIBO and Furby [1]. These robots are specifically designed to be taken care of by children and to simulate a range of emotions in response to human input, including pleasure, affection and distress when neglected. Using results from several years of observational studies, Turkle warned about the emotional attachments that children form in response to the robots' simulated signs of caring and love, even though these signs do not correspond to authentic emotions. Turkle posited that this kind of child-robot interaction, in which caring relationships are reduced to simplified, predictive models, might undermine the users' understanding of the complexity of human relationships. Indeed, some children exhibited signs of confusion and an inability to distinguish between simulated and "real" emotions.

Engaging children using technology that they care about and feel responsible for is a compelling design idea, even heeding Turkle's warning. How can we leverage the dynamics of caring and responsibility to motivate children to use a system or change their behaviour without deceiving them? Further, how can such a system support existing human relationships, rather than simulating or replacing them? These questions are even more intriguing when considering the design of such systems to motivate communication skills practice by children with Autism Spectrum Disorder (ASD). Previous research has shown that children diagnosed with ASD often have a tendency to be interested in digital technology [2]. We approached these questions in a recent research project called *Rafigh* ('*companion*' in Farsi) [3]. In this project, we created a system that allowed child users to

dynamics to motivate the children to engage in learning and/or therapeutic tasks and to increase communication and collaboration in their families.

Designing an engaging system for children can be a difficult task. It is hard to know what will capture their interest and what will not. Of course, a great source of inspiration and, indeed excellent design ideas, are children themselves. We included children in the design process as early as possible. Some of the children that we worked with were diagnosed with ASD, which limited their direct communication with us. While we included direct communication from these children in the design process as much as possible, we also benefited from the children's adult communication partners, including parents, teachers and therapists, who served to mediate communication. Thus, during the design process we worked closely with children and adults who work with them, live with them and care for them. We also draw upon the extensive and inspiring research in the area of child-

computer interaction. In recent years, many projects have emerged in this space that successfully use avatars, digital tablets, and digital tangible multiplayer games, among other means to engage children with communication disorders and help them participate in



The Rafigh system consists of a colony of living oyster mushrooms and an embedded networked irrigation system.

A theme that kept reemerging during our participatory design sessions was the children's interest in living beings: animal pets, plants and even insects. Several parents that we spoke with described how having pets in the home teaches children about caring and responsibility towards other life forms. Using these ideas, we designed Rafigh as a hybrid digital living media system that combines digital components and living organisms. For the living organism, we employed edible oyster mushrooms. For the digital components, we implemented a customized irrigation system that administers specific amounts of water to the mushrooms, which effectively controls their rate of growth (the growth and health of the mushrooms are linearly correlated to the amount of water they receive, as long as they are not overwatered). Our goal was to motivate children to undertake digital *target activities;* that is, activities that were felt to have beneficial learning and/or therapeutic outcomes. Therefore, we correlated the amount of water administered to the mushrooms to the time the children spent on these target activities. Thus, the more the children completed target activities, the faster the growth of mushrooms colony size and the size of the mushrooms themselves. This, in effect, meant that the children were caring for the mushrooms by completing the activities. Finally, we designed the system such that children had to collaborate with each other (siblings or playmates) to complete the activities.

We considered many factors when choosing the particular living organism to incorporate into Rafigh. The children had many imaginative suggestions: for example, a young girl asked for a system to help her care for a horse. However, we also had to consider factors in addition, including: safety, ease-of-control, and perceptibility (i.e., the organism's state could be changed in a way that children could perceive). We considered several possible living media, including sea monkeys and bean sprouts, and decided to choose edible oyster mushrooms. We worked with a particular type of mushroom that can grow in recycled used coffee grounds. The mushrooms and their growing medium are specifically tested to be safe for children and adults to grow in home or school settings. We also created a custom housing for Rafigh that separated the digital and living media components and was durable and safe for use by children. The mushrooms' growth can be controlled using the amount of water administered. Prior to user testing, we experimented with administering different amounts of water to the mushrooms to determine appropriate water levels that would correspond to high, medium and low speeds of growth. We determined minimum and maximum amounts of water that can be administered by the system without killing the mushrooms. We designed the algorithm to always water the mushrooms within this range to avoid killing them as part of the interaction. Finally, the mushrooms grow over a period of 7-12 days and, once they start growing, changes in their appearance over a period of hours can be easily perceived with the naked eye.

We intended Rafigh to be used in users' homes, a living entity that shares space with the family and whose quiet ambient existence is woven into the fabric of everyday life, akin to a house plant or family garden. Given the slow changes in the system's appearance, it was desirable for the children to be able to do spontaneous checks, taking place over long periods of time (hours and days). We also hypothesized that having the constant presence of Rafigh in the home would support a sense of caring and responsibility in the children and provide opportunities for spontaneous communication about it between family members. Therefore, we decided to evaluate Rafigh in two case studies conducted in participants' homes.

In each case study, two siblings used Rafigh for two weeks. Prior to bringing Rafigh to the participants' home, the parents identified a series of target activities that they wanted the children to conduct and we monitored how much time the children spent on these activities before Rafigh was introduced. The target activities included using tablet applications with therapeutic and learning outcomes, such as "Autism iHelp: Play" and "Touch & Learn: Emotions". In both case studies, Rafigh motivated children to complete more target activities when it was present. Rafigh also motivated the children to collaborate and communicate with each other when completing the activities. The children showed signs of caring and responsibility towards the mushrooms and checked their growth regularly. Additionally, the children asked their parents about how mushrooms

conversations with them about nature, life and technology, including the consequences on one's behavior on other living beings and the environment. Interviews with parents and children revealed that they clearly understood the system functionality and how the children's use of applications controlled the mushrooms' growth. At the end of the study, the children brought the harvested mushrooms to their school to show to classmates; afterwards the parents cooked and ate them.

Interesting and often unexpected dynamics emerged between siblings who participated in the study. In one study, two brothers, who were both diagnosed with ASD, exhibited different and complementary interests towards Rafigh. The older brother was only interested in using digital applications and did not pay attention to the mushrooms; the younger brother, on the other hand, was fascinated by how the organisms grew and kept asking questions about them. The younger brother was not initially interested in using digital applications, but once he realized that their use helps the growth of the mushrooms, he started to use them together with his brother. Their mother observed that, throughout the time that Rafigh was in the home, the brothers spent many hours using target activities together. She observed that the younger brother asked his brother several times to help him use digital applications so that "the mushrooms can grow faster".

Rafigh, both its physical from and its ambient presence in the home, supported unobtrusive and consistent possibilities for being observed and interacted with by the children: it existed in the family home and, like a house plant or family garden, became a part of the family's physical environment. Once the mushrooms started growing, there was no on and off button and they were "just there", creating possibilities for reflection and conversation. This contrasts to digital media that can be paused and turned on and off. Rafigh constantly existed in the users' homes, but it did not need to be constantly attended to. Its persistence meant that attention towards it could quickly move from the periphery to the center of focus, slipping back to the periphery again as needed.

The idea of combining digital and living media to create interactive systems is slowly being studied in Human-Computer Interaction (HCI) (e.g., [3, 5]). Using living media as materials is, however, well-known in the vibrant art movement of *BioArt* and has been explored for many years by prominent bioartists such as Joe Davis, Eduardo Kac and Oron Catts [6]. Rafigh and other similar projects, such as *Babbage Cabbage* that uses color changes in

situated at the intersection of HCI and BioArt.

Rafigh is a design artifact that combines the interactivity of digital technology with the living cycles of a biological organism. It does not "simulate" affection or love towards its users, dynamics that Turkle criticized in "social robots" such as AIBO or Furby [1]. Instead,

feel that it is this silent slow change of the living organism that opens up space for more

conversation between children and parents. Rafigh is engaging not only because of the fact that the mushrooms are alive but because the system is designed for the whole family. Once its interactivity engages children, possibilities for conversation about life, growth and death open up. In a world where children and adults are competing with engaging digital technologies for each other's attention and care, it is important to explore the design space of systems that can support and enrich human relationships rather than

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