Touchology: Peripheral Interactive Plant Design for Well-being

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Abstract. We present *Touchology*, a series of interactive plants that explore serenity and emotional attachment through meditative touch of plants with interactive audio-visualizations. Our approach focuses on creating various audio-visualizations for tactile interactions with living plants to enhance relationships betweeen the plants and users while evoking their empathy. *Touchology* was designed to offer a passive form of interaction. Our project offers a calming point of focus when needed. We particularly approached two populations (children with Autism and older adults in an elderly home) because it is known that both groups have limited access or have barriers to nature but they would still enjoy. Due to simple technical setups, the projects presented here can be placed anywhere at the ease of a user. Preliminary studies with target populations indicate that calming tangible interaction with plants evokes mindfulness in a similar way to gardening related experiences.

Keywords: Touch, Interactive Art, Audio-Visualization, Empathy, Therapeutic Design, Children with Autism, Older Adults, Periphery Interaction

1 Introduction

Plants have always played an important role in our lives. They are essential for our survival. Not only are plants a source of food, they also provide fibers for clothing, materials for buildings, and chemicals for medicines. The value of these tangible products can be easily appreciated. Plants also produce a wide range of intangible effects on people. For example, plants calm us, reduce stress, increase pain tolerance, and speed recovery from illness. This is in part because humans have lived with plants for such a long time; even in the prehistoric period, our ancesters depended upon plants for their safety and protection from animal predators and the harsh natural conditions surrounding them. Since then, people tended to keep plants close to them in various forms- gardens, or pots in their residents, etc. Studies show that having plants around us has positive impacts on health and well-being: interior plants improve worker productivity and reduce stress in a windowless environment [5]; flowers and ornamental plants increase levels of positive energy and help people feel secure and relaxed [6]; people who spend extended lengths of time around plants tend to have better relationships with others [5].

We can learn patience while waiting for plants to grow, increase our sense of responsibility while caring for another living creature, and experience loss when plants die. However, plants do not typically get our attention very often in our daily life because of their slow and quiet nature. Most plants do not grow quickly nor immediately respond to human interaction. Therefore, they are not usually at the center of our attention. Most of the time, they are in our periphery.

We explore how periperal interaction with indoor plants can evoke positive emotive memory and generate an emotional attachment. In addition, we look for how interactive plants can create positive impacts on well-being of people who are unable to benefit from active involvement with plants, such as the mentally and physically disabled. House plants serve to soften the edge of urban domestic living environments, offering respite from our day to day lives. Our approach focuses on creating various audio-visualizations to facilitate touch interactions with living plants when they become a main focus in daily life.

Our project, *Touchology* is a series of interactive plants that respond to human touch via audio-visualizations using various displays including LEDs strips. *Touchology* evokes serenity and emotional attachment by exploring the meditative quality of touch with plants. *Touchology* was designed to offer a passive form of interaction. We felt our project should not ask aggressively for user attention, but rather offer a calming point of focus when needed. We particularly approached two populations (children with Autism and older adults in an elderly home) because it is known that both groups have limited access or have barriers to nature but would still enjoy and benefit from contact with nature. In this paper, we introduce the design concept andimplementation of two projects of *Touchology* and preliminary participant observations with children with autism and older adults living in assisted living facilities.

2 Background Research

2.1 Horticultural Therapy

Gardening related activities are known to be very therapeutic. In horticultural therapy, plants are utilized to engage and improve cognitive, physical, social, emotional and spiritual well-being by caregivers and therapists. Engaging with a child in a garden or natural setting will help the child learn positive social patterns and provide the skills to see how the world works [12]. Ulrich [28] reported that hospital patients with views of natural scenery recovered faster than ones with a view of brick buildings. However there are barriers to gardening: Gardening requires investments of space, money, and labor, and possible exposure to fertilizers and other chemicals that may not be safe for patients susceptible to such materials. The garden itself may be inaccessible to certain patients with restricted mobility and for those who may not be able to venture outdoors, while various weather conditions can also be prohibitive [12].

Other research has reported that the presence of plants in our periperal view generated positive impact on well-being [17]. For instance, when plants were added to a computer lab, researchers were more productive (12% quicker reactions on the computer task) and less stressed (lower systolic blood pressure). They also reported participants felt more attentive when the plants were present. Additionally, the presence of plants was perceived as making the air in the room fresher [16].

In most horticultural therapy research, researchers focus on presence of plants or the process of planting acitivities to study health related benefits with plants. However, there is little research on how sensorial experience can enhance relationships between humans and plants.

2.2 Meaningful Touch in Healthcare Context

Prior research showed that interactive systems inviting human touch help children and older adults in various ways. Artists/researchers have been focusing on the educational relevance of tangibility as well as its health related potentials. In clinical research, therapeutic touch is beneficial to many populations including children with autism and seniors. Escalona et al. [11] reported that children with autism who had a 15 minute massage session everyday for 1 month exhibited less stereotypic behavior showed more on-task and social relatedness behavior during play observations at school and experienced fewer sleep problems at home. Grandin [15] presented clinical effects of 'deep touch pressure' using a 'squeeze machine'. She reported a deep pressure stimulation is beneficial in calming children with autism.

Touch is also substantial for older adults. Sansone and Schmitt [21] described a year-long study in which after 71 elderly patients with chronic pain and dementia were given (instrumental) massage therapy, they showed significant improvements in pain and anxiety scores. Over 84% of the patients expressed appreciation for the "tender touch" and 71% felt that it improved communication. After employing a video protocol to analyze non-verbal aspects of nurse-patient communication Caris-Verhallen et al. [7] showed that expressive touch participated in "establishing a good relationship with the patient". Field et al. [13] described that seniors who volunteered to give massages to infants had less anxiety and depression in comparison with seniors who massaged themselves.

Touch based interaction using soft materials could benefit many computer based applications dealing with familiar design objects. Seo and Aravindan [24] developed soft toys with haptic feedback for children with autism. This soft cat toy provides sensory relaxation and playful sensory feedback when it is hugged by a child. *T.Jacket* provides deep touch pressure to wearers, simulating the feeling of a hug to calm, comfort and soothe the nerves of anyone who is stressed and anxious [25]. A vibrating pillow, *Senseez*, is a comfortable and convenient way to provide soothing, regulating and healing effects to childern with autism [23]. The concept of touch has also been integrated into soft tangible interaction for older adults. *Tactile Dialogues* incorporates vibration motors with a big pillow. The main goal of *Tactile Dialogues* is to enable a dialogue between a patient with moderate-severe dementia and their family member or care giver. Even though plants have play a large role in our lives, tangible interaction with plants has not been rigorously explored. Thus, our research focuses on designing tangible interfaces that involve active and passive sensorial experiences in order to calm and relax.

2.3 Related Research and Artworks

The concept of interactive plants has been explored in the interactive art community: plants that react to the human presence, touch and gesture. One of the early art projects using plants was Christa Sommerer and Laurent Mignonneau's *Interactive Plant Growing* [29]. *Interactive Plant Growing* is an installation which explores the growth of virtual plant organisms and their change and modification in real time in the 3-dimensional virtual space of a computer. These modifications of predefined "artificially living plant organisms" are mainly based on the principle of development and evolution over time. The artificial growing of program-based plants is an expression of the desire to discover the principle of life, which is always defined by the transformations and morphogenesis of certain organisms. *Interactive Plant Growing* connects the real-time growth of virtual plants in the 3 - dimensional space of the computer to real living plants, which can be touched or approached by human viewers. In addition, *Akousmaflore* [1], *Eau de Jardin* [10] and *Botanicus Interacticus* [3] delved into the experiential, entertainment and aesthetic uses of plants. *Plants Demo* [2] and *Orchisoid* [14] are works that use plants as sensors. *Plants Demo* allows a plant to control its own environment. *Orchisoid* is an artwork that moves actuators by plants' biopotential variations. Most of these projects take plants out of our periphery and reintroduce them as points of focused interaction.

There are also interior design projects that have explored the concept of peripheral interaction, creating ambient and relaxing effect in our daily lives. *Clyde* is a desk lamp with a multi-colored ambient light. A user can manipulate the shape of the lamp in their environment [8]. It can interact with its surroundings in different ways and can be made to respond to touch. The *tempescope* is an ambient physical display that visualizes various weather conditions such as rain, clouds, and lightning [26]. By receiving weather forecasts from the Internet, it can reproduce tomorrow's sky in your living room. *Clyde* and *tempescope* work as traditional lights when in the periphery of the user's attention, but can became main characters and interact with the user when needed. Various plants' health monitoring systems like *Breathing Pot* [4] and *Pet Plant* [19] have been developed to explore periphery interaction between plants and human. *Breathing Pot* expands and contracts to simulate breathing of a plant and a user can be sure that when the breathing stops, the plant should be given more water and place it under sunlight. *Pet Plant* communicates what the plant needs via pictograms on an LCD display. When plants require human care, these pots help bring their needs to our attention.

3 Design of Touchology

3.1 Preliminary Studies of Plants

Touchology investigates how touch-sensitive interactive plants can evoke an emotional attachment with a user and how this relationship affects their quality of life. Since *Touchology* uses real plants as well as a synthetic plant of our design, we conducted preliminary studies on how target populations (children with autism and older adults in living in senior homes) feel about different plants depending on certain characteristics of plants: color, shape, texture, and smell. Children with autism during different events, including public autism awareness events and group therapy sessions, were very careful about touching plants. Some were hesitant to touch plants. Children also touched leaves differently according to their shape. They carefully held round leaves between the thumb and index finger. They were less gentle and more active and playful when touching the plant with narrow and long leaves (ex. Ponytail Palm) Generally, they liked bright green color leaves. Older adults living at a local elderly home made associations between plants and emotions. We provided 4 different plants (pothos, ivy, ponytail palm, and purple passion) with very different characteristics. They associated bright green pothos and ponytail palm with happy and playful feelings. They held, and stroked the leaves. Many of elderly were reminded of their happy memories, like family vacations, by this activity. They loved touching the furry purple passion leaves, yet many of them described it as lonely, sad and gloomy because they felt the purple passion needed more sun and water (though it was healthy). This was most likely due to its deep purple color.

We carefully chose plants based on scientific evidence, aesthetic qualities and our initial observations. We aim for the level of touch to be not only beneficial to humans as it generates soothing feelings, but also to plants development as well. Researchers found gently rubbing leaves or caressing plants between the thumb and forefinger can trigger plant defense system and can gradually become more resistant to various pathogens [17]. In this paper, we will introduce two small projects (*Flora Touch* and *Grass*) of *Touchology*.

Figure 1. Interaction of *Flora Touch*

3.2 Flora Touch

Flora Touch utilizes a small potted houseplant and a base which holds the electronic components. The plants tested thus far are a *Kalanchoe tomentosa* and a *Peperomia*. These plants were chosen due to their unique nature of touch and by researching their types for safety measures. Through preliminary user studies, we looked at how people interacted with the plants, how they felt upon touching them, and what they imagined for audio-visual feedback. Based on the preliminary result and the shape of the plants' leaf, we carefully designed interactive visualizations for each plant. Depending on context and the user group, we installed different display settings using a normal computer monitor or a tablet. We also fabricated different sizes of plant pots for each display setting. Both plant pots work very similarly: when each plant is being touched by a human hand, interactive visual components on the screen respond to the quality of the touch as explained below.

The visualization for a big pot on the 17 inch computer monitor displays a subtle grey scale animation beneath the pot. The pattern is intended to reflect the inner status of the plant. When the plant is touched, the grey animated object becomes bigger and creates a spiral flow that constantly changes its opacity, size, color and speed of the animation depending on the quality of the touch. This generative visual response was created to visualize energy transfer around the plant and to evoke empathy by the person who touches it.

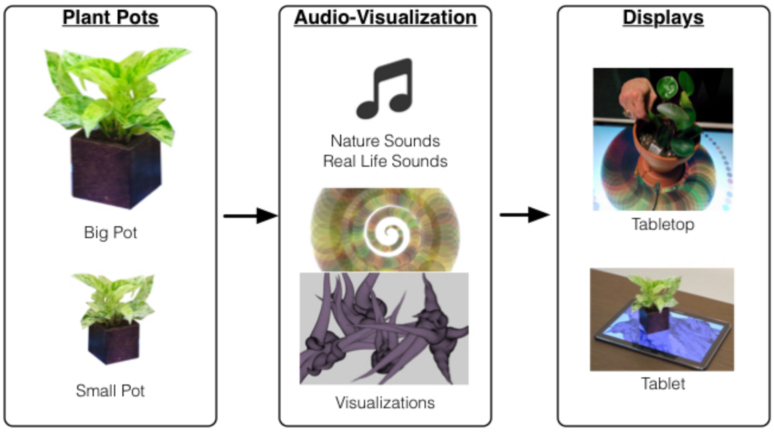

Figure 2. Interaction Flow Diagram of *Flora Touch*

For a small plant with a tablet, we focused on visualizing the growth of roots that, generally, we cannot see beneath soil. When the plant's location is moved on the tablet screen by a person, the roots would grow in the other directions, similar to how a real plant would in natural situations.

3.3 Grass

Figure 3. Interaction of *Grass*

We have been compelled by the beauty of reflected moonlight on a grass field harmonizing with the fluctuation of the grass by wind. This kind of experience with nature is quite relaxing and meditating. *Grass* includes two touch responsive installations (real wheat grass and fiber optic grass). For the real grass, we connect the pot to a control board that produces sounds when the grass is touched by humans. Nature sounds (i.e. ocean, forest) and real life sounds (i.e. children playing, laughing, playground, traffic) were implented to create a sound scape that evokes reminiscence or imagination. The fiber optic grass consists of a field of fiber optic strands painted in various shades of green to look like live grass and electronic components including a microcontroller, RGB LEDs and speakers in the base container. Users can explore a sound scape and can be mesmerized by LED light patterns projected on the tips of the optical fibers by gentle touch. We focused on developing a tactile interface with flexible, conductive materials that measures and responds to hand gestures (touching, stroking, or caressing). *Grass* enhances the multi-sensory experience, provoking participants' memories or imaginations through soft-computational/electronic technology. *Grass* takes into account the context of the environment in which it was used. Touching *grass* does not require fine motor skill which can be severely compromised in elderly populations given that most suffer from debilitating ailments such as arthritis.

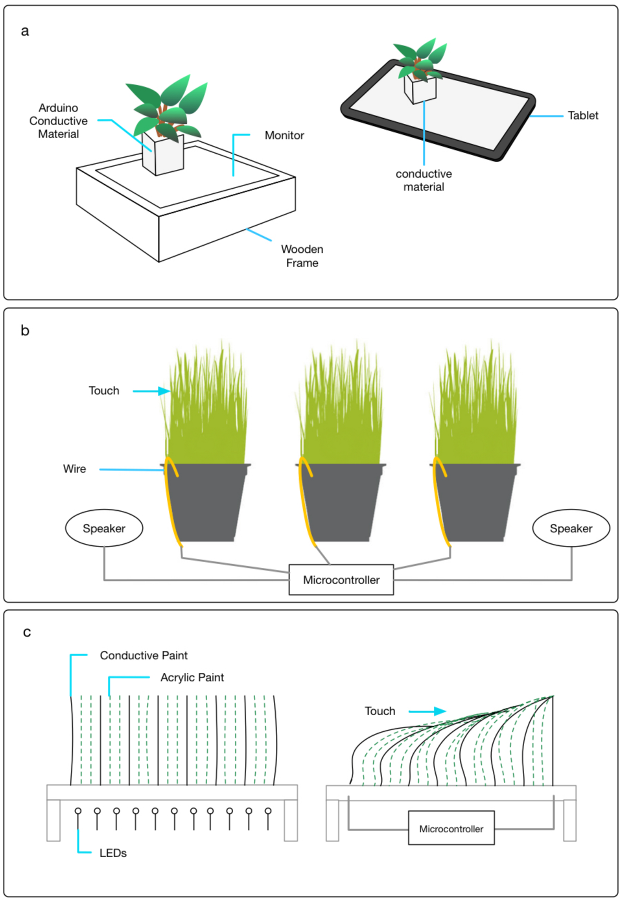

Figure 4. Hardware Diagrams: *Flora Touch* (a), *Grass* (b and c)

4 Implementation

Flora Touch and *Grass* utilize different sensing techniques and produce different aesthetic qualities of visual and sound components. Since *Touchology* projects keep all the necessary components in a small container, this can be maintained and placed anywhere at the ease of the user and extend his/her experience with nature in a unique way.

4.1 Sensing Gentle Touch

Flora Touch

The big plant of *Flora Touch* uses an *Arduino* with a capacitive sensing circuit. A single piece of wire was planted at the root of the plant, and then wired to reflect the visual output. This Arduino-Capacitive Sensor circuit can sense the electrical capacitance of the human body. Generally speaking, the electrical potential difference between human and plant gets measured through the living plants. This voltage difference varies depending on the proximity of a persons hand to the plant, the sensitivity of the plant, and the size and morphology of the real plant. All data values derived from the viewer and plant are interpreted as variables in the program. These values affect the computer generated responses. In our project we focus on measuring the qualities of touch when the plant is being caressed or petted.

Grass

Since *Grass* was developed for children with autism and older adults, we chose a simple electronic method to help users to maintain the interactive plant easily. For the real grass, a *Touch Board* [27] and conductive materials were utilized. A wire is pushed into the soil, near the roots, allowing for the wheat grass to be conductive without harming the actual plant. A *Touch Board* is an Arduino-compatible device that can connect anything conductive to one of its 12 electrodes and trigger a sound via its onboard MP3 player to play a MIDI note.

For fiber optic *Grass*, we used a *Lilypad* Arduino with *Lilypad Pixelboards*. It is made up of over 2000 strands of fiber optics. To create a grass field as a big touch or stroke sensor, we used a soft-circuit technique inspired by Hannah Perner-Wilson's stroke sensor [18]. The soft-circuit technique is similar to that of carpet making: fiber optics painted with conductive carbon paint are distributed in lines and the lines are connected together through conductive fabrics on the back side. When a fiber optic strand in one conductive line touches another strand in a different line, this can be detected as touch. A *Touch Board* system calculates how much the grass has been touched or stroked. Non-conductive fiber optic strands with green acrylic paint are also implanted to insulate the conductive lines if there is no touch.

4.2 Plant Specific Actuations

Interactive visualizations of *Flora Touch* were created using Processing [20]. They focused on visualizing invisible energy fields and the relationship with humans.

Each real wheatgrass pot for *Grass* was connected with a different sound. We installed three pots and sounds from nature, environments and humans were assigned to each grass pot. For the fiber optic grass, an LED matrix with 60 Lilypad Pixelboard LEDs was used for animated LED patterns. About 30 fiber optic strands bundled together and connected to a single LED (Figure 5). Light patterns are projected to the LED matrix connected to one end of the fiber optic bundles. The lights on the tips of the fiber optic grass are illuminated depending on how participants touch *Grass*. A *Touch board* was also used to utilize different sound sources responding to touch. As the main purpose is to evoke nostalgic memories, natural sound was easily installed into the device by using a micro SD card reader. The ease of this process could be used by anyone who desires to change the sound to something more familiar or calming to them.

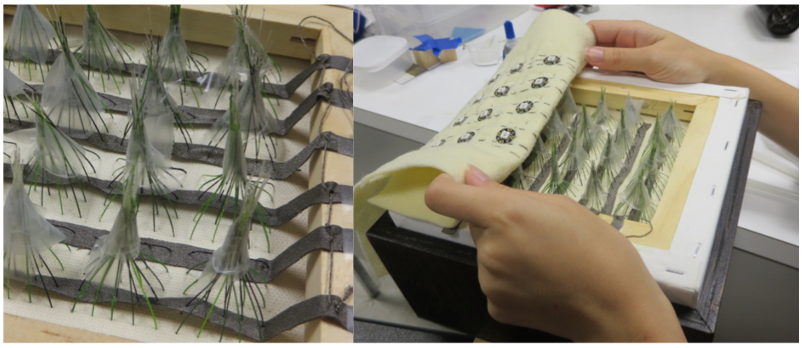

Figure 5. LED implementation for *Grass*

5 Experiences of Participants

5.1 Children with Autism Spectrum Disorder

To understand how *Touchology* projects work as periphery interaction and how they especially appeal to the target populations, we conducted preliminary observations of 7 children with autism at the Dallas Museum of Art. *Touchology* was presented at the museum's quarterly Autism Awareness Family Celebration events. The audience was comprised of children with autism, ranging from 5 years old to 12 years old, and their families. Participating families freely approached our projects and experienced them without any constraints. At first, most children didn't expect the plants to be touch responsive. They were hesitant in approaching the plants, most likely because a gallery setting was not normally associated with touching art pieces. Therefore gentle instruction was provided. One child screamed once he was told to touch the plants by his parents. However, some kids held strong interests in *Touchology* projects, as shown in Figure 5. Some made many energetic and positive comments how the project could be modified for other usages. Since it was presented as part of a public event, we weren't able to engage children very deeply and conduct formal user studies with autistic children related to emotional attachments to the plants. However interacting with plants seemed to make them engaged and relaxed. Before they found out that *Touchology* plants were responsive, *Flora Touch* and *Grass* were seen simply as plants. No one really paid attention to them. Once they became the children's focus point, however, they were finally meaningful to users and helped to create a strong relationship. It was observed that some children came back to experience our projects multiple times and they started talking about how plants grow and what the visualization meant.

We also visited a local autism clinic to present *Touhology* projects. We were able to invite a few children with low functioning (non-verbal) autism once a week for three months. Generally, children with low functioning autism took longer amounts of time to understand the interactions. They sometimes became very aggressive when touching the plants. They held the plants too hard or tried to tear them apart. Even though the plants were hurting, they didn't know that it was bad for the plants. It seemed that they didn't feel empathy or make emotional connections. Once they became used to the interactions, they were able to spend more time with *Touchology* and focus on holding leaves gently.

Figure 6. Participants Interactions with *Touchology*

5.2 Old Adults Living in a Senior Home

We conducted another preliminary study with seniors. We visited one of the local assisted living facilities in Bryan, Texas. *Touchology* projects were installed in an multi-activity room where residents could approach our projects freely. Some residents were on wheelchairs, while others used walkers. The elderly were also provided gently instruction just as we did with the children described above.

On the contrary to children with autism, older adults in an assisted living environment approached our projects with less hesitance and became more engaged with them. Average interaction time per person was about 3 minutes for the first time but stayed to interact with the projects much longer after multiple visits. When a sound or visual was triggered by their touch, they became deeply with the projects engaged and expressed happiness. In addition, they tried different things without asking. Most participants figured out the interaction in less than 30 seconds. Once they understood how *Touchology* worked, they freely touched the plants to explore different qualities of the audio-visualization. After experiencing the interactive plants, some of the seniors started sharing their experience with other residents and talked about their gardening related memories. Since participants didn't experience *Flora Touch* and *Grass* in a private setting, we could not observe whether the interactive plants induced any emotional attachment. However, we learned that *Touchology* evoked positive responses from the participants and helped them to recall their happy memories. *Touchology* was introduced to older adults in the same facility for 6 times (once a month). Many residents came back to our setup every time we visited them. Some people did bring their plant pots to us and ask questions about how to care for the plants. Many people reported they failed keeping many plant pots in the room but they re-started growing new plants.

6 Conclusion and Future Work

The studies showed that our interactive plants, Touchology series had potential to create healthy interactions, encouraging children with autism and older adults in an assisted living facility through audio-visualizations with tactile exploration. The desired reaction of calmness and feeling at ease was mostly seen in the elderly. It seemed that *Touchology* could be a great reminiscing tool for the group. Plants pots exist definitely in our periphery but touching interactive plants could become a way for older adults to reminisce about their memories and to feel happier and healthier. In terms of children with autism, *Touchology* provided playful but calming tangible interfaces that might help children with sensory development and extended engagement. We also learned that *Touchology* could be used as an education tool for gardening and allow them to become familiar with plants in a therapeutic way. Since *Touchology* was aimed to provoke peripheral interactions in daily life, repetitive use of the plant will soon allow autistic children to overcome any sensitivity over the material.

In the future, we would like to explore various interactive visualizations with different plants ranging from size, color, texture, shape and so on. Because most children with autism are very sensitive to new sensory conditions, scented plants, bright flowers or plants, even edible plants could be explored. In addition, we would like to conduct longitudinal studies with our target populations to study how *Touchology* may affect our life in the everyday context.

References

1. *Akousmaflore*. http://www.scenocosme.com/akousmaflore_en.htm
2. Barton, J., O'Flynn, B. Aherne, K., Morrissey, A., O'Sullivan, J., Cassells, A., Drossos, N., Goumopoulos, C., Tooke, F., Whitbread-Abrutat, F. *PLANTS DEMO - Enabling Mixed Societies of Communicating Plants and Artefacts*. in *Pervasive 2006*.
3. *Botanicus Interacticus* Available from: http://www.ivanpoupyrev.com/projects/botanicus.php
4. Breathing pot http://www.ubergizmo.com/2008/11/breathing-pot-for-a-more-interactive-plant/

5. Brethour, C., Weersink, A. *An Economic Evaluation of Food Systems 2002: A Program to Reduce Pesticide Use by 50% in Ontario Agriculture*. Canadian Journal of Agricultural Economics. 47 (4): 473-474, 1999.
6. Bringslimark, T., Hartig, T., Patil, G. G. *Psychological Benefits of Indoor Plants in Workplaces: Putting Experimental Results into Context*. HortScience. 42(3): 581-587. 2007
7. Caris-Verhallen, W.M.C.M, Kerkstra, A., Bensing, J.M., Non-verbal behaviour in nurse-elderly patient communication. Journal of Advanced Nursing. 1999. 29(4): 808-818.
8. Clyde http://www.fabule.com/clyde/
9. E. Wassim Chehab, C.Y., Zachary Henderson, Se Kim, and Janet Braam, *Arabidopsis Touch-Induced Morphogenesis Is Jasmonate Mediated and Protects against Pests*. Current Biology, 2012. 22: p. 6.
10. *Eau de Jardin* http://www.interface.ufg.ac.at/~christa-laurent/WORKS/CONCEPTS/EauDeJardinConcept.html
11. Escalona, A., Field, T., Singer-Strunk, R., Cullen, C., & Hartshorn, K., *Brief report: Improvements in the behavior of children with autism following massage therapy*. Journal of Autism and Developmental Disorders, 2001. 31: p. 4.
12. Etherington, N., *Gardening for Children with Autism Spectrum Disorders and Special Educational Needs: Engaging with Nature to Combat Anxiety, Promote Sensory Integration and Build Social Skills*. 2012: Jessica Kingsley Publishers
13. Field, T., Hernandez-Reif, M., Quintino, O., Schanberg, S. & Kuhn, C. , *Elder retired volunteers benefit from giving massage therapy to infants*. . Journal of Applied Gerontology, 1998. 17: p. 10.
14. Fujihata, M., and Dogane, Y. *Orchisoid*. http://www.nydigitalsalon.org/10/artwork.php?artwork=60.
15. Grandin, T., *Calming Effects of Deep Touch Pressure in Patients with Autistic Disorder, College Students, and Animals*. Journal of Child and Adolescent Psychopharmacology 1992. 2(1).
16. Lohr, V.I., C.H. Pearson-Mims. 2000. Physical discomfort may be reduced in the presence of interior plants. Hortechology 10(1): 53-38.
17. Lohr, V.I., C.H. Pearson-Mims, and G.K. Goodwin. 1996. Interior plants may improve worker productivity and reduce stress in a windowless environment. Journal of Environmental Horticulture 14(2):97-100.
18. Perner-Wilson, H.a.B., L., Satomi, M. . *Handcrafting Textile Interfaces from a Kit-of-No-Parts*. in *the Fifth international Conference on Tangible, Embedded, and Embodied interaction*. 2011.
19. Heo, J. Pet Plant. http://www.trendhunter.com/trends/pet-plant
20. Processing. http://www.processing.org/
21. Sansone, P., Schmitt, L., Providing tender touch massage to elderly nursing home residents: a demonstration project. In Geriatric Nursing, 2000. 21(6): 303-8.
22. Schelle, K. J., Naranjo, C. G., Bhömer, M. T., Tomico, O., & Wensveen, S. *Tactile Dialogues: Personalization of Vibrotactile Behavior to Trigger Interpersonal Communication*. Paper presented at the Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction, Stanford, California, USA. 2015.
23. Senseez vibration pillow. http://www.senseez.com/
24. Seo, J. H. & Aravindan, P. Designing Interactive Soft Toys for Children with Autism to Improve Communications through Sensory Relaxation. HCI International 2015 Posters. Los Angeles, USA. 2015.
25. Tjacket. http://www.mytjacket.com/
26. Tempescope. http://www.tempescope.com/
27. *Touch Board*. http://www.bareconductive.com/shop/touch-board/.
28. Ulrich, R.S., *View through a window may influence recovery from surgery*. Science, 1984. 224: p. 2.

29. Sommerer, C. & Interactive Plant Growing by Mignonneau, L. (1992). http://www.interface.ufg.ac.at/christa-laurent/WORKS/FRAMES/FrameSet.html