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Author	李, 冠儀(Lee, KuanYi) 奥出, 直人(Okude, Naohito)
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Master's Thesis

Academic Year 2012

"Motan"
Interactive Massaging Carpet System to Facilitate Play Between Parent and Child

Graduate School of Media Design,
Keio University

Lee, KuanYi

A Master's Thesis
submitted to Graduate School of Media Design, Keio University
in partial fulfillment of the requirements for the degree of
MASTER of Media Design

Lee, KuanYi

Thesis Committee:

Professor Naohito Okude	(Supervisor)
Professor Akira Kato	(Co-supervisor)
Professor Ichiya Nakamura	(Co-supervisor)

Abstract of Master's Thesis of Academic Year 2012

"Motan"
Interactive Massaging Carpet System to Facilitate Play Between Parent and Child

Summary

"Motan", an interactive massaging carpet system, supports the parent-child interaction experience for an exhausted parent to relaxingly play with his child in a mutually beneficial manner. With interactive roles and need for cooperation to continue the game, "Motan" encourages self-efficacy and conversations. It utilizes 7 EL wires embedded in carpet—providing lights to lure children to step on, sensors-embedded carpet and massage cushion—detecting users' movements, and wireless communication devices-embedded in carpet and massage cushion—converting instructions to corresponding activities. This paper describes our vision, design process, implementation, and user study that outlines the parent-child interactive experience of transforming individual entertainment input into massage therapy output. Through the design process—from ideation to the finished artifact—this research discusses how to design interactive massage carpet systems that respond to human situated actions, for use as an interactive game that enriches the parent-child experience.

Keywords:

Game, Massage therapy, Interaction Design, Parent-child communication, Situated Actions, Research through Design

Graduate School of Media Design, Keio University

Lee, KuanYi

Table of Contents

List of Figures

1. Introduction

An exhausted father came back home from work at 2000h. After having dinner, his 3 years old daughter toddled toward him. The little girl pulled her father to the living room and pointed out the cushion on the sofa.

Father: "Hahaha, you want to give daddy a massage?"

His 3 years old is giving him a heart-warming massage therapy by playing on a carpet! It is a colorful carpet with many swirl-shaped lighting spots in front of the sofa. The little girl exerts herself in looking for the shining spots from lots of swirl patterns.

Father: "Behind you!."

The little one found the spot with his father's hint and stepped on it quickly. She turned to look at her father with a satisfied giggling. He felt that all the painstaking work he had paid for throughout the whole day was worth it. Since they have "Motan" in the house, he always have this expectation for "Motan's time". Although he is always exhausted after work, "Motan" provides him with a relax way to accompany the child with no pressure. He can now enjoy TV or have some snack with his favorite beer while enjoying the massage his daughter is giving to him by playing a game.

"Motan" (Figure 1.1), an interactive massaging carpet system, supports the parent-child interaction experience for an exhausted parent to relaxingly play with his child in a mutually beneficial manner. It is made of a carpet with integrated game elements and two massage cushions activated by the movement of the person playing on the carpet. The parent user takes charge of the game controller by

pinching any of the buttons located on the 4 cushion corners in order to light the spot on carpet randomly. The child user, as the massage operator, has to find and step on those color swirl-patterns on the carpet that are lighted (7 of them are embedded in Electroluminescent wires) during the game. While doing so, massage rollers inside the massage cushion, which the parent will be lying on, would be activated.

If the game has ended, the child has to ask the parent to pinch the button again to continue the game. On the other hand, the parent would love to pinch it for him / her and hint to the child in order to get more massage. With interactive roles (game switch controller and massage operator) and need for cooperation to continue the game, "Motan" encourages self-efficacy and conversations.

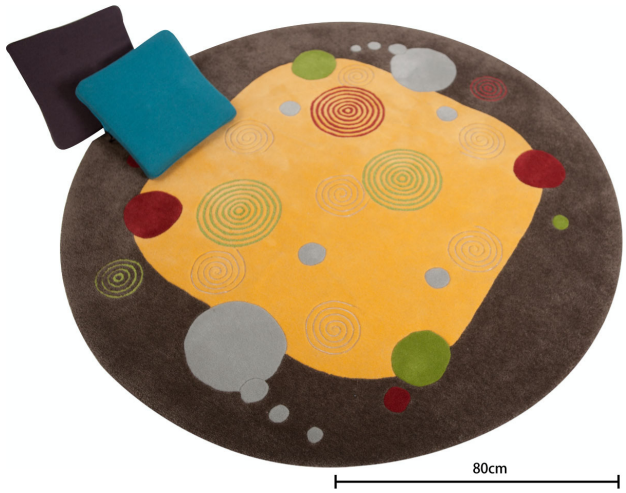


Figure 1.1: "Motan", interactive massaging carpet system

The idea comes from a realistic conversation between family members which occurred in S family, one of our ethnographic survey targets. An exhausted father came back home from work and was having his dinner with his wife in the dining room while his daughter was playing alone in the bedroom. After he finished his dinner..

Mother :"Play with your daughter for a while?"
(The daughter are concentrating on her toy)
Father : "I'm kind of tired. It's just fine watching her playing with a smile."

The critical insight obtained from the ethnographic interview done with the S family is the father has the desire to accompany his child after work but always has no physical strength nor is in the frame of mind to play with his child or to capture his child's attention. From this, we know a novel interactive object which is fascinated by both parent (even when they are tired) and children is needed.

In order to find out the elements that are fascinated by children and parents, we conducted an interview with the S family and did a survey of N nursery school's eurhythmics class. The reason we focus on these two groups is that preschool children has high expectations of their parents' company, which can in turn influence their personality developments. However, the father who has a full-time job, like the S family, finds it hard to meet the expectations of their preschool children.

After the fieldwork, we concluded that "sudden change", "falling from high places", and "repetition" are the three game elements that the preschool children are fascinated by in eurhythmics class because they trigger game climaxes which the children enjoyed and were excited by (Figure 1.2). Thus, a game that uses considerable body movements with mobility and repetition is desired.

On the other hand, the father longs for the comfort of home, which allows him to take a rest after coming back from work. Thus, a game that the children may continue playing on their own even if the parent is momentarily not looking is desirable. Moreover, the capability that enables the father to confirm if his child is playing safely is also demanded.

After investigating the needs of the father and children, we decided to focus on the exhausted parent back home from work. Based on their needs, we envisaged the implemented elements in our concept similar to elements in "Dance Dance Revolution"; "Whack-a-mole" etc. which has the characteristic of that "sudden

Figure 1.2: "Motan" is designed with elements which are fascinated by preschool children.

change", "falling from high places", and "repetition" fascinated by preschool children we observed. In addition, activities that can give someone a restful feeling similar to "Beer"; "Massage therapy" are also incorporated into the concept.

Thus, "Motan" is a carpet system that provides a game with fast and repetitive gaming characteristics, enabling children to use their physical ability to play, and also provides a haptic massage feedback through a massage cushion to the father, allowing him to play relaxingly with his child. Hence, this concept is mutually beneficial to both parties.

Although there are many products that contribute towards the parent-child interaction environment by providing remote synchronous communication, physical interaction games, haptic and emotional communication devices, most of these products, as we would discuss in the related works, provide users with specific environments to attain a common goal, which encourage interactive communication but are powerless in coordinating different mental desires, especially so when one user is physically tired but one is not. Moreover, the feedback from parents to implement parental value into the game is also less in most of the current parent-child interactive games.

"Motan" applies to the unexplored field that transforms individual entertainment input into massage therapy output in a parent-child cooperative relationship

system. “Motan” also contributes to research in terms of the parents’ value in game by supplying parent and child play indispensable interactive roles, needing to cooperate to keep the game going, which encourages their self-efficacy and conversations.

Chapter 2 will describe these related works in more details, followed by a description of the design process undertaken in Chapter 3, which sets up the design vision and the fieldwork is also further described in this chapter. With the insights gathered, a design concept is proposed in Chapter 4 and prototyping experiments are carried out to investigate the optimal designs and materials to be used in order to fulfill the design goals and requirements. For example, in order to implement our goal of encouraging children to use considerable body movements, we design 7 spots which will light up to be stepped. On the basis of our luminance experimental results, we then choose the most optimal material in luminance contrast to be used for the 7 spots. We also try to figure out the safer and more natural way in EL wire arrangement through the “Mantle”, “Interleave”, and “Trench” prototypes, in order to prevent accidents of children getting tripped by uneven arrangements. Chapter 5 then describes the implementation process for the embedded pressure sensors in the carpet, embedded speaker that inform the game state to the player for a more immersive experience, force sensitive resistors on the cushion that detect pinching pressure, and other technical aspects of the system. Chapter 6 discusses about the evaluation of the Motan system, describing the methodology employed, the users selected (families with at least a parent with a full-time job and are supporting preschool children), and the results of the user studies based on interviews with the users about their impressions and the level of facilitation for parent to relax while still playing with their children, and an questionnaire made up of 4 sections: “appearance”, “operation”, “charm”, and “emotional communication”. Lastly, the insufficiencies identified within the system are then discussed before a conclusion and recommendations for future works are made in Chapter 7.

2. Related Works

As "Motan" is expected to bridge the communication gap between exhausted parents and their children in a mutually beneficial manner, we look at remote synchronous communication as a reference for our design of the Motan system. As some researchers also believe interfaces designed with affective physical objects which children care for may encourage them to interact with their remote parents, we decide to look into physical interaction works and also physical interaction without video screen elements as precedent works. Subsequently, we also look at haptic and emotional communication related works because the sensation of "touch", which is dominant in almost every relationship, is considered an important element of human communication, especially for remote or separated time and space interactions. Lastly, previous works on game feedback and parents' value in a game are also researched into as game feedback elements are deemed to make the game more fun for kids and parents' involvement in a game also seems to be crucial in a parent-child interaction.

Therefore, the related works in these following areas are looked into: remote synchronous communication, physical interaction, physical interaction without video screen elements, haptic and emotional communication, feedback, parents' value in game.

2.1. Remote synchronous communication

Families, separated by distance and time zones and living their own separate lives, usually rely on remote, synchronous communication technologies to main-

tain a relationship. The phone is considered the most common way for keeping children in touch with distant relatives[1]. However, children has a hard time understanding how to communicate with a remote person through phone.[2] Since children generally has a easier time expressing their ideas through their actions, and has limitations on technology use[3], people start to take attention of video conferencing technologies.

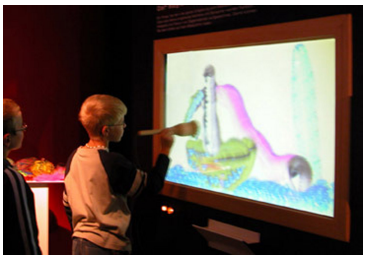
(a) Family Story Play (b) Globetoddler (c) Share Table

Figure 2.1: Examples for remote synchronous communication

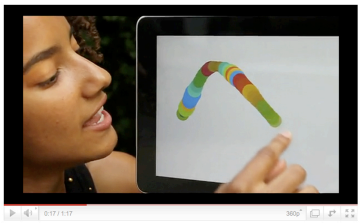
Family Story Play [4] is a system that supports grandparents to read books together with their grandchildren over the internet. It introduces the Sesame Street Muppet Elmo as an element of the user interface, encouraging active child participation in the book reading experience. Similar viewpoint was also referenced by Modlitba et al[5]. They believe interfaces designed with affective physical objects which children care for may encourage them to interact with their remote parents. The synchronous interaction with children was provided by Share Table[6], using a table as a projection surface to allow for a more pellucid shared viewing of physical artifacts. (Figure 2.1)[7]

(a) Dance Dance Revolution

(b) Wii



(c) I/O Brush



(d) Singing Fingers

Figure 2.2: Examples for Physical interaction

2.2. Physical interaction

Remote synchronous communication works provide media spaces for remote synchronous interaction. However, as more people asked for a more fun and interactive communication method, game elements were introduced. These games use users' physical movements and tactile touch as the input controllers and are supported by visual output displays.

The emergence of physical interactive digital games represents a technological milestone. Dance Dance Revolution[8] is a dancing game based on large body movements, whereby one has to perform steps combinations in accordance with the rhythm of the music being played. Since then, using physical body movements to control game interactions, like characters' movements, have replaced traditional game input devices, as exemplified by Nintendo's Wii Controller[9]. I/O Brush[10] provides a new drawing tool that allows children to "pick up" and draw with colors, textures or even movement of a brushed surface found in everyday materials. Interestingly, they also actively communicate with each other, discussing about patterns and features that are available. With Singing Fingers[11], you paint by touching a screen and also be able to record or remix the sound. It creates an interface that is both generative and simple. (Figure 2.2)[12]

2.3. Physical interaction without video screen elements

Physical interactive games without video screen elements has also made great progress since the emergence of interactive games. Compared to physical interactive games with visual displays, physical interactive games without visual output display elements capitalize on their ability to extend the game space.

Tactile/Audio based exergames that only involve motions of the dominant arm like Pet-N-Punch[13] have been successfully explored to engage individuals with

visual impairments in physical activities. In Finger Dance[14], visually impaired players listen to music and match the rhythm with keystroke patterns in response to unexpected auditory cues. These specially designed games empower these visually impaired users to play on their own, without depending on anyone else. Whac-A-Bee[15] retains the find-and-seek aspects of the pervasive game, Whac-A-Mole™, while extending the location, number of players, and time-span in which it can be played. (Figure 2.3)[16]

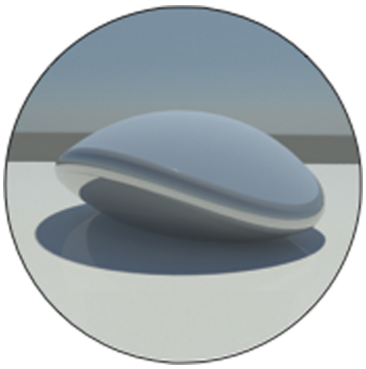
(a) Pet-N-Punch (b) Whac-A-Bee

Figure 2.3: Examples for Physical interaction without video screen elements

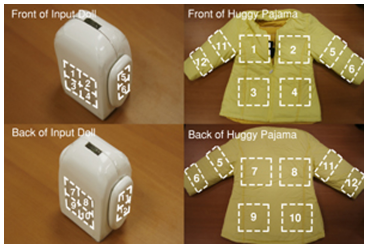
2.4. Haptic and emotional communication

The sensation of "touch", which is dominant in almost every relationship, is considered an important element of human communication and is often employed for remote interactions.

As Heikkinen et al[17] and Cha et al[18] described: the haptic modality could provide a means for richer multimodal and emotional communication between users over distance. Feelybean[19] is a touch device that brings couples closer together during Skype conversation, by affording each to feel the other's touch. Huggy

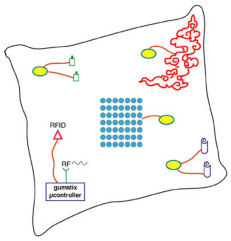


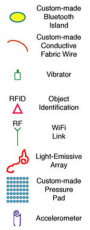
(a) Feelybean



(b) Huggy Pajama

(c) Freqtric Drums





(d) Move.me

(e) 'STEPS'

(f) Stress OutSourced

(g) Touch • Sensitive

Figure 2.4: Examples for Haptic and emotional communication

Pajama[20] enables parents and children to hug one another through a hugging interface remotely via the Internet. It contributes the ability to remotely reproduce a natural hug between two people. Baba and Tomimatsu's[21] Freqtric Drums is based on skin contact and sounds, which provides us with both face-to-face and body-to-body communication. Move.me[22] uses the cushion as an intelligent tactile interface, affording new approaches to pleasure, movement and play. Sharing a child's steps with a temporarily separated shopping mum enhances emotional communication is claimed by Hong et al[23]. Their work Steps not only helps remote and non-verbal communication in a shopping context, but also resolves the concern about children's safety while away from parents. Chung's et al[24] Stress OutSourced allows anonymous users to give each other therapeutic massages remotely in order to relieve stress, and thus contributing towards the new field of applying haptic and tangible interaction to a scalable social media network. Touch • Sensitive, designed by Vaucelle et al[25] is a haptic apparel that enables individuals to control a massage therapy through heat sensors, mechanically-driven textural sensations and liquid diffusion. The feedback system intelligently alerts and comforts the user by haptic means.

Haptic and emotional communication technologies successfully affect the creation of intimate relationships by tactile feedback during the interactions. (Figure 2.4)[26]

2.5. Feedback

One of the important elements of a fun game is to provide feedback to players at appropriate times. Gazzard[27] and Berlin et al[28] both agreed that providing such a feedback depends on the design of the game's user interface and the feedback given to the player through various signs of character and game progression. Such feedback positively influences players' motivation has also been mentioned.

2.6. Parents' value in game

Some interactive game researchers have made an effort to investigate the roles and value of parents in games. Kujala and Nurkka[29] tried to identify parents' value in relation to children's exercises to get some initial ideas for a game for children. Yarosh and Abowd[30] described that the parent's role and the role of the collocated adult in supporting existing synchronous and asynchronous communication practices should be considered. On the other hand, an easy to use technology can allow children to better operate it independently and thus reduces the amount of guidance by the parents, making it easier for their roles in games[31]. Hence, the cooperative interaction between parent and child in easy to operate games can afford both valuable and affective experiences.

2.7. Contribution

"Motan" applies to the unexplored field that transforms individual entertainment input into massage therapy output in a parent-child cooperative relationship system. "Motan" is expected to bridge the communication gap between exhausted parents and their children in a mutually beneficial manner. Based on our fieldwork results that the desires of father and child is mutually conflicting, we expect to design a one-active-one-static form of parent-child interactive massage game. Compared to existing physical interaction systems, the game component of "Motan" not only do not rely on video visual elements, it additionally provides emotional communication through haptic feedback. Chung et al[32] applies therapeutic massages to a scalable social media network, allowing anonymous users to send each other therapeutic massages. On the other hand, "Motan" brings such a haptic experience into parent-child communication. The parent can have a beer, and relax on the sofa while enjoying the massage that his or her child is giving him or her by playing on the carpet. This not only solves the prob-

lem of scheduling a suitable family communication time, it also creates a novel parent-child interaction experience.

"Motan" also contributes to research in terms of the parents' value in a game. Raffle et al[33] improved communication across generations and over a distance by using the Street Muppet Elmo element to attract a child's attention in reading. However, in such a system, the grandmother might not be familiar with Elmo, the "third party" that aid grandmother's interaction with her grandchildren, and thus reducing the effects. In order to better capture the interest of both the parent and child, "Motan" considers the roles parents play while the child is playing the game. The role of parent and child is arranged to be such: Parent takes charge of the switch controller for the game, while the child plays the role of the massage operator. Hence, parent and child play indispensable interactive roles, needing to cooperate to keep the game going, which encourages their self-efficacy and conversations.

Notes

1 Rafael Ballagas, Joseph 'Jofish' Kaye, Morgan Ames, Janet Go, and Hayes Raffle. 2009. Family communication: phone conversations with children. In *Proceedings of the 8th International Conference on Interaction Design and Children* (IDC '09). ACM, New York, NY, USA, 321-324.(Ballagas, Kaye, Ames, Go and Raffle 2009)

2 Gillen, J. Moves in the territory of literacy? - the telephone discourse of three- and four-year-olds. In *Journal of Early Childhood Literacy 2*, 1 (2002), 21—43.(Gillen 2002)

3 Rafael Ballagas, Joseph 'Jofish' Kaye, Morgan Ames, Janet Go, and Hayes Raffle. 2009. Family communication: phone conversations with children. *In Proceedings of the 8th International Conference on Interaction Design and Children* (IDC '09). ACM, New York, NY, USA, 321-324.(Ballagas et al. 2009)

4 Hayes Raffle, Rafael Ballagas, Glenda Revelle, Hiroshi Horii, Sean Follmer, Janet Go, Emily Reardon, Koichi Mori, Joseph Kaye, and Mirjana Spasojevic. 2010. Family story play: reading with young children (and elmo) over a distance. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10). ACM, New York, NY, USA, 1583-1592. (Raffle, Ballagas, Revelle, Horii, Follmer, Go, Reardon, Mori, Kaye and Spasojevic 2010)

5 Paulina L. Modlitba and Christopher Schmandt. 2008. Globetoddler: designing for remote interaction between preschoolers and their traveling parents. In *CHI '08 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '08). ACM, New York, NY, USA, 3057-3062. (Modlitba and Schmandt 2008)

6 Svetlana Yarosh and Gregory D. Abowd. 2011. Mediated parent-child contact in work-separated families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, New York, NY, USA, 1185-1194.(Yarosh and Abowd 2011)

7 Nokia Research Center, http://research.nokia.com/page/9341
Paulina Modlitba, http://web.media.mit.edu/ paulina/globetoddler.htm
Georgia College of Tech Computing, http://www.cc.gatech.edu/features/sharetable

8 Johanna Hoysniemi. 2006. International survey on the Dance Dance Revolution game. *Comput. Entertain.* 4, 2, Article 8 (April 2006)(Hoysniemi 2006)

9 Tetsuaki Baba, Taketoshi Ushiama, and Kiyoshi Tomimatsu. 2007. Freqtric game: video game which uses skin contact as controller input. In *ACM SIGGRAPH 2007 posters* (SIGGRAPH '07). ACM, New York, NY, USA, , Article 139 .(Baba, Ushiama and Tomimatsu 2007)

10 Kimiko Ryokai, Stefan Marti, and Hiroshi Ishii. 2004. I/O brush: drawing with everyday objects as ink. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '04). ACM, New York, NY, USA, 303-310. (Ryokai, Marti and Ishii 2004)

11 Eric Rosenbaum and Jay Silver. 2010. Singing Fingers: fingerpainting with sound. In *Proceedings of the 9th International Conference on Interaction Design and Children* (IDC '10). ACM, New York, NY, USA, 308-310.(Rosenbaum and Silver 2010)

12 KONAMI, http://www.konami.com/arcade/
blueunplugged.com, http://www.blueunplugged.com/Official-Nintendo-Wii-Nunchuck-Controller.aspx
I/O Brush, http://web.media.mit.edu/ kimiko/iobrush/
VIRALBLOG, http://www.viralblog.com/widgets-social-apps/singing-fingers-the-latest-cool-ipad-app/

13 Tony Morelli, John Foley, Lauren Lieberman, and Eelke Folmer. 2011. Pet-N-Punch: upper body tactile/audio exergame to engage children with visual impairments into physical activity. In *Proceedings of Graphics Interface 2011* (GI '11). Canadian Human-Computer Communications Society, School of Computer Science, University of Waterloo, Waterloo, Ontario, Canada, 223-230.(Morelli, Foley, Lieberman and Folmer 2011)

14 Daniel Miller, Aaron Parecki, and Sarah A. Douglas. 2007. Finger dance: a sound game for blind people. In *Proceedings of the 9th international ACM SIGACCESS conference on Computers and accessibility* (Assets '07). ACM, New York, NY, USA, 253-254.(Miller, Parecki and Douglas 2007)

15 Eugen Berlin, Kristof Van Laerhoven, Bernt Schiele, Pablo Guerrero, Arthur Herzog, Daniel Jacobi, and Alejandro Buchmann. 2009. Whac-A-Bee: a sensor network game. In *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems* (SenSys '09). ACM, New York, NY, USA, 333-334.(Berlin, Van, Schiele, Guerrero, Herzog, Jacobi and Buchmann 2009)

16 Perkins, http://www.perkins.org/news-events/eNewsletters/insight/spotlight/video-games-are-all-greek-to.html
ACM Digital Library, http://dl.acm.org/citation.cfm?id=1644087

17 Jani Heikkinen, Thomas Olsson, and Kaisa Vnnen-Vainio-Mattila. 2009. Expectations for user experience in haptic communication with mobile devices. In *Proceedings of the 11th International Conference on Human-Computer Interaction with Mobile Devices and Services* (MobileHCI '09). ACM, New York, NY, USA, , Article 28 , 10 pages.(Heikkinen, Olsson and Väänänen-Vainio-Mattila 2009)

18 Jongeun Cha, Mohamad Eid, Ahmad Barghout, ASM Mahfujur Rahman, and Abdulmotaleb El Saddik. 2009. HugMe: synchronous haptic teleconferencing. In *Proceedings of the 17th ACM international conference on Multimedia (MM '09). ACM, New York, NY, USA, 1135-1136.*(Cha, Eid, Barghout, Rahman and El 2009)

19 Dimitrios Kontaris, Daniel Harrison, Evgenia-Eleni Patsoule, Susan Zhuang, and Annabel Slade. 2012. Feelybean: communicating touch over distance. In *CHI '12 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '12). ACM, New York, NY, USA, 1273-1278. (Kontaris, Harrison, Patsoule, Zhuang and Slade 2012)

20 James Keng Soon Teh, Adrian David Cheok, Yongsoon Choi, Charith Lasantha Fernando, Roshan Lalintha Peiris, and Owen Noel Newton Fernando. 2009. Huggy pajama: a parent and child hugging communication system. In *Proceedings of the 8th International Conference on Interaction Design and Children* (IDC '09). ACM, New York, NY, USA, 290-291. (Teh, Cheok, Choi, Fernando, Peiris and Fernando 2009)

21 Tetsuaki Baba and Kiyoshi Tomimatsu. 2006. Freqtric drums. In *ACM SIGGRAPH 2006 Emerging technologies* (SIGGRAPH '06). ACM, New York, NY, USA, , Article 12 . (Baba and Tomimatsu 2006)

22 Thecla Schiphorst, Frank Nack, Michiel KauwATjoe, Simon de Bakker, Stock, Lora Aroyo, Angel Perez Rosillio, Hielke Schut, and Norm Jaffe. 2007. PillowTalk: can we afford intimacy?. In *Proceedings of the 1st international conference on Tangible and embedded interaction* (TEI '07). ACM, New York, NY, USA, 23-30. (Schiphorst, Nack, KauwATjoe, de, Stock, Aroyo, Rosillio, Schut and Jaffe 2007)

23 Yoonjung Hong, Jaesung Jo, Yoonhee Kim, and Tek-Jin Nam. 2010. 'STEPS': walking on the music, moving with light breathing. In *CHI '10 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '10). ACM, New York, NY, USA, 4799-4804. (Hong, Jo, Kim and Nam 2010)

24 Keywon Chung, Carnaven Chiu, Xiao Xiao, and Pei-Yu (Peggy) Chi. 2009. Stress outsourced: a haptic social network via crowdsourcing. In *CHI '09 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '09). ACM, New York, NY, USA, 2439-2448. (Chung, Chiu, Xiao and Chi 2009)

25 Cati Vaucelle and Yasmine Abbas. 2007. Touch: sensitive apparel. In *CHI '07 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '07). ACM, New York, NY, USA, 2723-2728. (Vaucelle and Abbas 2007)

26 Feelybean, http://www.feelybean.co.uk/projects/feelybean/feelybean/home.html
Huggy Pajama, http://www.roshanpeiris.com/Huggy-Pajama
Minor Interactive Environments, http://studiolab.ide.tudelft.nl/ie/2011/09/freqtric-drums/
Move.me, http://www.sfu.ca/ tschipho/moveme/technique.html
Tick Talk, http://www.yoonjunghong.com/category/Ashley%20Hong/Activity
SOS, http://stressoutsourced.com/
Cati Boulanger, http://web.media.mit.edu/ cati/portfolio/SelectedWorks.html

27 Alison Gazzard. 2010. Player as parent, character as child: exploring avatarial relationships in gamespace. In *Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments* (MindTrek '10). ACM, New York, NY, USA, 25-31. (Gazzard 2010)

28 Eugen Berlin, Kristof Van Laerhoven, Bernt Schiele, Pablo Guerrero, Arthur Herzog, Daniel Jacobi, and Alejandro Buchmann. 2009. Whac-A-Bee: a sensor network game. In *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems* (SenSys '09). ACM, New York, NY, USA, 333-334.(Berlin et al. 2009)

29 Sari Kujala and Piia Nurkka. 2009. Identifying user values for an activating game for children. In *Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era* (MindTrek '09). ACM, New York, NY, USA, 98-105.(Kujala and Nurkka 2009)

30 Svetlana Yarosh, Stephen Cuzzort, Hendrik Müller, and Gregory D. Abowd. 2009. Developing a media space for remote synchronous parent-child interaction. In *Proceedings of the 8th International Conference on Interaction Design and Children* (IDC '09). ACM, New York, NY, USA, 97-105.(Yarosh, Cuzzort, Müller and Abowd 2009)

31 Ren Vutborg, Jesper Kjeldskov, Jeni Paay, Sonja Pedell, and Frank Vetere. 2011. Supporting young children's communication with adult relatives across time zones. In *Proceedings of the 23rd Australian Computer-Human Interaction Conference* (OzCHI '11). ACM, New York, NY, USA, 291-300.(Vutborg, Kjeldskov, Paay, Pedell and Vetere 2011)

32 Keywon Chung, Carnaven Chiu, Xiao Xiao, and Pei-Yu (Peggy) Chi. 2009. Stress outsourced: a haptic social network via crowdsourcing. In *CHI '09 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '09). ACM, New York, NY, USA, 2439-2448. (Chung et al. 2009)

33 Hayes Raffle, Rafael Ballagas, Glenda Revelle, Hiroshi Horii, Sean Follmer, Janet Go, Emily Reardon, Koichi Mori, Joseph Kaye, and Mirjana Spasojevic. 2010. Family story play: reading with young children (and elmo) over a distance. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10). ACM, New York, NY, USA, 1583-1592. (Raffle et al. 2010)

3. Design Process

We designed "Motan" system through the process that consists of ethnography survey, hardware sketching, software sketching, and prototyping experiments as authors like Dourish & Bell's[1] and Bill Buxton's "Sketching User Experience"[2] referred to the importance of grasping the potential needs of people by ethnographic survey in order to design ubiquitous computing devices to support the daily life.

3.1. Vision

We want to design an object that children are fascinated by, transforming it into an output device that the parent is also engaged in and fascinated by while the child is playing and using it as an input device. Alternating turns of input and output by parent and child can make full use of the parental value in the game and also enhance the parent-child interaction experience. Thus, this vision can change the perception that children's games are only for children by providing a game environment that actively involves the parents in a mutually beneficial manner. The game still has a common goal, but yet able to coordinate different mental desires, especially when one is physically tired but the other is not.

In order to realize the elements which is fascinated by children and parents, we conducted surveys in the nursery school and did a family interview. We focused on the preschool children group that has high expectations of their parents' company, which can in turn influence their personality developments. As for the parents group, we focus on the family that at least one person has full-time job employees and may have less time to accompany their children on weekdays.

3.2. Survey

Nursery school

Figure 3.1: The eurhythmics class in B nursery school

In order to find out what kind of game elements that preschool children are fascinated by, we went to B nursery school in Yokohama on June 28, 2011. B nursery school provides eurhythmics course for 3 – 5 years old children. Eurhythmics is a method of teaching music, acquainting children with melody by performing physical movements associated with the melody and rhythm. The eurhythmics teacher Miss M is a 30 something years old woman who goes to the nursery school twice a month on Tuesday. Miss M first taught children how a melody and pitch would correspond to a certain movement (Figure 3.1). She would then play different instructions on the piano and ask the children to present the corresponding expressions. This can train their musicality, physical coordination and also use it to capture back the children's attention if they are distracted, which is easy to happen at the preschool children's age.

Family interview

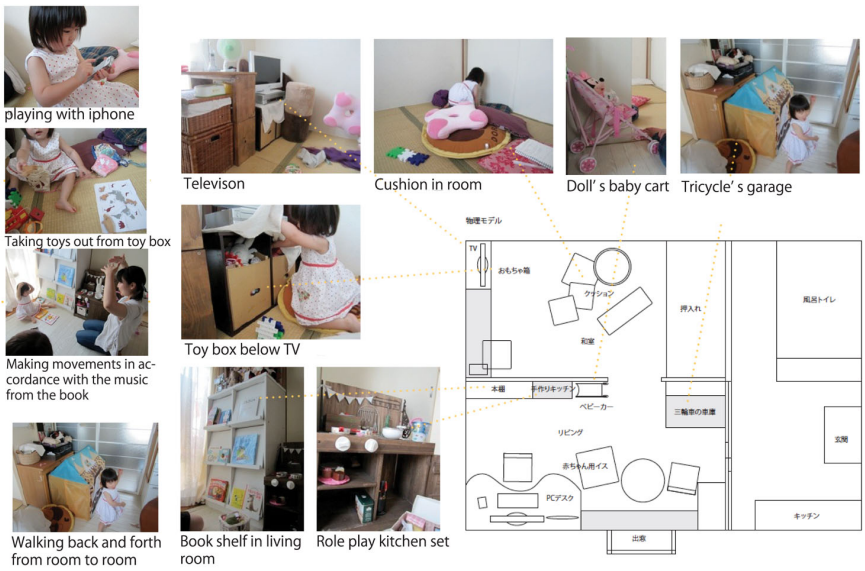


Figure 3.2: The arrangement of S family

In order to observe the interaction between the child and the parent, who usually comes home from work at night during weekdays, we went to S family's house on Aug. 10, 2011. Mr. S is a salaried employee who has a 2 years old daughter attending nursery school and usually spends 2.5 hours commuting back and forth to work. The day after Mr. S came home, he was eating at the dining table while his daughter was playing alone in the other room (Figure 3.2). According to Mr. S, he often has no physical strength and is not in the frame of mind to play with his child after work. When touching upon the parent-child communication between him and his daughter on weekdays, he answered that he basically has to go to the room and initiate the conversation with his daughter, actively asking questions such as "what did you do at school today?". However, the reply from such a young child are often telegraphic answers like "swim". Therefore, father has to keep asking to continue the conversation. When it comes to activities that

can enhance their communication, he said he in fact has no preference for any games as long as they can make his daughter smile and help him to engage with his child.

3.3. Design points

After the fieldwork, we concluded that "sudden change", "falling from high places", and "repetition" are the three game elements that the preschool children are fascinated by in M's eurhythmics class because they trigger game climaxes which the children enjoyed and were excited by. Thus, a game that uses considerable body movements with mobility and repetition is desired.

On the other hand, the father longs for the comfort of home, which allows him to take a rest after coming back from work. Thus, a game that the children may continue playing on their own even if the parent is momentarily not looking is desirable. Moreover, the capability that enables the father to confirm if his child is playing safely is also demanded.

Notes

1 Dourish, P., and Bell, G. *Divining a Digital Future: Mess and Mythology in Ubiquitous Computing.* The MIT Press, 2011.(Dourish and Bell 2011)

2 Buxton, B. *Sketching User Experiences: Getting the Design Right and the Right Design (Interactive Technologies).* Morgan Kaufmann, 2007.(Buxton 2007)

4. Concept

4.1. Overview

After investigating the needs of the father and children, we decided to focus on the exhausted parent back home from work. We may realize the hope of letting dad enjoys his leisure hours in comfort but also be able to play with his child on the side. As a result, based on their needs, we envisaged the implemented elements in our concept similar to elements in “Dance Dance Revolution”; “Whack-a-mole”; and “Beer”; “Massage therapy” etc. Eventually, we use these four elements to present our concept as shown in Figure 4.1.

Thus, “Motan” is a carpet system that provides a game with fast and repetitive gaming characteristics, enabling children to use their physical ability to play, and also provides a haptic massage feedback through a massage cushion to the parent, allowing him or her to play relaxingly with his / her child. Thus, this concept is mutually beneficial to both parties.

① Parent pinches any corner of the cushion to switch it on.
(cushion converts instruction to carpet)
EL wire lights up. System enters “waiting” state.

② Child starts stepping on lighted spots.
Massage rollers start rolling right.

③ If child steps on the wrong spot, an alert sound from the speaker would be activated.

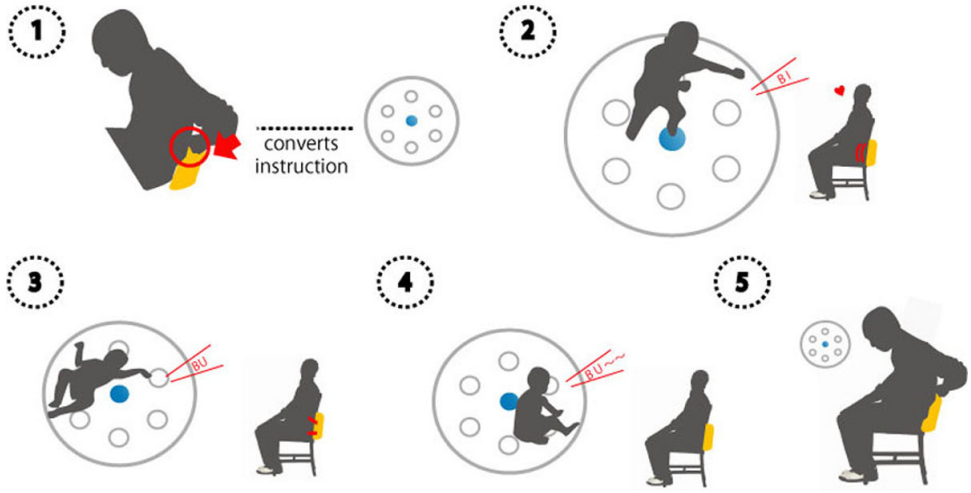


Figure 4.1: The concept of “Motan”

Massage rollers roll left and right alter nately as alert, but will almost immediately resume its right rolling playing state.

④ If child does not step on the right spot in 3 seconds, speaker would sound a longer alert this time.

Massage rollers stop. System enters “off” state.

⑤ Parent has to pinch any corner of the cushion to restart it.

(cushion converts instruction to carpet)

EL wire lights up and system waits for child to play on it once again.

With a mutually beneficial relationship and the convenience of the common space they share, we expect to promote their willingness to keep on playing “Motan”, and hope to create more communication sparks and triggers during parent and child’s cooperation. Moreover, it can alleviate the anxiety of parents on child safety caused by separate activities. In addition, we made two cushions for both the father and mother, expecting this interactive parent-child massage game to involve the whole family. As long as one parent is already involved, another parent is free to decide when to participate or drop out, which will not interrupt the flow of the game that the children are already involved in. Lastly,

with this setup and depending on circumstances, full attention from the involved parent is not needed throughout the game, allowing the parent to relax more when needed.

4.2. Prototyping Experiments

Luminous source

In order to implement our goal of encouraging children to use considerable body movements, we design 7 spots adequately spaced apart which will light up to be stepped. As a carpet that is normally placed in front of a 2 person sofa is about 160cm in diameter and an estimated 15cm diameter for each spot is needed to accommodate a preschool child's foot, only 7 spots can be designed within the carpet's space if they are to be adequately placed apart. These 7 luminaries are arranged in swirl shapes, and can be clearly seen while playing in the house. The luminary material must has the properties to withstand stepping and also has sufficient brightness so as to distinguish itself from others even when enveloped in indoor lamplights. We choose electroluminescent wire (EL wire), electroluminescent fiber (EL fiber), which are both flexible, and LED, which is very commonly thought of when it comes to illumination. We connected the LED with a light pipe which can transmits light along its length, producing an EL-like effect. We chose these three types of luminous source to compare the luminance. (Figure 4.2).

LED

We initially thought that the LED (OS5YAA5111P 5mm Round, 75000mcd luminous intensity, DC 3V power requirement) could be arranged and lodged in the carpet. However, we found that it caused a sense of discomfort and anxiety due to its thickness and glass material. Besides, LED was not outstanding in the

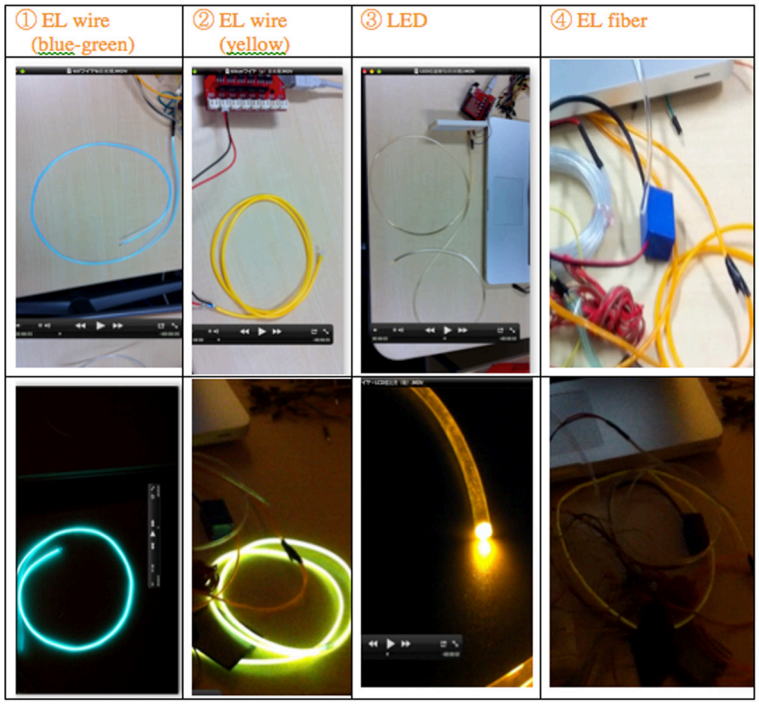


Figure 4.2: Luminance sources compare below indoor lamp light

luminance test. Even with smaller and brighter LED types, like the SMD and strip types LEDs, they might still not be durable enough or easy to install onto the carpet. Therefore, in order to enhance the LED brightness and to make it easier to install on the carpet, we connected the light pipe to the head of the LED, causing the entire length of tubing to light up and be able to be curved into a swirl shape. Unfortunately, the brightest area is the cross sectional face of the pipe, making it difficult to be placed on the carpet, as that face cannot be easily bent to face upwards and still provide sufficient luminance to be seen under indoor lighting. On hindsight, using a light guide with better light dispersion properties along its pipe might have helped but we suspect that the increase in luminance would not be comparable to that of an EL wire or fiber, as discovered later.

EL wire & EL fiber

Initially, we planned yellow light as the color of illumination but unexpectedly found that EL wire with the blue-green luminance (COM-10199/RTL-11429,

30cd/m2∼126 cd/m2, 120V AC power recommended) provides better precision and brightness than EL wire with the yellow luminance (COM-10192/RTL-11431, 30cd/m2∼126 cd/m2, 120V AC power recommended), LED, and EL fiber (9535, 12V DC power required) (according to the order). In fact, EL wire in yellow and EL fiber are unable to be seen under indoor lamplight. We cut the length of EL wire (both blue-green and yellow) and EL fiber into 60cm which is the minimum requirement of one swirl shapes, trying to concentrate the light by reducing the depletion from long distance in pipe. However, because of the similar color between color and pipe, EL wire (yellow) could provide a brighter light than LED but is still hard to notice. EL fiber is difficult to be seen whether if the room is lit up or in full darkness.

On the basis of our luminance experimental results, we consider EL wire (blue-green) as the most optimal material in luminance contrast to be used in "Motan". The critical element that differs EL wire (blue-green) from others is its transparent pipe. Not only does it provides clear, stable blue-green light, which is prominent on both light color and dark color carpets, its length can also be varied, which serves as an useful brightness enhancement.

Pressure detecting

In order to ensure the pressure sensors hidden below the EL wires (arranged in swirl shapes 15 centimeters in diameter which is a appropriate size for preschool children to step or slap on) can accurately detect pressure stepped on any part of the swirl, we divide the swirl shaped EL wire into 9 sections (from A to I) and use 3 different intensity levels of stepping (1 is the lightest) to test and observe the sensitivity of the pressure sensors FSR406 and FSR408 which are produced by Interlink Electronics Inc.

Pressure sensor FSR406

At first, we tried FSR406 pressure sensor (406 sensor), a square sensor (43.69 millimeter on each side) in size with a force sensitivity range of 0.1 - 10.0 square Newtons, active area of 38.1mm x 38.1mm, and nominal thickness of 0.54mm. For the purpose of making 406 sensor detects simultaneously with a stepped EL wire whose proportion is more extensive than itself, we installed the sensor under a sponge (15 centimeters in diameter and 2 millimeter thick) to increase its sensitivity, and cover the sponge with swirl shaped EL wire. Besides this, in order to eliminate the height difference between the carpet and EL wire caused by installing the sensor on the sponge, we set cotton all-around the stepping area to prevent any effects on the experimental results due to the user tripping over. The cotton is then covered with polyester which allows greater light transmittance for EL wire (Figure 4.3). In level 2 and 3 stepping intensities, 406 sensor exactly detects the steps, however, the F,G, and H sections in right side had a hard time in detecting low stepping intensities.

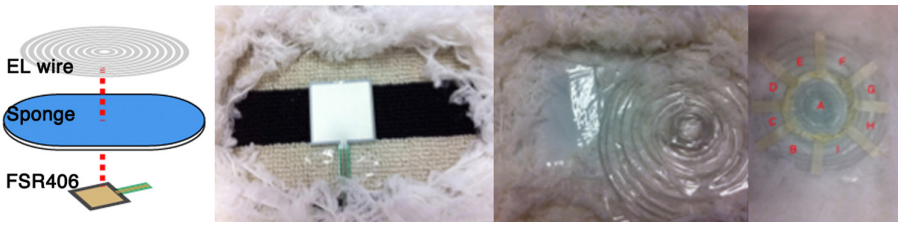


Figure 4.3: Pressure sensor FSR406 covered by sponge and EL wire

Pressure sensor FSR408

Owing to the considerations of intense activities on “Motan”, we think up a way to use FSR408 pressure sensor (408 sensor) with a force sensitivity range of 0.1 - 10.0 square Newtons, active area of 5mm width, and nominal thickness of 0.28mm instead. 408 sensor is a strip sensor 622.3mm in length but can be cut

down to 15 centimeters which we requires (same as the diameter of swirl shaped EL wire). We set 408 sensor at a slanted angle under the sponge and EL wire, expecting to enhance the pressure sensitivity (Figure 4.4). In this event, 408 sensor appears a stable sensing capability, all of the 9 sections successfully detected to the pressure in all the levels of stepping intensities. However, we began to consider that if there is any other material that can replace the thick sponge which gives a strange feeling.

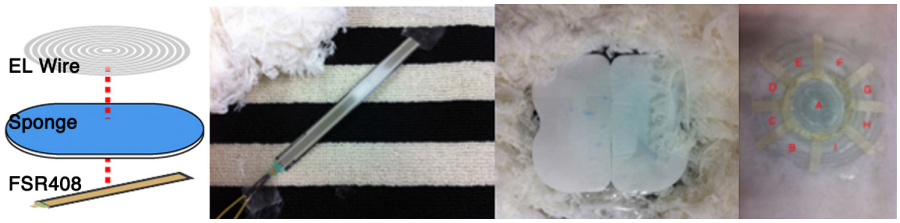


Figure 4.4: Pressure sensor FSR408 covered by sponge and EL wire

Thus, we tried to use a common piece of A4 paper instead of sponge, setting it over sensor 408 (cut down to 15 centimeters) but below EL wire. Although the sensing capability in H and I sections didn't detect all the levels of pressure intensities, it still provides a high level of sensing. According to the serial results, we concluded that compared to 406 sensor, slanted 408 sensor contributes better sensing capability and also lowers the need for a covering like sponge to increase the sensor's sensitivity.

Arrangement

To prevent accidents of children getting tripped by uneven arrangements, we figured out the safer and more natural way in EL wire arrangement through the "Mantle", "Interleave", and "Trench" prototypes.

The mantle prototype

At first, we chose polyester whose generous intervals between fibers allow light to pass through. We covered polyester over the carpet that is sewed with EL wires and the sponge attached, and discovered that the polyester with light color as shown in Figure 4.5, absorbed the illumination of EL wire. Therefore, we tried the other one with black patterns (Figure 4.6). However, although the assimilating problem is been alleviated, user is bothered by a feeling of strangeness. The covering polyester makes it look like a mat filled with electronic components, not like a natural carpet.

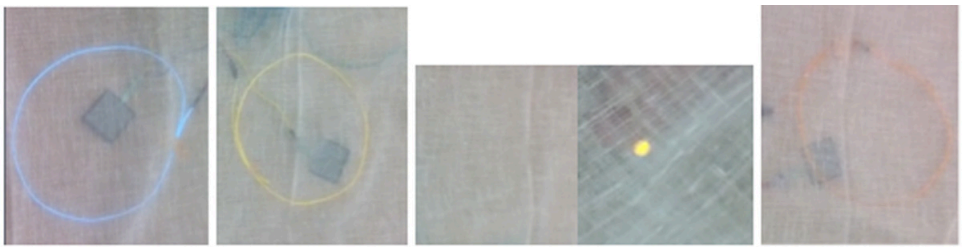


Figure 4.5: The mantle prototype1:Covered by polyester in white color

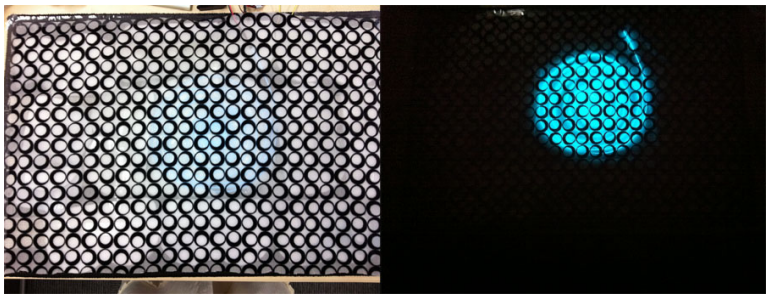


Figure 4.6: The mantle prototype2: Covered by polyester in black patterns

The interleave prototype

In order to improve the contrived mantle prototype appearance, we made the interleave prototype, whereby EL wires are sewn within the carpet wool in a swirl shape. On the other hand, with the understanding that the 408 sensor is detectable without the dependence on covering, we set sensors below the carpet, making use of the carpet's tension to maximize the sensitivity of the sensors instead of using sponge. However, the carpet's long wool concealed the illumination, making it visible as dots instead of the initial linear illumination, which may confuse users as shown in Figure 4.7. The wool length is about 0.3 0.5 centimeters would be more appropriate for the EL wire as the EL wire's diameter is 0.2 centimeters.

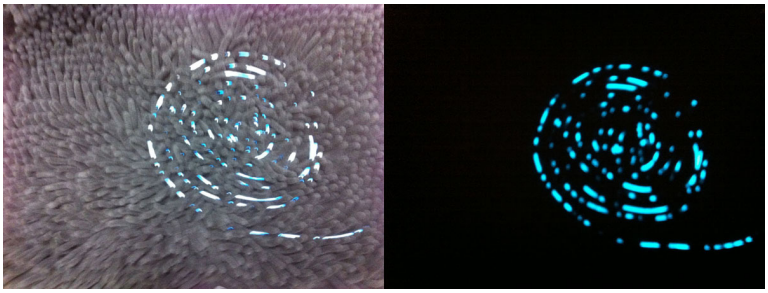


Figure 4.7: The interleave prototype

The trench prototype

We are convinced that the trench prototype, which has a swirl shaped trench cut out by a laser cutter, provides relative practicality in conforming to our requirement of safety and visual purpose. As long as the carpet's fur is dense enough, these swirl shaped channels not only overcome the feeling of strangeness caused by stepping on the EL wires directly, but also contributes a rigid space (due to the melted fabric) to lock in the EL wires, which protects children from tripping while they are playing on the carpet (Figure 4.8).

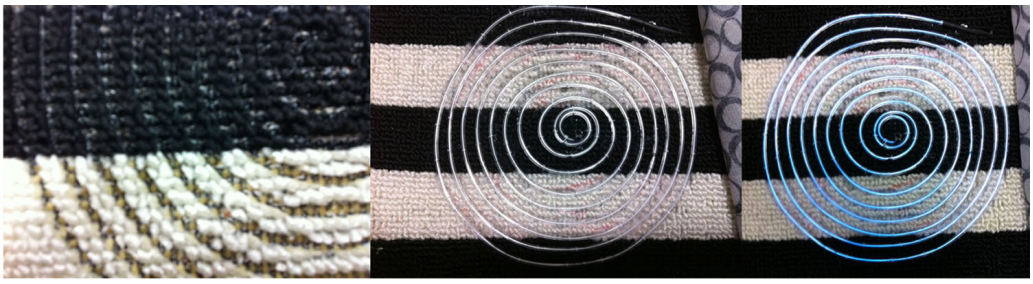


Figure 4.8: The trench prototype

5. Implementation & Architecture

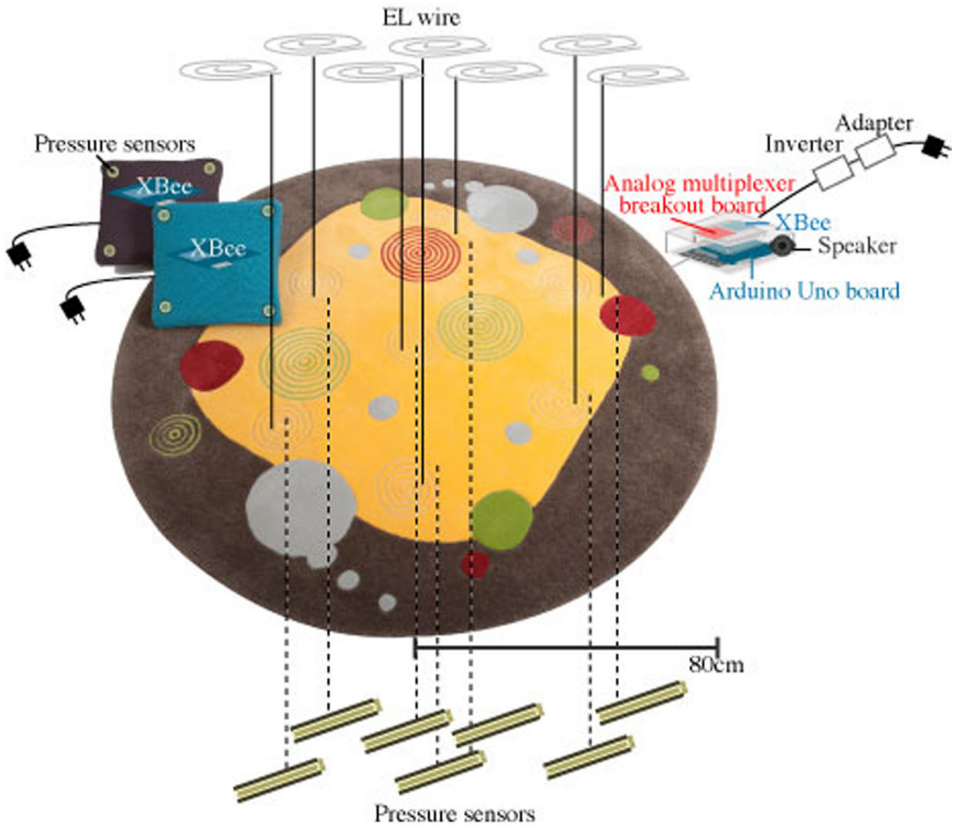


Figure 5.1: Implementation of "Motan"

"Motan" is an visual-haptic interaction system with wireless communication. This interactive system consists of massage cushions and a gaming carpet. We use the open source hardware prototyping platform, Arduino, to build and demonstrate this prototype as Figure 5.1.

5.1. Driving EL wires of a carpet

In order to control 7 EL wires for 7 lighted spots by an Arduino Uno board, we chose solid state relays to drive the EL wires. As the Arduino Uno board only has 6 available analog pins and yet 7 analog pins are needed for the pressure sensors, an analog multiplexer (Texas Instruments CD74HC4067) breakout board with 16 analog channels was added in order to successfully connect 7 pressure sensors. Thus, "Motan" is a carpet system that provides a game with fast and repetitive gaming characteristics, enabling children to use their physical ability to play, and also provides a haptic massage feedback through a massage cushion to the father, allowing him to play relaxingly with his child. Thus, this concept is mutually beneficial to both parties.

5.2. Pressure sensor in carpet

7 pressure sensors (FSR 408 pressure sensor in 15 centimeters length) are embedded in the carpet, corresponding in position with the 7 spots. The pressure sensors will detect any pressure exerted on them and determine if the pressure spot corresponds with the lighted spot.

5.3. Speaker in carpet

A 5g, 24mm in diameter piezo transducer speaker (PT08-Z185) is used, which can produced a 85 dBA min sound pressure level. The speaker is installed in and protected by the electronics casing placed just outside the carpet. A "bi" sound is produced by the speaker whenever the child steps on the correct spot, giving a more immersive experience. If the child gets it wrong, a "bu" alert tone is produced. If the correct spot is not stepped on in 2 seconds, a longer alert tone would sound off to signify the end of the game.

5.4. Pressure sensor in cushion

We also added force sensitive resistors (Interlink Electronics FSR402) to each corner of the cushion to detect the pressure when user pinch the corner.

4 FSR 402 pressure sensors are located inside the 4 corners of the cushion as shown in Figure 5.2, which detect pressure when pinched and would send the information wirelessly to the carpet through the wireless communication device (XBee).

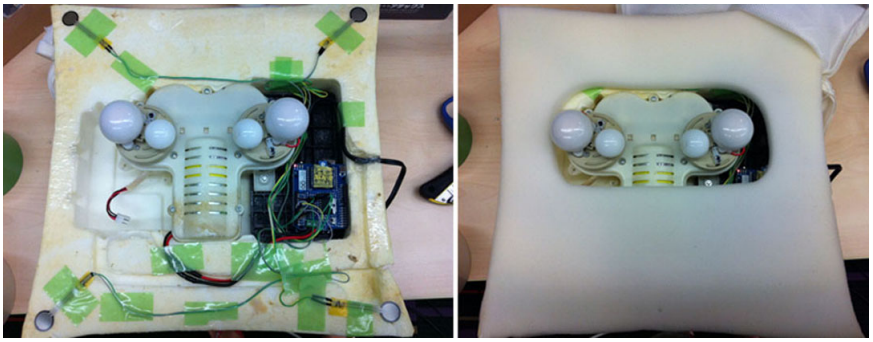


Figure 5.2: The FSR402 sensors placed at 4 cushion corners

5.5. Driving the motor of the cushion

To make the prototype, we modified an existing massage cushion (Atex AX-HL148). We replaced the original controller circuit with a motor driver (Toshiba Semiconductor TA8428K) and an Arduino board to control the massage rollers' movement in response to the corresponding commands from a carpet, making it to execute right rolling, left and right reverse rolling, or to stop rolling.

5.6. Power system for carpet and cushions

All the carpet and cushions are separately powered by connecting them to the commercial power supply circuit of 100V AC in Japan.

5.7. Wireless communication device (XBee)

XBee can be used for wireless communication with low power consumption. Referring to Rob Faludi's *Building Wireless Sensor Networks* [1] , as the information that wireless communication device (XBee) may move stably under various environments, and also widely used in prototyping is rich, we use XBee in each carpet and cushion to convey instructions between carpet and cushion to each other.

Once the cushion on/off switch is turned on, it will send an instruction to the carpet to start the game. The game will then begin and once the player on the carpet has stepped on a lighted spot, an instruction will be sent back to the cushion. After receiving the data from the carpet, the cushion's XBee would convey a corresponding instruction to the cushion's microcontroller, and vice versa as shown in Figure 5.3.

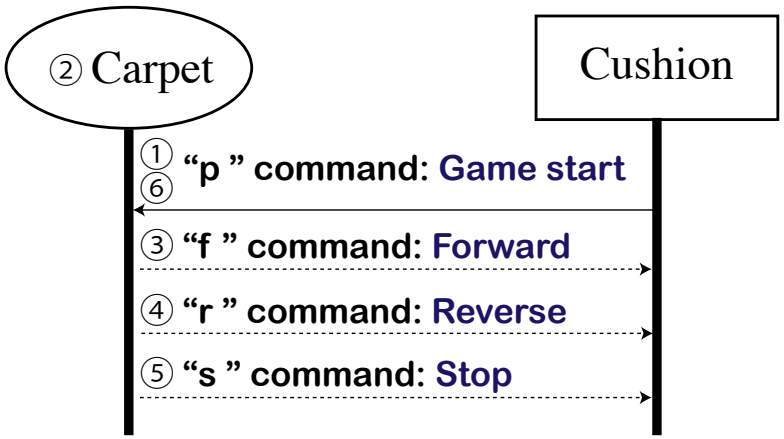


Figure 5.3: The instruction and action between carpet and cushion

① Enter into Wait state

When father pinches any corner of the cushion to switch it on, the Xbee in the cushion gives a "p(game start) instruction" to the other Xbee in the carpet. After receiving the "p (game start) instruction" from the cushion, carpet enters into "wait state", which has been configured as such that a random EL wire would light up, selected from 3 possible lighting sequences, until it is stepped on and thus serving as the standby indicator.

② Wait state → Play state

Once child starts stepping on lighted spots, system will enter into "play state", a corresponding "f (forward) instruction" will be sent to the cushion.

③ Play state

Once they received the "f (forward) instruction", massage rollers inside the cushion will start rolling right. A "bi" sound is produced by the speaker whenever the child steps on the correct spot, giving a more immersive experience.

④ Play state → Alert state → Play state

However, If child steps on the wrong spot, the system will enter "alert state". A "bu" alert tone from the speaker would be activated. Carpet will send "r (reverse) instruction" to cushion to command the massage rollers to roll left and right alternately as alert, but will almost immediately resume its right rolling "playing state".

⑤ Play state → Alert state → Stop state → Off state

However, If child does not step on the right spot in 2 seconds, "stop state" will be activated and a "s (stop) instruction" is sent to the cushion. The speaker would then sound a longer alert, and massage rollers will stop this time. System will immediately enter into "off state" which means game is over.

⑥ Off state → Wait state

This time, father has to pinch any corner of cushion to restart it. By pinching, "p (game start) instruction" will be sent to the carpet once again to light up the EL wire and the system will wait for the child to play on it once again.

Notes

1 Faludi, R. *Building Wireless Sensor Networks.*O'Reilly Media, 2011(Faludil 2011)

6. Evaluation of Motan

Figure 6.1: The arrangement in user families' living rooms

This section describes the user experience of interaction using the "Motan" system. In order to obtain detailed user experiences, we observed how the system affected the parents and children's behavior while playing, confirming the usability of the current prototype, and found its problems. The user study was conducted in the living room of regular Japanese 2LDK (two bedroom apartment with a living room, dining room, and kitchen) houses for the reason that we want to obtain user reflections from regular Japanese nuclear families. The environment was arranged as shown in Figure 6.1, The "Motan" carpet is be placed near the sofa in the living room. 2 "Motan" cushions on the sofa provide massage therapy which will coordinate with the carpet. We use the greenish-blue and the purple cushions, which would obtain the instructions from the carpet and then coordinate

the massage function for a maximum of two seated users. In the following sections, we are going to mention three families' user experiences. All of the three families are supporting pre-school children at home.

6.1. Method

We consult the user study process of I/O Brush [1]which also focuses on the interaction between preschool children while they are playing and doing their art with the brush. The user experience is conducted in the following sequence. Firstly, we posted invitations with a brief description of "Motan" into the mailbox of these families and asked the families if they would like to experience "Motan". After acquiring the approval, we moved the system into the house, spent about 15 minutes moving the furniture such as the dining table and the puzzle mats, which are common in child raising families, and lastly to set up the system.

Then we gave the seated users (parents) an introduction of how to start the system. When a spot lighted up after the cushion's switch was pinched, we would then ask the player user (children) to try to step on it. Thereafter, we would explain to the parents that the massage rollers are linked to the stepping on the spots, in this way he or she may enjoy the massage while the child is playing. However, we did not tell the parents that the massage rollers will roll left and right alternately as an alert for the reason that we want to observe how much did visual and haptic transmissions influence their emotions while watching their children enabling the massage for them. On the other hand, in order to help children get into the playing mood, we told children that he or she have a mission which is to find the lighting place and put it out.

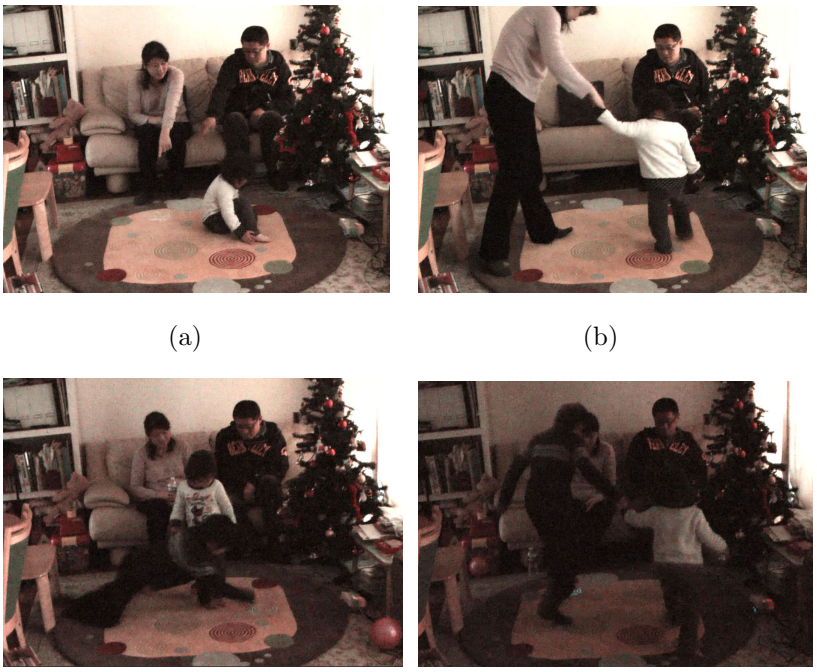
After the introduction and one practice, we let users played "Motan" without restraint and took a video, recording the visuals and sounds of interaction of play throughout the whole process. Each family had at least 20 minutes with the "Motan" system during their "choice time" activities. All persons, with the

exception of family members, left the house in order to keep the house situation as normal as possible by minimizing external influences. Thereafter, we interviewed the users about their impressions and the level of facilitation for parent to relax while still playing with their children. We also asked about their daily routine and parent-child interactions during ordinary days. Eventually we asked them fill in a questionnaire which is made up of 4 sections: "appearance", "operation", "charm", and "emotional communication".

Through this procedure, we want to know whether both the parent and children are fascinated by this system and if the exhausted parent can relaxingly play with the child. The game behavior employed to continue the game, the willingness of continuing the game, and any obstacles that cause any unnatural user experiences are also our observation points.

6.2. Users

For this user study, we searched for families with at least one approximately 3 to 5 year old child and finally asked 3 families to use this system. Besides parent and child one-to-one interaction, we also want to learn about the user experiences of both parents and siblings because we assumed they would be potential users if the future work gets commercialized. Therefore, for family A and B, we asked one child to play "Motan" first, and then let the sibling join the game on her or his own free will. However, for Family C, as both children are around the age range of 3 to 5 years old, we decide to let them play together simultaneously in order to observe how they interact with each other.



(a) (b)

(c) (d)

Figure 6.2: Family A siblings are playing “Motan”

Family A

parents & daughter (2.6 years old girl)
parents & siblings (2.6 years old girl & 9 years old boy)

In this first case study, Family A (Figure 6.2) consists of 40-something years old parents and his 2.6 years old daughter who attends nursery school. They also have a 9 years old son who is studying in elementary school. On the user test day, he went to the park to play ball with friends, and then came back in the middle of the experiment. He was not accounted into our test initially because his age is over the preschool-aged, and the game is too easy for him. However, when faced with such a skillful opponent, the daughter made complaints which contribute meaningful data to our research.

Father A is a company high level executive who works from 0900 h until 2400 h. The busy work does not allow him to play with his children in his daily life. Even during holidays, he always wants to take a break, so he almost does not spent

time in accompanying his children. Therefore, after he heard about "Motan", he was very excited and said he really needed a product like this. Thus he gave a lot of opinions at the end of the research.

Mother A is a part-time job worker who has to work from 1000h till 1800h. After work, she is usually busy with housework. As a result, she always let the 9 years old brother take care of his 2.6 years old sister. Mother B seldom plays with her children, not during the week nor on holidays.

The siblings always play together. After the mother picks the daughter up from the nursery school and back to home at 1800h, the siblings usually watch TV , or play the iPad together (or let his sister watch him play). Therefore, they are familiar with games using the Tablet Computer.

Family B

parents & son (5 years old boy)
parents & daughter (1 year old girl)
parents & siblings (5 years old boy & 1 year old girl)

In the second case study, Family B (Figure 6.3 & Figure 6.4) consists of the 30-something years old parents and their 5 years old son who attend kindergarten. They also have a 1 year old baby girl who was not accounted into our user test initially because her young age may not allow her to cognize this game. However, she presented stunning imitating ability which was out of our expectations and this will be stated in the results.

Father B is a company employee who usually comes home at around 2000h or 2100h during weekdays. As he is always very tired, he spends at most 30 minutes reading picture books for his children or playing physical games together. The game he and his children enjoy the most is the "tickling game". After that, father B usually starts to eat his dinner and watch TV, enjoying his personal time to relax and reflect.

Mother B is a housewife who drives son to kindergarten at 0800h every weekday. Then she starts to do the housework and also take care of her baby girl on the side. She usually takes a nap or reads magazines, enjoying her free time until 1400h, the time she has to pick her son up from school. After that, she usually reads picture books, plays tickling game with children, or takes siblings to the park (twice or three times once a week). As long as she has finished her housework, she would love to interact with her children.

Son B is a kindergarten kid who is going to attend elementary school next year. He is very active and has a sense of justice. He admires "Masked Rider" who is a Japanese superman character he knew from kindergarten and loves to watch "Masked Rider" anime during afterschool time. He also plays blocks or reads books together with his 1 year old sister. On Saturday or Sunday, Family B will go to the zoo, or go shopping. The active boy kindly prompts me that they went to the aquarium before.

(a) (b)

Figure 6.3: Singular players of family B is playing "Motan"

(a) (b) (c)

Figure 6.4: Multiple players of family B are playing “Motan”

Family C

parents & siblings (5 years old boy & 3 years old boy)

Family C (Figure 6.5), attendees of Study 3, consists of the 30-something years old parents and their 5 years old and 3 years old siblings who are both attending kindergarten. Father C is a busy company employee, He usually finishes work and reaches back home at 2200h from Monday till Friday, which is past the sleeping time (2100h) of his children. In addition, he has overtime work on Saturday mornings, depriving him the parent-child time more than the other ordinary employee fathers. After coming home, father C usually eats dinner with the company of his wife, and would then relax in the bath. Because of their staggered work and rest schedules, he almost has no time to play with his children during weekdays. Even though he makes an effort in participating in the child’s growth process. For example, he would take the family out or play the “thumb game” that the children have learned from school together with them, as long as he has free time during holidays. He also wants to capture and preserve his children’s growth through photos, which has become a habit of his.

To support the busy father, mother C play a large role in childcare activities. Mother C is a full-time housewife who spends almost all her time on doing house work and taking care of the children. She sends the siblings to school by bicycle at 0900h and thereafter would then start to do the housework. She would do this until 1500h, and then pick up the siblings from school before taking them to the

library, zoo, or even go shopping together. She let the siblings play together most of the time so that they can learn how to mix around with other people and also so she may concentrate on her housework and affairs.

The siblings always play together with car toys or the games they learned from kindergarten such as “thumb game” and “paper, scissors, stone game”. The older brother would teach his brother the new game he learned, and then play with his family members. The younger brother is recently addicted to the “maze game” which he has just learned from a children’s book in the library.

(a)

(b)

(c)

Figure 6.5: Family C siblings are playing “Motan”

6.3. Results

Play cognition of children in ages

Figure 6.6: Initially, the boy thought the swirl pattern on carpet as a labyrinthian game he just learned from books.

According to our user study results, children in different ages appeared to have different play cognitions. The children above 3 years old have enough experience and cognition to press or step on a spot in a fixed place. For example, the brothers in family C were kneeling so closely in the middle of the carpet, knowing that they should stay within the carpet in order to have a better chance of pressing on the lighted spots.

On the other hand, the children under 3 years old may not have established the cognition as to how such a game should be played, and for example will tend to go across the carpet instead of limiting him or herself to play within the carpet, as initially shown by the B family's 1 year old baby girl and the 2.6 years old daughter of family A.

However, the cognition may be learnt from the parents instructions or through quick observations of their siblings just like the girls did in family A and B. We also discovered that the learning experiences not only influenced the children's cognition in the game but also the interactions between them and their parents. For example, when the younger brother in family C saw the swirl patterns on the carpet, he thought it was the labyrinth game that he had just learnt from the books and thus he was following the lines with his finger and was saying proudly, "it is so easy!" (Figure 6.6) The siblings usually learnt a game from their kindergarten and would integrate it into a parent-child activity in their daily life.

Endurance of game player

Singular player

The longest record for a single player on the carpet is made by the younger brother of family C, who enjoyed playing "Motan" alone for 4 minutes. We believed that he could have played for more than 4 minutes until he was requested by his mother to exit the game because his brother was complaining. The sec-

Figure 6.7: Children under 3 years old are easy to be distracted by extra things they noticed

ond longest period played by the single players (A family's 2.6 years old girl and B family's 5 years old boy) and recorded in the user study was 2 minutes each time. Although children in this age range are easy to get distracted by things they noticed or get tired quickly if they have difficulty to achieve the game requirements (Figure 6.7), the parent's call for them to return and encouragements would provide them with the motivation to return to the game again.

Multiple players

Figure 6.8: The boy sad: "From now, it's a 3 people competition" excitedly

Interestingly, the suddenly appeared lighted spot seems to have the magic power in attracting the children back to the game immediately, which occurred frequently in family B and C. Similarly, for family A, even though the mother was only announcing that she was going to pinch the cushion again, it also achieved the same effect of attracting the child back to the game.

We also discovered the other factor that tempted the children to return to the game again was if they saw that their sibling was playing or were going to play,

as evident in the case of family A and C. This is also verified in family B as son B had decided to take a rest after playing for about 1 minutes and 30 seconds originally. However, when he saw his mother stood up and walked towards the carpet, he returned back to the game immediately with excitement.

According to our user study research, there is no doubt that playing "Motan" with multiple "stepping" players might not only enhance the gaming atmosphere but also increase the players' interest and duration in the game as observed in all of the 3 cases (Figure 6.8). However, conducting the game in a multiple player mode often transforms it into an invisible competition and leads to frequent and unavoidable arguments between siblings.

Competition and cooperation between siblings

In normal situations, siblings will play "Motan" competitively as they fight for the limited "resources", seeing their triumphs as individual achievements. The notion of cooperation is seldom accomplished during the game as we saw how the older brother in family C was annoyed with his brother for pressing the spots that were not allocated as him. .

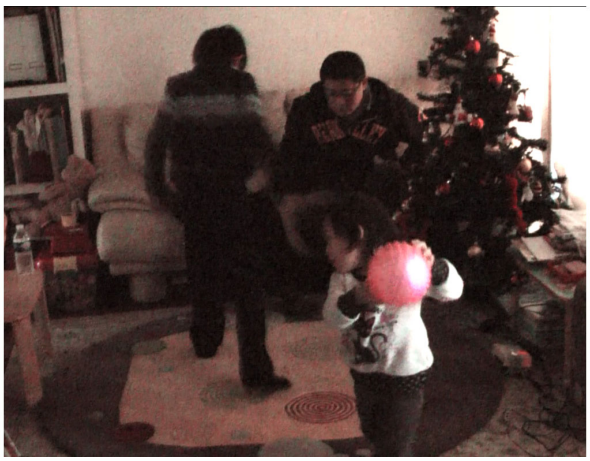


Figure 6.9: The girl threw a ball to hit her brother, complaining him pressed the lighted spot which she wanted to press

On the other hand, the jealousy from the younger children towards their older siblings, who were playing better, was also a sort of competition between the siblings which we observed in family A and C. The brothers both displayed displeasure towards each other when one is being restrained while the other is playing happily. Unfortunately, this kind of competition usually results in behaviors to obstruct the game from the younger siblings, and this generates a vicious circle, leading them to fight with one another. This type of behavior happened in family A and C frequently, such as covering the lighted spots on purpose, moving away the other person's hands, trapping the opposite party's foot, or even roaring to parents asking for an alternation (Figure 6.9).

The cooperation between siblings only happened in the situation that one of the siblings' actions are restrained by the parents as was the case we saw in family C (Figure 6.10), or he noticed that the other party was already unsatisfied with him, which was what happened in both family A and C. The older brother would also hint for their younger siblings under the premise that both of them were not annoyed with each other.

Figure 6.10: The cooperation between siblings happened rarely but as the boy was limited by his parent, he gave his brother a hint.

Alternations of players in game

Occurred during the single played period

There are several reasons lead to the alternations of play between family members.

The reasons that caused the alternations to occur during the game in single player form was that the children have difficulty in keeping their patience. For example, Family C had an agreement on taking turns every 3 minutes. However, the older brother could not stand the loneliness of not playing while watching his brother playing happily and thus he requested an alternation again even though he was just waiting for about 1 and a half minutes. In addition, once the children could not achieve the game requirements, they may also lose their patience easily. This case occurred in son B who asked for an alternation because he was frustrated the game always ended prematurely and was getting tired after playing for about 5 minutes and 30 seconds in total (Figure 6.12 & Figure 6.13).

Sometimes the alternations were requested because children prefer environments with family company, which made them feel safer. The 2.6 years old girl in family A asked her mother to play with her after she played for about 7 minutes in total alone (Figure 6.11).

Occurred during the multiple played period

The alternation was used as a way to resolve arguments by the parents. For example, the parents persuaded the child to try the massage cushion in order to separate the arguing siblings in family C.

The alternation request for competitions between family members was brought up by a 5 years old boy of family B. He had the inspiration for the idea due to his mother's active participation initially. As he had enjoyed the experience, he desired for the experience again by requesting competitions between family members in different combinations for 4 times.

Family A

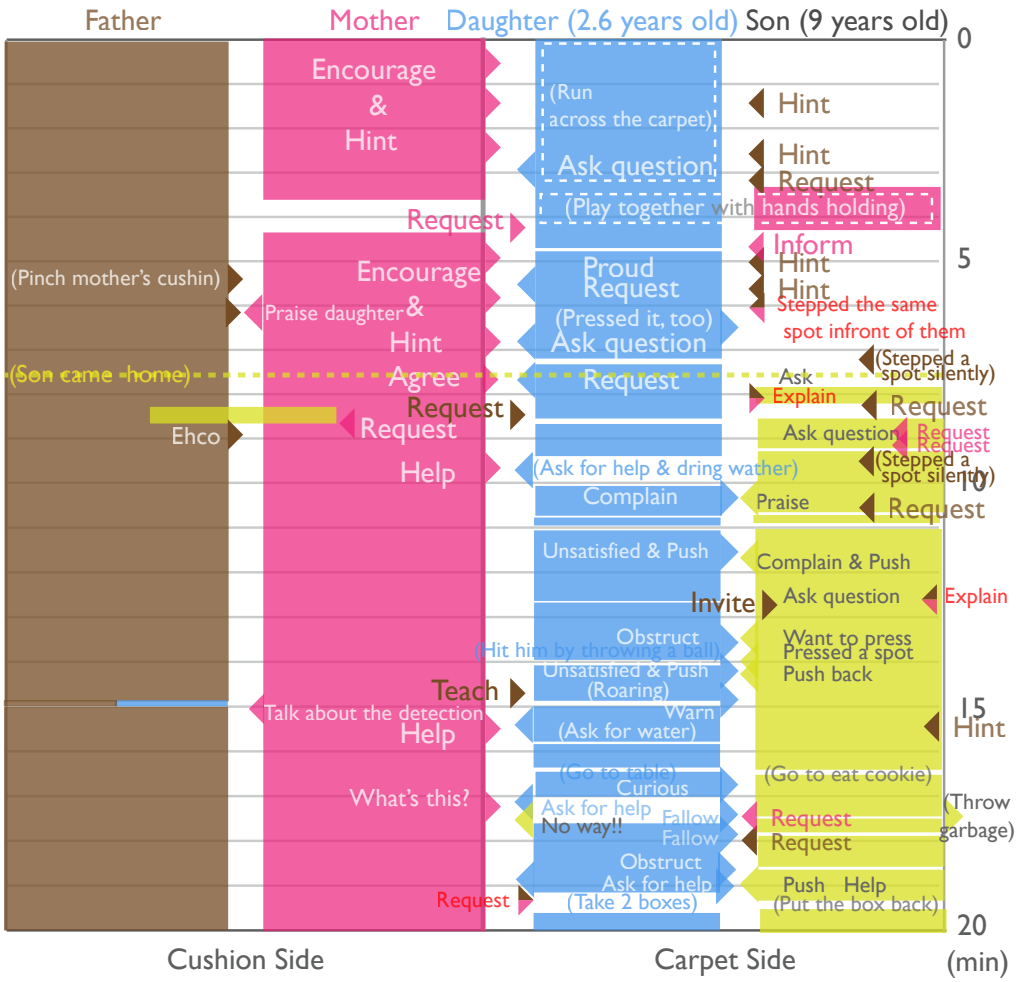


Figure 6.11: The alternation in Family A

Family B

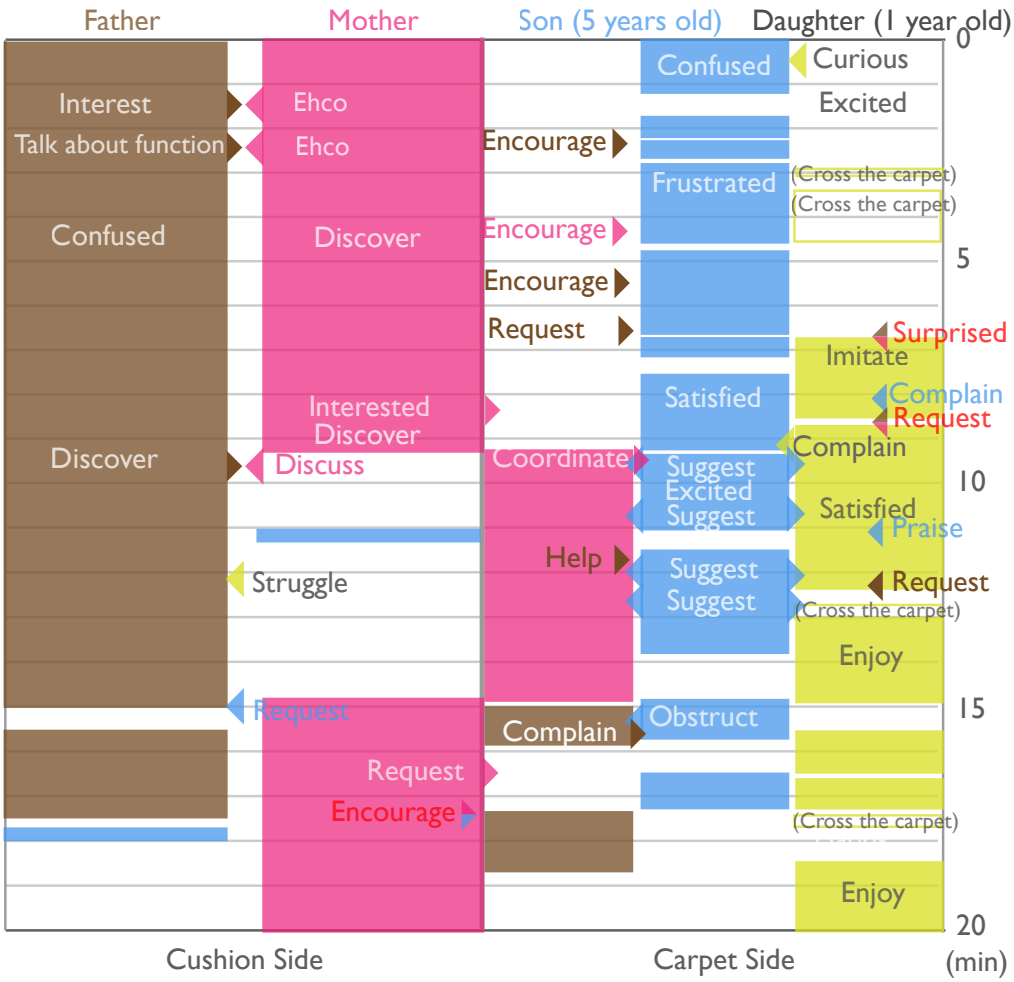


Figure 6.12: The alternation in Family B

Family C

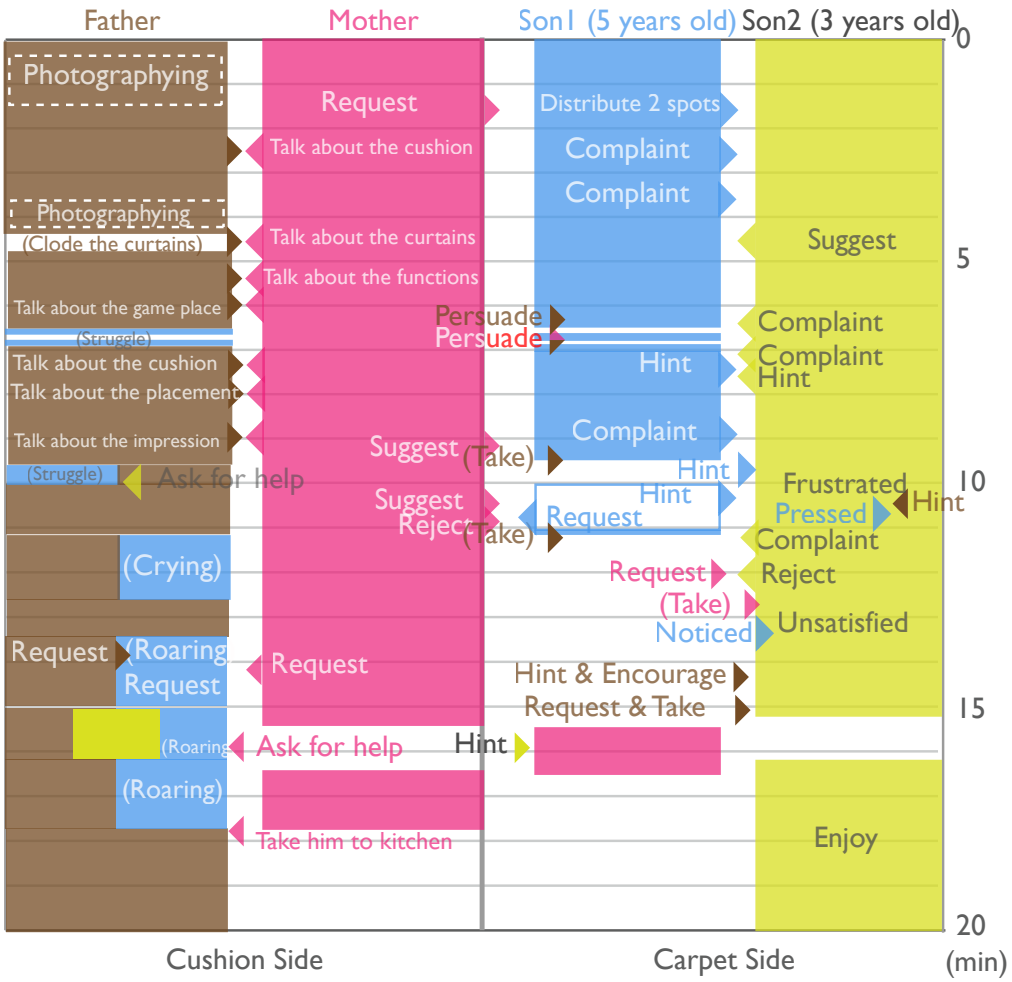


Figure 6.13: The alternation in Family C

Evaluation of massage cushion

The cushion corner of our prototype is set at an unfavorable angle. Thus the users of the cushion have to curve their arm backwards to pinch the corner, which makes the user uncomfortable, especially when "game over" situations occurred frequently. Father C developed an easier way by putting his wife's cushion on his knees, pinching the cushion while having his own cushion on his waist (Figure 6.14).

Figure 6.14: Father C developed an easier way to pinch cushion. He put his wife's cushion on his knees, pinching the cushion while having his own cushion on his waist.

6.4. Discussion

In this section, we are going to discuss the actual achievements of our current prototype. Based on the user study, we analyze the degree of facilitation for parent being able to relaxingly play with child on the side while still enjoying his leisure hours, and the children fascination in playing with "Motan".

Appropriate age for player

Compared to other users in the user study, 3 – 5 years old children displayed greater interest in playing the current prototype of "Motan". This is especially so for the 5 years old children, who showed the most curiosity and passion.

Although easily distracted by the environment especially when playing in single player form, the players under 3 years old also showed strong interest in eliminating the lights as long as they could learn from their parents or siblings.

Insufficiency in attractiveness to singular player

According to our user study result, parents and siblings shared an enjoyable parent-child time together and healthy sibling competition with "Motan". In fact, such sibling competition can generate the most communication sparks.

However, the current prototype is still insufficient in attractiveness because of the immutable and frozen lighted spots. This is especially so for the singular player, unlike the multiple players who have to pay attention on their competitors' actions and thus making the game more interesting and attractive for them.

This is shown from the case studies whereby the 5 years old child in family B played excitedly after he got used to the continuously-lighted spots but soon felt bored when playing alone and so he requested other family members to play "Motan" together. The 2.6 years old girl in Family A was also getting easily distracted by the video camera and by questions she thought of suddenly.

Moreover, the speaker was not loud enough to notify the game condition to the users, especially in noisy situations such as someone talking loudly nearby which made it difficult for these singular users to get into the mood of the game without the enhanced immersive experience that the game condition sound can give.

Achievement in facilitate parent playing with children

2/3 of the 6 parent users agree with the achievement: "Motan" facilitates parents to play with child easily. When the family C's siblings are arguing about the division of the playing time, the mother was busy pacifying her senior son while still pressing the cushion button for junior son. Both of the parents in family C agree that "Motan" helps them to play with the children more easily. As for family B, the parents were excited about the novel carpet system, and concentrated on their playing children, making hints for them. As a result, they did not feel the leeway to relax during their first "Motan" experience but greatly agree that "Motan" can provide the leeway for relaxation while still playing with their children from the second time onwards that they use "Motan".

However, different comments were given by family A. They thought that new conversations occurred within the whole family, making them feel closer to each other. But they could not feel the effect in facilitating play easily because the cushion button is not ergonomically friendly for the user, which annoyed them and they spent a lot of time in adjusting it.

Significance of massage cushion

All of the parent users in our research did not feel the alternating rolling massage rollers occurring when the player made a mistake. The reason is that the contrast between normal and alert state is not clear enough to be noticed, and the connection between the steps of children and massage therapy was weak.

Furthermore, the parents expected continuing massage therapy even if the children's stepping rhythm and the rolling frequency of the massage rollers are not in sync and the rollers would not be rolling.

Notes

1 Kimiko Ryokai, Stefan Marti, and Hiroshi Ishii. 2004. I/O brush: drawing with everyday objects as ink. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '04). ACM, New York, NY, USA, 303-310. (Ryokai et al. 2004)

7. Conclusion

"Motan" provides a prepossessing impressions in concept and appearance design. Compared to other users, 3 – 5 years old children displayed greater interest in playing the current prototype of "Motan". The players within 1 to 3 years old showed the ability to realize the game play conditions after a learning experience from parent or siblings.

Referring to the communication among the game, hints and encouragements from parents have occurred as to our anticipation that influence children's play motivation very much. It meets our design intent that parents may play with their children in an interactive and cooperative way. Once the children got used in playing "Motan", the parents have more leeway to chat with each other or and enjoy their leisure time. Especially the parents who spend less time in accompanying children suffered from the less topic of conversation between children and them may solve the problem and found a common conversation by playing "Motan" together.

It is an usual practice for multiple players that the game form mostly develops into a mutual competition which creates high atmosphere, especially the sibling competition not only lighten the mental and physical efforts of parents but also generates the most plentiful resonances until arguments resulted.

However, the current prototype is still not ideal in the sufficiency to singular player, especially the junior children players who are under 3 years old tend difficult to maintain a long playing time because the permit time and activity range are strict to them.

Cushion button placement is not perfect yet neither. The cushion corner of our current prototype is set at an unfavorable angle. Because of the responsive ability, “game over” situations occurred in junior players frequently which cost parents time in looking for the button which is divergent against our intention: “play relaxingly with children”. “Motan” contributes on the transforms individual entertainment input into massage therapy output to facilitates parents to play with their child relaxingly even they are exhausted from work. The current achievements reached our purpose in several regions but still have the space to be better.

7.1. Future Vision

The current prototype is still not ideal in projecting the attraction in the Insufficiency to singular player. Moreover, it also has problems in switching on the game as the position of the cushion's switch is not ideal for users. As a result, some users who are the switch controllers in the game are not fascinated by the current prototype.

Steps with musical scale accompany

A carpet system with musical scale elements is thought of to attract the players' attention in the future. Since the preschool children are fascinated by musical responses as we had observed in our survey, we plan to introduce a continuous massage therapy coordinated by the flick tempo of lighting spots with musical scale elements instead. Therefore, children may create the unique melody by their own.

Cushion switch replacement

In future prototypes, we would wish to design a smart phone application not only as a replacement of the cushion's switch, but also the melody controller in order to activate the system. Through a smart phone application, the user can more easily and naturally activate the system, and therefore not comprising on the concept of relaxingly playing with child.

Scoring system

A game scoring system can not only be used to attract the family to play "Motan" together but also the provides the chance to challenge with other family members even play there is only singular player playing.

Through logging scores for different instances of game play between the parent and the child, memories of that particular experience can be preserved by the family members. Healthy scoring competition between siblings and a parent-child pairing may also motivate families to play more often, and thus increasing family interaction and communication opportunities.

Elective difficulty

The user should be able to choose the level of game difficulty. "Motan" is described as a carpet game which suits children from age 3 – 5 years old in the current prototype. However, depending on different users' abilities and preferences, we consider to provide three levels of elective difficulty for them. Therefore, the users may chose a different level to challenge, which can increase their curiosities towards the game.

Expansion

We also expect other family members to join in anytime, and would provide expanding functions to accommodate different demands for different growth process. All the family members can increase the game's complexity and excitement with the introduction of another lighted spot to be stepped on. In addition, when the boy or girl grows up, he or she may use "Motan" to do muscle or diet training while giving their parents a heart-warming massage.

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References

Baba, Tetsuaki, Taketoshi Ushiama, and Kiyoshi Tomimatsu (2007) "Freqtric game: video game which uses skin contact as controller input," *ACM SIGGRAPH 2007 posters*.

Baba, Tetsuaki and Kiyoshi Tomimatsu (2006) "Freqtric drums," *ACM SIGGRAPH 2006 Emerging technologies*.

Ballagas, Rafael, Joseph 'Jofish Kaye, Morgan Ames, Janet Go, and Hayes Raffle (2009) "Family communication: phone conversations with children," *Proceedings of the 8th International Conference on Interaction Design and Children*, pp. 321–324.

Berlin, Eugen, Kristof Van, Laerhoven, Bernt Schiele, Pablo Guerrero, Arthur Herzog, Daniel Jacobi, and Alejandro Buchmann (2009) "Whac-A-Bee: a sensor network game," *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems*, pp. 333–334.

Buxton, Bill (2007) *Sketching User Experiences: Getting the Design Right and the Right Design (Interactive Technologies)*.

Cha, Jongeun, Mohamad Eid, Ahmad Barghout, ASM Mahfujur Rahman, and Abdulmotaleb El, Saddik (2009) "HugMe: synchronous haptic teleconferencing," *Proceedings of the 17th ACM international conference on Multimedia MM '09*, pp. 1135–1136.

Chung, Keywon, Carnaven Chiu, Xiao Xiao, and Pei-Yu (Peggy Chi (2009) "Stress outsourced: a haptic social network via crowdsourcing," *Proceedings of the*

27th international conference extended abstracts on Human factors in computing systems, pp. 2439–2448.

Dourish, Paul and Genevieve Bell (2011) *Divining a Digital Future: Mess and Mythology in Ubiquitous Computing*.

Faludil, Rob (2011) *Building Wireless Sensor Networks*.

Gazzard, Alison (2010) "Player as parent, character as child: exploring avatarial relationships in gamespace," *Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments*, pp. 25–31.

Gillen, J. (2002) "Moves in the territory of literacy? - the telephone discourse of three- and four-year-olds.," *Journal of Early Childhood Literacy*, Vol. 2, No. 1, pp. 21-43.

Heikkinen, Jani, Thomas Olsson, and Kaisa Väänänen-Vainio-Mattila (2009) "Expectations for user experience in haptic communication with mobile devices," *Proceedings of the 11th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pp. 28:1–28:10.

Hong, Yoonjung, Jaesung Jo, Yoonhee Kim, and Tek-Jin Nam (2010) "'STEPS': walking on the music, moving with light breathing," *Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems*, pp. 4799–4804.

Hoysniemi, Johanna (2006) "International survey on the Dance Dance Revolution game," *Comput. Entertain.*, Vol. 4, No. 2.

Kontaris, Dimitrios, Daniel Harrison, Evgenia-Eleni Patsoule, Susan Zhuang, and Annabel Slade (2012) "Feelybean: communicating touch over distance," *Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems Extended Abstracts*, pp. 1273–1278.

Kujala, Sari and Piia Nurkka (2009) "Identifying user values for an activating game for children," *Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era*, pp. 98–105.

Miller, Daniel, Aaron Parecki, and Sarah A. Douglas (2007) "Finger dance: a sound game for blind people," *Proceedings of the 9th international ACM SIGACCESS conference on Computers and accessibility*, pp. 253–254.

Modlitba, Paulina L. and Christopher Schmandt (2008) "Globetoddler: designing for remote interaction between preschoolers and their traveling parents," *CHI '08 extended abstracts on Human factors in computing systems*, pp. 3057–3062.

Morelli, Tony, John Foley, Lauren Lieberman, and Eelke Folmer (2011) "Pet-N-Punch: upper body tactile/audio exergame to engage children with visual impairments into physical activity," *Proceedings of Graphics Interface 2011*, pp. 223–230.

Raffle, Hayes, Rafael Ballagas, Glenda Revelle, Hiroshi Horii, Sean Follmer, Janet Go, Emily Reardon, Koichi Mori, Joseph Kaye, and Mirjana Spasojevic (2010) "Family story play: reading with young children (and elmo) over a distance," *Proceedings of the 28th international conference on Human factors in computing systems*, pp. 1583–1592.

Rosenbaum, Eric and Jay Silver (2010) "Singing Fingers: fingerpainting with sound," *Proceedings of the 9th International Conference on Interaction Design and Children*, pp. 308–310.

Ryokai, Kimiko, Stefan Marti, and Hiroshi Ishii (2004) "I/O brush: drawing with everyday objects as ink," *Proceedings of the SIGCHI conference on Human factors in computing systems*, pp. 303–310.

Schiphorst, Thecla, Frank Nack, Michiel KauwATjoe, Simon de, Bakker, Stock, Lora Aroyo, Angel Perez Rosillio, Hielke Schut, and Norm Jaffe (2007)

"PillowTalk: can we afford intimacy?" *Proceedings of the 1st international conference on Tangible and embedded interaction*, pp. 23–30.

Teh, James Keng Soon, Adrian David Cheok, Yongsoon Choi, Charith Lasantha Fernando, Roshan Lalintha Peiris, and Owen Noel Newton Fernando (2009) "Huggy pajama: a parent and child hugging communication system," *Proceedings of the 8th International Conference on Interaction Design and Children*, pp. 290–291.

Vaucelle, Cati and Yasmine Abbas (2007) "Touch: sensitive apparel," *CHI '07 extended abstracts on Human factors in computing systems*, pp. 2723–2728.

Vutborg, Ren, Jesper Kjeldskov, Jeni Paay, Sonja Pedell, and Frank Vetere (2011) "Supporting young children's communication with adult relatives across time zones," *Proceedings of the 23rd Australian Computer-Human Interaction Conference*, pp. 291–300.

Yarosh, Svetlana and Gregory D. Abowd (2011) "Mediated parent-child contact in work-separated families," *Proceedings of the 2011 annual conference on Human factors in computing systems*, pp. 1185–1194.

Yarosh, Svetlana, Stephen Cuzzort, Hendrik Müller, and Gregory D. Abowd (2009) "Developing a media space for remote synchronous parent-child interaction," *Proceedings of the 8th International Conference on Interaction Design and Children*, pp. 97–105.

Appendix

8. Motan Schematics

A. Cushion Schematics

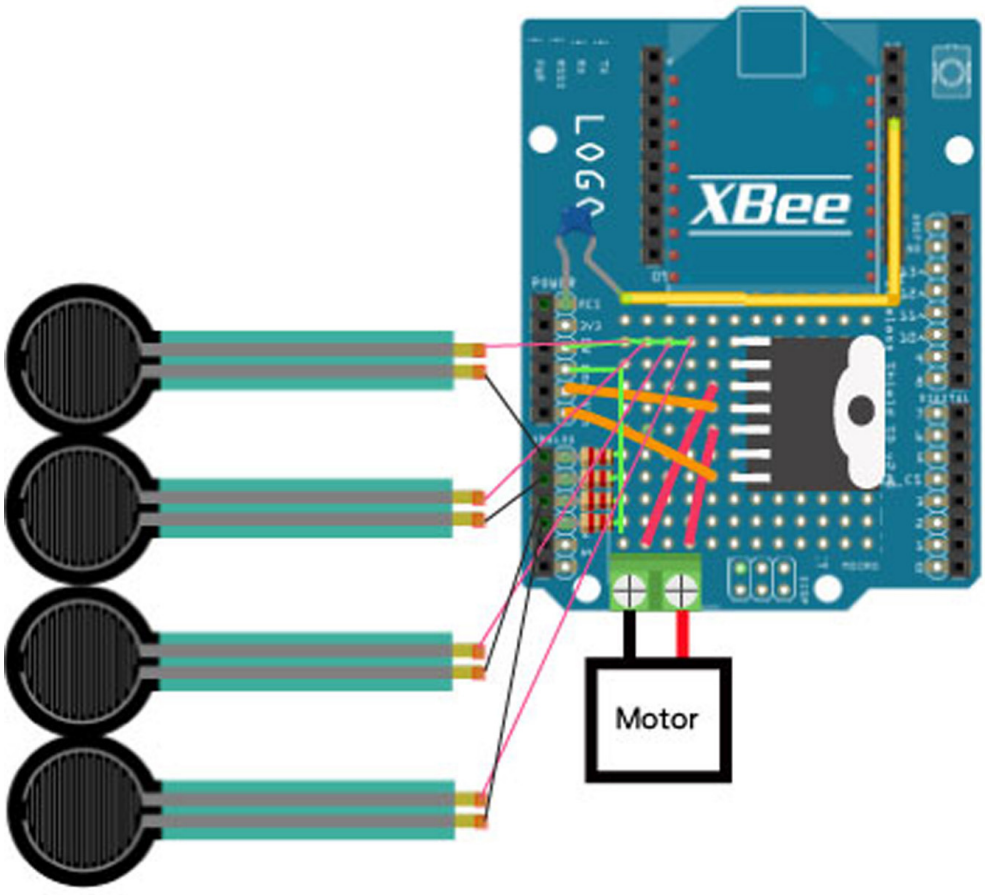

Figure 8.1: Cushion Breadboard

B. Carpet Schematics

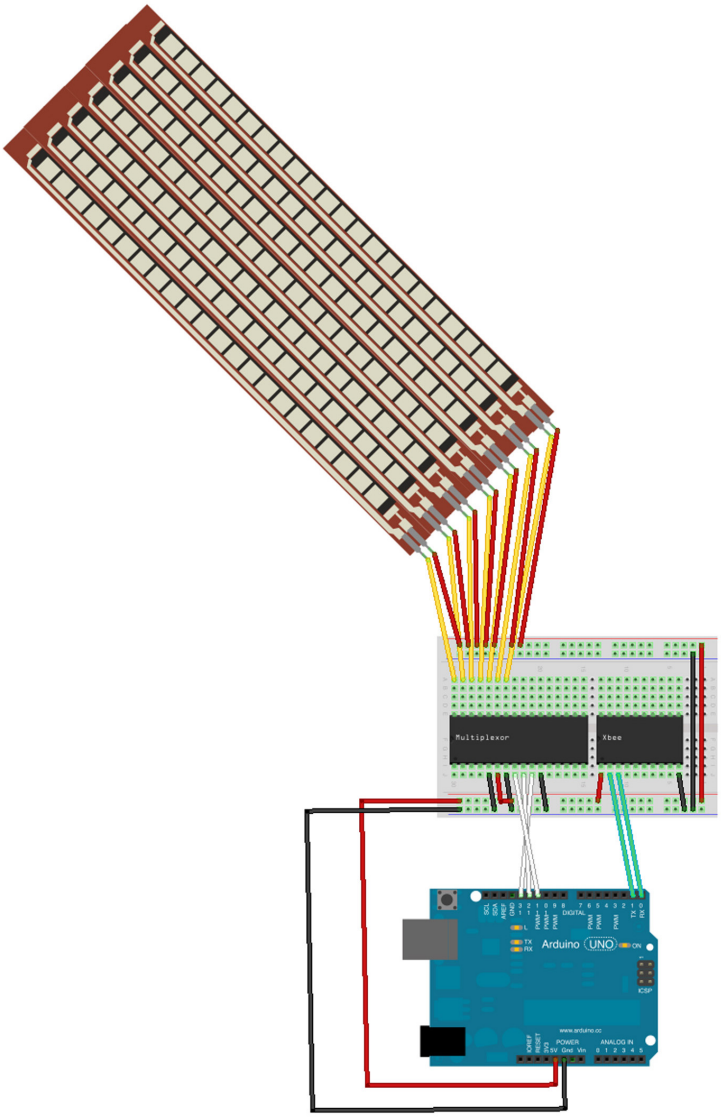

Figure 8.2: Carpet Breadboard 1

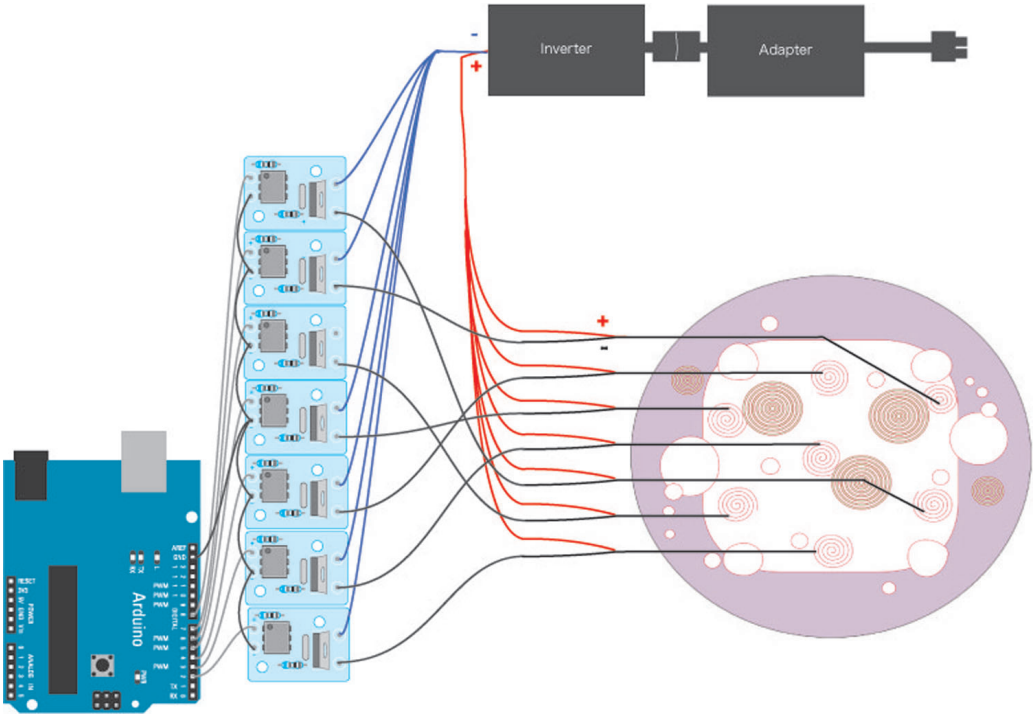

Figure 8.3: Carpet Breadboard 2