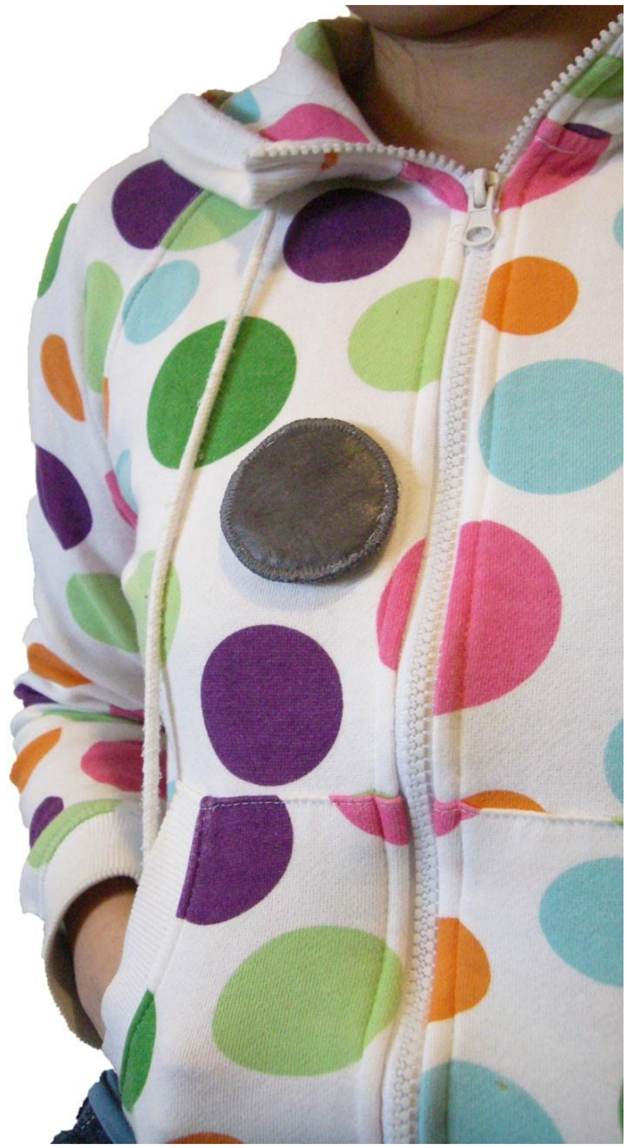

DESIGNING A WEARABLE SOCIAL NETWORK

by

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BSc Applied Science, Queen's University, 2007

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ABSTRACT

This thesis explores the design of a nonverbal communication system for a circle of friends. An exploratory design process helps to gain insight into designing a Wearable Social Network (WSN). The WSN is rooted in concepts of social interaction in HCI augmented by traditions of sociology to create more human-centric systems. Patches applies this framework to develop a wearable system that allows users to physically ‘feel’ a friend’s online expression (like a virtual poke) and respond through natural interaction with clothing. My studies show that the WSN creates a tactile experience that extends current social networking applications to be more interesting, entertaining, and fun. The WSN is a “warm network” that is comforting and intimate for communicating with close friends and family. Exploratory design research creates a new design space for examining virtual expression and interaction. This framework can also be applied to a broader range of social networking applications.

Keywords: wearable computing; social networking; social computing; touch; exploratory design; Facebook

For Yi and Zhang

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CHAPTER 1: INTRODUCTION

1.1 Motivations

This thesis explores the design for a wearable computing system that enhances nonverbal communication for a ‘circle of friends’. The goal is to enrich the quality of communication for non-collocated friends through implicit, personal, and expressive methods rather than the typical explicit, goal-oriented, and information-centric methods of communication. A process of exploratory design was used to gain insight into the creation of a Wearable Social Network.

This thesis posits that effective communication can be achieved by appealing to a greater range of senses such as touch, in concert with the traditional methods of communication such as text, picture, and sound. Touch is an important nonverbal communication method that has the power to elicit meaning through the mood and emotion being exchanged. For instance, a hug may be an expression of love and a poke may express playfulness. More importantly, nonverbal communication complements and adds nuances of meaning not communicated by the explicit verbal means. Imagine the differences in emphasizing the same message with a caress rather than a punch. Incorporating touch to technological systems may redefine the type of information to be exchanged and a new design space in which to share it. Understanding this design space may open new opportunities for expression and interaction in HCI.

These concepts are explored through the design of a Wearable Social Network, a ubiquitous system that provides an ‘always-on’ mode of communication that is not limited in social networking scope. Although prior research in wearable computing has produced evocative and interactive garments, many wearable systems limit connection to only a few friends (Labrune & Mackay, 2006) while others further restrict users to share the same physical space (Berzowska & Coelho, 2006). This research views a user’s social network as including numerous and complex connections. The Wearable Social Network supports all individuals within a circle of friends and their activities.

This framework incorporates social interactions from HCI research with traditions from sociology to create more human-centric and interactive systems, capable of richer interaction and subtleties of expression. The Wearable Social Network was applied to the development of Patches, a wearable system that allows users to physically ‘feel’ a friend’s online expressions such as poke, cuddle, and hug through actuators inside the wearable Patch. Like a real social interaction, users can also respond to their friends by simply touching the Patch. The Patch recognizes a variety of touch gestures that mimic natural face-to-face interactions such as caress, tickle, and punch. Patches allows friends to communicate with each other through the natural method of interacting with clothing. The Patches system allows us to explore touch as an expressive, emotional, and meaningful method of communication that supports friendship activities beyond traditional social networking technologies.

1.2 Expressive Computing

The development of machines capable of interacting with humans is integral to the development of intelligent computational systems. While the standard definition of effectiveness within human computer interaction (HCI) depends upon efficiency, usefulness, and task analysis, affective computing argues that affect, emotion and expression are critical factors in effective and efficient systems design. Feeling and emotion play a critical role in our experience and interaction with the world (Picard, 1997). Picard was among the first to state that adding emotional competence to computer systems makes interaction more efficient and effective. Lutz reminds us that emotion is engrained into our cultural and social life (Lutz, 1988). This thesis takes the position that the cognitive side of HCI can benefit from combining with the emotional side to create more computer systems capable of effective interaction.

In affective computing, sensors typically measure affect in discrete units, which are then transmitted from people to computational systems and back again. Instead of considering emotion solely as an objective and externally measurable unit of affective response, this thesis considers emotion as a social and cultural product experienced through our interactions. Boehner et al. propose an interactional approach to emotion that shifts the focus from helping computers to better understand human emotion, to helping people to understand and experience their own emotions, leading to new design and evaluation strategies (Boehner et al., 2005). This thesis extends their interactional approach to suggest practical methods for design, implementation, and evaluation.

1.3 Process

This thesis takes a “design-oriented research” approach where research is the primary focus and design acts as the means to answer the research question and produce new knowledge. More specifically, the design process taken by this thesis belongs within the domain of “design exploration” (Fallman, 2008). Design exploration is not about satisfying the needs of a client, nor is it about how well a product fits into a market. In design exploration, research is driven by the most important question: “What if?” Exploratory research seeks to test ideas and discover what is possible. This research method provokes, criticizes, and experiments to reveal alternatives to the expected and traditional standards. An iterative design cycle tested the ideas and drew conclusions about the user experience and social implications of the system. This type of systematic inquiry, whose goal is knowledge, belongs in a category that Fallman describes as “design study”, which aligns with the goals of research. The kind of knowledge and user experience sought could not be obtained if the design is not a vital part of the research process.

This thesis endeavours to answer the question: what if we design a system that enhances nonverbal communication for a circle of friends? The question is complex and involves many aspects of consideration including technology, social and cultural issues, emotions, expressions, and interaction. This thesis analyzes the question from three perspectives – 1) technology, 2) interaction, and 3) sociability – to effectively design an expressive, wearable social network for friends.

Design exploration research has no specific design process, as each question is unique. This thesis follows a research framework that is based on the design processes as described by Laurel (Laurel, 2003) and Preece (Sharp et al., 2007). The intention is to follow a design process to support research goals and not to make a marketable product. Laurel and Preece identify interaction design methods that are relevant to this form of exploratory research. Following their lead, a combination of qualitative approaches are used, as described by Laurel, and at each step of the design process, formative evaluations are conducted to verify the design goals, as suggested by Preece.

Table 1.1 illustrates the Modified Design Process implemented by this thesis. The central two sections are similar to that described by Laurel but the two outer steps make this process suitable for research. This design process enabled theoretical concepts to be developed and evaluated for a proof of concept prototype. Both the theoretical concept developed from extending the literature review combined with the participatory remarks shape the design of the Wearable Social Network (WSN) and the Patches system.

Table 1.1: Comparison of design processes.

	Quantitative Design Process	Modified Design Process
		Problem statement and initial research. (Wearable Electronics Research).
Beginning	Assess the potential market, new product opportunities, and needs of the consumer.	Create new concept with potential needs of target demographic in mind, (Wearable Social Network). Assess the opportunities of the concept through pilot testing (Patches).
Middle	Feature testing and usability testing.	Refine the design considerations of the concept through usability and experience testing (iterations of Patches).
End	Refine the branding.	Analyze results for future research directions.

Steps in the design process are shown in Figure 1.1. The problem statement – to design a system that enhances nonverbal communication for a circle of friends – is motivated by the research of Labrune (Labrune & Mackay, 2006), Berzowska (Berzowska & Coelho, 2006), Picard (Picard, 1997), and Lutz (Lutz, 1988). An initial wearable electronics exploration established suitable wearable computing tools such as materials and techniques for integrating electronics with clothing. The goal of the wearable electronics exploration was to create thin and flexible fabric interfaces that support tactile interaction. A series of experiments explored the expressive qualities of thermochromic ink, a non-emissive colour changing ink, and developed a technique to create fabric-based touch interfaces through quantitative and qualitative analysis. This initial exploration is critical to defining the technology's abilities and potential applications.

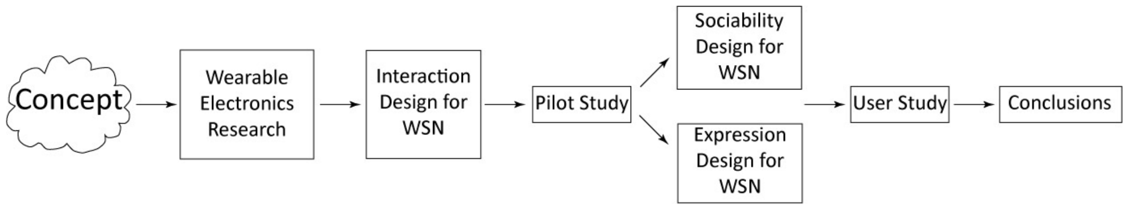


Figure 1.1: The exploratory design research process.

The next stage developed the concept and assessed the opportunities of a wearable framework. A Wearable Social Network was created by examining key social interaction characteristics from successful social networking technologies – Social Networking Sites, Mobile Computing, and Wearable Computing. This framework was applied to the design of Patches, a wearable prototype that brings virtual 'poke' into the physical domain. Patches extends online Facebook actions to the real world by allowing users to physically feel a friend's virtual poke. A text message notifies users who poked them. Users can then respond by performing a poke action to their wearable Patch. Like a real social interaction, if users do not respond within an allotted time (in this case 10 minutes) the interaction is lost. Further interaction can be mediated though the Patches system alone. A pilot study was conducted based on Laurel's (Laurel, 2003) concept testing, where design ideas were taken to an audience of early adopters and tested. The purpose was to explore the effects of sensory information on the traditional internet experience.

The third step refined the design considerations of the concept through usability and experience testing. Encouraged by pilot study results, an Interaction Model developed a range of physical expressions beyond simply poke to extend the design space to include cuddle, blush, caress, bite, etc. Social traditions such as symbolism, personalization, and gift culture were applied to the WSN framework to connect the richness of social interactions from HCI with traditions of sociology. This improved framework was motivated by pilot study results and extends the first iteration of Patches. The second iteration allowed users to order a kit that includes instructions to personalize the Patch. Users can give their personalized Patch to a friend to establish a direct channel for sending and receiving a range of physical expressions beyond simply poke.

Finally, a user study verified the design considerations of the Wearable Social Network and the Patches system. It also answered questions that had emerged out of the design process.

1.4 Thesis Layout

This thesis presents the design process in terms of concept, implementation, and evaluation.

Chapter 2 describes the conceptual framework for a Wearable Social Network by incorporating dynamic social interactions with traditions of sociology. A literature review identifies key characteristics of social interaction that are pertinent to the design of any social networking technology. Themes of expression, emotion, and meaning, emerge throughout this review to enhance sociability of the WSN framework.

Chapter 3 narrows the focus of each concept to create specific design goals for the WSN framework and implement them in Patches, a wearable social network that brings virtual interaction to the physical world. A pilot study shows the importance of adding sensory information to augment the traditional social networking experience. Formative evaluation (Sharp et al., 2007) was used to evaluate parts of the design. Chapter 4 presents the final implementation of the Patches system after two design iterations.

A user study in Chapter 5 examines the value of incorporating sociability and interaction to digital communications technologies and extends findings from the pilot study. Finally, Chapter 6 highlights the main ideas of the thesis and defines the Wearable Social Network in terms of a communications system to support friendship.

CHAPTER 2: DESIGNING A FRAMEWORK FOR WEARABLE COMPUTING

2.1 Introduction

Traditionally HCI and sociology have advanced as separate areas of research. Only recently have HCI researchers started to connect the richness of social interactions with the concepts that sociology brings into computing (Bickmore & Picard, 2005; Taylor & Harper, 2002; Zeitlyn, 2003). This chapter develops a framework for wearable computing from a social computing perspective and considers interaction and sociability as pivotal elements that can enrich the quality of communication, especially for a circle of friends. Understanding human-to-human interaction is essential to the development of computing systems in order to extend their capabilities to create more natural, social interactions with which humans are already familiar. Translating this understanding from a human-to-human view to computing will aid in the creation of machines capable of richer interaction and subtleties of expression.

The Wearable Social Network framework (WSN) is developed following a literature review of interaction and sociology and is further shaped by the design process. The chapter begins by examining how friends within a social network interact with each other and focuses on three successful social networking technologies: Social Networking Sites, Mobile Computing, and Wearable Computing. Key characteristics of social interaction were identified and form the basis of the Wearable Social Network. Encouraged by pilot study results, the review also examines theories from sociology and applies traditions of symbolism, personalization, and gift culture to the framework. Particular emphasis is placed on examining the 18 to 34 year old demographic as they dominate the usage of social networking technology (Compete, 2008; Facebook Global Monitor, 2009) on stationary computers and mobile phones. This review also identifies motivations for future work to aid the design of social computing.

2.2 Design for Social Interaction

A literature review examines the success of social networks based on their key characteristics of social interaction. Social interaction is viewed from three perspectives - Social Networking Sites, Mobile Computing, and Wearable Computing. Particular emphasis is placed on technologies that enhance interactions between person-to-person, person-to-group, and group-to-person. Figure 2.1 illustrates these key characteristics. The next sections describe how these technologies support social interaction.

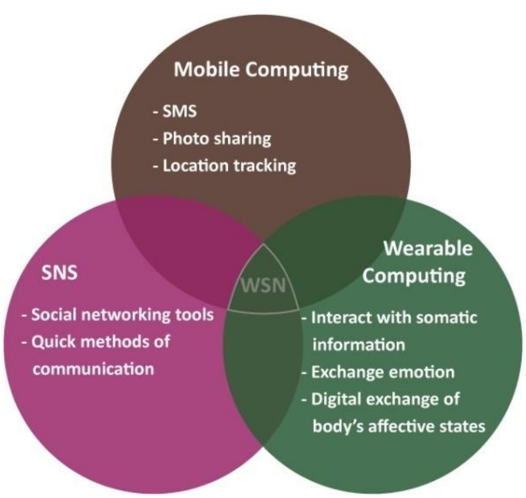


Figure 2.1: Incorporating social interaction to the Wearable Social Network.

2.2.1 Social Networking Sites

Social networking sites, or SNS, have been a main internet success story in recent years. Among them, Facebook is the most visited social networking site in North America, third most popular in Europe, and continues to grow rapidly (Lipsman, 2007). This is illustrated by numerous publications about Facebook in the last year alone (Hart et al., 2008; Lampe et al., 2008; Nazir et al., 2008).

A Social Networking Site such as Facebook offers many social networking tools: browsing or sharing photos, checking other's profiles, joining a group or network, reading or writing on the wall, finding new or old friends, creating or updating a profile, and adding or using applications. According to Hart et al., Facebook users like to keep an eye on the activities of their friends. Quick methods of communication such as poking, sending drinks or gifts, as well as applications that involve innovative ways of interacting with friends through gaming and quizzing are preferred (Hart et al., 2008).

Nazir et al. presented quantitative evidence regarding the popularity of their social game, Fighter's Club, over non-games like friend and virtual hug applications (Nazir et al., 2008).

2.2.2 Mobile Computing

Key features of Mobile Computing such as portability and mobility offer a different set of social interactions.

SMS, or text messaging, is a feature of mobile phones that has been rapidly adopted by teenagers. According to Ling et al., teenagers are attracted to mobile telephony as a method to quickly call or text others in order to coordinate activities (Ling & Yttri, 2002). Dodgeball is a mobile service that helps friends to keep in touch and enhances social coordination by allowing friends to check in to report their time and location (Google, 2008).

Camera phones enable friends to interact through photo sharing. Slam is a mobile application that combines real-time communication, location awareness, and photo-sharing (Microsoft, 2006).

Other mobile computing applications use the phone's location tracking ability to enhance social interactions. Serendipity uses Bluetooth in phones to initialize face-to-face interactions among people with similar interests, when they are in close proximity (Eagle & Pentland, 2005). Sparks is a similar 'ice breaker' or 'match maker' application (Chew et al., 2005). Plazes is a mobile service that allows users with similar interests to connect based on proximity (Plazes, 2008).

Though Dodgeball, Slam, and Plazes, have existed for years, they are nowhere as popular as Social Networking Sites. With reduced cost in mobile phone plans, the number of US wireless subscribers who accessed social networks via mobile devices increased 182% in the last year, according to Kelsey Group and ConStat (Ankeny, 2008).

Mobility is central in transforming social networking access to a wider audience. Developing mobile systems that literally sew social networking into the fabric of our everyday lives is the next step.

2.2.3 Wearable Computing

One of the main visions of wearable computing research is to integrate personal computing into one's daily wardrobe to allow ubiquitous access to computational power and universal connectivity (Berzowska, 2005). This thesis examines wearable computing for social networking purposes. The act of physically wearing a computer on the body has developed new methods of communication and a wide variety of social networking behaviours that are beyond the capabilities of SNS and Mobile Computing. Wearable computing supports unique interactions that add to the value of human experience.

One of the strengths of wearing a computer is to transmit human emotion more vividly. For instance, people can exchange a virtual hug over a distance using a Hug Shirt. While wearing the shirt, the sender hugs himself and the recipient who is also wearing a Hug Shirt will feel pressure and heat in those areas (Cute Circuit, 2008). The next chapter looks at how more expressions other than hug can be brought to the digital world.

Early projects investigated how somatic information such as heart rate, body temperature, and galvanic skin response can turn into lights and sounds (Mikhak et al., 1999). Later research examined how clothing can collect our body's affective non-verbal data and use it as a mechanism for social interaction (Schiphorst, 2005). Other wearable garments react to human intimacy such as whisper, touch, and human connectedness (Berzowska & Coelho, 2006).

Though many wearable devices excel at transmitting and receiving human behaviours, limitations prevent wearable social networking from becoming as popular as SNS and Mobile Computing technologies. The majority of these devices require face-to-face interaction to exchange digital information about the users and their relationships (Borovoy et al., 1998; Kanis et al., 2005). Only Telebeads designs for teenage social networks (Labrune & Mackay, 2006) but the designs cannot be effectively scaled for large groups. Some of them are further limited to sharing the same physical space (Berzowska & Coelho, 2006). Wearable computing applications should support the numerous interactions and complex interconnections of a user's social network since they typically have more than just two or three friends.

2.3 Design for Sociability

To better understand the richness associated with human-to-human interaction and the lived experience and encouraged by pilot study results, the literature review further develops the WSN framework by applying theories from sociology - traditions of symbolism, personalization, and gift culture. A general treatment of the terms is given first including definition and application in the everyday context from a traditional sociologist's perspective. Their applications are also extended to the digital domain. A number of examples pertain to teenagers because they are the most studied group. Incorporating these traditions to the target demographic, 18 to 34 year olds, may open new design opportunities for social computing and HCI.

2.3.1 Symbolism

A sign consists of a signifier (the form the sign takes) and a signified (the concept it represents). Together, the signifier and the signified describe an associative link (Lepschy, 1985). We make meanings through our creation and interpretation of signs and according to Peirce, “we think only in signs” (Peirce, 1931-58). Symbols are one of three forms of signs, with the other two being icons and indexes. Language is an example of a symbolic mode where the signifier does not resemble the signified. Because symbolic relationships are arbitrary or conventional, their relationship must be learned (Chandler, 2009).

Symbolism in the Everyday

People place symbolic meaning on material things, such as a wedding ring to symbolize attachment. Csikszentimihalyi writes that objects can evoke emotion that is symbolic of one’s attitude; It is through symbols that experiences such as fear, love or awe can be communicated in words, pictures, or ritual acts (Csikszentmihalyi & Rochberg-Halton, 1981).

Additionally, people are avid consumers of symbols because they embed meaning into everyday experience (Belk, 1988; Leigh & Gabel, 1992; Solomon, 1983). People use goods to create, foster, and develop their identities (Piacentini, 2004), which helps to shape an individual’s self-concept and connection to society (Elliot, 1999) and reflect their affiliation and connection to a particular social group (Elliott, 1998). As teenagers enter new phases of their lives, they negotiate feelings of uncertainty and perhaps insecurity about how to behave and rely on the symbolic properties of goods to assist them in performing the desired role (Hill, 1992) and establish their identity (Belk, 1988).

Symbols, personalization, and gift exchange are cultural specific, which will influence the design of social computing systems. This thesis designs for North American adults who frequently use social networking sites and mobile phones to stay in touch with their friends.

Symbols in the Digital World

Traditionally, symbols have been researched in linguistics where developers of language systems aim to create a universal writing system based on visual language (Marcus, 2003; Ota, 1973). Today, computer science researchers, particularly in AI, try to create machines that think and understand based on our current understanding of human cognition (Abney et al., 1991; Mayo, 2003; Newell & Simon, 1976; Pallet, 1998; Searle, 1980).

Most of the digital research in AI deals with representing symbols in a visual form, which only plays on one aspect of the human senses. However, symbols have the power to evoke emotion to create a deeper meaning, an aspect that has not been fully explored in digital systems. Initial research has been done to explore embodiment and aesthetics within human computer interaction by introducing the concept of ‘somaesthetics’ as an approach to designing for embodiment (Schiphorst, 2009). This research derives from dance and somatics, a domain that is not well understood. More research needs to be conducted to effectively use symbols as a means of communicating experiences in the digital domain.

2.3.2 Personalization

Personalization is the process of changing a system to increase its personal relevance to an individual, mainly through functionality, interface, information content, or distinctiveness (Blom, 2000; Mackay, 1991). As Ahde (Ahde, 2007) writes, people need significant and personal items in order to grow the feeling of safety and familiarity in their everyday experiences. Hence, they adorn their environment in order to make spaces and products their own.

Motivations for personalization are twofold: those that facilitate work, and those that accommodate social requirements (Blom, 2000). This thesis is interested in the latter. Social motivations of personalization include eliciting emotional responses and expressing identity. For example, a work desk is personalized by adding one’s own things such as photographs, etc. The process of personalizing a desk has been shown to help workers to cope with and enjoy aspects of working (Scheiberg, 1990).

Personalization for the Everyday

There is no doubt that personalization allows people to express their unique identities. Personalization creates a strong emotional connection as exemplified by the ritual of a friendship bracelet, common among teenage girls. These bracelets have little exchange value as they are typically created from inexpensive woollen or cotton threads with stone, wooden pearls, or plastic.

Giving the woollen thread to the best friend adds the value of significance (Sahlins, 1976); otherwise, it remains as a piece of thread. These pieces of threads may look worn but each tells a story. Are computers capable of eliciting the same strength of emotional ties? Its potentials are examined below.

Personalization in the Digital World

Today, research in personalization is largely confined to developing computer software such as databases and dynamic web page generation. There are several popular techniques for creating recommender systems that are used for primarily work related motivations such as pattern matching (Babaguchi et al., 2001), machine learning algorithms (Andruszkiewicz et al., 2004), rule based inferencing (Adomavicius & Tuzhilin, 2001), and data mining (Kramer et al., 2000; Mulvenna et al., 2000).

On the other hand, much research is devoted to personalizing software by creating a user experience that is primarily web based (Anderson et al., 2001; Karat, 2003; Schwabe et al., 2002; Surprenant & Solomon, 1987). Though this dialog for system design is necessary and valuable, much of this research pertains to mass customization and mass personalization for the end user from a business perspective (Kramer et al., 2000; Riecken, 2000; Surprenant & Solomon, 1987) which may not align with the goals of personalization. Customization is a system-initiated process of increasing the personal relevance to an individual while personalization is a user-initiated process. It is questionable whether the mass production of individually customized goods and services supports the creation of individual identity. Furthermore, it is still left to be seen whether these implementations are worth the trouble involved in personalizing in the first place (Mackay, 1991).

Digital projects outside of pure computing are only beginning to develop emotional and expressive systems. Early work in electronic personalization involved teaching children to make their own electronic jewellery. Researchers of CodaChrome (Dekoli & Mikhak, 2004) noted that children felt more connected to their pieces due to their engagement in the personalization process. Only Telebeads allowed teens to create, modify, and share their jewellery as a way to communicate across small social circles but these applications were not physically realized due to hardware constraints (Labrune & Mackay, 2006).

2.3.3 Gift culture

One common theme in friendship is gift exchange, such as the exchange of friendship bracelets. One of the most widely accepted theories of gift culture is proposed by Mauss (Mauss, 2000) who states that gift giving is a transaction of objects coordinated by a system of rules. He describes the act of reciprocity in gift giving as a power struggle between the giver and receiver. The act of giving a gift demands a return of a gift and puts the giver in an advantageous position in his relation to the recipient. Conversely, Hyde (Hyde, 1983) views a gift as something that cannot be bought nor acquired through an act of will; it is bestowed upon us like a talent. The spirit of a gift is kept alive by its constant donation, which establishes interconnected relationships in its wake, and a kind of decentralized cohesiveness emerges within the group. Reciprocity in his view is the back and forth movement of the gift, changing hands in a circular fashion. The objects themselves are not commodities.

Gift Culture for the Everyday

Today, gift exchange is viewed in two ways: economic exchange and social exchange (Ekeh, 1974). The social model places the gift value as that determined by the giver and the recipient. Preferences between gifts with different economic values depend on their symbolic value and there is an obligation to respond with something of comparable symbolic worth. This practice stresses gifting as a bonding tool.

Gift Culture in the Digital World

The activity of gift exchange proliferates in digital times, extending research from Mauss and Hyde. The value of gift exchange has been studied more closely in the digital domain than the other two traditions. Taylor et al. (Taylor & Harper, 2002) studied the ways in which teenagers use their mobile phones to participate in social practices. They noted that teenagers treat certain text messages, call-credit and the mobile phones themselves as gifts. For example, text messages to bid the other ‘goodnight’ is made special through the observation of ceremony that instils a value through this ritualistic exchange so that the words are no longer text but become an offering of commitment to a relationship. The power of reciprocity is demonstrated when teenagers feel compelled to answer the messages, even in the early hours of the morning. Similarly, researchers have argued that the success of open source software development in online communities is a result of social gift economy (Bergquist & Ljungberg, 2001) where people do things for one another out of the spirit of building 'something' between them (Rheingold, 1993).

2.4 Tying it Together: Interaction, Sociability and the WSN

Figure 2.2 shows a Wearable Social Network framework that is capable of supporting all of the individuals and their social activities. At the base of this framework are key characteristics of social interaction that have led to the success of three social networking technologies: Social Networking Sites, Mobile Computing, and Wearable Computing. The WSN lies at the centre of the three and inherits all of the common characteristics. Equally important to the framework are themes of social computing that emerged through the review of sociology relating to traditions of symbolism, personalization, and gift exchange. The next sections describe the Wearable Social Network in more detail.

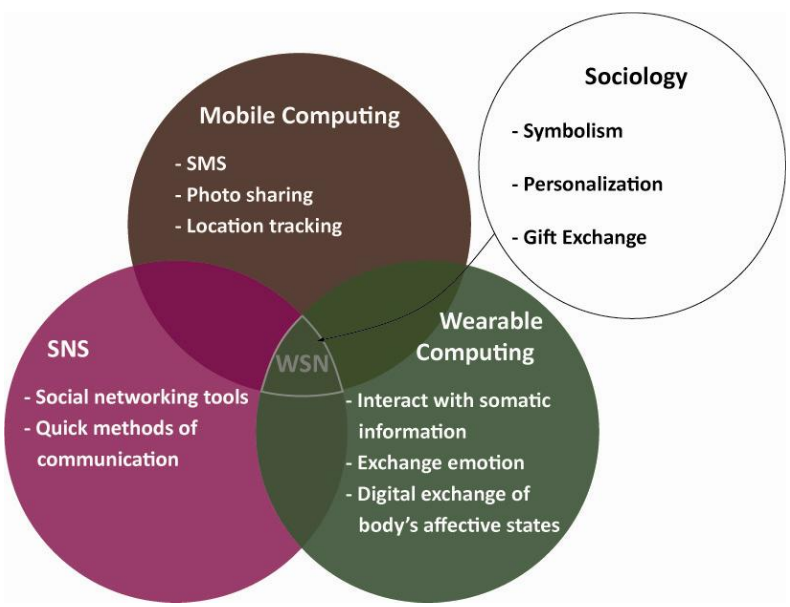


Figure 2.2: Augmenting the Wearable Social Network framework with traditions of sociology.

2.4.1 Social Interaction and the WSN

The social interaction review identified some important characteristics that are pertinent to the design of social networking technology. While Social Networking Sites have the capabilities to support a vast social network, it is one dimensional in its approach to support friendship activities: the internet. The dimension of portability that Mobile Computing provides seems to compensate for the limitations of social interactions offered by SNS. However, Mobile Computing has been unable to reach a wider audience largely due to the high cost of mobile plans. More research should be conducted to better understand social computing and mobiles. Research in Wearable Computing has shown that mobility can be integrated with sensors to transmit and receive remote human behaviours more vividly. Wearable Computing offers a rich set of social interactions and expressions that are vital to supporting and maintaining social relationships. However, this research is relatively new and technical limitations prevent them from leaving the research labs.

The WSN inherits all of the common qualities of SNS, Mobile Computing, and Wearable Computing. Overlaps in the Venn diagram represent common themes that are pertinent to the design of social networking technologies.

Rapid Communication

Particularly in SNS and Mobile Computing, there is a desire for fast and simple communication through text, SMS, and voice. It is not known whether people with wearable devices show the same sentiments. The WSN provides people with many different opportunities for communication that may be more direct, intuitive, quick and easy for maintaining contact with friends.

Digital Exchange of User Information

All three research directions state that people commonly share their own information and enjoy browsing their friends' information. The main interaction techniques are through exchange of text and photos to evoke emotional responses. The WSN extends the type of information exchanged between friends and opens new opportunities for expression. For instance, one of the main aspects of Wearable Computing is to allow people to interact with somatic information rather than text and photos. Transmitting the physical sensation of touch through a distance may create more emotional and playful technologies. This sensation can be enhanced and brought into the real world by actuators embedded inside a garment, indicative of Wearable Computing. These ideas are explored through design and evaluation of a prototype, Chapter 3.

From an interaction perspective, these themes represent critical features of a social network. The ability to share user data, and share it quickly is essential in maintaining a social connection between friends. In practice, these design elements translate into an easily accessible, ‘always-on' network that is capable of large amounts of data storage on a fast communications channel. This analysis makes Social Networking Sites a preferred choice among the three, as exemplified by its popularity. A Wearable Social Network is advantageous in that by incorporating the other modes of communication, it redefines the type of information to be shared, and more importantly, a new design space in which to share it. This framework also extends the scope of traditional social networking technologies by supporting all of the individuals and their expressive activities.

2.4.2 Sociability and the WSN

Themes corresponding to expression, emotion, and meaning, emerge throughout this review of symbolism, personalization, and gift exchange. These themes are now discussed to enhance sociability of the WSN framework.

Communication through Symbolism

The meaning that people place on objects is symbolic of their experiences, which helps them to communicate through words, pictures, or ritual acts. A social network should allow people to express their self-concept and connection to society. The Wearable Social Network explores communication using non-explicit and non-verbal methods: through icons and touch. Touch is a natural method of interacting with clothing. For example, a poke from a friend can express playfulness; a pat on the back can be associated with a job well done, etc. Icons can enhance this tactile quality. Furthermore, the WSN leverages the communication strength of social networking to allow the target demographic to communicate with their entire circle of friends, not just two or three.

Create Strong Emotional Ties through Personalization

Personalization allows people to elicit strong emotional ties and express their identity. A social network should support people to express themselves within their group of friends. One method of achieving this goal is through a Do-It-Yourself (DIY) approach. In this thesis, DIY refers to a culture that is known to tinker, hack, fix, reuse, and assemble materials in creative ways and often share their production process with others (Buechley et al., 2009). DIY explicitly critiques consumer culture where instead of purchasing a solution, it encourages people to create things for themselves. Originating in the alternative and punk music scenes where members blurred the lines between creator and consumer, DIY has re-emerged as open source, zine (DIY magazines), and home improvement communities, just to name a few. This thesis is interested in the social implications of DIY. DIY workshops have shown to convey feelings of connection (Dekoli & Mikhak, 2004) and empowerment (Buechley & Eisenberg, 2009) in previous research involving children. This thesis examines DIY behaviour in adults, more specifically how DIY can enhance social networking among a group of friends.

Create Bonds through Reciprocity

Gift giving creates a bond between the giver and receiver. On the one hand, this bond may be a power struggle, while on the other, an interconnected relationship. In previous examples, reciprocity was described as gifting of digital artefacts such as text messages but perhaps specifically designing for reciprocity may have different outcomes. The design of a tangible system that supports gifting should be portable and easy to exchange.

2.4.3 Examining the WSN

The WSN is designed with specific goals of social computing. A number of claims were made in previous sections about incorporating concepts of interaction and sociability to technology for enhancing nonverbal communication for a circle of friends.

A review of social interaction identified a variety of methods to exchange information beyond traditional text and images. Incorporating Mobile Computing and Wearable Computing to traditional Social Networking Sites may redefine the type of information to be shared and opens a new design space in which to share it. This thesis explores the value of transmitting touch as a method of enhancing nonverbal communication between friends. A number of questions arise: How do social networking sensory interactions differ from traditional online interactions? Will users want sensory input? Will it be disconcerting for users or will they feel in control of their environment? More importantly, why is this design space important? These questions are examined through a pilot study and a user study.

The review also identified important themes pertaining to traditional human-to-human interaction, which may translate into systems more capable of natural social interactions. This thesis examines the value of incorporating symbolism, personalization, and gift culture to digital communications technologies. A number of questions arise: How do symbols, such as icons and touch, help friends to communicate with each other in the digital domain? How does the personalization process allow users to increase the relevance of their digital objects? How do friends bond through gifting of a digital artefact? A user study further investigates these questions.

2.5 Summary

This chapter proposes the design of a framework for a Wearable Social Network from a social computing perspective that combines HCI with sociology. A literature review examined the success of social networking technologies from an interaction perspective: Social Networking Sites, Mobile Computing, and Wearable Computing. These characteristics developed a social framework that is not limited in social networking scope and is capable of supporting all of the individuals and their expressive activities. Sharing user data quickly is essential in maintaining a social connection between friends and an integral feature of social networking technologies. The literature review also examined the traditions of symbolism, personalization, and gift culture in terms of sociology and investigated how they may be used in the digital world. Key themes such as expression, emotion, and meaning emerged and three key characteristics were isolated as design goals of the Wearable Social Network: communication through symbolism, creation of strong emotional ties through personalization, and creating bonds through gifting. This framework can be applied to any social network, not just for a wearable network. The Wearable Social Network redefines the type of information for sharing, not just the typical text and pictures, and creates a new design space in which to share it. These claims are verified through the design and implementation of Patches, a wearable system that is based on the WSN framework. The next chapter describes the design of Patches from a social interaction and sociability perspective and examines the design space created by the Wearable Social Network.

CHAPTER 3: IMPLEMENTING PATCHES

3.1 Introduction

This chapter applies the Wearable Social Network framework to a wearable system called Patches following two design iterations. The first iteration designs a system that accommodates a wide variety of social interactions currently only possible from Social Networking Sites, augmented with communication strengths from Mobile Computing, and emotional affordances from traditional Wearable Computing. Research into wearable electronics further guides the design of the system. A pilot study is conducted using Patches to better understand the WSN and explore the design space. Motivated by pilot study results, the second iteration of Patches aims to extend human-to-human interaction and develop the system to be more natural and social. Patches Expressions, the second iteration of the system, incorporates social computing design goals from the WSN framework: communication through symbolism, creating strong emotional ties through personalization, and creating bonds through reciprocity. This chapter implements the social interaction and sociability concepts identified in the literature review and begins to explore their practical implications through a pilot study.

3.2 Design Process

To reiterate, this thesis takes a “design exploration” approach to research (Fallman, 2008). The previous chapter developed a framework for a Wearable Social Network by incorporating concepts of social interaction and sociability. Important ideas about social networking as well as expression, emotion, and meaning, emerged through the literature review. This chapter and the next seek to explore these ideas and discover new possibilities within the context of social communication for a circle of friends. In this chapter, the goals of social interaction and sociability that were identified from literature review are implemented and the design space created by the WSN is explored. Figure 3.1 shows the design phases this chapter emphasizes. This design process is a vital part of the research process in order to explore the user experience and obtain the knowledge sought by the research question.

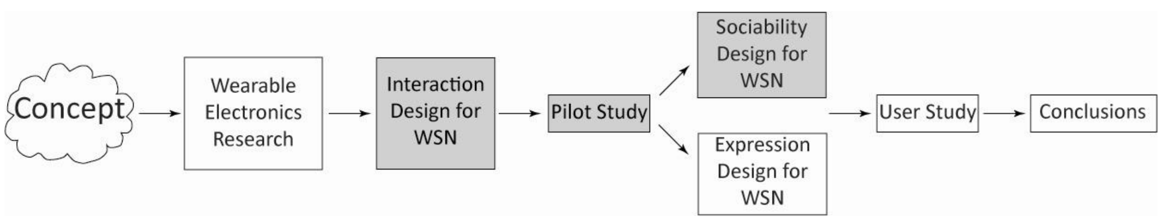
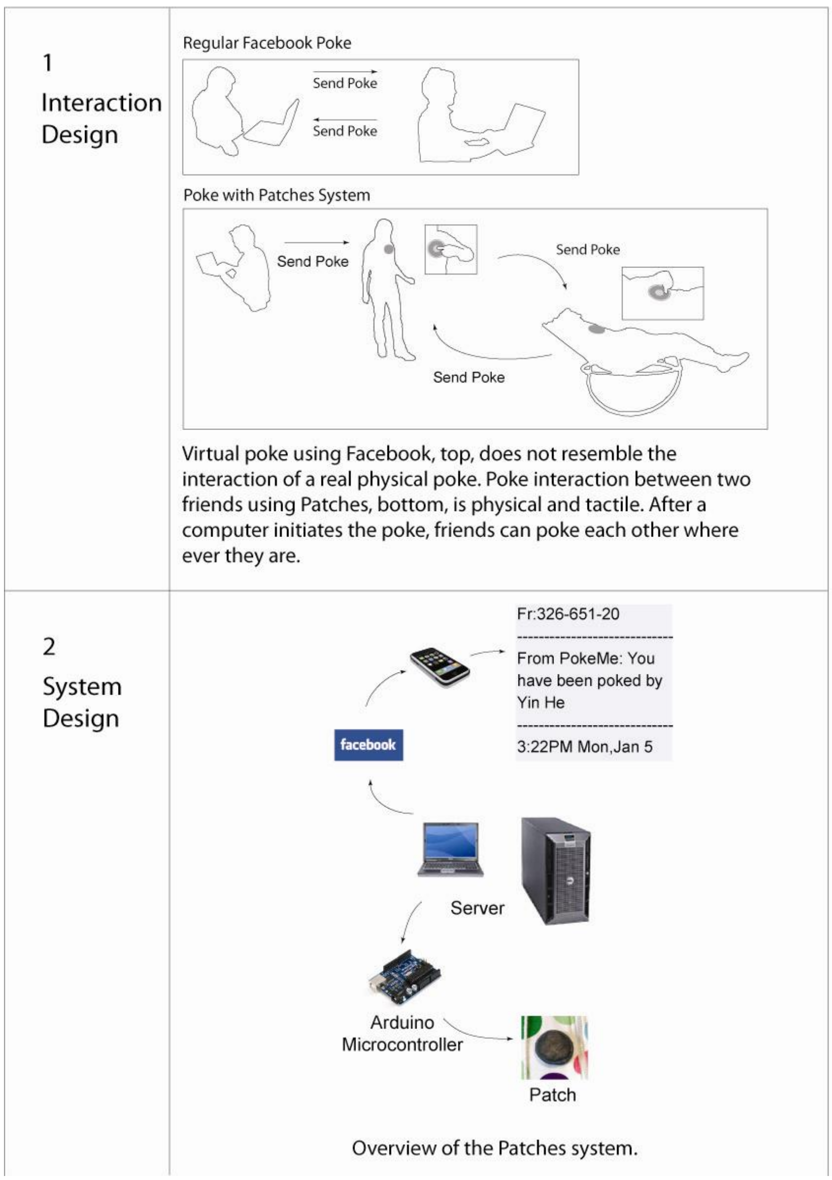


Figure 3.1: Research process emphasizing social interaction and sociability design.

3.3 Patches for Social Interaction

Patches is a unique mobile device that brings virtual online internet expression into the real world through a physically actuated and sensory augmented wearable Patch. Patches is designed to extend social networking activities, not to create a social network. Therefore, Facebook was chosen as a backend infrastructure for its rich set of social interactions and its existing large social network. In the first design iteration, the ‘poke’ feature was explored, a tool that encourages interaction among a variety of people – a friend, a group of friends, or a stranger – by virtually poking them.

The first iteration of Patches incorporates social interaction concepts from the Wearable Social Network. There were three design phases: Interaction Design, System Design, and Patch Design, resulting in the Completed Prototype illustrated in Figure 3.2.



Virtual poke using Facebook, top, does not resemble the interaction of a real physical poke. Poke interaction between two friends using Patches, bottom, is physical and tactile. After a computer initiates the poke, friends can poke each other where ever they are.

Overview of the Patches system.

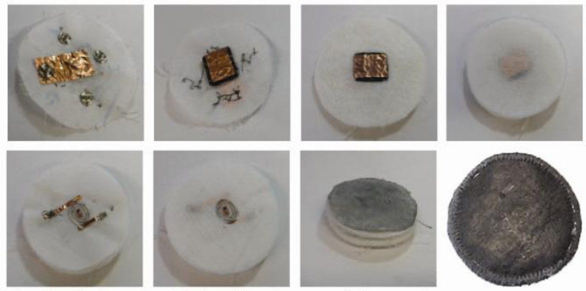
3 Patch Design	 The Patch is embedded with 7 layers of electronics.
4 Completed Prototype	 A wearable social network integrates seamlessly into a sweatshirt.

Figure 3.2: Patches design steps and the completed prototype.

3.3.1 Interaction Design

The first design phase develops the social interaction concept for Patches. In this iteration, Patches is intended to help people to better understand and experience a virtual poke. In a regular Facebook poke, Figure 3.2, the sender logs onto Facebook and clicks a button to poke her friend. The sender sees the following message, “you have poked…”, while the recipient sees, “you have been poked by…”. The experience and understanding associated with this virtual poke can be ‘fun’ but the rich sensation and embodied response of the real world is lost since it does not resemble the physical sensation, or flirtation, associated with a real poke. Consequently, some active users of Facebook do not use virtual poke (data from pilot study) while others write on forums asking for clarification (Yahoo, 2007). This is one instance where computer mediated interaction can help people to better understand and experience their own emotional responses. Patches physically enhances the Facebook poke to augment social networking.

3.3.2 System Design

This design phase implements the social interaction concept into a computer network. The server runs on JBoss, a Java application server. Since standard Facebook Java API forbids retrieving poke information such as who sent the poke, a JavaScript application called PokeMe parses the Facebook homepage for new pokes. PokeMe communicates with the Java server using cookies. On receipt of a new poke, the server communicates wirelessly via wifi to the Arduino microcontroller, which then triggers the Patch. At the same time, PokeMe sends a text message to the recipient letting him know the name of the sender. The recipient can poke the sender back simply by touching the Patch within an allotted period, 10 minutes, after receiving the poke message. If the recipient waits too long, like in real social interactions, the interaction ends. If the recipient pokes the sender within the allotted time, further interactions can be communicated via the sender's Patch thereby creating a strictly mobile communication without need for a stationary computer.

3.3.3 Patch Design

This phase explores the design of a computationally augmented wearable Patch that seamlessly integrates into clothing. Research into wearable electronics informed the design of the Patch. This research developed a set of tools for creating interactive fabric interfaces and further explored the expressive and interactive possibilities of wearable computing. Thermochromic ink, a non-emissive colour changing ink was painted onto fabric and a variety of electronics and sewing materials were used to control its states. A variety of techniques and specifications were developed to successfully control nichrome wire, conductive thread, and diodes as heating elements. This research extends the contributions from Orth (Orth et al., 1998; E. R. Post & Orth, 1997), Berzowska (Berzowska, 2004), and Buechley (Buechley & Eisenberg, 2009) by exploring the dynamic properties of the ink: hide and reveal information, animation, and fabric pixels. This research also proposes the design of a fabric touch-pad, which can measure touch qualities as a natural method of interaction with clothing. Appendix A summarizes results from the research.

The wearable electronics research was applied to the design of the Patch as a wearable and interactive interface rather than an element of fashion. This was accomplished by integrating the system into clothing to comply with the current trend, in this case a sweatshirt. The computational elements were hidden within fabric and a design was chosen that was appropriate for clothing; the round shape of the Patch complemented the design of the sweatshirt.

The steps described below effectively embed electronics into clothing to allow for expressive communication that is irrespective of the outward appearance of the garment. The Patch consists of seven different layers with embedded electronics, Figure 3.2. From top to bottom and left to right, the first picture shows the back of Layer 1. Four metallic snaps attach the Patch onto clothing and power the two sensors. Conductive thread and conductive tape fasten the electronics onto fabric. Layer 2 shows the top view of the touch sensor, made of conductive foam. Layer 3 is a felt layer that separates the conductive foam. The vibration motor is integrated into this layer which is better seen in Figure 3.5. Layer 4 separates the two sensors. Layer 5 shows the heating element, a diode. Layer 6 is an oval cut-out and separates the leads of the diode. Layer 7 is cotton fabric coated in thermochromic ink. The completed prototype figure shows the Patch during regular and poke conditions.

3.3.4 Completed Prototype

The electronic sensing actuator Patch integrates seamlessly into clothing and maintains its flexibility and thickness just like a regular patch. The electronics including Arduino and power supply are sewn into the sweatshirt’s pocket. The

Arduino connects to a laptop for transmitting data between the server and the Patch via wifi. Future iterations of this project should make use of small embedded wireless device servers, such as the WiPort from Lantronix, for true portability. Wires are sewn along the seam of the sweatshirt to metallic snaps that connect to the snaps of the Patch. Embedded inside the Patch are vibration motor, as well as touch and heat sensors. The vibration motor creates an initial jolt as felt by the recipient, similar to the physical sensation. The touch sensor lets the recipient poke the sender while the heat sensor triggers the heat-sensitive thermochromic ink on the surface. A text message tells the recipient the identity of the sender. See Appendix B for circuitry details and Appendix D for source code and running instructions.

3.4 Pilot Study

The pilot study uses Patches to explore the effect of sensory information on the traditional social networking experience by gauging user understanding and interpretation of the design space. This design space is exemplified in Patches where online virtual events such as the Facebook poke are expressed as a physical event contextualized within the social and physical world. Understanding this space will open new opportunities for expression and interaction within HCI.

To reiterate, the pilot study takes a preliminary look at these questions: How do social networking sensory interactions differ from online interactions? Will users want sensory input? Will it be disconcerting for them or will they feel in control of their environment? More importantly, why is this design space important?

Since little research has been conducted in this area, this pilot study presents an initial investigation. The approach was to target a wide audience in order to receive a variety of responses. The quality of the responses will help to describe the design space and make suggestions for future work. A more detailed user study was conducted once the design was complete, Chapter 5.

The pilot study was conducted as a technical demonstration during two events: at a booth at an Open House event at the university and at a panel discussion at a conference. As participants passed by the booth, they were given an explanation of the Patches project followed by an experiential ‘test-interaction’ where they became recipients of the poke interaction: feeling the vibration and sensing the heat on the Patch. After, they filled out a questionnaire that tried to obtain an initial experiential response of the design space, Figure C.1. Respondents could have more than one response to a query. Content and quality of the responses were analyzed and coded for keywords. In total, there were fourteen participants. They were both Canadians and Americans who varied in ages (teens to middle-aged adults) and Facebook comprehension levels (from some understanding of Facebook to professional user) as the aim of the study was to receive a general experiential response. A user study in Chapter 5 is more focused.

3.4.1 Analysis

Overall, participants welcomed adding sensory information to online communication. When asked about how sensory information such as heat and vibration changes their online experience, participants gave 21 different responses: 48% of the respondents agreed that sensory information such as heat and vibration brings a physical, tangible, real world experience to online communication; 24% of the responses stated that sensory information extends, broadens, enhances, and completes the online experience. When asked specifically how the sensory information changes the online Facebook poke experience, participants gave a total of 19 responses: 47% agreed it made the experience more personal and real, and 21% said it was more fun. The word ‘fun’ was scattered throughout the responses; and 16% noted that they became more aware of the network and felt more connected. Human connection is an important aspect of social networking that is successfully brought out through Patches. One respondent noted the following:

“[Patches] makes it even more fun, to actually ‘poke’ other people but in real life, knowing you ‘actually’ poke them physically”.

One participant did not welcome the project and stated the following:

“[Patches] feels a bit gimmicky, the hardest part being an interaction without anyone there physically triggering [the poke]”.

When asked whether participants saw any benefits of using Patches for communicating with their friends instead of using a computer, a total of 14 responses were collected. 39% of the responses considered Patches advantageous because of its direct physical nature, they no longer need to log into Facebook to experience a poke. Again, this response points to connection as an important factor in social networking. Another 38% of the responses suggested they wanted some level of customization, whether a different type of output, a customizable sign signifying friendship, or customizable social signals. Some envisioned using Patches to communicate with close friends and family while others envisioned using the device while on the go.

All participants wanted some sort of device that incorporates sensory input to online communication: 79% responded yes while the rest replied maybe. For those that said maybe, they wanted to see other functions and styles before deciding. The participant who called the project “gimmicky” did want such a device. One participant stated the following:

“[Patches] gives a neat sense of taking your social network with you”

3.4.2 Discussion

The importance of the ‘online vs. offline’ design space emerged as the main theme from the pilot study: the addition of sensory information that can be worn and felt created a much stronger physical connection than the traditional internet experience. Social networking sensory interactions differ from regular online interactions because they create a more real and personal experience for the participants. The nature of this connection also creates a fun experience with which participants easily identified. Clearly, users want sensory input to enrich their traditional internet experience. Encouraged by the results of the pilot study, a second iteration of Patches, Patches Expressions, further defines the possible types of expressions and interaction opportunities for this design space.

In addition, the pilot study acted as a preliminary evaluation for the WSN framework. A user study in Chapter 5 will further strengthen these results. Some key characteristics from the pilot study were consistent with the design goals identified in the social framework and are discussed in the next section.

3.4.3 Implications of the Patches System

Patches recreates the expressiveness associated with the social interaction of a physical poke, which is playful, intimate, and possibly flirtatious. Like real social interactions, the recipient of the poke can either ignore it and end the interaction, or poke the sender to encourage the game. The Patch represents the sender and touching the Patch mimics physically poking him.

Translating Facebook's virtual poke offline offers many interaction techniques not found in current wearable devices. These interaction techniques were found to be key characteristics in the WSN framework and explored below.

Timely Responsiveness of Communication

With Patches, people no longer need to log onto Facebook to experience a poke. Sending a text message takes time on a small keypad, while communication offered by Patches is direct, intuitive, quick, and easy. Similarly, one of the most reoccurring themes revealed that Patches was more useful because it provided a direct connection to Facebook for instant online communication with friends. This direct connection allowed participants to feel more connected with their network of friends.

Interaction with Somatic Information

A main feature of Patches is its ability to transmit the natural human sensation of touch through a distance. Touch is essential in our emotional health and development, by helping to treat infants, the elderly, people that are isolated, and sufferers of mental illness or trauma (Champagne & Stromberg, 2004). Furthermore, Patches transmits this physical, tactile, information in a familiar manner, through the natural interaction with clothing. Though many wearable devices can be considered emotional interfaces, (Bonanni & Vaucelle, 2006; Mikhak et al., 1999; Mueller et al., 2005; Teh et al., 2008). Patches eliminates the need for an 'external' object, such as a stuffed animal (Teh et al., 2008), thus creating a more natural experience. It also allows two-way communication to allow recipients to directly respond. Patches quite literally adds to the non-verbal communication associated with our clothing (Lee et al., 2005). Most people enjoyed feeling the physical poke from the virtual environment in the pilot study. They felt the direct connection offered by Patches adds to the novelty and brings meaning to the interaction.

Exchange Emotion

Patches allows wearers to experience a poke more directly. Wearers feel a jolt on their body, similar to the physical poke interaction; see an oval imprint, resembling the shape left from a friend's finger; and feel heat on their body from the Patch, resembling the heat left behind from the friend's finger. The experience of poking can also be modelled further with sensors. For example, sensors can physically depress the shirt for the duration of a poke. The purpose of this project was not to accurately recreate the poke sensation but rather illustrate that it is possible to send such a sensation as a communication between friends. Likewise, participants in the pilot study enjoyed the physical, tangible, real world, direct, experience created by Patches. Participants found that this direct connection creates a more personal and real interaction. One of the reoccurring themes from the pilot study revealed that Patches makes the poke interaction on Facebook more fun. To enhance playfulness, participants expressed the desire to personalize the appearance of their Patch as well as incorporate subtle social signals such as Punch Me, etc. The design process further explores the expressive range of Patches, Chapter 4.

3.5 Patches for Sociability

The second iteration of Patches, Patches Expressions, was designed in response to pilot study results where the direct connection it created allowed participants to immediately see its social implications. Participants wanted to buy them for family and friends as gifts or DIY their own with other styles. Many of them wanted more methods of interaction other than poke. This prompted the addition of sociability design goals to the WSN framework. Patches Expressions implements social computing design goals from the Wearable Social Network - communication through symbolism, creating strong emotional ties through personalization, and creating bonds through reciprocity – in order to extend human-to-human interaction and develop more natural and social systems. The development of Patches Expressions is presented in two parts: this section describes implementing social traditions to Patches while the next chapter develops a range of physical expressions and presents the final design.

3.5.1 Scenario

The second iteration of Patches, Patches Expressions, builds from the original to include sociology design goals and a range of physical expressions to extend the poke interaction on Facebook. A scenario describes the proposed usage of Patches from a user perspective. A DIY approach was taken to empower the user and harness creativity and imagination. The DIY steps are meant to be simple and knowledge of electronics should not be required. Harder steps are also included for experts.

Figure 3.3 : Patches kit includes blank Patch, thermochromic ink set, paint brush, thread, iron-on transfer paper, needle and snaps.

Mary just bought a Patches kit from the Patches Expressions Facebook site and is eager to start sending physical expressions to her friends. Mary opens *her kit eagerly and finds the materials. The instructions state that the Patch can be given away to whomever she likes so that they may communicate directly to each other. She decides to give it to her best friend Alicia. She notices that there are two different sets of instructions for personalizing: an ironing and a sewing method. Having never sewn before, she opts for the former. Following the novice instructions, she quickly makes a design using Paint and draws a four-leaf clover to bring her friend luck. She prints it out on her inkjet printer. She cuts out the design and irons it onto the front of the Patch. She paints over the front of the Patches with the thermochromic paint and brush from her kit and dries the paint with her hair dryer. When she warms the surface of the Patch with her hand, the thermochromic paint disappears revealing her four-leaf clover icon. She then registers the Patch on Facebook to indicate that it belongs to her and connects with Alicia. The next day she exchanges Patches with Alicia at school. Alicia has sewn her name in the Patch so that the word "Alicia" lights up when an expression is sent. She pins Alicia's Patch on her shirt and puts the microcontroller and power pack inside her jeans pocket.*

She decides to send a test expression to Alicia. Logging onto the Patches Expressions application, she clicks the 'send expression' tab and Alicia's name is already selected. The interface tells her to press the start button and start drawing. As she draws, she notices that the words below the cursor change according to her mouse movements. Satisfied with the 'tickle' expression she drew, she clicks the play button and watches her drawing unfold in real-time. She sends the expression to Alicia by clicking the send button. Five minutes later, she *feels a vibration on her Patch and sees the word Alicia light up. A text message on her phone tells her that Alicia had sent her a 'hug'. She logs into Facebook to check the drawing Alicia has sent her. She consults the instructions for sending physical expressions and decides to send a 'shake' by grasping the left and right sides of the Patch and shaking.*

This scenario illustrates the proposed usage of Patches from a user perspective and describes methods to obtain a Patch Kit, to personalize, and to send and receive physical expressions. The next sections describe how sociability design goals are implemented into the system.

3.5.2 Communication through Symbolism

The Patches system allows people to express themselves using icons and symbols; a possible example is outlined in the scenario. By taking the DIY approach, these designs are no longer confined to selection from limited choices that are typical of mass customization. Additionally, Patches can be used to examine touch as a symbolic, natural method of communication through clothing. Some areas of the body may respond differently to a physical poke such as the stomach may be prone to being tickled.

3.5.3 Creating Strong Emotional Ties though Personalization

Patches supports the process of personalization for social purposes. The surface of the Patch can be personalized by heating the thermochromic ink in one of two ways. The choice of method may depend on the user's sewing skills.

The first and easier method for novices is to personalize by backlighting a message, Figure 3.4. By using an inkjet compatible iron-on transfer, users are free to make any design they wish on a computer and print it onto the transfer paper. The size of the printed message should be no greater than 2cm in diameter so that it can fit inside the lighted section. The design should be printed in a mirrored fashion to transfer correctly. To transfer the design, cut it out and iron it onto the Patch. The final step is painting the thermochromic ink to the Patch surface. Due to the properties of the paint, it must be dried with a blow dryer for curing.

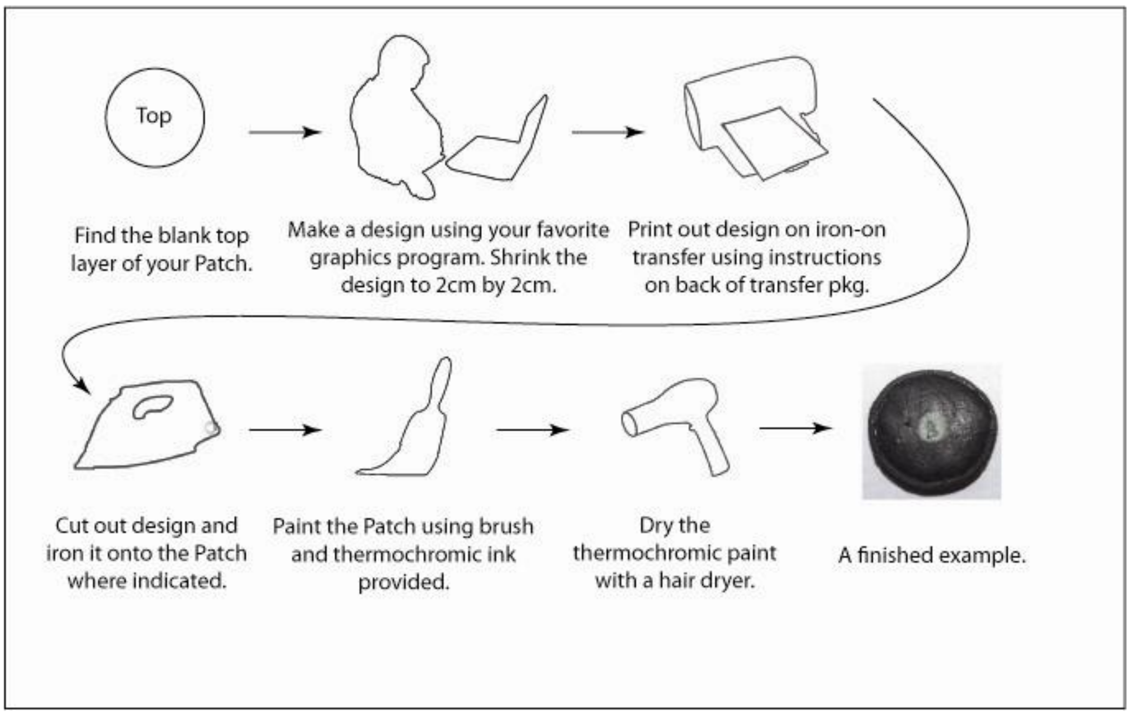


Figure 3.4: DIY instructions for novices using iron-on transfer approach.

The expert method requires some sewing to personalize the lighted message. Instead of using the diode to heat the thermochromic ink on the Patch, like in Layer 5 of Figure 3.2, conductive thread can be sewn into this layer instead. The leads of the conductive thread must be attached to the two metallic snaps at the back in order to create an electrical connection to the microcontroller. Figure 3.5 details steps for experts for creating a Patch.

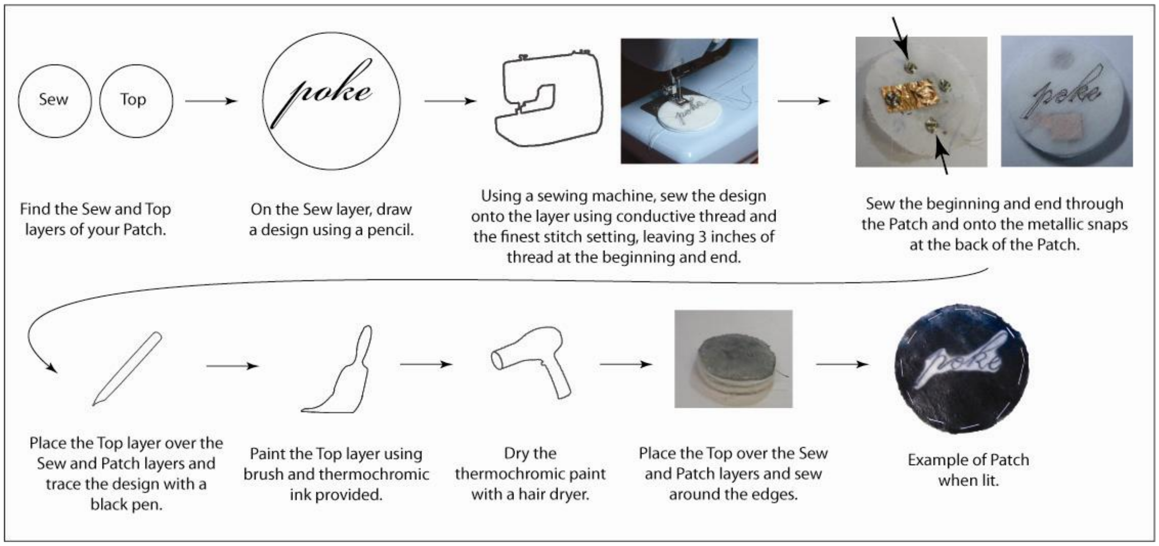


Figure 3.5: DIY instructions for experts involving sewing.

DIY is just one approach to creating sociable systems that enhance expression and create strong emotional ties. These characteristics, which emerged from the review of social traditions, are vital elements for enhancing the quality of communication for a circle of friends. Implementing the characteristics at the system level will create natural social computing interactions with which humans are already familiar and enrich the value of social networking.

3.5.4 Creating Bonds through Gifting

Gift exchange creates a personal bond between the giver and receiver and enhances social networking. The exchange of a tangible physical medium, the Patch, extends the capabilities of traditional social networking sites from a pure online presence and into the physical domain. It would be interesting to see how reciprocity occurs. Will recipients feel compelled to gift a Patch in return as in Mauss' case or will gifting be gradually reciprocated as described by Hyde?

A server is used to store sharing information. In the above scenario when Mary registers her Patch, the server stores her Facebook identification number along with the IP addresses of each wifi enabled Patch, using an SQL database. The server also stores her sharing options with her friend's Facebook identification number, also in the database. Therefore, when she receives a poke from Alicia, only Alicia's patch will trigger, lighting the word "Alicia". Non-Patches users can only visually communicate with Mary through the drawing interface on Facebook. Patches also supports a 'global option' where the recipient can choose to receive all pokes from all friends on Facebook, instead of sharing with one particular friend. In this case, the server stores the Facebook identification number as well as the IP address of the Patch. The next chapter describes this option in more detail.

3.6 Summary

This chapter describes the design and implementation of a wearable system called Patches following two design iterations; the first focused on social interaction while the second on sociability, with a pilot study in between.

Patches was originally designed to help people to better understand and experience a virtual poke by physically actuating these experiences. Like a real face-to-face communication, recipients can choose to respond through physical interaction. If the recipient waits too long, the interaction ends. The design of the Patch is guided by research that developed a set of wearable computing tools.

The pilot study assessed the role of sensory information in augmenting the traditional internet experience and better defines the “online vs. offline” design space created by the WSN framework. The addition of sensory information that can be worn and felt was found to create a stronger physical connection than traditional internet systems and led participants to feel more enjoyment, pleasure, and engagement. This new dimension may open many possibilities for studying expression and interaction. The Wearable Social Network encourages interaction unlike most wearable technologies today: timely responsiveness of communication, interaction with somatic information, and exchange emotion. The WSN is capable of sharing sentiments, which extends the scope of social networking. Patches is merely one application that uses this design space to enhance social networking.

The pilot study revealed some unexpected findings relating to sociability and expression that encouraged the second iteration of Patches. Participants expressed the desire to extend sociability of the system through personalization and they all wanted to see more interactions. This prompted the addition of social computing design goals to the WSN framework: communication through symbolism, creating strong motional ties through personalization, and creating bonds through reciprocity. The next chapter describes the final design of Patches Expressions.

CHAPTER 4: PATCHES EXPRESSIONS

4.1 Introduction

Encouraged by positive results from the pilot study where 100% of the participants wanted to incorporate sensory input to online communication, a range of physical expressions were developed for Patches Expressions to extend the poke interaction on Facebook, in addition to extending the sociability of the original system. This chapter describes an Interaction Model for these physical behaviours and acts as a protocol for the online and offline design space. The Interaction Model is applied to the final Patches Expressions prototype, which includes an online Patch interface, Patch DIY kits, and a sensory enabled wearable Patch. Aspects of the final prototype were verified by formative evaluation. The next chapter describes a user study to verify the design goals. In this thesis, it is by following the exploratory design process that knowledge of expression was obtained and this chapter implements these ideas.

4.2 Interaction Model

The Interaction Model opens a range of new and interesting expressions for the online vs. offline design space, extending the poke interaction. The model maps the online visual expressions to offline physical expressions and vice versa and develops a language for the design space. There are four parts of the model: a Dictionary of Affective Verbs, Patches Web Interface, Patch touch-efforts, and a Communication Layer.

4.2.1 Dictionary of Affective Verbs

At the heart of the Interaction Model is a Dictionary of Affective Verbs that creates a meaningful, symbolic language for the sender and recipient. The original Patches system emphasized social interaction in terms of action and response where the recipient of the poke can choose to respond like in a real social interaction. With Patches expressions, the sender may send a cuddle action and the recipient may respond with a blush because she is shy. Alternatively, the sender may perform a jab as an act of playfulness and the recipient frowns because she is not amused. Table 4.1 shows the complete dictionary arranged in terms of action and response and words with similar meanings are grouped together. A subset of these behaviours was implemented in the final design.

Table 4.1: A dictionary of affective verbs arranged in terms of action and response.

Action	Response
cuddle, hold	blush
caress, massage	shake, shudder, quiver, shiver, tremble
bite	smile
flick	wink
hug	sparkle, gleam, glisten
poke, nudge	gasp
jab, punch, push, pinch	retreat, retract
tickle	frown
whisper	pout

4.2.2 Patches Web Interface

The Patches Web Interface allows users to send expressions online. The web interface is a drawing interface that will extract the emotional characteristics from the user's lines using behavioural psychology methods. These characteristics will then be converted to physical expressions that can be felt by the recipient, through the Communication Layer of the model.

Behavioural psychologists and philosophers have long regarded the quality of line forms as the most valuable means to artistic expression. The quality of lines can help us to grasp the embodied meaning of a visual scene without the use of propositions or language (Johnson, 2007). The following reviews work by Lundholm, Poffenberger and Barrows to better understand the emotional quality of lines. Applying their findings to web interfaces may enhance interaction and expression beyond traditional text and images.

Lundholm (Johnson, 2007) was among the first to relate the expressive forms of lines to emotion. Lundholm asked eight participants to draw the affective tone of an adjective. The adjectives were classified into thirteen classes of synonyms describing feeling (sad, quiet, lazy, merry, agitating, furious, dead, playful, weak, gentle, harsh, serious, and powerful). Three characteristics of lines were examined – curves (big, medium, small), angles (big, medium, small), and direction (horizontal, up, down) - and striking uniformities were found among the participants' reactions to the various adjectives. For instance, there was a high degree of agreement that a big curve expressed sad, quiet, and lazy; small angles expressed hardness; a line moving downward expressed sad while a line moving upward expressed merry. These findings suggest that the movement in the lines in some way imitates the motor expression of an emotion. Later, Poffenberger and Barrows (Johnson, 2007) used Lundholm's technique to examine feelings aroused when looking at line forms rather than drawing them. They asked five hundred participants to give their reactions and analyzed emotion with respect to qualities of lines: curves, angles, and direction. Poffenberger and Barrows identified important characteristics of emotion embedded in line forms.

The Patches Web Interface applies this research to map the qualities of lines to the Dictionary of Affective Verbs. As users draw on the interface, their mouse movements are mapped to the expressions and the emotional words are continuously updated below the cursor. The server saves mouse coordinates to preserve the quality of expression that was intended by the sender. In this manner, recipients can experience a physical expression as it unfolds in real-time. The communication layer translates the online and offline mapping.

4.2.3 The Communication Layer

The Communication Layer converts the expression in the line forms to affective verbs and then maps this information to sensory output on the Patch.

The Patches Web interface measures five qualities of lines to determine expression, Table 4.2. Here, weight, direction, and style, are the same as Poffenberger and Barrows' classification of rhythm, direction, and form. The affective verbs that elicit a certain emotional response are mapped to the same line characteristics determined by Lundholm, Poffenberger and Barrows. For instance, the direction of a line is closely related to activity level where high activity is often characterized by an upward line and low activity is described by a downward line. Moreover, the style of line elicits certain emotional responses such as angles express hardness. Finally, the increasing weight of the line suggests power and strength of activity.

Table 4.3 shows the final mapping that is stored in a database on the server. Each line characteristic has a range of meanings, 0 to 100, to account for the different symbolic meanings that the words hold for different people. Some affective verbs may have two ranges to account for different contexts. For instance, the affective verb 'tickle' may refer to a positive experience (represented by style in the table) at first, with a mapping of 30-50, but may become a negative experience through prolonged tickling, 60-75. The length of time to 'tickle' may be short, 25-40, or long, 60-75. Two designers agreed upon these ranges. It is beyond the scope of this thesis to formally examine the expressive qualities of line forms.

Table 4.2: A mapping of line qualities and affective verbs.

Line Characteristic	Quality	Mapping
weight	thin…thick	type of emotion elicited (thin and positive or thick and negative)
style	curve…angular	level of positive or negative (swirling positive curve or pointy negative angle)
size	together…apart	physical closeness for action to occur
direction	downward…upward	intensity of expression (rising or lowering)
length	long…short	length of action

Table 4.3: Mapping of line quality to affective verb, stored on the Patches database.

Action	weight	style	length	size	direction
cuddle, hold	0	0	0	0	0
caress, massage	0-25	0-10	0-10	0-10	0-10
bite	90-100	90-100	0-10	50-75	100
flick	80-90	80-100	90-100	90-100	80-90
hug	0-25	0-25	0-10	0-80	0-75
poke, nudge	70-90	50-80	50-70	70-90	25-75
jab, punch, push, pinch	100	100	100	100	100
tickle	90-100	25-40 60-70	25-40 60-75	90-100	25-40 60-75
whisper	25-75	25-75	0-25	0-75	0-25
Response	**weight**	**style**	**length**	**size**	**direction**
blush	0	0	25-75	0	25-75
shudder, quiver	90-100	90-100	9-100	90-100	90-100
smile	25-50	0-50	25-50	20-80	0-50
wink	90-100	0-25	50-75	90-100	25-75
gleam, glisten	70-80	20-50	25-75	70-90	10-50
gasp	80-100	80-100	50-100	25-100	50-75
retreat, retract	30-70	75-100	50-75	25-75	75-100
frown	30-70	75-100	50-75	25-75	75-100
pout	0-50	50-80	25-75	50-100	50-75

Each line characteristic has a range of meanings, 0 to 100, to account for the different symbolic meanings that the words hold for different people. The different ranges account for meanings to change over time.

Table 4.4 shows a mapping of line qualities to actuate the physical Patch. Weight and style are combined, as these parameters are very similar. The user may not understand the expression at first and a text message will clarify the meaning. It is hoped that over time, these actions will become natural and the text message will no longer be required.

Table 4.4: Patch interface mapping.

Output	Parameters	Mapping
vibration motor	duty cycle	size
	strength of output	direction
	time	length
heating diode	time	weight and style

4.2.4 Touch-Efforts

One of the interesting aspects of Patches is responding to the sender through touch. Previous research shows that a variety of simple, tactile qualities can be recognized and differentiated by extracting parameters for computation such as pressure, number, size, speed and direction (Schiphorst, 2009; Schiphorst et al., 2005). Borrowing this approach, touch-efforts were developed for Patches to enable a variety of responses, Table 4.5. The Patch measures pressure, number, length and speed and these variables are mapped to line qualities such as weight and style, size, length, and direction, respectively.

In addition to converting visual expression to physical form, this model also maintains consistency in converting physical response back to visual representation for display on the web interface. The server stores line quality information for each expression like a template. The physical qualities of the response augment the template and the physical expression is displayed on the web interface. This allows users who do not have Patches to still interact and respond visually through the Patches Web Interface.

Table 4.5: Touch-efforts to represent each affective verb.

Action	Touch - Effort
cuddle, hold	A warm, soft, enveloping, slow touch using the whole palm.
caress, massage	Slow light gliding strokes with the fingers.
bite	A quick gripping action involving the thumb and fingers handled on top and bottom sides.
flick	A quick whipping action with the top of the index finger.
hug	A slow enveloping touch with the whole palm accompanied by a squeeze.
poke, nudge	A slow prod involving the pad of the index finger.
jab, punch, push, pinch	A hard, enveloping fast blow involving the whole palm or knuckles.
tickle	Quick light strokes with one finger.
whisper	Soft hushed airy breaths.

Response	Touch - Effort
blush	Touching the reddening of cheeks in an attempt to hide the embarrassment.
shake, shudder, quiver, tremble	Grab left and right sides and shake.
smile	Tracing with the index finger an upwards curved arc.
wink	A small squeeze involving the thumb and fingers handled on opposite sides.
sparkle, gleam, glisten	Quick light strokes involving all fingers.
gasp	A gripping action involving the whole hand and release after an extended period of time.
retreat, retract	Tracing with the index finger in a downwards line.
frown	Tracing with the index finger in a horizontal zigzag.
pout	Tracing with the index finger in a downwards arc.

4.3 Patches Expressions Prototype

4.3.1 Patch Interface

An online Facebook application for Patches Expressions allowed users to order a Patch Kit, view instructions to personalize the Patch, register a Patch, send and receive physical expressions, and invite their friends, Figure 4.1. Three web developers informed the design of the website. Please see Appendix D for source code and running instructions.

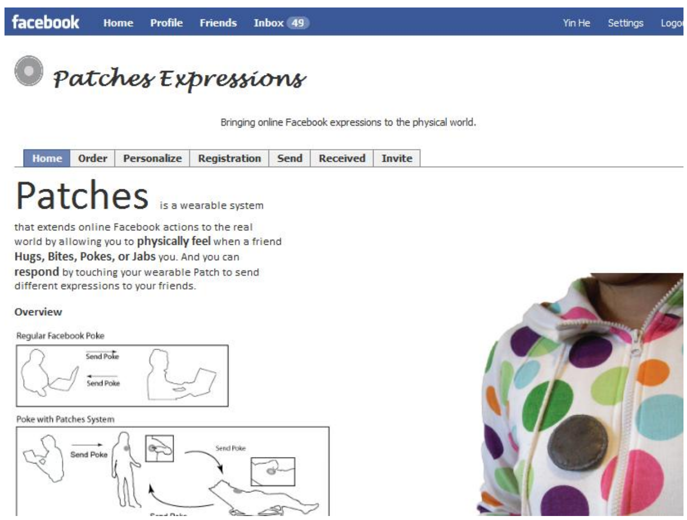


Figure 4.1: Patches Expressions homepage on Facebook.

Users can order a Patch Kit from the online interface by clicking the Order tab. Figure 4.2 shows the different kits: the original Patch plus six others. The design of the six other Patches was informed by formative evaluation with the members of the target demographic and will be described later. Each Kit includes a blank Patch, iron-on transfer paper, paintbrush, thermochromic ink, novice DIY instructions, Patch PCB board, 9V battery, and USB cable. Instructions for personalization are also included and if lost, they can be found under the

Personalize tab. Each kit also has a name. Figure 4.3 shows a finished Patch connected to a PCB board.

Figure 4.2: All seven different kinds of Patch DIY kits.

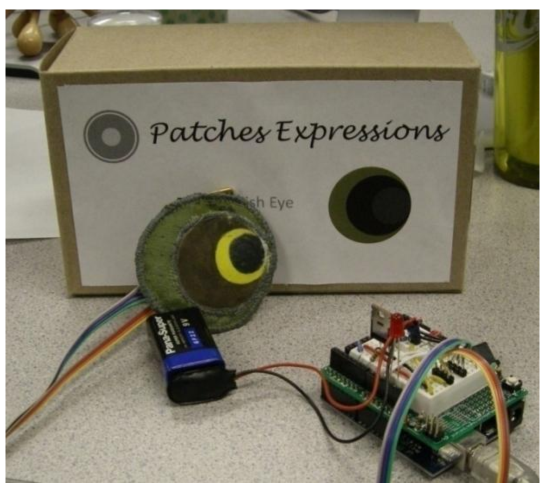


Figure 4.3: A finished Patch connected to Patch PCB board.

The Send tab allows users to record their drawings in real time and send it to a friend. After clicking the record button, the screen becomes a drawing surface, Figure 4.4. Qualities of lines from the drawing are mapped to expressions per the Interaction Model and affective words are displayed below the cursor. When satisfied with the drawing, users can click the stop button. The play button allows them to watch their expressions unfold onscreen. Users can then send the expression to a friend for physical actuation. For recipients who do not have Patches, they can still watch the expressions unfold on Facebook. Users can check their messages visually by clicking the Receive tab.

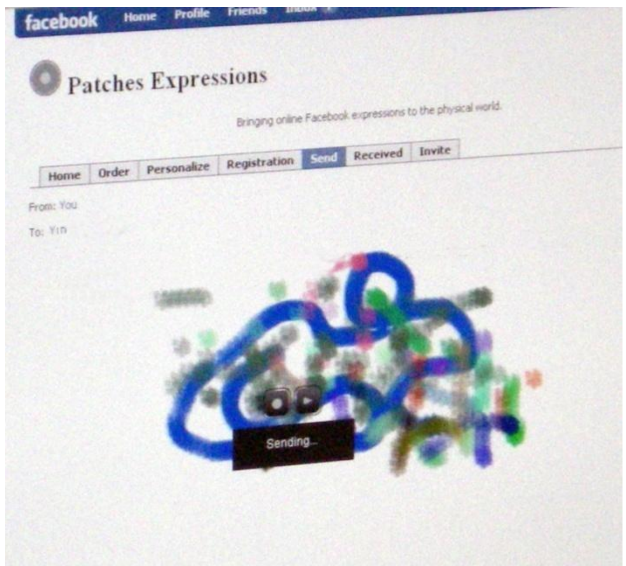


Figure 4.4: A drawing created on the Patches Web Interface.

The Registration tab allows users to choose their sharing options, Figure 4.5. Users can share their Patch with one friend so that only physical expressions between the two can be felt. Communication from other friends will not trigger that particular Patch. This option requires the Patch to be physically given to the friend. Users can alternately choose not to share the Patch and will feel all physical expressions from all friends on the network.

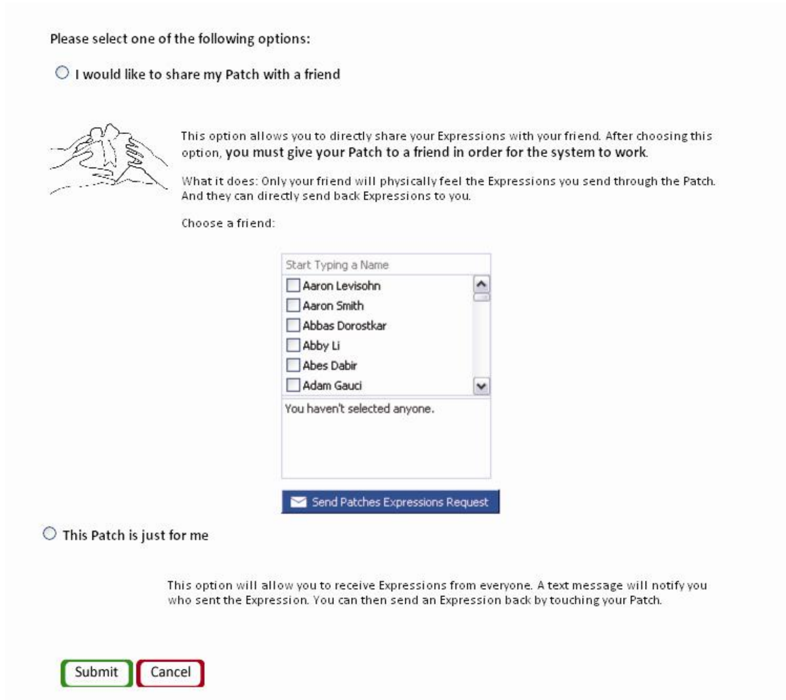


Figure 4.5: Patches Expressions registration page.

4.3.2 The Patch

Patch Look and Feel

The Patch was designed to be more expressive to comply with pilot study results. Though this thesis is not about studying the expressive aspects of what we wear, there is no doubt that the physical and aesthetic design of a wearable device will affect its success in communicating emotion and expression to others. Therefore, it is only fitting to ask members of the target demographic their opinion on the appropriate shape, colour, and size of the physical Patch.

Figure 4.6 shows a moodboard that consists of a variety of possible Patch shapes. A selection of shapes was paper prototyped to give participants a feeling for the size and thickness of the real Patch.

Figure 4.6: Moodboard showing most popular Patch shapes.

Six individuals, both males and females of the target demographic, informed the shape and design of the Patches. Each participant was asked to choose his six favourite shapes from ten paper prototypes and speak about their selection process. Ideas pertaining to shape, colour, and size, emerged from this discussion. First, the most ambivalent topic was the selection of dolls or no dolls. Half of the participants, both males and females, chose the dolls, or characters, and stated, "...it helps to bridge the imagination if [the Patch] had the distinct shape" and found that the "head and eyes are very expressive". Participants would rather interact with characters because they are symbolic of interacting with the real people they represent. The other half rejected the dolls for this same reason and selected simpler, organic shapes. Some of these also enjoyed geometric shapes and would like to use these shapes as accessories. Colour is also an important aspect. All participants agreed that the colour of the Patch should match with whatever they are wearing. None of them liked vibrant colours but opted for more muted colours. Lastly, size also played an important role for Patch selection. Due to the addition of electronics, the size and thickness of the Patch is slightly larger than that of the original. Nobody wanted a Patch larger than the paper prototypes. All enjoyed the original size of the Patch, and one wanted even smaller, like the size of a quarter. From these informal discussions, the most popular shapes were prototyped and Figure 4.7 shows the finished prototypes in regular and poke conditions.

Patch Electronics

Patch electronics were augmented to measure the different touch-efforts described in the Interaction Model. Instead of a single touch sensor, each Patch is now fitted with four touch pads. To limit the number of connections, a row-column- addressable structure was used for wiring, similar to the touch interface in Appendix A. There are now eight connections between the Patch and the Arduino microcontroller, two more than the original. Figure 4.8 shows the different layers of Patch electronics. Silk organza creates flexible electrical connections for the conductive foam. Diode or conductive thread heats the thermochromic area to reveal the hidden icon.

Figure 4.7: Finished prototypes in regular and poke conditions.

Figure 4.8: 4 layers of Patch electronics simplified from original design.

To encourage mobility, ribbon cable is soldered to the Patch so it can be pinned to various areas of the body, Figure 4.9. The Arduino, clipped to the belt loop, connects to a laptop computer for wifi communication. The computer also measures the touch expression and sends the information to the server.

Figure 4.9: Different placements of the Patch on the body.

Patch Expressions

When receiving expressions, the recipient will feel a level of vibration and see the thermochromic ink dissolve. Twelve physical expressions were implemented from the Interaction Model, Figure 4.10. These icons are meant to aid the user in performing the physical expressions. For instance, a cuddle is a warm soft touch using the whole palm while a hug requires more pressure than a cuddle. A user study tests these physical interactions in the next chapter.

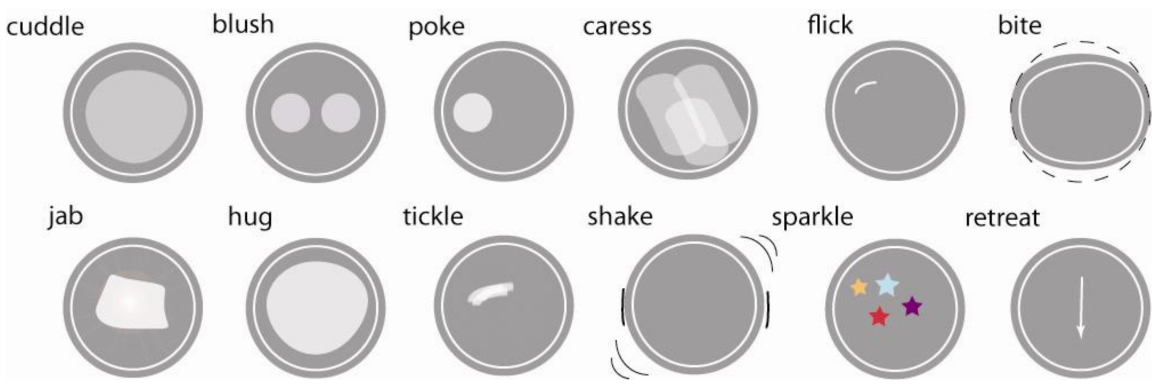


Figure 4.10: Patches physical expressions.

4.4 Summary

The final design of Patches Expressions incorporates an Interaction Model to expand its expressive range as well as the traditional social behaviours identified from sociology research. The Interaction Model was applied to the design of the final prototype, which includes an online Patch interface, Patch DIY kit, and a sensory enabled wearable Patch. The next chapter analyzes sociability, interaction, and expression using the prototypes.

CHAPTER 5: EVALUATING PATCHES EXPRESSIONS

5.1 Introduction

The purpose of the user study is to evaluate the design goals of the Wearable Social Network by testing the Patches Expressions prototype in a social environment with the target demographic. First, the user study examines the value of incorporating sociability to digital communications technologies and verifies the claims about symbolism, personalization, and gifting culture. These concepts were investigated by testing the Patches system in a social environment, including the DIY kits and Facebook application. The user study also examines the social interaction design of the system as new features were added since the pilot study. The second iteration of Patches allows users to physically control the system and not passively feel the expressions like in the pilot study. Unlike the pilot study whose purpose was to gain a general understanding about sensory interaction and the online experience, the user study focuses on examining the value of transmitting and receiving touch as a method of enhancing nonverbal communication between friends. User study results begin to define the Wearable Social Network and make suggestions for future work. This analysis helps to uncover important social, interactive, and expressive considerations, which may contribute to the design of HCI systems. These findings could not have been obtained if the design is not a vital part of the research process.

5.2 Participants

To encourage a social environment in a lab setting, participants were selected based on prior friendship and membership of target demographic. As Kalanithi writes, it is important to recruit groups with an existing informal, friendly and playful relationship when testing social technologies (Kalanithi & Bove, 2008). Some participants were graduate students who worked in close proximity while others belonged to a circle of undergraduate friends. The target demographic is tech-savvy urban professionals aged 18 to 34 years living in North America. This group has been shown to dominate the usage of social networking applications, such as Facebook and Twitter, on both stationary computers and mobile phones (Compete, 2008; Facebook Global Monitor, 2009). In fact, this age group accounts for 66% of the users on Facebook and about 44% on Twitter (Quantcast.com, 2009). An entrance survey determined their eligibility, Appendix C, and gauged their social networking software usage.

5.3 The Study

The study was structured as a mini focus group research method as it creates a social atmosphere that promotes discussion (Laurel, 2003) which helped to answer the research questions. Three males and four females were selected to participate based on the entrance survey results and they ranged in ages from 20 to 29. The session took about three hours and the testing room contained all the necessary equipment for the study: computers for each participant, shared printer, iron, and scissors.

Participants were first given a brief synopsis of the Patches project. Patches Kits were distributed and participants were asked to follow the DIY instructions for novices to personalize their Patch. These Patches did not contain electronics, as the focus was personalization. Photos were taken of the DIY process as well as of the finished projects. At the end of the DIY section, they wrote a statement about their design in Comment Card 1, Appendix C.

The second portion of the study was the patches testing phase. Participants were given finished Patches with electronics to try, Figure 4.7. This ensured that Patch electronics was sufficient to heat the thermochromic ink. Participants registered their Patch using the Facebook application on the computers provided. The primary investigator guided them through the process of seeing and feeling the physical expressions on the Patch Web Interface and the physical Patch. The text message was not tested. An odd number of participants were intentionally chosen to study reciprocity behaviours. Photos were also taken of participants completing their tasks. Questions were distributed on Comment Card 2, Appendix C.

A group exit interview concluded the study. First, a cognitive walkthrough of the interface was conducted followed by a general discussion. Audio comments were recorded and then transcribed. Appendix C shows the questions for group discussion.

5.4 Analysis

5.4.1 Examining Social Networking Software Usage

Analysis of the entrance survey revealed the participants' social networking software usage patterns. These findings suggest that Facebook is the preferred social networking software. More importantly, the survey revealed important motivating factors and features of social networking software applications, which may aid the design of future communications technologies. These findings confirm some social networking design considerations of the Wearable Social Network.

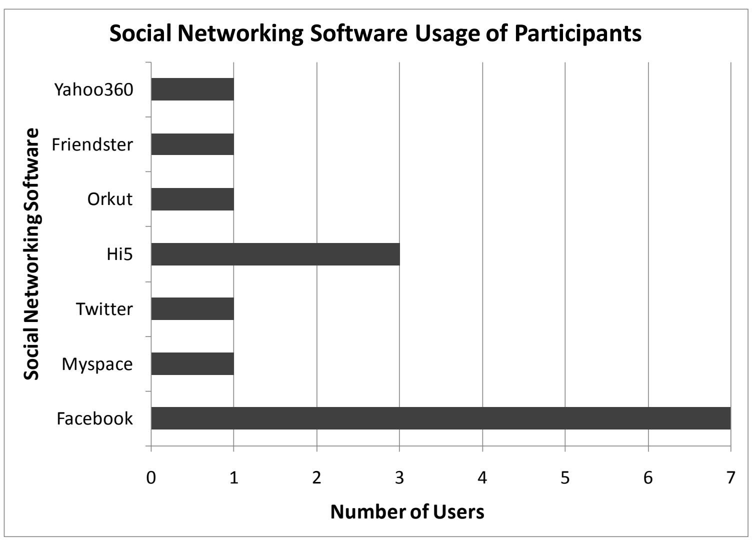


Figure 5.1: Social networking usage patterns of participants.

All seven participants have used or currently use Facebook and five of them are active users. They also use other social networking software such as Twitter, Hi5, Orkut, Friendster, and Yahoo360, see Figure 5.1.

Participants stated that they choose social networking applications primarily based on the ease of access to their network of friends. For most participants, this ease of access was Facebook while for others it was instant messaging or email. A vast friendship network was also the main reason participants switch to and remain on social networking sites like Facebook. For example, active users of Facebook typically check their account hourly, daily, or every other day as opposed to other comparable social networking sites (Orkut, Yahoo360, Hi5, and Friendster) where they only check these sites monthly or not at all. However, Twitter, Skype, Instant Messaging and e-mail maintain their popularity, possibly for the different purposes that the applications serve.

In addition to ease of access to their network of friends, active users of Facebook stated that the site offers useful features that allow them to maintain a social connection. Three main Facebook features helped friends to keep track of each other: the mini blog allowed friends to read news from many different friends at a time; the chat system allowed friends to instantly communicate with each other privately; and the wall allowed friends to communicate with each other publicly. Not surprisingly, the most popular social networking activity on Facebook was reading and writing public and private messages to friends. Other popular activities were uploading photos, checking friends' profiles, and playing games. Less popular activities were joining groups, instant messaging, checking out events, and filling out quizzes. All participants in the study preferred to access social networking software through their computers rather than other means such as mobile phones.

Social Networking Software Usage and the WSN

This survey confirmed some previous notions about social networking usage and validated aspects of the WSN. As expected, Facebook is currently the most popular social networking application in North America for the target demographic, which justifies the development of social applications such as Patches on this platform. Because Patches was developed as its own fully functional system, irrespective of Facebook, it can be easily integrated with the next popular social networking software. In addition, despite the increase of subscribers who accessed social networks via mobiles in the last year (Ankeny, 2008), the high cost of mobile plans still makes mobile social networking costly for this group. This justifies Patches developed primarily as a computer-based system that incorporates mobile and wearable interaction. Computers remain a vital communications tool especially for social networking. Future ubiquitous communications technologies will benefit from the WSN architecture.

5.4.2 Examining the Wearable Social Network

Figure 5.2: Personalizing the Patch following the DIY process.

The user study evaluates the sociability and interaction design considerations of the WSN from concept to implementation. In order to properly analyze the design goals, each of these phases is broken down in terms of Concept (intended design goal), Experience Qualities (intended user experience), and Technical (significance of goal according to literature review) levels and organized into a tabular format. These tables ensure that the original design goals and intended user experience are both implemented and evaluated. This method of analysis helped to gain a better understanding of experience and usability of the Wearable Social Network as well as answer the research questions that emerged from the design process. Figure 5.2 shows the DIY process and Figure 5.3 shows the icons created during the DIY project.

Figure 5.3: Finished Patches from the DIY process.

Examining Sociability Design

Table 5.1 breaks down the design goals –communication through symbolism, creating strong emotional ties through personalization, and creating bonds through gift exchange – in terms of Concept, Experience Qualities, and Technical levels. The Evaluation column ensures that the implementation results are based on the design goals as intended. Table 5.2 shows how each level was implemented in the Patches system. The experience and usability of the system were evaluated according to each design goal, Table 5.3 to Table 5.5, in order to answer the research questions.

Communication through Symbolism

How do symbols, such as icons and touch, help friends to communicate with each other in the digital domain? The user study showed that icons and touch are meaningful methods of communication that created a pleasurable, exciting, and new experience for participants that benefit friendship activities in the digital domain.

Some icons immediately carried more meaning than others. For instance, a sunshine image represented “an essential necessity that usually lacks in Vancouver” and that sending the sunshine represented “a little wish from somebody that knows what you need”. Another icon was meant to convey a message of “calmness and peace” to others. Patches enables this wish to be sent and received repeatedly to support friendship unlike traditional methods of communication. As Kalanithi stated, meaning takes time (Kalanithi, 2007) and perhaps with time, the meanings from other icons may emerge. This user study illustrates the potential of digital communications technology such as Patches to transmit and receive digital icons to support friendship.

Similarly, touch is an affective and powerful method of communication. Vibration created a powerful sensation that caught some participants off-guard as a “good kind of surprise”. For one participant, this sensation felt like a “fun tickle” which represented a “sign of love from [her] sister”. This shows that touch can be a very meaningful method of communication. Interestingly, participants found the touch-qualities very different than the real-life gestures they mimic but they were understandable enough to be usable to communicate with friends. As one participant stated, "it might not be the real physical expression but still creates a language between you and your friends so it allows for social interaction even if it is not like the ones you have face to face", showing the symbolic potential of Patches. It is hoped that through prolonged use, this language of touch may become more natural. The emotional responses created by Patches are examined in the Interaction Design section.

The meanings that emerged through these implicit communication methods, through icons and touch, added to the novelty of interaction and enhanced communication beyond traditional text. The physical manifestation of a virtual gesture was quite "cool" and "new". Participants liked the idea of physically sending a message to a friend and not just writing on their walls or sending a text message, stating, "this project is a new thing, an emerging thing … it's a real nice idea". Perhaps a longer study may flush out these meanings but that is beyond the scope of this thesis.

Creating Strong Emotional Ties through Personalization

How does personalization allow users to create strong emotional ties with their Patch? The user study showed that the process of personalization encouraged creativity, uniqueness and expression of identity among participants and helped them to convey feelings of connection.

Using materials in the DIY kit and the equipment provided, participants followed unique thought processes to design their Patch: Design to Theme, Design to Self, and Design to Other. An example of Design to Theme was a teardrop shape on Blue Blob because the colour reminded the participant of the sea. Toad from Mario Brothers was an example of Design to Self as it conveyed the interest of the designer. A little green creature exemplified Design to Other because the recipient meant to convey a message of "calmness and peace".

Participants found the DIY process fun and creative; DIY allowed them to “make [their Patch] unique”, “show other people [their] interests”, and “represent [their] personality”. The DIY process appealed to most participants because it was interesting and fun, and they stated: "the process was fun because it allowed me to choose a paint and design that symbolizes me" and "it's fun to design my own graphics and print it onto the Patch". The DIY process did not appeal to one participant who does not like "assembling things". Clearly DIY met the goals of personalization by encouraging creativity, uniqueness, and expression of identity as identified by Blom (Blom, 2000).

It was observed that the process of personalization allowed participants to connect with their Patches. A few of these instances were documented. First, participants looked amazed and intrigued the first time they peeled back the transfer paper and saw their computer designs printed on fabric. In addition, some of them started calling their Patch by name on the Comment Cards. Near the end of the study during the exit interview, some of them played with their Patches when articulating an answer to a question. Throughout the study, participants wanted to keep their Patch. The process of personalization showed evidence of conveying feelings of connection among adults that are consistent with previous research involving children (Dekoli & Mikhak, 2004).

Most participants enjoyed the hands-on opportunity to design and described the process fun, easy, and creative. Their unique thought processes lead them to create unique and personal Patches with which they formed emotional connections. As one participant noted, “it’s nice to get a digitally-enabled object that has such a hands-on tactile feel to it”. In terms of usability, some steps were harder to follow than expected and Future Work examines the DIY process and other personalization practices.

Creating Bonds through Gifting

Patches was designed on Facebook to accommodate a large number of friends. Patches is a unique gift: first, as a physical gift and then, as digital gifts that can be sent and received between friends whenever they like. The user study explores how friends bond through gifting of Patches.

Interestingly, all participants shared their Patch with an existing friend and none added a new friend on Facebook in order to test the Patch. This behaviour directly translates from the physical world where touch is very private and was best described as, "...you wouldn't normally physically poke less close friends anyways". Therefore, participants chose to share the Patch with close friends or even existing not-so-close-friends on Facebook when testing the system rather than adding new participants. Facebook's large existing social network still makes it a useful tool to enable sharing with the closest people.

Patches is like a gift that keeps on giving where after the initial gifting of the physical Patch, friends can continue gifting the virtual representation. The type of bond created by Patches was described as “warm, comforting, nice, and intimate”. Clearly, this type of gifting is not a “power struggle” as suggested by Mauss but something that is “bestowed upon us” as suggested by Hyde.

Patches is a unique gift of touch, which is a very private matter that creates a strong bond between friends. The deep social relationships created by Patches, requires fewer social connections, which is consistent with previous research involving tangible devices (Kalanithi, 2007). It was surprising to find that the information embedded within Patches maintains a level of privacy, even when transmitted through the public internet. While the Facebook platform was initially chosen for its large existing social network, it is still a useful tool to enable sharing Patches with the closest people.

The following tables illustrate how these sociability design conclusions were derived. Each table shows the progression of the sociability design goals in terms of conception, implementation, and evaluation.

Table 5.1: Breakdown of sociability design goals.

General Design Goal	Specific Design Goal		
	Conceptual	Experience Qualities	Technical
Communication through Symbolism	Implicit methods of communication such as icons instead of traditional explicit, textual methods	New, engaging.	People place symbolic meaning on material things. Pictures can communicate experiences (Csikszentmihalyi & Rochberg-Halton, 1981).
	Examine touch as an implicit and symbolic method of communication	Fun, exciting, pleasurable, new, entertaining.	Touch can communicate experiences (Csikszentmihalyi & Rochberg-Halton, 1981) such as a pat on the back is a job well done.
Creating Strong Emotional Ties through Personalization	Encourage creativity, uniqueness, and expression of identity.	Creative, enjoyable, easy, feeling of ownership.	Socially related motivations for personalization help people to elicit emotional responses and express identity (Blom, 2000).
	Help participants to feel more connected with their Patch.		Personalization helps people to make spaces and products their own (Ahde, 2007). DIY has shown to convey feelings of connection and empowerment in children (Dekoli & Mikhak, 2004). This study examines the DIY process in adults.
Creating Bonds Through Reciprocity	Enable all friends to share their expressive interactions.	Sharing with more friends is more fun because a user's social network is numerous.	A user's social network is numerous and complex and should support all individuals and their activities unlike (Labrune & Mackay, 2006) and (Berzowska & Coelho, 2006).
	Increased opportunities for gifting will encourage bonding between friends.	Warm feelings of friendship.	Reciprocity creates a bond between the giver and the receiver which is either seen as a power struggle or an interconnected relationship. It is the constant donation of the gift that keeps it alive (Mauss, 2000).

A literature review revealed the importance of three social traditions and identified their main points (Technical column). The three social traditions are each broken down into two specific concepts (Conceptual) and intended user experience (Experience Qualities).

Table 5.2: Implementation of sociability design goals.

General Design Goal	Implementation (part 1)			
	Conceptual	Experience Qualities	Technical	Evaluation
Communication through Symbolism	The Patch should be a physical object where participants can freely express themselves using visual symbolic representations.	The design holds meaning for the user.	Users can make a design on the Patch surface by either choosing an image from the internet or designing one using a graphics editor. The symbol will light the icon for incoming communication (not studied).	By allowing participants to design on the Patch surface, both the sender and recipient associate meaning to the Patch.
	The Patch should be a tactile object that measures symbolic touch qualities.	Feel a level of incoming and send a level of outgoing communicati on.	Vibration motor alerts of incoming communication and touch pads measure the quality of outgoing messages from the Patch.	Incoming touch represented by vibration and physical touch representing outgoing communication, express symbolic touch qualities.
Creating Strong Emotional Ties through Personalization	The DIY process will encourage creativity, uniqueness, and help participants to express themselves through their designs.	DIY steps should be easy to understand and follow.	Participants follow the novice DIY method to personalize their Patch, Figure 3.4.	Novice DIY method guides the participant through the process of personalization which encouraged creativity, uniqueness, and expression of identity and helped them to convey feelings of connection.

General Design Goal	Implementation (part 2)			
	Conceptual	Experience Qualities	Technical	Evaluation
Creating Bonds Through Reciprocity	The Patches system should accommodate a large number of people and their sharing activities.	Choose one friend to share the physical expression or share with all friends.	Patches uses Facebook for its vast friendship network. Users can share in 2 ways: with one friend or with all friends on the network. Upon registration, a database stores FacebookID and sharing option.	The first sharing option allows participants to directly connect with another while the second supports many connections (one at a time). These two options together support numerous and complex connections.
	The Patches system should include a physical object to initiate the gift exchange and a virtual object to continue the momentum of the gift.	The satisfaction of growing connections through giving a physical gift and continuously sending and receiving virtual gifts.	The Patches system includes 2 parts: the physical gift (Patch) initiates gift giving; and the virtual touch expression.	Participants enjoyed both the gifting of the physical Patch which initiates the gift giving and the virtual touch expression which can be constantly donated to keep the gift alive.

The three sociability design goals are implemented in Patches. Each level of implementation directly relates to its design goal. Conceptual column to how the system should react, Experience Qualities refer to what the user will experience, and Technical refers to how the system works. The Evaluation column confirms that the implementation results are based on the design goals.

Table 5.3: Evaluating symbolism design goal.

Evaluation		
Conceptual	Experience Testing	Usability Testing
Examine meaning created by iconic symbols. (Comment Card 1 and Exit Interview)	Some designs immediately carried more meaning. One participant selected a sunshine image online and described it as "an essential necessity that usually lacks in Vancouver". Sending a sunshine represented "a little wish from somebody that knows what you need". Another designed a cancer zodiac sign which is symbolic of the birth month.	Participants successfully created a variety of designs using the Patches DIY kit, Figure 4.2. The traditional arts and crafts method of personalization may not be best suited for this digital age group. (See Personalization)
Examine the symbolic sensation of touch for sending and receiving information. (Comment Card 2 and Exit Interview)	All participants found the idea of a physical manifestation of a virtual gesture quite "cool" and "new". They felt surprised ("a good kind of surprise"), excited and ecstatic when receiving a physical expression. For some participants, the vibration seemed too short and light that it was difficult for them to understand what it meant. One participant related the "fun tickle" sensation as "a sign of love from my sister" showing the symbolic potential of Patches. Participants were able to respond from the Patch and found the physical touch-qualities understandable. These touch-qualities were very different than the real-life gestures they mimicked but the interaction was "good enough". They enjoyed watching the physical gestures manifested on-screen. A longer study period would better habituate users and make this method of communication more "natural".	The study was structured such that participants were expecting to receive a vibration and send an expression back by touching the Patch. Participants were eager to see the results of their expression on their friend's Facebook page. The system can improve. When receiving expressions on the Patch, a more varied sensation would be more meaningful, such as a rhythmic form of Morse Code. It would also help participants to differentiate between expressions.

The concept, Communication through Symbolism, is analyzed according to Experience and Usability. Experience testing revealed strong evidence to suggest that icons and touch are meaningful methods of communication that benefit friendship activities in the digital domain. Usability testing showed that the meaning of the physical expressions could become clearer with varied sensations.

Table 5.4: Evaluating personalization design goal.

<table>
<tr><th colspan="3">Evaluation</th></tr>
<tr><th>Conceptual</th><th>Experience Testing</th><th>Usability Testing</th></tr>
<tr><td>Is this process easy, difficult, expressive, etc.? (Comment Card 1, Exit Interview)</td><td>Participants found the DIY process creative, unique, and it allowed them to express their identity stating: "fun and creative project", "I liked how I could customize [the Patch] to make it unique", [the project] allows me to show other people my interests", "[the project] allowed me to communicate with others through the use of colours and designs that represent my personality". The DIY project appealed to most participants because it was interesting and fun, stating: "the process was fun because it allowed me to choose a paint and design that symbolizes me" and "it's fun to design my own graphics and print it onto the Patch". The DIY project did not appeal to one participant who doesn't like "assembling things".</td><td rowspan="2">Instructions were "simple clear and easy to read and follow". For one participant, "more detailed instructions like a LEGO kit" would make the DIY project more attractive.

Some steps were troublesome:
- Half the participants were not familiar with graphics software and required help to shrink their images to 2cm diameter. More instruction is required. One participant would have liked to make the process even easier using regular ink to draw directly onto the Patch.
- Painting and drying the thermochromic ink was a challenge. Some did not like the rough, uneven quality of the dried paint and would have liked a more finished look. Furthermore, the paint may be too thick to be properly heated by the Patch.
- DIY only provides one opportunity for personalization. While one participant called the effect "interesting" after the sun was ironed horizontally and not vertically, another was a little disappointed at the imperfection left by her hair in the dried paint.

Solution: DIY process should be revisited in order to determine the proper amount of materials and instruction. Alternately, an online personalization interface is an option.</td></tr>
<tr><td>Observe how participants connect with their Patch. (DIY process. Comment Card 1, Exit Interview)</td><td>In the beginning, participants looked amazed and intrigued the first time they peeled back the transfer paper and saw their designs printed on fabric. Some participants referred to their Patch by name on the comment cards. At the end, during the exit interview, some played with their Patches when articulating an answer to a question. Throughout the study, they asked if they can keep their Patch. This demonstrates that their engagement in the DIY process helped to convey feelings of connection and ownership.</td></tr>
</table>

The process of personalization is analyzed according to Experience and Usability testing. There was strong evidence to suggest that the DIY project met the goals of personalization by encouraging creativity, uniqueness, and expression of identity to convey feelings of connection. Usability testing uncovered some troublesome steps, which are examined in Future Work.

Table 5.5: Evaluating gifting design goal.

<table>
<tr><th colspan="3">Evaluation</th></tr>
<tr><th>Conceptual</th><th>Experience Testing</th><th>Usability Testing</th></tr>
<tr><td>Examine how sharing is accomplished through Patches. (Comment Card 2, Exit Interview)</td><td>There is a certain private quality about touch that translates directly from the physical world, one that was best described as "you wouldn't normally physically poke less close friends anyways". Therefore, participants chose to share the Patch with a few close friends or significant others. One participant liked the idea of "linking a pair of Patches with someone, like a girlfriend, to be able to carry around a little piece of contact with them". Other participants would like to share the Patch with a small group of close friends and one expression would be received by all members in the list.</td><td rowspan="2">All participants successfully registered their Patch online through the Registration interface. They all chose the option of sharing their Patch with a friend. Interestingly, no participant added a new friend on Facebook in order to test the Patch.</td></tr>
<tr><td>Examine the type of bond that Patches creates. (Comment Card 2, Exit Interview)</td><td>The bond was described by the participants as "warm, comforting, and intimate" which infers that this type of gifting is not a "power struggle as suggested by Mauss, but something that is "bestowed upon us" as suggested by Hyde.</td></tr>
</table>

Experience and Usability testing uncovered interesting insights into how friends bond through gifting of Patches. Experience testing revealed that Patches is a unique gift of touch that creates deep bonds between friends. Accordingly, no participant added a new friend on Facebook during the Usability testing.

The Wearable Social Network met all of its sociability design goals: communicating through symbolism, creating strong emotional ties through personalization, and creating bonds through gifting. Some of them were expected, others surprising.

The user study showed evidence of icons and touch as meaningful methods of communication among a group of friends in the digital domain, which confirms the hypothesis. Though the real physical expressions are very different from the real world interactions they mimic, evidence suggests that Patches still creates a language between friends, showing the symbolic potential of the project. More time is required for these symbols to fully develop and change their meanings. Patches is a platform on which to study touch-at-a-distance.

The DIY approach met the goals for personalization such as encouraging creativity, uniqueness, and expression of identity and helping to convey feelings of connection. Most participants found DIY process fun, easy, and creative. However, some steps posed more difficulty than expected and personalization practices are explored in Future Work.

Finally, Patches creates a unique gift of touch that, as the literature review suggests, creates a strong bond between friends. However, this type of bonding requires fewer social connections that affect the size of the social network created by WSN. Facebook is still a useful tool to enable sharing Patches with the closest people. The next section examines interaction design goals of the Wearable Social Network.

Examining Interaction Design

Table 5.6 shows the conceptual breakdown of the social interaction design goals in the Wearable Social Network. Table 5.7 shows how the original design goals and intended user experience were implemented. The evaluation column guarantees that the implementation is consistent with the design goals. Table 5.8 to Table 5.10 take a deeper look at the experience and usability of the Wearable Social Network by comparing pilot study results.

Timely Responsiveness of Communication

Participants in the pilot study found Patches useful because it provided a quick, easy, and direct connection to Facebook and their network of friends. These ideas are reiterated in the user study where this connection was further described as intimate, comforting, accessible, and fun. One participant liked “the idea of linking a pair of Patches with someone, like a girlfriend, to be able to carry around a little piece of contact with them”.

Furthermore, the user study revealed just how fast and simple this communication needed to be to support friendship. People may not have the time to explore all the intricacies associated with the Patches Web Interface and prefer more direct methods such as clicking a button, or dragging and dropping an animation. Simple methods of communication are essential in maintaining a friendship connection and are discussed in Future Work.

Interaction with Somatic Information

Most people enjoyed feeling the physical poke from the virtual environment in the pilot study and attributed this experience as a more direct connection with their friends. From the user study, all participants liked the idea of physically sending a message to their friends instead of just writing on their walls. Interacting with somatic information using Patches was described as "comforting, intimate, meaningful, entertaining and more fun" than traditional text based methods. Incorporating somatic information such as touch to traditional communications technology enables Patches to add a depth of communication that supports friendship activities beyond traditional means.

Surprisingly, the user study showed that this mode of communication is "hugely different" than the face-to-face interactions they mimicked. This will take time for users to become accustomed to. The placement of the Patch on the body will define the types of physical expressions users send. For instance, it would be "weird for a woman to perform caress while the Patch is on the chest". In addition, performing a jab on the wrist may look violent to others. Users will have to test these new experiences and interaction techniques themselves. Luckily the Patch welcomes exploration. The ribbon cable allows users to place the Patch anywhere on the body. Other suggested placement areas include back pocket of jeans, on the wrist like a bracelet, on the sleeve, or on top of the shoulder. Determining a mapping between the physical expression and location of Patch on the body is an area for future research.

Exchange Emotion

The pilot study revealed that the direct connection provided by Patches created a more personal and real interaction for the participants. One participant in the user study described the social network created by Patches as a "warm network". Participants in the user study only tested a few physical expressions and not all twelve, due to limitations of the system (discussed in the next section), but those who tried were successful in transmitting the expressions. Sending and receiving physical touch was "more intimate and meaningful than a text message". This experience supports friendship interaction because it was more "fun, entertaining, new, and emerging" than the traditional visual internet experience. Furthermore, the Interaction Model extends the level of visual interaction and the Patches Web Interface amazed participants by dynamically encoding emotions in their images.

Despite the interest for playful expressions in the pilot study, the user study showed that participants did not see Patches used in this manner. The user study demonstrated that Patches created an intimate experience for exchanging affectionate expressions between close friends and family. Participants chose to send and receive “nice” expressions rather than “violent” ones.

The Patches system augments the traditional internet experience in both physical and visual ways that participants in both studies agree, make it a useful extension to social networking and expression. The following tables show how these social interaction conclusions were derived.

Table 5.6: Detailed breakdown of interaction design goals.

General Design Goal	Specific Design Goal		
	Conceptual	Experience Qualities	Technical
Designing a Wearable Social Network	Timely responsiveness of communication	quick and easy	The review of SNS and mobile computing revealed that sharing user data quickly is essential in maintaining a social connection.
	Interaction with somatic information	natural, pleasant	Touch is essential in our emotional health and development (Champagne & Stromberg, 2004). The goal is to transmit this natural sensation through a distance.
	Exchange emotion	pleasing, enjoyable	Allow participants to physically feel an expression rather than through explicit means. Illustrate that it is possible to send such a sensation between friends.

A literature review identified these interaction techniques as the key characteristics of the WSN framework. Each specific concept (Conceptual) and intended user experience (Experience Qualities) were further developed through a pilot study. This user study takes a closer look at the experience and usability of the WSN by testing the Patches prototype in a social setting.

Table 5.7: Implementation of interaction design goals.

General Design Goal	Implementation			
	Conceptual	Experience Qualities	Technical	Evaluation
Designing a Wearable Social Network	Patches should be an always-on network that stores large amounts of data on a fast communications channel.	The direct connection offered by Patches should allow participants to feel more connected with their network of friends.	Written in Java, Patches uses Facebook platform. It allows participants to physically feel a virtual expression. A text message clarifies the expression (not tested). Participants can respond through touch.	Patches is a quick method of communication that participants feel creates a more direct connection with friends.
	Patches should support both send and receive of visual and tactile information.	The visual and tactile information transmitted by Patches will convey feelings of connection and warmth.	Send: 4 touch pads in the Patch measure touch qualities and calculate the expression. Recipients will feel the expression and see it on the Web Interface. Receive: Information from the Web Interface is passed to vibration motor, heating element, and mobile.	Allowing participants to send and receive visual and tactile information through a distance adds a depth of communication than traditional methods.
	Patches should send and receive sentiments through implicit means rather than explicit methods such as text.	Users can send and receive 12 different expressions visually through the Patches Web Interface and haptically through the physical Patch.	An Interaction Model connects the online and offline domains, the Expressive Web Interface and the Patch. There are 4 parts to the model: dictionary of affective verbs, Patches web interface, the physical Patch, and a communication layer between them. This model was implemented on the Java server.	The Interaction Model is a communication layer that facilitates the transmission of tactile and visual information. Participants see Patches as a "warm network".

The goals of social interaction are implemented to the design of Patches. Each level of implementation directly corresponds with its original design goal. The Evaluation column confirms that the implementation results are based on the design goals.

Table 5.8: Evaluating design goal Timely Responsiveness of Communication.

Evaluation		
Conceptual	Experience Testing	Usability Testing
The user study further describes the meaning of a rapid communication system in supporting friendship.	From the pilot study, participants saw Patches as a direct connection to Facebook for instant online communication with friends. The user study further described the connection as intimate, comforting, accessible, and fun.	The pilot study revealed that Patches is a useful communication system because it provided quick and easy access. The user study revealed just how quick and simple this communication needed to be to support friendship. People may not have the time to explore all the intricacies associated with a Patches Web Interface and prefer more direct methods such as clicking a button and dragging and dropping an animation. Clarity in communication is essential.

Experience testing further described the direct connection created by Patches as intimate, comforting, accessible, and fun. Usability testing clarified just how quick and simple this communication needed to be to support friendship.

Table 5.9: Evaluating design goal Interaction with Somatic Information.

Evaluation		
Conceptual	Experience Testing	Usability Testing
How can touch support friendship activities?	In the pilot study, participants found the physical experience to be a more direct connection with their friends. All participants in the user study liked the idea of physically sending a message to their friends instead of writing on their walls. Interacting with somatic information was “fun, intimate, meaningful, entertaining and more fun”.	The user study revealed that the type of experience is "hugely different" than the face-to-face interactions they mimicked and require a period of adjustment. The placement may determine the type of interactions. For example, it would be "weird for a woman to perform caress while the Patch is on the chest" and performing a jab on the wrist may seem violent to others. Users will have to test these new experience and interaction techniques. Luckily the ribbon cable welcomes this exploration and the Patch can be placed anywhere on the body. Determining a mapping between the physical expression and location of Patch on the body is an area for future research.

Experience testing revealed that incorporating touch to Patches adds a depth of communication that supports friendship activities beyond traditional means. Usability testing showed that this new mode of communication is very different from the face-to-face interactions they mimic and that future research is required.

Table 5.10: Evaluating design goal Exchange Emotion.

Evaluation		
Conceptual	Experience Testing	Usability Testing
How do physical and visual representations allow the exchange of emotion?	The pilot study revealed that the direct connection provided by Patches creates a more personal and real interaction for the participants. From the user study, Patches creates a "warm network" that is a "fun and comforting way of staying in touch with closest people". Sending and receiving physical touch is "more intimate and meaningful than a text message". This experience supports friendship activities because it is more "fun, entertaining, new, and emerging". Participants agreed that the tactile, physical expressions created by Patches make it a useful extension to social networking and expression.	Participants in the pilot study liked the physical interaction that Patches brings to the traditional visual internet experience. The Interaction Model allowed participants to physically interact in more ways. Participants in the user study were amazed at the emotions encoded in their images and would like to have more control over the Patches Web Interface for sending expressions. A varied vibration would more closely connect the physical and digital worlds in a manner participants will better understand.

Patches is a “warm network” that augments the traditional visual internet experience by making the interaction more intimate and meaningful. The Patches Web Interface amazed participants by dynamically encoding emotions in their images.

The user study took a deeper look at the Wearable Social Network in terms of interaction design and compared with results from the pilot study. While the plot study gained a general understanding about sensory interaction and the online experience, the user study focused on examining the role of touch as a method of enhancing nonverbal communication between friends. With all of the features included, the user study evaluated the design goals: Timely Responsiveness of Communication, Interaction with Somatic Information, and Exchange Emotion. Some findings were consistent with pilot study results while others were unexpected.

The user study further described the direct connection created by Patches as intimate, comforting, accessible, and fun. It also clarified just how quick and simple this communication needed to be to support friendship. Users may not have the time to explore emotion through drawing and prefer buttons and short animations.

Incorporating touch adds a depth of communication that supports friendship activities beyond traditional means. The user study showed that this new mode of communication is very different from the face-to-face interactions they mimic. Even the placement of the Patch on the body will define the types of physical expressions users send. More time may be required for users to fully test these new experiences and interactions. More research relating touch and the body is required. Overall, participants describe the experience created by Patches as “warm, comforting, and intimate”. The next section states the limitations of the system during the user study.

5.5 Limitations of Patches

During the user study, technical limitations of the system prevented Patches from working ideally.

Though much research in this thesis has been dedicated to understanding the properties of thermochromic ink and controlling it using wearable electronics, the result is still far from ideal. For instance, the Patches were kept in a cool air conditioned testing room 24 hours prior to the user study and unfortunately, this prevented Patch electronics from sufficiently heating the thermochromic ink to reveal the icon underneath. During the study, an LED shone to represent heating of the ink. Without the intended result, this may have affected user study results. The visual effect created by thermochromic ink was meant to add to touch as a method of communication. Even without the thermochromic ink, participants still found the experience enjoyable, entertaining, new, and emerging. Ideal temperature conditions during the pilot study enabled the ink to perform as expected. Future e-textile research may create more robust fabric interfaces that will benefit Patches.

Another limitation was the Patches Web Interface. Technically, participants described it as "pretty understandable, very straightforward, simple to use, and user friendly". However, participants found difficulty in creating meaningful messages because the motions of the mouse did not match the perceived gesture and they wanted more control over the interface. Interestingly, one participant did not try to understand the mapping but merely drew a smiley face. The mapping between the line qualities and mouse movements should be revisited to make the system more sensitive. As a result, participants only tested a few physical expressions.

Finally, server problems prevented the Patches Web Interface to communicate directly with the Patch. After a user clicks the send button, the expression should be sent to the recipient. However, the server would time out. A work-around was created where after the send button is clicked, a link would appear, and after the sender types the link into a blank new webpage, the expression will be sent to the recipient. Some participants may have misunderstood the extra step. Communication from the Patch to the web interface was unobstructed.

While limitations hindered participants from fully enjoying the physical expressions, meaningful aspects of communication still emerged and analyzed.

5.6 Future Work

The user study generated possible improvements to the Patches system.

5.6.1 Varied Sensation for more Meaning

For some participants, the vibration they felt when receiving an expression seemed too short and light that it was difficult for them to understand what it meant. They suggested that a more varied sensation would be more meaningful, such as a rhythmic form of Morse Code where each expression would be identified with a unique combination of longer and shorter segments of vibration. It would also help participants to better differentiate between the twelve expressions. The user study was too short for participants to fully grasp these expressions. Perhaps through prolonged use, users will naturally come to understand these meanings and a more varied sensation will help this process.

5.6.2 Simpler is Better for Social Networking

Participants had their own suggestions for improving the Patches Web Interface: a guide relating the motion of the mouse to emotion, buttons with emotional words on them, or emotional animations. Buttons and animations are simple methods of online communication that align with the social interaction goals identified in the Wearable Social Network. Users may not have the time to draw their emotion because fast and simple communication in this context is more important to maintain a social connection. Similarly, future iterations of the project should also give participants easier access to their messages. Currently they can only check their messages through the Patches Expressions application. Creating notification messages on the profile and side panel of the Facebook homepage will give them easier access. Simple methods of communication may be more conducive for fast-paced social networking.

5.6.3 Meeting Personalization Goals of Young Professionals

While participants enjoyed the hands-on opportunity to design and described the DIY process as fun, easy, and creative, certain steps were more difficult than expected for participants and alternative personalization practices should be explored.

Half of the participants in the study were not familiar with graphics software and required help to shrink their images to 2cm diameter. More instruction is required. With the multitude of graphics software available, it would be difficult to provide instructions for all of them. One participant would have liked to make the process even easier using regular ink to draw directly onto the Patch, which is an alternative that Patches already supports. Also, painting and drying the thermochromic ink was difficult for participants. Some did not like the rough, uneven quality of the dried paint and opted for a more finished look. The paint that participants applied was too thick to be properly heated by Patch electronics. Finally, the DIY process only provides one opportunity for personalization, which is a physical limitation of the process. While one participant called the effect "interesting" after the sun was ironed horizontally and not vertically, another was a little disappointed at the imperfection left by her hair in the dried paint. It was clear that participants would not try DIY again if the intended effect was not achieved the first time. Clearly the DIY process should be revisited in order to determine the proper amount of materials and instruction to enrich the experience for the target demographic. HCI researchers have only recently begun exploring DIY practice, such as DIY methods, as an important alternative design practice (Buechley et al., 2009).

Alternatively, participants suggested that an online personalization interface would better suit their needs. An online system will give them many opportunities to redesign and alleviate challenging steps such as applying the thermochromic paint. Those who are not familiar with graphics software will not have to worry about shrinking the image. Most of all, participants can receive a perfect looking Patch in the mail. An online system will also give participants more control over the design, which aligns with the goals of personalization, such as creating a shape and choosing a fabric colour. This method of personalization may appeal to the participant who does not like “assembling things”. Options of finished work and example templates will guide them through the design process. Creating a successful interface that is easy to use for beginners while promoting creativity for experts is a challenge for future work. It is unknown whether a hands-on DIY project is more advantageous than a quick and simple web interface in terms of meeting personalization goals, an area for future exploration.

5.6.4 More Sharing Options

In the future, participants would like more opportunities to share the Patch with their friends. Instead of merely sharing with one friend, they would like the option of creating a small list of close friends so that all members in the list can send and receive physical expressions to everyone at once. Participants in the pilot study also expressed interest in packaging the Patches in sets or bundles and giving them away as gifts.

This is consistent with entrance survey results showing that participants enjoy communicating with their friends on both public (Facebook wall and status bar) and private (inbox) channels. However, tactile devices such as the Patch make this level of communication more difficult than on Social Networking Sites. To communicate directly with each friend in the group, separate Patches would be required in addition to this ‘group Patch’. To enable both public and private communication, perhaps this group Patch can have one button to send to the entire group and smaller buttons to send to a specific member of the group. There are still many logistical aspects of the group Patch that have not been considered and should be examined for the future.

5.7 Defining a Wearable Social Network

The transmission of virtual human expression over a distance becomes more vivid and meaningful when the sensation can be experienced on the body. Exchanging touch in this manner is very private, even when the connection is made through the internet. Hence, the social network created by Patches consists of intimate relationships such as a significant other, a good friend, or a small group of good friends. The deep social relationships created by Patches, requires fewer social connections. In turn, users tend to send and receive "nice", affectionate messages with each other such as cuddle, stroke, and hug rather than "violent" messages such as jab and punch.

By bringing digital communication into a tactile form that can be worn, Patches creates a stronger physical connection than traditional methods of communication. Patches extends current social networking communication to create a more interesting, entertaining, "fun and exciting way of socializing with one's friends and family". The Wearable Social Network is a "warm network" that creates a "comforting way of staying in touch with close family and friends".

The Wearable Social Network is a new paradigm that enhances nonverbal communication for a circle of friends. The ability to send and receive physical messages is "hugely different" than the real-world interactions they intend to mimic and more research needs to be done before this method of communication becomes "natural". With some refinement of the system, Patches will be a "cool" and effective method of communication for the masses.

5.8 Summary

This chapter describes a user study that examined the design considerations of the Wearable Social Network. Seven participants were selected based on prior friendship and membership of target demographic to encourage a social environment in a lab setting. Design considerations of the WSN were verified by examining social networking software usage as well as the sociability, and interactivity of Patches. It is through the research process that findings emerge to define the Wearable Social Network.

Entrance survey revealed that the high cost of mobile plans still makes mobile social networking costly for this group. This justifies Patches developed primarily as a computer-based system that incorporates mobile and wearable interaction. Computers remain a vital communications tool especially for social networking. Future ubiquitous communications technologies will benefit from the WSN architecture.

A mini focus group gave participants an opportunity to test the Patches Expressions prototypes and allowed for deeper discussion of the research questions. While the DIY approach met all of the design goals pertaining to Creating Strong Emotional Ties through Personalization and the icons created were meaningful methods of communication that met the goal of Communication through Symbolism, alternative personalization practices should be explored. Creating an interface that meets the goals of personalization and not of mass customization is a challenge for future research.

The Patches testing and exit interview revealed that interacting with Somatic Information such as touch is a powerful method of communication. Physically sending a message is more meaningful than traditional textual methods and meets the design goal of Communication through Symbolism. Exchanging the sensation of touch between friends creates an intimate Bond through Gifting, one that can be shared with a close friend, significant other, or small group of close friends. These messages are affectionate and the Exchange of Emotion is warm and comforting. A more varied sensation will make these messages more meaningful. These meanings emerge over time and a longer study period is required. Allowing users to create a small list of close friends will make Patches more sociable and interactive.

Touch adds to the traditional online internet experience. The user study also tested the Patch Web Interface, a drawing tool that infers expression and extends traditional screen and mouse interaction. However, simpler methods of communication such as clicking a button or dragging and dropping an animation were preferred and revealed the importance of Timely Responsiveness of Communication for social networking.

The WSN enhances communication for a circle of friends. This circle of friends is small but intimate. The type of communication is more interactive and social than current technologies.

CHAPTER 6: CONCLUSION

The focus of this thesis is to answer the question: How can we enhance nonverbal communication for a circle of non-collocated friends? An exploratory design process examined the research question in three phases: technology, social interaction, and sociability. At each step of the design process, formative evaluations were conducted to verify the design goals. This design process is a vital part of the research process in order to explore the user experience and obtain the knowledge sought by the research question.

Research into wearable electronics developed a set of tools, including materials and techniques, to successfully integrate elements of computing with fabric. These tools enabled the exploration of expressive fabric-based interfaces that contribute to wearable computing and e-textile research.

The question was also examined from a social computing perspective in hopes that translating our understanding from a human-to-human view to computing will aid in the creation of machines capable of richer interaction and subtleties of expression. A Wearable Social Network (WSN) was developed from concepts of social interaction in HCI and traditions of sociology to create a framework that is not limited in social networking scope. The framework was applied to the design of Patches, a wearable system that allowed users to physically feel online interactions and respond through touch and gesture.

A user study revealed some interesting results about the WSN that contribute to social computing research and proposes new areas for research. Patches creates a unique gift of touch, a physical gift that can be continuously exchanged between friends through digital representation. Experiencing a digital touch on the body is very private even when the connection is made through the internet. Hence, the social network created by Patches consists of very intimate relationships that are few in number such as a significant other, a good friend, or a small group of good friends. Users tend to send and receive “nice” and affectionate messages to each other such as cuddle, stroke, and hug rather than “violent” messages such as jab and punch. Incorporating somatic information such as touch to traditional communications technologies enables Patches to add a depth of communication that supports friendship activities beyond traditional textual means. While a user’s social network is numerous and complex, the deep social relationships supported by Patches requires few social connections. Developing Patches on the Facebook platform, initially chosen for its large social network, is still a useful tool to enable sharing with the closest people.

The experience created by the Wearable Social Network extends current social networking communication to create a more interesting, entertaining, fun, and exciting way of socializing with one’s friends and family. The Wearable Social Network is a “warm network” that creates a “comforting way of staying in touch with close family and friends”. Sending and receiving physical messages is “hugely different” than the real-world interactions they were designed to mimic and even the placement of the Patch on the body will define the types of physical expressions users send. More research is required to make this method of communication more “natural”.

Bringing digital communication into a tactile form creates an “online vs. offline” design space that opens many opportunities to study social interaction and expression. In this case, meaningful communication becomes the content through the mood and emotion being exchanged. This framework can be applied to the design of any social network, not just for wearable computing. With some refinement of the system, Patches will be a “cool” and effective method of communication for the masses.

This thesis also makes some interesting observations about social networking and the demographic that are worth mentioning. The high cost of mobile plans still makes mobile social networking costly for the target demographic. Perhaps communications technologies should be primarily computer-based and incorporate mobile and wearable interaction to add nuances of meaning. Future ubiquitous communications technologies may benefit from the Wearable Social Networking architecture. In addition, people may not have the time to explore all the intricacies of an expressive interface and prefer more direct methods such as buttons and animations. Simple methods of communication may be more conductive for fast-paced social networking.

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APPENDICES

Appendix A: Wearable Electronics Research

The wearable electronics research investigates the expressive and tactile qualities of fabric that is suitable for wearable computing applications. A variety of materials and techniques were explored to incorporate electronics and computational elements into clothing and effectively hide computation within fabric. The goal is to create thin and flexible interfaces that support touch as a natural method of interacting with fabric. This section summarizes the materials and techniques used to explore the expressive and interactive qualities of thermochromic ink for wearable computing interfaces. The collection of these materials and techniques form tools for wearable computing research, which were applied to the development of Patches, a wearable social networking device. This section is intended as a resource for researchers interested in creating wearable computing devices as specifications are rarely discussed in papers, only the finished product.

A.1: Materials for Wearable Computing

Thermochromic ink is a heat sensitive, non-emissive ink that can change colours at a variety of temperature ranges, even at body temperature. It has two states: in its inactive state, it takes on a specific colour while in its active state, it changes to another colour or clear. Industry uses thermochromic ink as a fun way of indicating a winner on some promotional cups or containers and even battery testers. The ink was also used in art pieces such as Berzowska's Shimmering Flower (Berzowska, 2004) and Orth's Moving Target. For the purposes of this thesis, a series of experiments was conducted to explore the expressive properties of thermochromic ink as a natural fabric interface. The approach was to paint the ink onto a surface and control its states using electronic and sewing materials. Various inks were tested in the experiments as different viscosities and colours affect the temperature ranges. All experiments were conducted indoors at 22 ˚C. Silk organza, nichrome wire, conductive thread, and diodes were tested for their expressive heating ability. Their properties are described below.

Silk organza is a traditional fabric from India known for its smooth, flat, finish. It is weaved from two types of fibres - in one direction is ordinary silk thread while in the other is a silk thread that is wrapped in a thin copper foil. The second thread is conductive and has been used in wearable electronic projects (R. Post & Orth, 1997). The spacing between the conductive fibres allows silk organza to be individually addressable and function like a ribbon cable. This fabric also supports soldering.

Nichrome wire is an alloy created from nickel and chromium. It is commonly used in toasters to irradiate bread, as well as hair dryers and ovens. It is typically wound in wire coils to a certain electrical resistance and current passes through to produce heat. Its high resistivity means that a short length of it has enough resistance to create heat. However, more power may be required to heat the thermochromic ink, which may be undesirable for mobile electronics.

Unlike iron, it cannot rust. The experiments use 28 gauge nichrome wire with a resistance of 11.165 Ω/m.

The main purpose of conductive thread is to sew various electronics into clothing to carry electrical signals from one place to another. Conductive thread can be made in many ways including spinning metal strands with regular thread (stainless steel), or coating the thread in a silver or metallic paint. The experiments use 2-ply, silver plated nylon thread with a 269 Ω/m resistance.

A.2: Techniques for Wearable Computing

The following experiments reveal a set of techniques for creating thin and flexible interfaces for wearable computing. In all experiments, thermochromic ink is applied to the fabric interface like paint. This section summarizes how silk organza, nichrome wire, and conductive thread may be used to uniformly heat and control the ink.

While silk organza is effective at transmitting electrical information such as through a ribbon cable (R. Post & Orth, 1997), it was found that its low resistivity makes it an ineffective heating element. Figure A.1 shows a fabric interface that consists of various colours of thermochromic ink. The strands of copper foil break at 4V and this voltage is not enough to heat the ink.

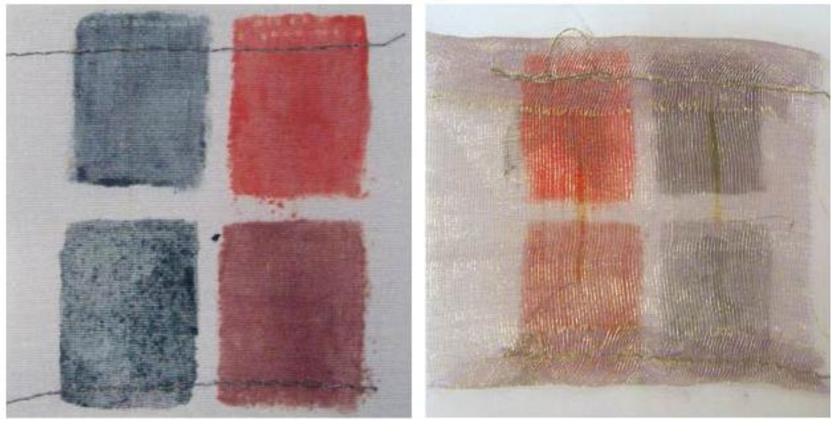

Figure A.1: Silk organza is ineffective at heating thermochromic ink as the copper foil incinerates at 4V.

Conductive thread produces better results than silk organza. A sewing machine can uniformly distribute conductive thread on the fabric to create preferable heating results compared to hand sewing, Figure A.2. Machine-sewn conductive thread also requires less voltage than the hand-sewn method, which is advantageous for mobile electronics, Table A.1.

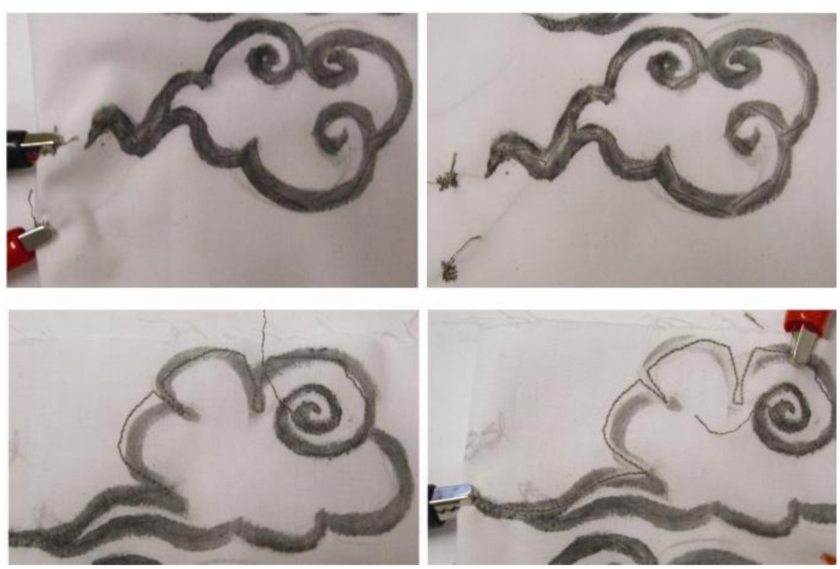

Figure A.2: Hand-sew conductive thread (top) is ineffective at heating the cloud design but machine-sew (bottom) creates desired results.

Like conductive thread, nichrome wire can also heat the ink to change states. However, nichrome wire must be broken up into segments to effectively heat a design, which causes the fabric to lose its flexibility, Figure A.3. It also requires more power and a longer cooling time than conductive thread, Table A.1. These disadvantages make nichrome wire less desirable for mobile wearable electronics.

Table A.1: Conductive thread and nichrome wire power specifications.

Hand Sewn Conductive Thread				
Current (A)	Voltage (V)	Power (W)	Time To Heat (s)	Time To Cool (s)
0.02	7	0.14	7	20

Machine Sewn Conductive Thread				
Current (A)	Voltage (V)	Power (W)	Time To Heat (s)	Time To Cool (s)
0.05	4.5	0.225	7	33
0.06	5	0.3	10	20
0.06	5.5	0.33	6	24
0.07	6	0.42	4	26

Nichrome wire				
Current (A)	Voltage (V)	Power (W)	Time To Heat (s)	Time To Cool (s)
0.79	1.5	1.185	9	31
1.05	2	2.1	5	39
1.33	2.5	3.325	3	42
1.59	3	4.77	2	48

This table shows power and time specifications for conductive thread and nichrome wire. Because mobile wearable electronics are limited by their power requirements, this table examines the effect of voltages below 7V. The table shows that machine-sewn conductive thread requires less voltage to heat the ink than hand sewn conductive thread. While nichrome wire operates at even lower voltages, it requires more power and takes longer for the ink to cool, making it less desirable for mobile electronics.

Figure A.3: Nichrome wire must be segmented to heat sophisticated designs.

Properties of conductive thread were examined in more detail. Various sewing machine stitches can also affect heating and cooling times as well as the amount of colour change. Figure A.4 shows thermochromic ink applied to a variety of conductive thread stitches. Some stitches were doubled to avoid breakages. Table A.2 shows that the optimal sewing machine stitch changes the ink's states in 2 seconds at a minimum of 5V. These findings influence the type of microcontroller and circuitry required for controlling the thermochromic ink interface. For instance, the Patches project uses the Arduino Diecimila microcontroller whose pins output 5V to comply with heating requirements. However, the output was still not powerful enough and MOSFETS were added to increase the power, see Appendix B for circuitry details.

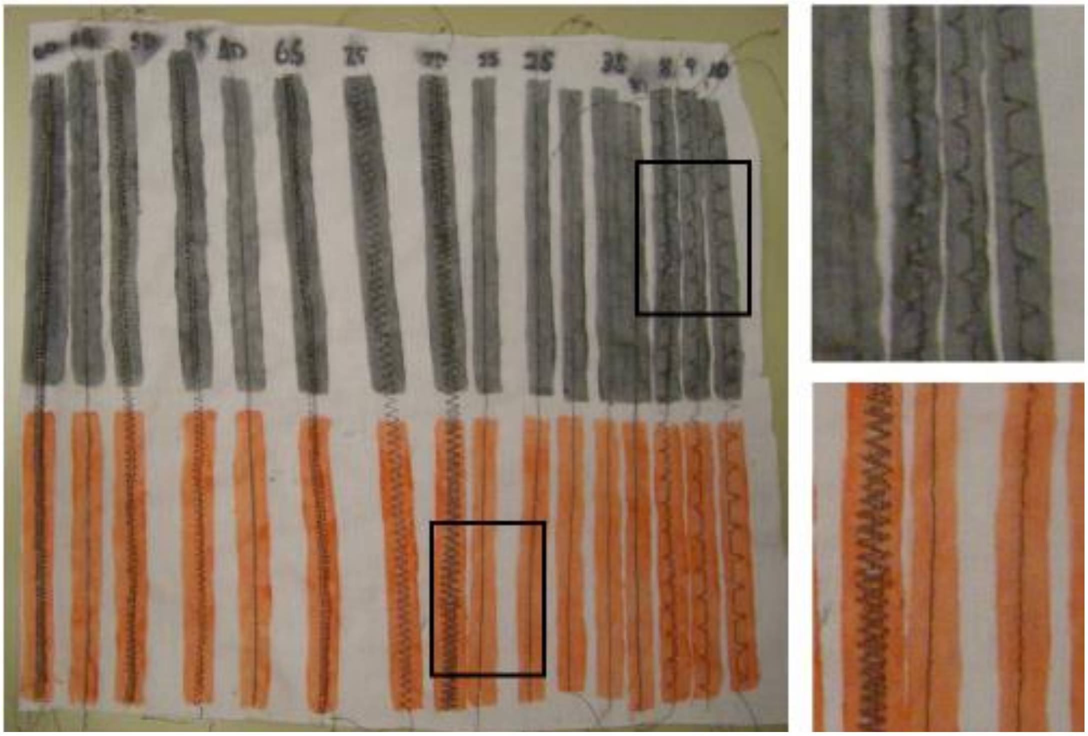

Figure A.4: Thermochromic inks applied to various sewing machine stitch patterns.

Table A.2: Best sewing machine stitches based on amount of ink change, voltage, and heating and cooling times.

Orange ink	Stitch	Type	Voltage (V)	Heat Time (s)	Cool Time (s)	Amount of change (cm)
Best Stitch	1	single	5	2	13	0.6
2nd Best	2	single	5	2	17	0.6
3rd Best	4	double	6	2	26	1

Grey Ink	Stitch	Type	Voltage (V)	Heat Time (s)	Cool Time (s)	Amount of Change (cm)
Best Stitch	3	double	5	2	60	0.6
2nd Best	3	double	4.5	3	60	0.6
3rd Best	4	single	5.1	4	20	0.6

This table identifies the optimal sewing machine stitch patterns for conductive thread based on parameters of voltage, time to heat and cool the ink, as well as width of colour change of the ink. The optimal stitch heats the ink in 2 seconds at 5V.

These experiments developed a set of tools for wearable computing such as materials and techniques to integrate electronics into fabric. A variety of techniques was tested to control thermochromic ink using silk organza, nichrome wire, and conductive thread. Power and time specifications for nichrome wire and conductive thread were determined which may serve as a resource for future researchers. For the purposes of this thesis, conductive thread is a better solution for wearable computing for its low power requirements and uniform heating abilities.

A.3: Expressive Properties of Thermochromic Ink

The expressive properties of the ink were explored using the wearable electronics tools developed in the previous section. Thermochromic ink can dynamically hide and reveal information. Figure A.5 shows that the green thermochromic ink turns clear to reveal the pink flower design when power is applied. The nichrome wire, sandwiched between the layers of fabric, has been twisted into a flower shape consistent with the design. The Patch is built using this idea of hiding electronics in layers.

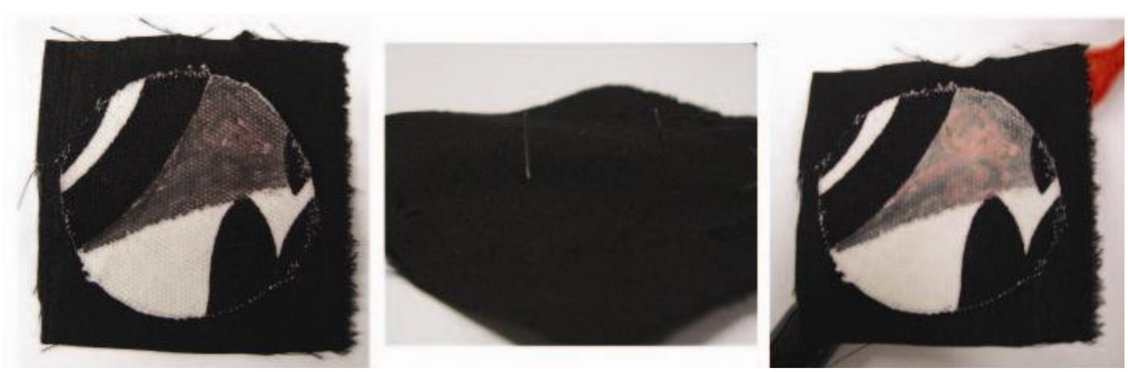

Figure A.5: Thermochromic ink can hide and reveal information such as the flower design underneath.

Actively hiding and revealing the ink can create passive animations as demonstrated by Berzowska's Shimmering Flower (Berzowska, 2004) and Orth's Moving Target. Figure A.6 shows the propagation of a slow wave like in an animation. However, this slow delivery may be ineffective for rapid communication with friends and other means of faster transmission, such as vibration, were explored in Patches.

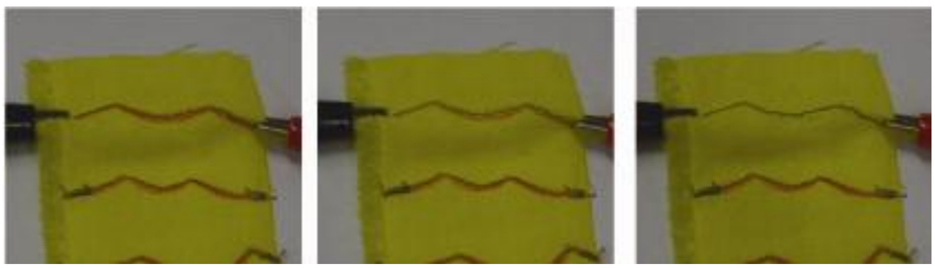

Figure A.6: Actively hiding and revealing information can create passive animations such as a ripple of water.

Thermochromic ink can also hide and reveal information like a pixel on a fabric screen. While conductive thread can heat interesting designs, it is ineffective at heating a large surface as demonstrated in Figure A.7 where not all of the ink changed states after one minute. Nichrome wire, sandwiched between polyester batting, created a soft fabric surface that uniformly heated the ink in about one minute, Figure A.8. Figure A.9 shows diodes arranged in a row-column- addressable structure to individually address each diode for finer heat control. Different configurations of diodes were soldered to copper tape to maintain the natural flexibility of the fabric. Extending the number of diodes can mimic a digital fabric screen. Further research is required to fully realize this potential.

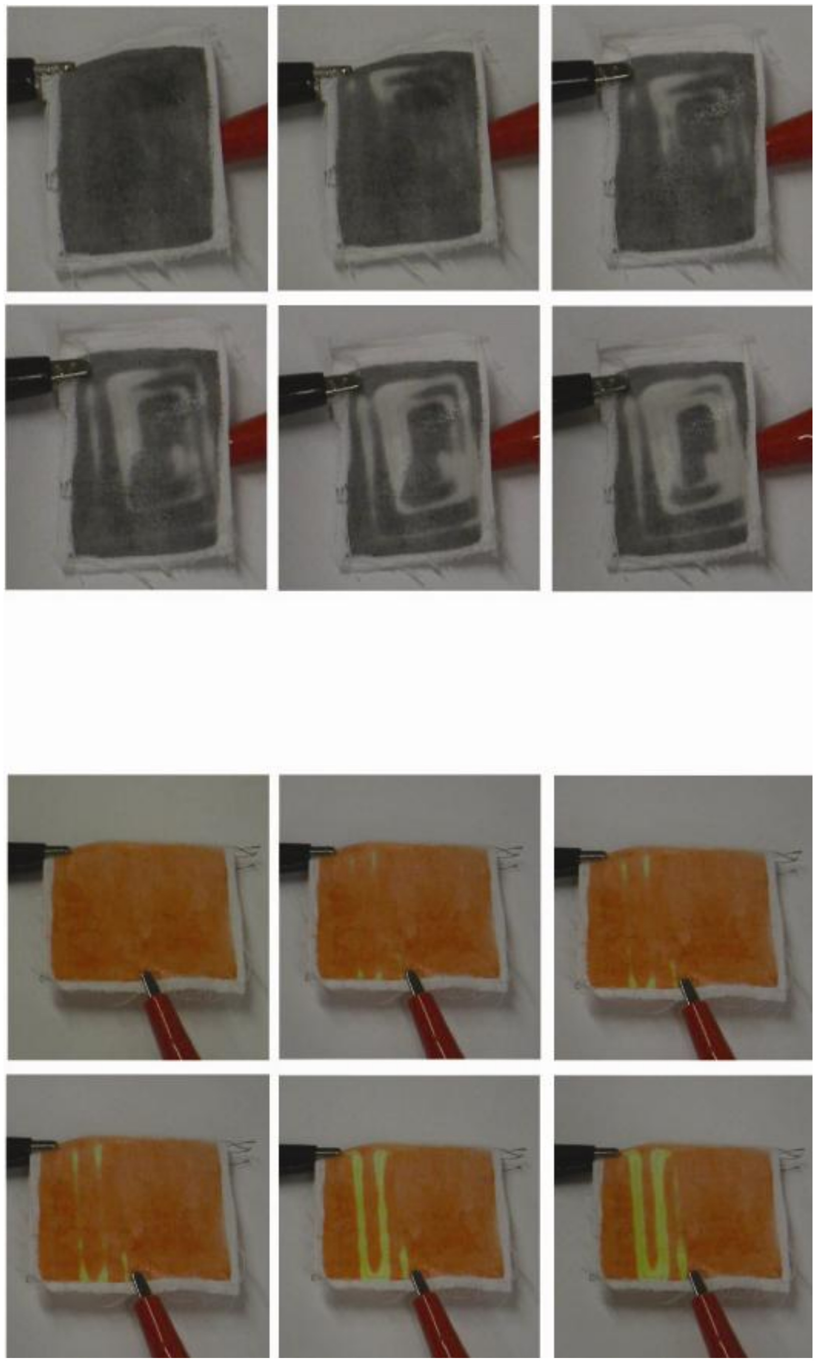

Figure A.7: Two configurations for controlling pixels using conductive thread

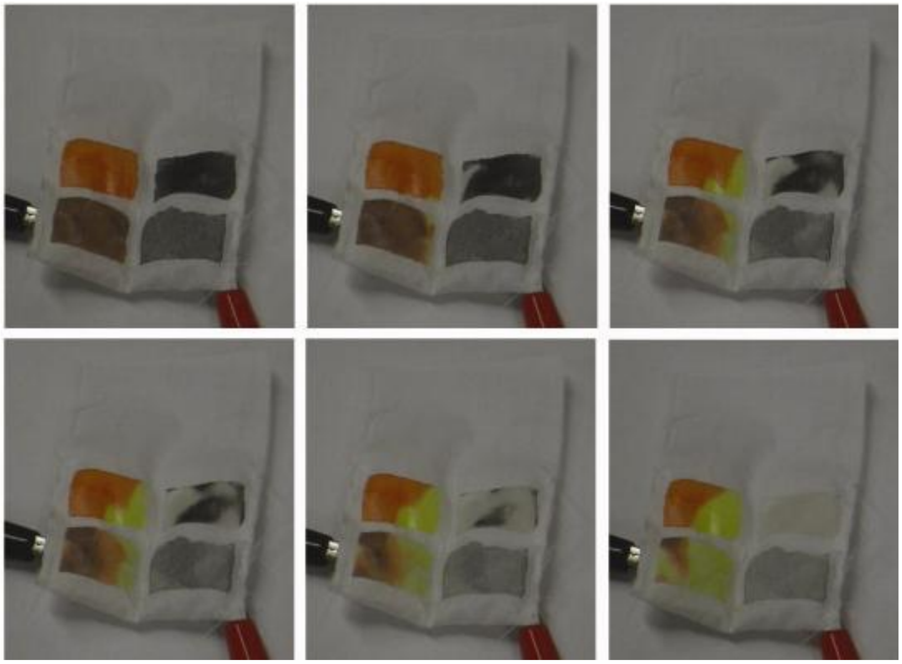

Figure A.8: Nichrome wire uniformly heats the fabric surface in less than a minute.

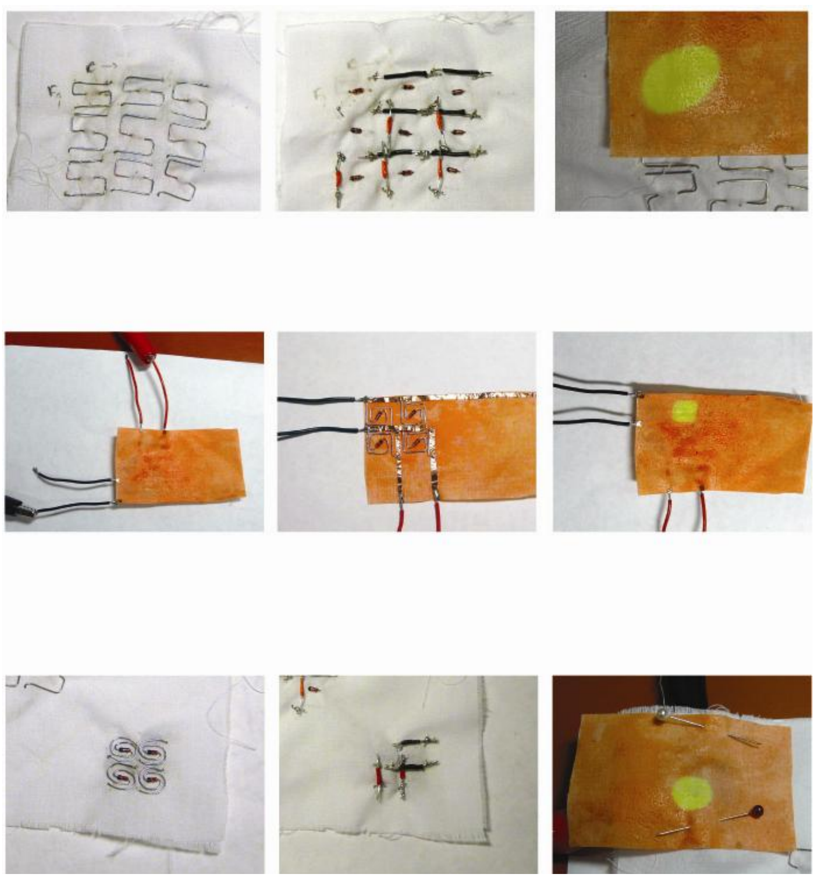

Figure A.9: Different configurations of diodes creates different heating patterns.

This section explored the expressive properties of thermochromic ink using the wearable electronic tools developed in the previous section. Experiments demonstrated the expressivity of the ink using nichrome wire and conductive thread to dynamically hide and reveal information, create animations, and test fabric like pixels on a screen. This research extends contributions from Orth (Orth et al., 1998; E. R. Post & Orth, 1997), Buechley (Buechley & Eisenberg, 2009) by exploring the dynamic nature of the ink to create interfaces that are more expressive. More research is required to fully realize this potential.

A.4: Fabric Touch Pad

To promote interaction, a fabric touch pad was developed to support touch and gesture recognition. The main material is conductive foam, which acts as a variable resistor with applied pressure. For example, a piece of 1.5 cm by 1.5 cm by 0.5 cm has a resistance from 0 Ω to 400 Ω. A microcontroller can pick up these signals for further processing. The fabric touch pad also comprises of fabric, silk organza, and diodes. Figure A.10 shows a 2 by 2 fabric touch pad. A diode is poked through the light cotton fabric and the ends are twisted in a circular fashion to increase surface area for connecting to conductive foam. A conductive foam piece is placed on top followed by another diode while silk organza acts as flexible wires. Figure A.11 shows the touch pad connected to an Arduino microcontroller. The columns of the touch pad are outputs from the Arduino while the rows are inputs. A voltage divider regulates the voltage at the input using a 10 kΩ resistor. The Arduino drives each column and reads each row in quick succession to measure pressure on each pad. This fabric touch pad also supports multi-touch, which opens more possibilities for interaction. The Patches system applies this touch-pad design.

Figure A.10:A fabric touch pad made from conductive foam (black), diodes, and silk organza.

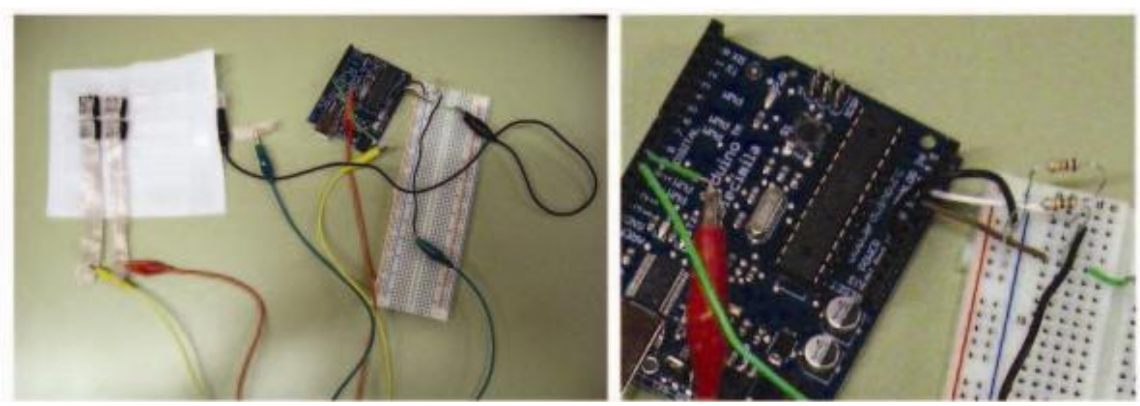

Figure A.11:The fabric touch pad connects to an Arduino microcontroller using voltage dividers to regulate the voltage at the input.

The wearable electronics research developed a set of tools for wearable computing including materials and techniques to successfully integrate elements of computing with fabric. These tools include power and time specifications for thermochromic ink and techniques to control conductive thread, nichrome wire, and diodes. Machine-sewn conductive thread was the best technique and various sewing methods were identified to optimize the result. This research extends the contributions from Orth (Orth et al., 1998; E. R. Post & Orth, 1997), Berzowska (Berzowska, 2004), and Buechley (Buechley & Eisenberg, 2009), by exploring the dynamic nature of the ink to create more expressive interfaces. To enable interaction, the research also proposes a fabric touch-pad design, which can measure touch as a natural method of interaction with clothing.

Appendix B: Patches Circuitry

A PatchShield is created specifically for the Patches system to act as an intermediary between an Arduino microcontroller and the physical Patch, Figure B.1. Figure B.2 shows the required circuitry for the PatchShield including sensors and power source and Figure B.3 shows the sensors required for the Patch. Please note that in Figure B.3, an “M” symbol inside of a circle represents a vibration motor and a resistor inside of a circle represents a conductive foam touch pad. Please see Appendix D for source code.

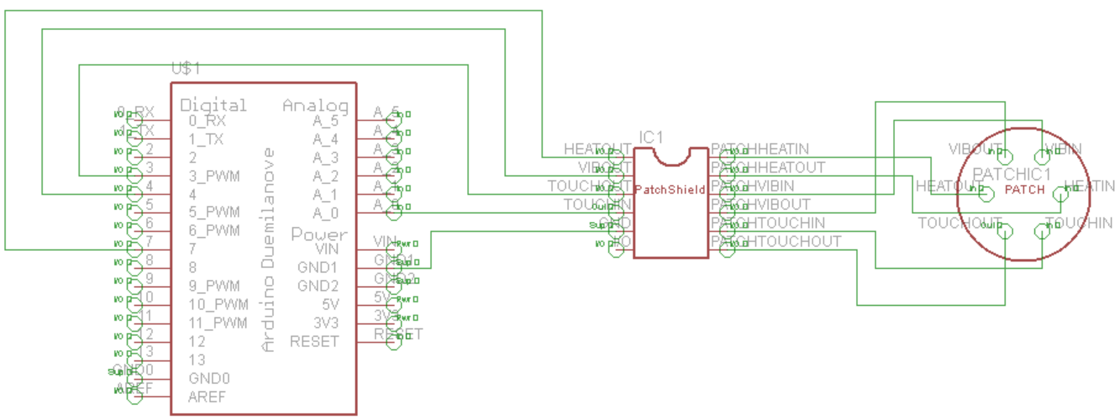

Figure B.1: Full circuitry for Patches System.

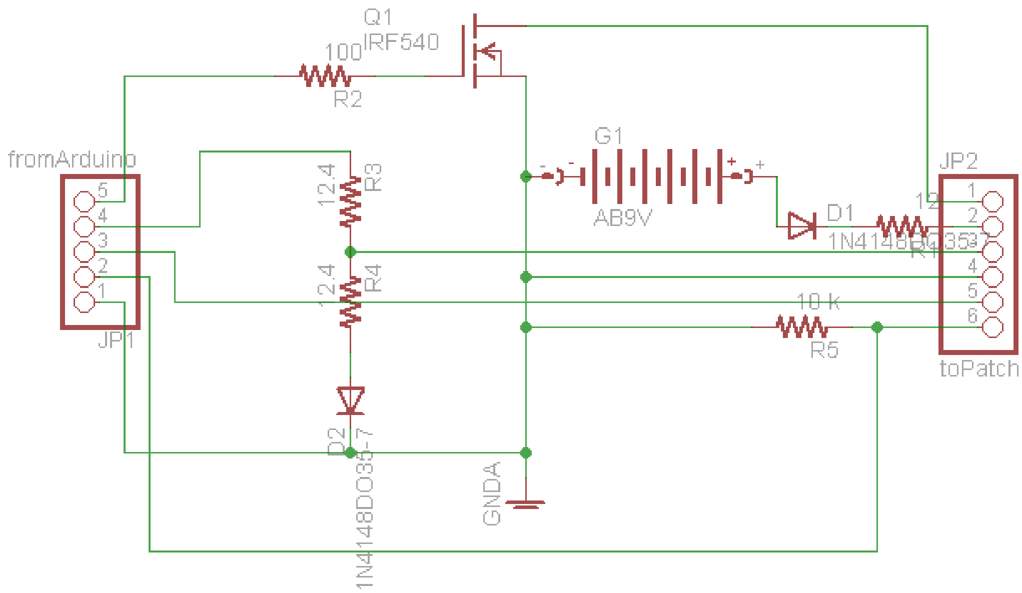

Figure B.2: Circuitry for the PatchShield.

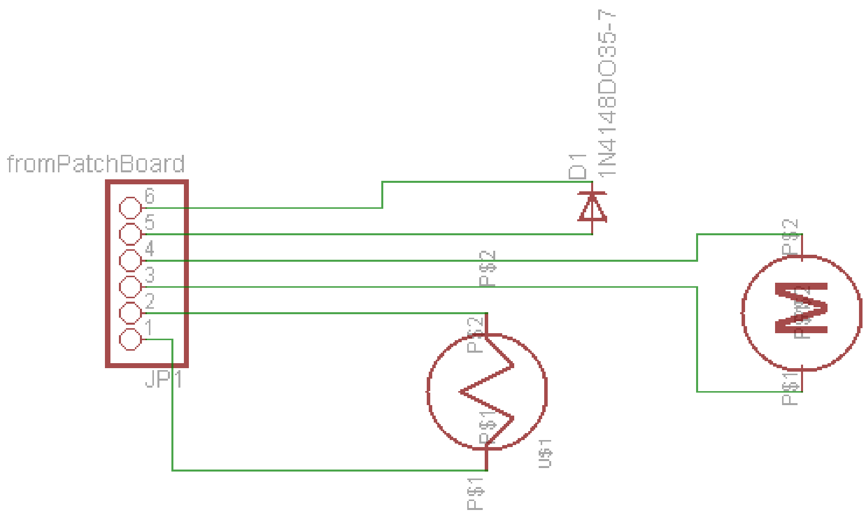

Figure B.3: The Patch circuit.

Appendix C: Comment Cards

Figure C.1 shows the pilot study questionnaire. Figure C.2 is the pre-test survey for the user study, Figure C.3 shows the DIY questionnaire, and Figure C.4 shows the Patches testing questionnaire.

Here is the group exit interview questions in the order presented:

1. What are some positive features of the expressive online interface?
2. What are some negative aspects of the expressive online interface?
3. How can the interface be improved?
4. Were you able to figure out what you needed to do in order to create the specific expressions?
5. Do you have any further comments about the online interface?
6. What did you feel when you received a physical message? What are some similarities and differences between the received physical message and the actual sensation?
7. Were the touch gestures adequate in order for you to send a physical expression? What are some similarities and differences between these gestures and the real physical expression?
8. Was there anything particularly challenging or ambiguous about sending and receiving messages? How might this be improved?
9. How does Patches (including the expressive online interface and physical Patch) extend the current Facebook action features such as ‘poke’?
10. Do you see any benefits of using the Patches system for communicating with your friends instead of using a computer?
11. Did you enjoy making your own Patch during the DIY portion, or would you rather buy a finished Patch, given the style is not an issue?
12. Where on your clothes can you see the Patch being placed?
13. Does this placement have any bearing on the types of expressions being sent and received?

Patches: A Wearable Social Network

Comment cards

How does adding sensory information (such as heat, vibration) change your internet experience?

How do the senses of heat, vibration, and touch change the online Facebook Poke experience?

Are there any benefits of using the Patches system for communicating with your friends (given they have Patches as well) instead of using a computer?

If the Patches product existed on the market, given that cost and style are not issues, would you buy it? Why?

Additional comments:

Thank you for your comments,
they greatly benefit the Patches Research

Figure C.1: Pilot study questionnaire.

Patches Expressions

Entrance Survey

Thank you for your participation in the Patches Expressions Workshop. Before we begin, we would like to get to know a little more about you.

What is your age?

Do you or have you used social networking applications to communicate with your friends? (Circle all that apply)

Facebook MySpace Twitter LinkedIn Bebo Hi5 Orkut Friendster Cyworld

Are there other social networking applications that you use?

How often do you check these applications? Hourly? Daily? Weekly? Monthly? ...

Please describe your usage. Do you mosty play games or write messages to your friends?

What is your preferred mode of accessing these applications?

How else do you interact with your friends online?

Thanks for your comments

Figure C.2: Entrance survey.

Patches Expressions

Comment Card 1 - DIY

Tell me about your Patch design. What did you create? Does it have any meaning?

Did the Patches Kit adequately allow you to express yourself to others? What other materials would you like to see in the Kit?

Did you find the project easy? difficult? fun? expressive? ... and why?

Is the DIY approach appropriate for you? What elements would you require for DIY to be useful and attractive to you?

Additional comments:

Thanks for your comments

Figure C.3: DIY questionnaire.

Patches Expressions

Comment Card 2 - Patches Testing

Did you choose to share your Patch? If so, with who? Else, why not?

When sending interactions: Did you find the online Patches interface understandable? Were you able to expressively communicate your intentions?

How did you feel when you physically received an expression? How did you understand the sensation? How can the experience be improved?

When physically responding: Were you able to communicate your intentions physically?

Do you see Patches as a useful extension to social networking communication and expression?

Additional comments:

Thanks for your comments

Figure C.4: Patches testing questionnaire.

Appendix D: CD-ROM Data

This CD-ROM is meant to accompany the thesis. The PDF file was created with Adobe Acrobat and may be opened in any PDF program. The MP3 file was created with iTunes and may be opened in iTunes program. The WAR files were created in Eclipse and can be opened in Tomcat server. The 'client' source code can be open and executed in Eclipse while the 'server' source code can be open and executed in NetBeans. This information can also be found online at http://sr-yin.iat.sfu.ca/.

Contents:

• ReadMe	3 KB

User Data

• Pilot study data	13 MB
• User study data (Entrance survey, Comment Card 1 & 2, and Exit Interview)	47.5 MB

Code

• Patches (for pilot study) (Instructions, Arduino, JavaScript, client, and source files)	5.45 MB
• Patches Expressions V1 (for user study) (Instructions, Arduino, server, client, and source files)	50.4 MB
• Patches Expressions V2 (post user study) (Instructions, Arduino, server, client, and source files)	50.4 MB