
Interactive Therapy Gloves: Reconnecting Partners After a Stroke

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Abstract

This paper explores the challenges that affect long-term partners after one of them suffers from a stroke, and offers a design solution as part of the CHI 2011 Student Design Competition. The challenge posed was to create a design that would help us to appreciate and celebrate our differences through the novel use of technology. We examined the changes that both partners go through during the recovery period after a stroke. We then designed an interactive glove as part of the rehabilitation process. The intent was to foster acceptance of each partner's contribution and to help them reconnect. This paper details the iterative design process involved.

ACM Classification Keywords

H.5.2. User Interfaces: User-centered design. H.5.2. User Interfaces: Haptic I/O.

ACM General Terms

Design, Experimentation, Human Factors, Performance

Keywords

Stroke therapy, rehabilitation, caregiver, RFID, haptic interface, wearable technology, user-centered design

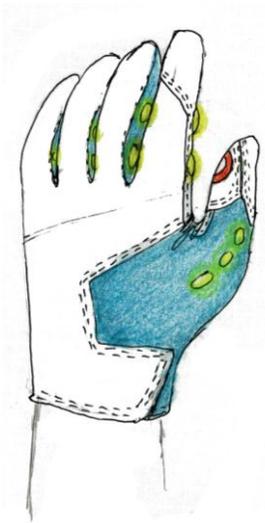


Figure 1: Sketch of early concept.

Introduction

Stroke is a pervasive agent of change, as this sudden loss of brain function can alter a person's cognitive and psycho-motor functioning; including how they respond to familiar objects and events, how they learn, and how they relate to their family and friends. Rehabilitation requires dedication and a significant investment of time to a series of continuously repeated and constantly changing tasks, prompting the brain to remap the lost function [2]. This dedication is required from the partner as well, and the newly shared burden can place a strain on the relationship [1].

Design Challenge

The CHI 2011 Student Design Competition challenged us to facilitate our understanding of and celebration of difference through the novel use of technology. Stroke as a source of difference distinguishes itself by carrying with it the expectation of reversal, or a return to a norm [2]. The struggling partner may have trouble accepting the survivor as the same person after the stroke – this becomes an increasingly discriminatory point of view if they show little chance of recovery from their disability [10].

User Definition

We chose to focus on the differences that exist between a stroke survivor and a long-term partner, now caregiver, with emphasis given to people around the age of 55, where the risk of stroke begins to increase. The stroke survivor would likely be seeking treatment through a rehabilitation clinic for some minor cognitive dysfunction, and would likely be looking for a supplemental recovery tool for use at home. Their partner would likely be looking to play an active role in their recovery.

Design Goals

We approached this problem by developing an interactive wearable device to guide the user to learn by exploring the world around them; augmenting the natural tendency to touch and grasp objects to understand them better. We aimed to use this device as a tool for communication between the partners that would engage the caregiver directly in the progress of their partner's rehabilitation. The first difference that we addressed was the caregiver's perception of how their partner had changed, from before the stroke to after, and the struggle they undertake to accept their partner in this new context. We also wanted to address the perceptions held by each partner in relation to the degree of intervention needed to mediate the stroke's impact, and to assess the stroke survivor's changing perspectives of their caregiver [11]. Ultimately, we desired to give them a way to reconnect after the injury, and to ease the burden of the recovery process.

Experience Prototyping

Prior to implementing this research, approval for the project was obtained from ECUAD's Research Ethics Board. Following which, to meet the needs of this challenge, we built our process around experience prototyping – rapidly constructing iterative prototypes that explored a new concept, and testing them immediately with human participants to pinpoint opportunities to improve the interaction. Establishing a cycle of divergence based on research and ideation, followed by a convergent period of refinement and prototyping, gave us the freedom to test a number of concept artifacts and gain results quickly [12]. This approach also allowed us to ramp up the technical complexity of the models as we came closer to a workable solution.



Figure 2: Detail of LEDs on a prototype.

Prototype 1 - Haptic Controller Glove

Concept

We began by ideating on the topic of occupational therapy, and the rehabilitation of the hand, in the context of a shared experience between the survivor and care-giver. The scenario we envisioned had the partners able to connect to each other by participating in the rehabilitation process together – developing games and activities that could be created using a simple interface. We met with staff at the G.F. Strong Rehabilitation Center (GFS) in Vancouver, Canada to discuss the viability of a rehabilitation glove. We were provided with a framework for home therapy and encouraged to continue [4]. After researching some mirrored interface exercises used in neuroplasticity, we developed a concept based on twinned interactive gloves, so that data could be transmitted between the partners [2].

Users

Through an informed consent process we invited 6 students from our university to test our initial prototypes, as we had limited access to patients through the rehabilitation center at this early stage.

Prototypes

Our initial prototypes were built quickly, sewing small vibrating motors and LEDs onto the fingers of cotton gloves. User control was achieved through one of two features; a joystick or by a matching glove with conductive fingertip contact pads and powered by an Arduino microcontroller. The controller glove functioned by touching the thumb to each finger, which stimulated the corresponding finger on the affected hand.

Testing

Our participant testers worked in pairs - one in the role of the survivor putting on the haptic glove, and one in the role of the caregiver wearing the controller glove. We first tested the sensitivity and positioning of the haptic motors on the fingers, and then started the testers on a session of free play and blindfolded pattern matching. In addition we gathered feedback through interviews and the think-aloud protocol where our users talked about the process of moving through the activities. We tried to determine whether the vibration motors were adequately indicative as a means of communicating motion instruction, and the usefulness of the LED indicators, in relation to the nature of the communication between the two participants.

Results

Our participants reported various responses to the haptic vibration, ranging from pleasant to irritating. The testers using the controller reported confusion as to the mapping of the joystick positions to each finger, while the tests with the twin gloves were deemed to be much more intuitive. Users did complain when they had to wait for input and response from each other, which could be slowed by the need to interpret the haptic feedback as movement instructions [6]. As we progressed we began to feel that this solution was problematic as our implementation of the vibrators seemed limited. The semiotics of the controller was also identified as problematic. It's configuration established a power relationship of one person being in charge, with the other being subordinate.

Prototype 2 - Touch Sensitive Glove

Concept

We began this prototype with the intention of creating a

touch sensitive interface that could be used to measure the survivor's progress through a series of occupational therapy activities at home [3]. We looked to existing performance tracking precedents like the Nike+ running system, and considered how we could collect and present data in a similar way using our glove, in order to motivate the survivor [8]. Making this information visible would allow the caregiver to better celebrate on their partner's as they progression, while providing comfort and encouragement in times of stagnation or regression [7].

Prototype

We constructed a new glove pattern designed to hold a dense network of sewn circuits. Each glove finger had a custom-built Force Sensing Resistor (FSR) sewn into the fingertip, an array of LEDs with a different colour for each finger, and a small vibration motor placed just below the fingernail on the top of the finger [9]. The glove was then connected to an Arduino, which communicated to a laptop running Processing over a serial connection to drive the interaction.

Testing

As a proof of concept, we programmed the glove to play piano tones on the laptop, using MIDI. Our test participants were encouraged to play simple songs (limited to those playable with 5 consecutive notes in a major key), and to improvise with chords and piano exercises. We also provided them with a number of common household objects and tested the capabilities of the glove as an indicator of grip strength. Finally, we asked for subjective feedback about fit, comfort, ease of use, and comments on the activity.



Figure 3: Components in the prototype.

Results

Our test participants were much more engaged with this prototype than the previous ones, learning and performing basic songs with little instruction as to the function of the glove. We were also able to effectively measure relative grip strength with objects where pressure was applied using the fingertips. Each of the users tested indicated that they were comfortable wearing the glove, and understood the interface and feedback mechanisms. Most participants reported enjoying the combined experience of the visual, audible and tactile feedback, one respondent reporting that "This is more fun than playing the piano".

Prototype 3 - RFID Glove

Concept

The Touch Sensitive Glove proved successful as a responsive and inviting peripheral, but it did little to foster communication between our partners. We decided to try to apply our recently gained knowledge to the more practical concerns of their daily lives. Stroke survivors can have trouble remembering the use and meaning of objects in their homes, as they may also struggle to remember details about their own lives and identity. It falls to the partner-caregiver to be the source of this knowledge and to be patient enough to provide it whenever requested [10].

To address this need, we proposed a system that would allow the partners to communicate directly through the objects that formed the source of the questions. By integrating a Radio-frequency identification (RFID) reader into the glove, and tags into the objects, we could identify the object in the user's hand, and provide them with answers. To seed the objects with recorded meaning, we provided the caregiver with a similar glove

which allowed them to record audio and attach the recording to the tagged object. Using their glove, the stroke survivor could therefore ask a question about an object simply by picking it up, and would get the answer in the familiar voice of their partner through headphones. By guiding the caregiver to create these recordings, they would be reflecting on their partner and their relationship, encouraging them to better appreciate the work their partner is doing to recover.

Usage Scenarios

We designed two primary interactions with the gloves, to investigate a broad array of daily uses for when the partners are apart:

- Providing reassurance, explanation and assistance for common objects and tasks that the stroke survivor may be confused by when the caregiver is absent
- Leaving personal messages and stories about their history as partners, and aspects of their lives together, before and after the stroke.

We also examined two secondary interactions built around music that would allow them to connect through the gloves while they were together:

- Playing music using their fingers, while switching instruments with different RFID tags
- Getting an audio preview of tracks on records/CDs to help them choose an album to play together.

Users

We intend to test the prototype with 3-5 stroke-affected patients from G.F. Strong Rehabilitation Center, and their partner-caregivers. We will supplement this testing with a group of 3-5 couples aged 50-65.

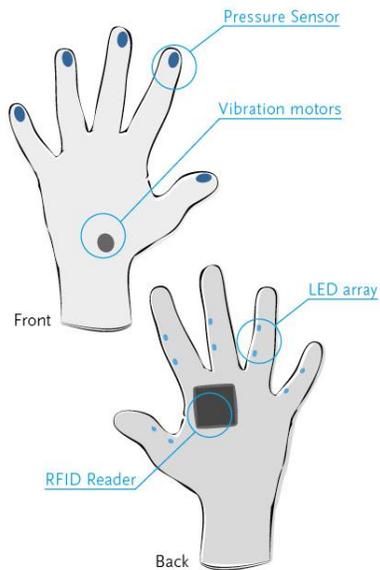


Figure 4: Component schematic.

Prototype

Building on the Touch-Sensitive Glove prototype, we have added an RFID reader and removed the haptic vibrators from the fingers. A motor has been added to the base of the palm, the intention of which is to aid the discovery process of the RFID tags.

Testing

After a detailed task-analysis of the interaction, we foresee the following tests

- Gestural testing to determine the most appropriate use of the fingertip pads in combination as an interface for playback and recording of the audio
- Ergonomic testing to position the RFID reader and haptic vibrator for comfort and ease of detection of the RFID tags, when visible and hidden.
- Focus group testing to learn about the objects that couples use to communicate with each other.

Feasibility and timeline

Building on our existing touch sensor prototype, the RFID version will be relatively straightforward to implement. At the time of this submission, we are beginning the next prototyping cycle, and expect to have a working solution by April 2011.

Conclusion

The injury sustained in the brain of a stroke survivor may well serve as a metaphor for the damage done to the relationship of a couple suddenly cast into the new roles of dependent and caregiver. Change at this traumatic rate can provoke feeling of loss and confusion at the difference that each partner sees in the other, and demands understanding and acceptance of each other and their new relationship to be able to move



Figure 5: Working prototype.

forward together. Our therapeutic system aims to acknowledge the burden that each partner carries, and to engage them in such a way as to better understand and connect with each other, while assisting with the rehabilitation that may be able to allow them to once again feel normal in their life routine.

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