Stroke Imprint: Knitting Reassurance into Anxious Moments

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Abstract

Imagine if, during moments of heightened anxiety, you could once again feel the gentle, familiar touch of a loved one's hand. Stroke Imprint is a knitted wearable that simulates stroking sensations to comfort young women experiencing anxiety through pressure sensing and SMA-based actuation. Paired with a digital interface, the glove allows users to record personalized tactile sensation. Through user interviews, design iterations, and user testing, the study demonstrates the its potential as an anxiety tracking, therapeutic, wearable within a closed biofeedback loop.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**; • **Applied computing → Psychology**.

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1 Introduction

1.1 Background and Motivation

Anxiety Disorders (AD) are the leading mental health disorder among adults, yet their evaluation relies on self-report data, which is prone to patient denial and inaccurate memory. However, when combining contextual self-report data and biometric data, particularly Heart Rate Variability (HRV), we may accurately detect the onset of anxiety [Hickey et al. 2021]. One recent study further proposes that personal health tracking wearables may enhance mood tracking when combined with biometric-data-triggered self-report prompts which assess mood and triggers [Malhi et al. 2017].

On the other hand, studies have shown that affective touch, such as hand-holding and stroking, between humans have a calming effect on anxiety and stress [Eckstein et al. 2020]. Hands are the dominant sensing organ for humans, as illustrated in the Sensory Homunculus. The back of the hand has the primary function of receiving tactile sensory input, making it useful for the affective touch systems, particularly inter-personal touch [Ackerley et al. 2014].

Such a framework demonstrates the need for an on-hand wearable device that 1) simulates human-to-human touch when it is not readily available, and 2) detects the onset of anxiety. Research has shown that females are more than twice as likely to develop an anxiety disorder than male counterparts during their lifetime [U.S. Food and Drug Administration 2025]. Our research targets young women prone to anxiety with limited social support. We propose the following speculative narrative: "Adia longs for independence, but being away from loved ones triggers anxiety that can strike anytime. She finds comfort in the all-day knitted glove—it feels intimate and warm, like the way her loved ones would stroke her hand to ease her anxiety."

Additionally, users can record multiple Stroke Imprints via their phone. When the glove detects a change in HRV, it gently checks in, prompts the user to log a trigger, and replays comforting strokes—simulating how a loved one might offer reassurance in person—if received user confirmation.

1.2 Sensing and Actuation System

We designed an open-palm, fingerless glove with finger straps. In contrast to rigid, "hard looking" smart wearables, hand knitting creates a bi-elastic, customizable, intimate fabric in direct contact with the skin. The sensing unit utilizes a three layer structure to obtain analog pressure readings from Arduino.For actuation, four Flexinol Shape Memory Alloy (SMA) springs were inserted into four I-cords (tubular channels) to integrate into the knitted structure. When activated, the SMA springs contract and cause part of the knit to slide down toward the wrist and the finger straps to tighten. Bias force is created by the fixed anchor from the tight wrist cuff and elasticity from the finger straps. When cooled down, the springs are stretched, and the knit shifts upward to its relaxed state.

During the Stroke Imprint recording phase mentioned above, the pressure change is detected and recorded into a 2 x 4 matrix. The data is then translated into variables that control the contraction of four individual SMA springs.

1.3 Precedents Mapping

Pressure-sensing matrices have been widely explored in interaction design and DIY coommunities, such as *Textile++*, which proposes a resistive touch sensing matrix consisting of a non-conductive mesh in between two conductive fabrics for a cuff-based user interface [Cao et al. 2018]. Few research and applications have been centered around the sensing capability of the back of hands and fingers. Additionally, most on-skin tactile interfaces use servos, pneumatics, or vibrotactors—often bulky, loud, or limited in expression. SMA offers a compact, silent alternative with organic motion. Prior work like *KnitDermis* and *Skin+* explored the potential of SMA-based actuation in wearables to deliver tactile and visual feedback [Kim et al. 2021; Ono et al. 2017].

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Our contribution lies in integrating these technologies into a speculative, emotionally situated use case, shifting the goal from functionality to felt experience. We propose a localized, dynamic on-hand interface with both sensing and actuation of affective strokes, as well as the speculative use case with closed bio feedback loop using the pulse sensor and a digital user-interface.

2 Methods and Results

2.1 Primary Research

Primary research was conducted by interviewing 17 volunteers (10 females, 7 males). Both male and female participants were recruited because the target user group—young females with limited social support and prone to anxiety—may have close relationships to both groups. Each participant was presented with the question "How would you comfort someone whom you are close with and who is feeling anxious by interacting with their hand?" We documented their hand interactions to analyze the pattern and location of affective touch performed.

2.2 Primary Research Results

Two participants expressed discomfort in physical touch as a soothing strategy. Among the remaining 15 participants, 11 of them performed holding, among which six performed holding the comforted party's fingers. Six of them performed stroking. Seven performed a combination of affective touch, among which five performed holding and stroking simultaneously.

Due to the impractical nature of finger gloves, mittens, or mitts for the speculative all-day wear use scenario that calls for breathability, elasticity, and durability, we strategically 1) designed an open-palm, fingerless glove with wrist cuff and adjustable finger straps to hold in place, as well as 2) focused on stroking the back of the hand—the second most common affective touch.

2.3 User Testing

Ten female participants with an average age of 24.5 (SD = 2.42) were recruited for the user testing. During each 20-minute session, they were first debriefed about the project objective and asked to read the speculative use case narrative. To evaluate the sensing and actuation, the participants put on the glove, received a stroke at a random location on the glove from the researcher, experienced the SMA-spring-actuated sensation, and were asked to 1) describe the sensation and 2) choose one human touch with the most resemblance to the sensation: pinch, squeeze, tap, or stroke. To evaluate the speculative use case, the participants were presented with the following questions: "If you were Adia, 1) what would strengthen the association of glove-actuated sensation with your loved one's physical touch, and 2) what would make the sensation more pleasant or soothing?" Participants' audio was recorded upon consent.

2.4 Key User Testing Results

The most commonly mentioned adjectives for describing the SMA-spring-actuated sensation were "warm," "strange," and "pleasant." Seven participants reported that the sensation matches with "stroke," while two participants reported "pinch." Some described the tightening of the finger straps as "gripping," while others reported that the shape-changing visual of the glove influenced their perception. Eight participants mentioned that the rhythm, pressure, and location of stroke would strengthen the association of SMA-spring-actuated sensation with their loved one's physical touch. To heighten the intended soothing property of the sensation, four participants proposed incorporating olfactory experiences into the fabric, and two participants mentioned thicker finger straps for comfortability and full-hand sensation.

Based on the abovementioned user feedback, we switched to smaller-diameter SMA springs, reducing cooling time from nine to two seconds. The rhythmic actuation, paired with clenched-fist interaction—users start with their fist clenched and release it after receiving a stroke to stretch the contracted SMA spring—supports stroke patterns to "unbuild the [user's] anxiety."

3 Conclusion and Future Work

We confirmed the soothing and pleasant qualities of SMA-spring-actuated sensation, largely due to the soft, intimate nature of hand-knitted fabric and the warmth generated from the actuation. Rather than replacing human touch, Stroke Imprint glove intends to serve as a therapeutic tool that allows our target user group to self soothe anxiety and a reminder of the tangible presence of their support system even in their absence.By framing biometric sensing as care from loved ones—and reinforcing it through compassionate UX writing—privacy concerns may be softened.

Future iterations will explore more localized actuation for personalized stroke patterns with varying rhythms, pressure, and locations. While further testing is needed to assess sustained, all-day calming effects, we see promising opportunities in anxiety regulation training through a speculative biofeedback loop that blends tactile memory, physiological sensing, and emotional design.

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