# Telehaptic Awareness

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## Abstract
In this paper we present the next iteration in our study of wearable and mobile haptic communication, proposing to conduct a many-to-many haptic communication experiment over time. We wish to present the project and results in both the Demo and Poster format.

## Keywords
Haptic, telehaptics, social haptics, haptic language.

## ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User interfaces.

## Introduction
There are several projects that have investigated telehaptic communication between single users. However, there are few, if any projects that have investigated telehaptic communication between many-to-many users. Given the mass usage of smartphones and social media; such 'social haptics' promise to shed new light on technologically possible, future applications that employ embodied communication.

The project group has developed several single user, full body haptic systems with up to 80 variable vibrotactile outputs [1]. These represent advanced and specialized single user haptic systems. In this experiment we propose to change focus toward a telehaptic system targeting multiple users. A critical issue for mobile haptic applications is that users physically have to wear the system on their body. Current full body systems are too complex to be worn over time [2]. A simplified system enables the user to wear and use haptic interactions more frequently. Reducing the complexity of our previous solutions enables us to investigate haptic communication and stimulation in an everyday setting and over longer periods of time. This study will help us understand more about the effects of haptic interactions in a many-to-many scenario where users are distributed over large distances; it will also work as the foundation for defining our future studies within distributed haptic interactions

*Telehaptic Communication History*

There are several projects that have investigated telehaptic communication between single users. One of the first was The Transatlantic Telephonic Arm Wrestling system developed by Norman White and Doug Back in 1986. It was a simple force-feedback system that allowed participants in two remote locations to arm wrestle [3]. The technology was based on a motorized custom-built force-feedback system. Through remote modem connection the force exerted on the local electro-mechanical wrestling arm would be transmitted to the remote location, and vice-versa. It was shown in a transatlantic link between the Canadian Cultural Center in Paris, and the Artculture Resource Centre in Toronto. As a system it is interesting for the study of haptics in several ways. Firstly it is a real-time, two way system where the users can exchange brute force immediately, thereby gaining a good sense of presence as well as communication. Secondly, this immediacy creates a shared and social event. It also demonstrates the importance of having 'real' players at each end. If the opponent was replaced by a computer it would function like a Turing test, possibly revealing a machine-like behavior over time. Relevant for this paper is how the project apparently causes a strong sense of telepresence with only one actuator device. However, its haptic resolution appears limited and the range of meaningful expressions is for that reason uncertain. A project related in technology is the 'Networked Neuro-Baby' by Naoko Tosa, demonstrated in 1995 between Tokyo and Los Angeles. Users could both communicate to the emotionally expressive visualization of the Neuro Baby software and remotely shake hands by squeezing a 'Handshaking Device'. This device measured the handshake's pressure and relayed the position and pressure data to the remote user through a force feedback interface [4], [5].

The first telehaptic system to connect two users wearing bodysuits was the cyberSM experiment. In 1993 it connected participants between Paris and Cologne [2].

One of the first mobile and telehaptic art projects was the 'Mobile Feelings' project by Christa Sommerer & Laurent Mignonneau [5]. Here two users each held an egg-shaped communication interface that let the users exchange heartbeats. The haptic effect was created with only one vibratory output, but still let users 'feel a strong sensation of bodily connection' (ibid). They also note that 'the sense of touch still remains one of our most private sensations for which we still lack a concise language to describe'. However, as a language of touch appears contingent on haptic resolution (as the number of stimulators over surface of stimulation), it is likely that the minimal haptic resolution of one vibrator influenced a lack of haptic expressivity [2].

The 'Hug Shirt' by the CuteCircuit company attempts to construct haptic communication for simple, personal messages between users wearing what appears to be a normal looking shirt. The shirt transmits 'hugs' in the form of vibrotactile stimulation to another, similar shirt via a Bluetooth and Java enabled telephone device. Although scarcely described the shirt apparently has a haptic resolution of 10+ effectors. The company has worked on developing a taxonomy of hugs, but its effects are unclear.

Another similar project is the 'Huggy Pyjamas' by Cheok [6] that exchanges hugs through pneumatic actuators, allowing stronger sensations, but on the cost of wearability.

In the field of interaction design, the Strangely Familiar [7] project at Ivrea produced two projects that dealt with remote communication and use indirect haptic feedback. The Tok Tok by Aram Armstrong was a communication system connecting two distant lovers in faraway cities such as Tokyo, Toronto or Tel Aviv. When each lover knock on their box shaped interface, this is heard as a sonar like pulse in the box in the remote location. The receiving box then automatically 'ping's' the sound back to the original box. The time delay for the signal to return is based on the distance between the lovers locations. The further away, the longer the delay. In the other project, Tug Tug by Haiyan Zhang, dedicated and old style telephones offer an extra layer of interaction. By pulling the cord connecting the handset to the base on each phone, each person physically affects the other cord.

The Lega project [8] is a system used as a communication enhancer. It is made of a series of identical devices used in exhibitions. Lega devices are used in groups of 2-5 people. Each person carry their own Lega and moves around the exhibition freely. The devices, somehow egg shaped, provide haptic feedback resembling the movements made by users when experiencing a piece of art. Each device communicate wirelessly with all the other Legas in the confinement of the museum, replicating the movements by means of vibrations.

All these mentioned projects create some kind of dedicated telehaptic communication between two users. However, besides Lega there are few, if any projects that have investigated many-to-many telehaptic communication using wearable devices. Therefore, we propose to investigate how multiple users experience telehaptic interactions over extended periods of time and large physical distances.

## The Telehaptic Awareness Project

State of the art of Smartphone technology allows prototyping new scenarios where users can be located almost anywhere and where they can wear the devices at any time of the day. Smartphones and the Arduino [9] system are lightweight and relatively transparent and can therefore be mounted/worn both ergonomically and aesthetically pleasing. To test how well this can be done we propose to build and explore a telehaptic experiment between multiple users and over longer periods of interaction. Based on the experiences from the above mentioned projects and our many haptic systems we want to gain more knowledge of possible focal areas in a many-to-many haptic interaction scenario. Several open research questions will be explored. How does long term telehaptic communication affect and possibly increase our (social and physical) awareness of those we interact with? Indicators of this can be differences in the sense of (others) presence, multimodal interactions (touch in combination with voice, sms, mail, images) and more. Research parameters of importance in networking are [10] similarity between group members, incentives for communication (research in haptics), standards to to types of inquiry and response (our own platform), facilitators for increased system functionality (iterative improvement throughout the project) and finally attitudes conducive to information exchange (all four participants have a stake in the research).

*Experiment Setup*
The four users will attempt to wear the system for up four weeks. There will be scheduled daily Skype meetings to monitor and register use and problems of use of haptic feedback. Throughout the test period we also expect several cycles of system improvement, in particular with reference to software, but also possibly hardware issues such as battery cycles/systems as well as modifications to the initial layout of the haptic 'necklace'.

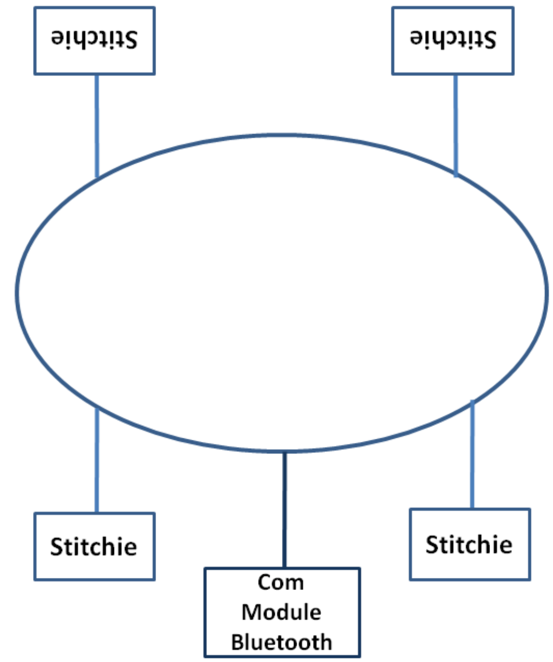


**figure 1.** Wearable haptic interface layout.

When applying touch in multiple user interactions it is necessary to identify who is doing what.  We call such recognizable patterns for haptic identifiers. These are expected to contribute to the formation of meaning. At the outset there will be an open exploration of the systems. The experiments will start without individual identifications. Other open research questions this might answer are whether users over time create and leave identifiable, unique tactile ‘fingerprints’? What are our behavioral haptic patterns? Who 'scratches' what and when?

*System Setup*

The work in progress setup involves four users. Each user wears a lightweight, wearable and mobile haptic input/output (IO) system shaped as a necklace and worn over the neck. The necklace has a tactile resolution [2] of four variable, vibrotactile actuators. Each actuator is called a 'Stichie' and is an addressable mini smartboard.

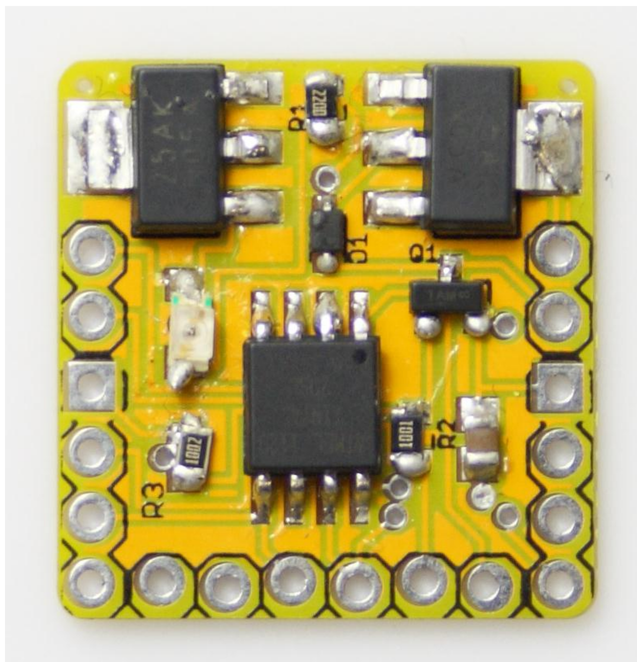

**figure 2.** Stichies module version 2, assembled.

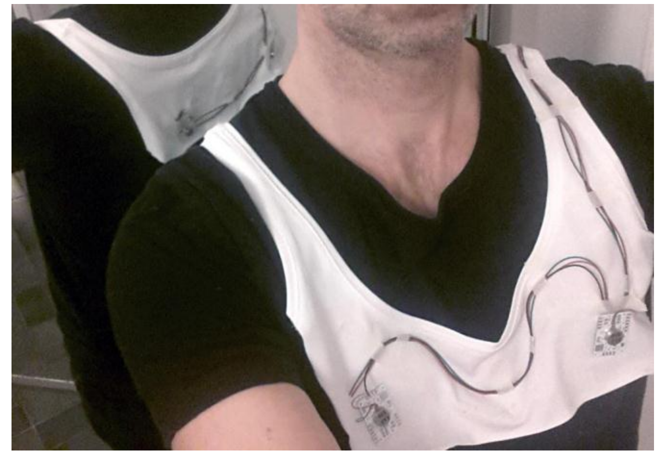

**figure 3.** First prototype of necklace

These Stitchies are designed for easy application in almost any context. They allow for simple expansion of the system, even attaching multiple systems together, creating a very high maximum tactile resolution. The ‘Stitchies’ have been tested in a one suit, one user environment [1].

The publish/subscribe paradigm, as described by [11], makes a lot of sense when developing a distributed haptic system like this because of the inherent space, time and synchronization decoupling between senders and receivers of haptic events.There are multiple publish/subscribe protocols developed, each intended for specific contexts.

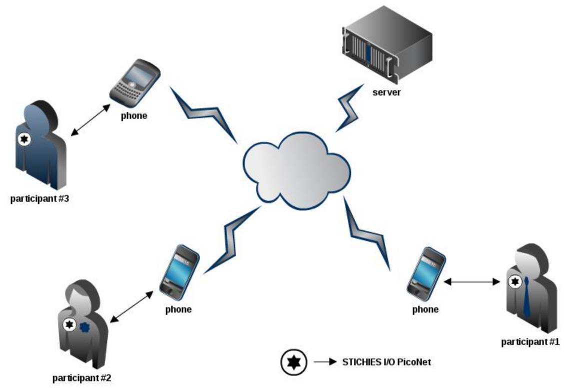


**figure 4.** Overview of the experimental setup.

The Message Queue Telemetry Transport protocol (MQTT) [12] is one of these protocols which are designed to be lightweight with a low overhead. Because of its small footprint it works well on low-bandwidth connections, such as mobile data networks.

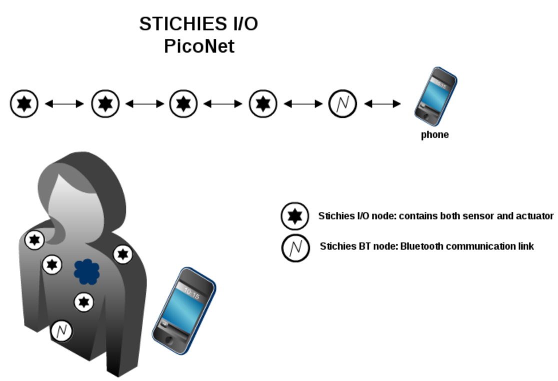


**figure 5.** The internal network diagram of Stitchies.

*Haptic Stimulus positioning*

With only four variable vibrotactile actuators, it is vital that their positioning on the body is optimal and distinctly recognizable. To keep the system as simple as possible, both in terms of technical complexity and wearability, we have opted for two haptic zones on the back of the shoulders and two on the chest. All vibrators will be placed on soft tissue as not to reverberate through bones and thereby stimulate larger, unidentifiable parts of the body. Based on our initial 'necklace' prototype and testing, these four zones appear to be the optimal locations of vibrators on the body. The prototype with four Stitchies producing variable, vibrotactile stimulus indicates that a range of haptic sensations and illusions [13] can be produced.

*Haptic Language*

Previous projects have a common difficulty in clearly describing what haptic sensations and illusions [13] can be produced and what perceived meanings they convey. How to understand tactile information in an intutive and easy manner is a challenging question. Braille and Tadoma are examples of how it can be generalized, but on the cost of for example a steep learning curve [2].

The project will initially apply clearly distinguishable haptic sensations such as the so called TAU phenomenon that describes a tactual illusion of apparent movement. When a multiple point haptic system produces a series of short and discrete pressure sensations on the skin, they are perceived as movement between the points. Various patterns of vibrations over time promise to let the users form and distinguish between haptic messages. Another of our open research questions is what meanings are perceived. How can haptic communication form a haptic language? In relation to this Thecla Schiphorst has worked on developing a 'Semantics of Caress' [14] that investigates how the meaning of touch can be applied to tactile interaction. Her approach represents touch and movement as something meaningful, contributing to quality sharing. Having identified vague, but intrinsic values of haptic communication in systems with relatively low haptic resolution, one of our research questions will be how this can be translated into functioning, wearable systems that produce a greater degree of tactile immersion? Here fore we will apply new smartphone technologies and open source Arduino hardware.

*Methodology*
The experiment will apply a qualitative research design mix of participatory action research and ethnomethodology. Action research methodology is useful as it involves the process of actively participating in an experimental change situation whilst the members conduct the research. Ethnomethodology is useful as the members will self-reflect on their participation in the exploration of the haptic communication and its phenomena. The result will be presented as a case report reflecting the knowledge and meanings that the four participants reported.

The setup will first be tested by four members of the research team. Advantages for this approach are, among other i) short prototype cycles, ii) fast feedback, iii) friendly familiarity between participants and iv) expected lower threshold to experiment with patterns.

*aWearness*
The combination of a communication system targeting increases in social awareness with a wearable haptic system can be termed an 'aWearness system'. A key indicator in the experiment is if users will report an increase in aWearability? That will be measured both as awareness of the other group members and transparency of the lightweight and invisible (to others) hardware. Other indicators we are looking for will range from awareness of others somatic sensations to their movement, state of mind, and emotions. As such as experiment has not been done before, we expect to uncover several other issues and questions as the project develops. Some of the questions that may arise through our study might be i) How is a haptic communication system perceived when worn over longer periods of time? (Steve Mann), ii) In a many-to-many haptic system, how are individual users identified?, iii) Who is touching what, and when?, iv) Will users develop unique touch patterns?, v) Can users be distinguished through 'haptic fingerprints'? and vi) How are haptic patterns influenced and changing due to contextual changes in everyday settings? Question related to usability issues are for example if such a system is suitable in an everyday setting and whether the lightweight necklace is perceived as 'transparent'?

## Expected Outcomes
We believe this Telehaptic Awareness project will bring in new knowledge about wearable haptic communication systems such as indications if it is sustainable to be used by a mass audience.

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