inHale, a teletangible device for synchronized breathing

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ABSTRACT
In this article, we introduce inHale, a teletangible device that inspires synchronized breathing by enabling groups of individuals to create their own rhythms, patterns, and self-define their own collective metronome. With the recent outbreak of the COVID-19 pandemic, there has been a significant shift seen in the yoga community to a remote setting, resulting in a social disconnection between individuals. We propose inHale as a tool that facilitates group synchronization in remote settings through breath. This paper presents an initial, designed, functional prototype utilizing force-feedback actuation.

CCS CONCEPTS • Tangible User Interfaces • Respiration • Wearables

Additional Keywords and Phrases: Synchrony, Interpersonal Communication, Haptics, Force-Feedback

1 INTRODUCTION

A key element of the ancient practice of yoga is controlling one's breath in order to connect the mind and the body [1]. When practiced communally, group breathing is considered an essential part of attaining a sense of unity. However, when all activities shifted online in response to the COVID-19 pandemic, opportunities for in-person connections were lost. When individuals do yoga in separate places, seeing and hearing one another over a video call does not create this same effect of unity found in in-person yoga.

inHale mimics this synchronization of breath by allowing any number of physically distanced people to feel the movement of one another's breath. inHale is a wearable device that enables individuals to feel the expansion of other participants' diaphragms as they breathe, and to contribute to the collective breath–a phenomenon usually experienced audibly in in-person environments.

2 BACKGROUND

Existing research highlights various benefits of yoga. These areas primarily focus on both mental and physical health, along with social connection and general well-being. "Studies suggest that, as a group of yoga students breathes and moves together, a mental synchronization is taking place as well," [2]. This

correlates to social connectedness, which has suffered greatly since the start of COVID-19: “social isolation, because of a lack of social connection, can result in a deterioration in well-being with negative consequence[s] on health,” [3]. Therefore, our work strives to meet the individual desire for social connection, which would inherently lead to positive health benefits. In regard to synchronous behaviors, Mogan, Fischer, and Bulbulia state, “it has been theorized that synchronous activities increase social cohesion amongst group members, enhancing cooperative behavior” [4]. Furthermore, they state “for example, Macrae et al. (2008) argued that a social allocation of attention during synchronous action affects positive social outcomes through greater attention to and processing of the actions of group members” [4]. Which further supports the benefits of communal activities such as yoga. When speaking to a yoga instructor about their experience with virtual yoga classes, they stated, “In a yoga class, hearing other people’s breath and listening to my own breath informs how well I am listening to my body’s needs...Zoom is completely disconnected from that energy.” A virtual environment inhibits the senses one would normally be able to utilize in a live in-person class, inHale provides a new form of sensory feedback –making breath tactile.

3 RELATED WORK

inHale allows individuals to meet their desire for communal connection through the application of a wearable device, which is responsive to breath. Other devices typically are used for individual regulation/relaxation, rather than to synchronize an entire collective through a form of movement. For example, aSpire is “a clippable, mobile pneumatic-haptic device designed to help users regulate their breathing rate via subtle tactile feedback,” [5]. This “non-intrusive tactile feedback” also can contribute to various health benefits, and reduce mental stress through the implementation of a wearable device. aSpire is geared toward individual use and for personal breathing regulation. It is separate from connecting other people with the same motion of taking a deep breath. But the versatility in this device is inspirational when thinking about our own work with inHale, and future iterations of the project.

Much like the preceding project, inTouch, inHale works with the same concept of “physical expression over distance” [5]. Since yoga classes are designed to allow users to feel one another’s breaths, the idea of shared touch translates. By mimicking the haptic sensation of other people’s breathing, inHale creates a new kind of shared touch.

Additionally, OmniFiber is a “reconfigurable fiber technology for movement-based interactions based on thin fluidic fiber actuators with closed-loop strain control” [6]. This device can cause fiber to contract and expand, helping with breathing and “help patients regulate respiratory actions in post recovery” [6]. Our design was inspired by these designs, however inHale uses a programmable spiral railing instead of making the fabric itself programmable.

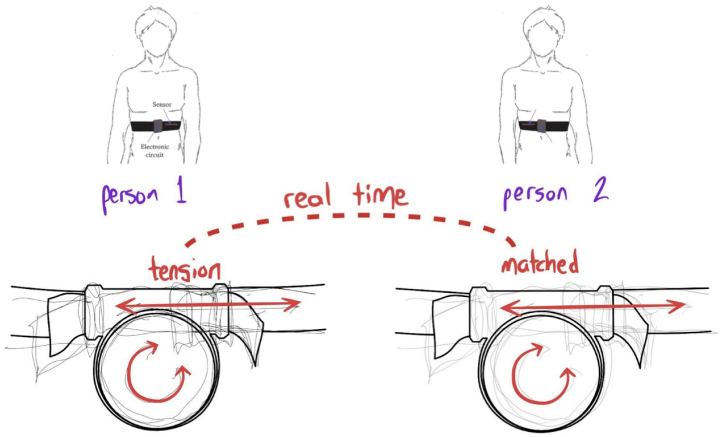
Unlike the many precedent haptic wearables that affect respiratory states, inHale combines telecommunication with collaboration by introducing a group regulated tempo, rather than an externally designated rhythm.

4 INHALE

This prototype is designed to be a wearable haptic device that wraps around the user’s chest to externally actuate the diaphragm to contract and expand in synchrony with other users.

4.1 THE CONCEPT

While most current haptic wearable research focuses on the recreation of physical sensations in virtual environments (e.g. haptic VR gloves) or embodying virtual feedback through touch (e.g. music rhythm), inHale aims to create interpersonal connections through a physical and essentially human input and output [Figure 1]. The device is strapped onto each person's chest or stomach, depending on use (e.g. singing utilizes 'belly' breathing), and buckled into the actuating belt. In the case of a chest-strapped scenario, when one participant inhales, other participants feel a slight expansion of the device, and when a participant exhales, other participants feel the contraction around their diaphragms. The expansion and contraction suggests the wearer to inhale and exhale in synchrony with the movement of the device. When synchrony is attained, the device is effectively passive.



one-to-one (communication), **one-to-many** (instructor), **many-to-many** (synchrony)

Figure 1. Conceptual sketch of real-time synchrony and the actuating function of inHale

4.2 THE DESIGN

The current design of inHale [Figure 2] reflects both the smooth flow, inspired by the relaxed, flow state in yoga, and the need for the wearable to be minimally invasive. This iteration of inHale consists of six fundamental components: the inner motor, encoder, inner casing, spiral railing, and actuating belt. In addition, our prototype includes a large strap for physical stabilization and an outer casing to encase the device in a single, appealing package. The inner motor and encoder are controlled by a Raspberry Pi and synchronized by a server-based script. The inner casing, consisting of four 3D-printed parts and four bearings, houses the motor, fixes the actuating belt onto the device, and allows for the actuating belt to expand and contract smoothly. The spiral railing was designed to minimize the size of the device. The double-spiral design also enables the direct translation of the motor's rotational movement to a symmetrical, bilateral linear movement. Lastly, the actuating belt, comprising two straps, a buckle, and two unique, bearing-relieved 'hooks' that latch onto the spiral railing, creating the dynamic contraction and expansion of the device.

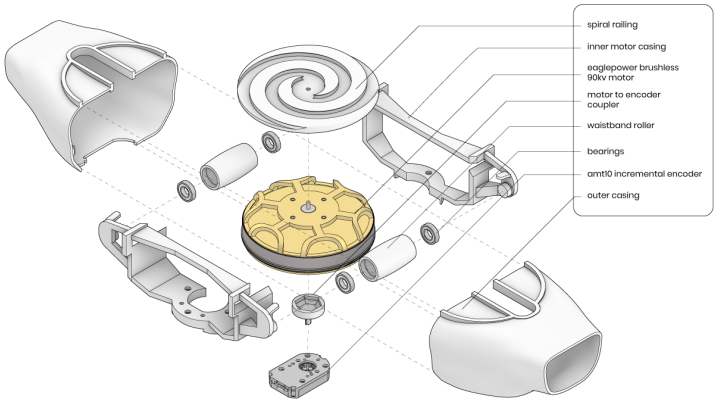


Figure 2. Exploded Drawing of inHale

4.3 THE PROTOTYPE

This prototype was built with an Eaglepower 90KV Brushless Motor, coupled with an AMT10 Incremental Encoder. We foresee that this device can be recreated with a smaller motor in future prototypes. Beyond the motor, the encoder, the bearings, and the straps, all of the fabrication was done through PLA 3D-printing, designed on Onshape, a collaborative CAD platform, and Rhino3D.

The device is powered by a Raspberry Pi and connected via a web server that synchronises the users based on the rotational position of the device. The prototype works for any number of users.

Figure 3. Two participants wearing inHale

5 OTHER USES

Connected Uses

Feeling genuine connection in long-distance relationships is tricky, but there has been much research and experimentation in trying to make people feel closer and connected, primarily through the use of touch. For example, there are ample touch devices such as bracelets and lamps that can signal to a partner that

they are being thought of. Harder to accomplish is a meaningful, thoughtful connection lasting longer than a few seconds. We imagine inHale as a tool for creating a space for coupled mindfulness. That is, couples in long distance relationships would be able to set time aside to meditate with one another through the use of inHale. Through implementation of a wearable device, “touch desire” could potentially be met, while the introduction of synchronization based on individual breathing movement would serve to increase feelings of closeness [7]. Increased mindfulness can also provide stronger relationship satisfaction [8] which is important for the success of a relationship, especially in relationships disconnected by distance.

Breath Device

Additionally, we see the potential for a personal-use breath training and meditation device. There are many different types of breath, and this device can lead wearers in specific breathwork practices. It can also guide meditation practice without sound or visuals.

Synchronous Activities

Singing music/rowing/dancing

6 CONCLUSION & FUTURE WORK

We explored a novel tool, inHale, a tangible device that enables telecommunication through synchronous breath. While much of the research focuses on the use-case of yogis and the synchrony of breath in remote yoga classes, we imagine that inHale can be used in different scenarios such as: synchrony of musicians, long-distance relationships, and other forms of meditation. Our preliminary prototype can be run through an online remote server that can track breathing patterns in real time for the purpose of sharing breath synchronization remotely. inHale is comparable to other, similar tools which have been developed in the past, in its ability to sense and cue breathing rhythms, while extending these tools to the context of multiple individuals and larger groups. With inexpensive hardware, inHale is an available interaction option now. We observe the limitations of many existing breathing wearables in their lack of sharing and syncing functionality, and stress the need to design strategies for communicating breathing and other bio-signs typically only observable in person which anticipate a near future wherein the remote practice of yoga, singing, and other synchronized activities is commonplace.

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