InExChange: Fostering Genuine Social Connection through Embodied Breath Sharing in Mixed Reality

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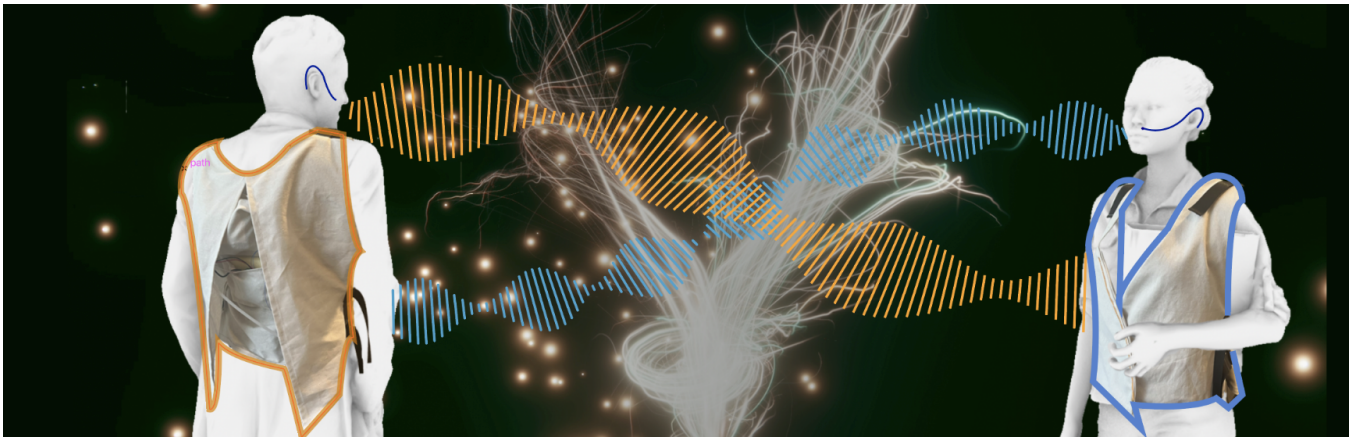

Figure 1: Each participant's breath, measured through a microphone sensor, plays as a haptic sensation through their partner's inflatable vest. The projected tree image is co-created by their breathing patterns.

ABSTRACT

InExChange is an interactive mixed reality experience centering around an inflatable vest which conveys a physical sense of shared breathing on the diaphragm between two or more participants. The experience is composed of three acts in which the participants' breaths are transformed into metaphorical projected representations: expansive waves, flowing light trails, and growing tree branches. The inflatable wearable devices physically enact in near real-time the inhale/exhale pattern of the other person's breath, varying in intensity level to create an attention interplay between the embodied sensation and the projection. Through this embodied sense of playful shared breathing, we aim to cultivate a genuine feeling of connection and contribute to the integration of somaesthetic design principles in mixed reality HCI.

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CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**.

KEYWORDS

social connection, mixed reality, somaesthetics, breathing biofeedback, haptics, interactive installation

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1 INTRODUCTION

Breath is not only essential for existence, but also plays a central role in our emotional lives, both individually and socially. Communicating biorhythms like breath can help improve our understanding of another person's emotional state and make individuals feel more connected [Min and Nam 2014]; natural synchronization of our breath in social settings correlates with feelings of social affiliation, improved communication and empathy[Chanel and Mühl 2015;

Palumbo et al. 2017]. Many biofeedback mixed reality (MR) or virtual reality (VR) experiences use breath as an interaction element, but typically this is communicated through audiovisual feedback [Chanel and Mühl 2015; Stepanova et al. 2020a]. The practice of somaesthetic research suggests an alternative design approach, which emphasizes physical sensations we want to evoke in others and communicates what an experience might 'feel like' for others [Windlin et al. 2019]. To further the integration of soma principles and embodied perception research in social MR[Hook 2018], we created InExChange, an interactive MR experience centering around an easy-to-wear inflatable vest which conveys a physical sense of shared breathing on the diaphragm between two or more participants.

InExChange seeks to cultivate social connection through tangible sharing and synchronizing of breath patterns, in a playful projection-guided MR environment. The overall experience is composed of three acts in which the participants' breath, sensed in real-time via microphone, is transformed into projected metaphorical representations: expansive waves, flowing light trails, and growing tree branches. The participants' inflatable vests create a physical sensation on the diaphragm representing each other's breathing pattern, varying in intensity to create an interplay of attention between the projection and the embodied sensations. Additional tactile pillows with embedded inflatable layers and touch sensors provide bystanders with an affordance to briefly hold or touch, allowing a broader audience to join the haptic experience of the primary participants. The name of the experience, InExChange, is an abbreviated composite of the words "Inhale, Exhale, Exchange"; the phrase "in exchange" also reflects the dynamic of playful symbiosis between two participants exchanging their breath sensation. Through InExChange we aim to explore how the exchanged sensations might contribute to the perception of social connection and foster social play in a mixed-reality environment.

2 RELATED WORK

InExChange builds on prior ideas rooted in the somaesthetic framework, which places emphasis on the state of "being in correspondence" [Hook 2018], where the user perceives an interactive system as an extension of their body. Researchers have explored rhythmic pulsing compression to guide breathing during meditation, which helps users improve focus and adopt a slow breathing rhythm [Foo et al. 2020]. Shape-changing actuation driven by breathing sensing has been shown to contribute to awareness and controllability of breathing [Choi et al. 2021; Jung et al. 2021; Kilic Afsar et al. 2021]. Our breath is also susceptible to influence from external rhythms and patterns, tending to synchronize with music or an applied beat, or the pulsing of light [Frey et al. 2018; Ghandeharioun 2016].

Prior works have also investigated social synchrony, a primary element in the phenomenon of social emotional contagion, the sharing of affective state between two or more people [Bizzego et al. 2019]. Physiological synchrony, in which two peoples' physiological rhythms fall into alignment, occurs most often between people who feel emotional connection [Hove and Risen 2009]. These feelings of connectedness have been shown to emerge from induced synchrony as well; for example, from instructing people to tap a rhythm in the same beat or move in the same pattern [Vacharkulksemsuk and Fredrickson 2011], or by exposing people to synchronized visual stimuli [Golland et al. 2015]. Taking inspiration from this work, InExChange aims to create a connected social experience through an embodied rhythmic sensation representing another person's breath, with the potential to induce physiological synchrony between the participants.

3 EMBODIED BREATH SHARING WITH INEXCHANGE

3.1 Installation Setup and Technical Realization

The InExChange installation is set up in a room with dimmed lighting to create an immersive projection environment (see Fig. 2 and accompanying video). The full 5-minute immersion experience is designed for 2 primary participants who wear the inflatable vests; bystanders are encouraged to engage with the experience freely through the two wireless inflating tactile pillows. The system is composed of two vests, two tactile pillows, two wireless ear hook microphones, an iMac computer, and one wall-facing projector. This installation can be flexibly adapted to various participant numbers and display configurations.

When the user breathes through their nostrils, the sound of air flow is detected by their ear hook microphone. The software calculates the respiration rate by detecting peaks in the audio envelope and determining a peak-to-peak interval over a running average. Outlier noise such as spoken voice is discarded. The calculated respiration rate and inhale-exhale state detection drive the visuals in Unity. The data is simultaneously sent over Serial communication to the central Bluetooth control device, which broadcasts back out to the remote devices, controlling the inflation and deflation of the shape-changing devices to match the two users' breath patterns. Each of the users feels inflate-deflate sensations that reflect their partners' breathing pattern. These patterns are also broadcast to the shape-changing devices embedded in the two tactile pillows, which allow a broader audience to engage with the experience (Fig.2) .

3.2 Inflatable vest

The primary interaction device consists of a vest garment with interior chambers which contain inflatable pouches, air tubing, and control and communication electronics (Fig. 3). Nylon webbing at the sides and shoulders of the vest can be changed in length with strap adjusters to quickly achieve a comfortable fit for a broad spectrum of body sizes. Interior pockets on the front hold the inflatable pouches, which are positioned to sit at the front diaphragm, just below the ribs, in the position which people typically associate with locating belly breathing on the surface of the body. Interior pockets on the back hold the control electronics (Fig. 3g), with a single flexible pneumatic tube connecting front to back. A thin, flexible LED wire traces the front overlapping panel of the vest, providing a visual reference for the haptic inflation pattern occurring within the device (Fig. 3c).

The inflatable pouches are made of PVC vinyl, a soft fabric-like material, which is divided into air chambers using a heat sealing method, allowing for a more distributed inflation with less air volume exchange (Fig. 3d). The pneumatic interface is controlled by two 5V motors, one operating as a pump for inflation and one as a vacuum for deflation, mediated by a pneumatic valve relay.

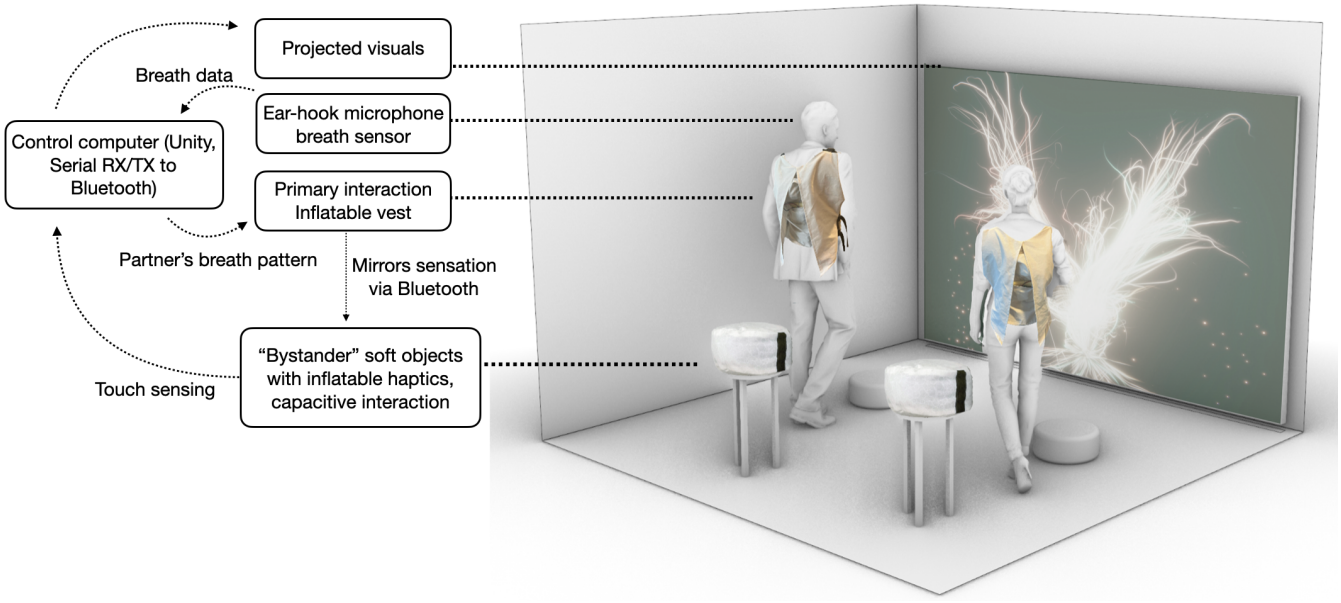

Figure 2: Installation rendering of InExChange with system diagram of the sensing and haptic output process.

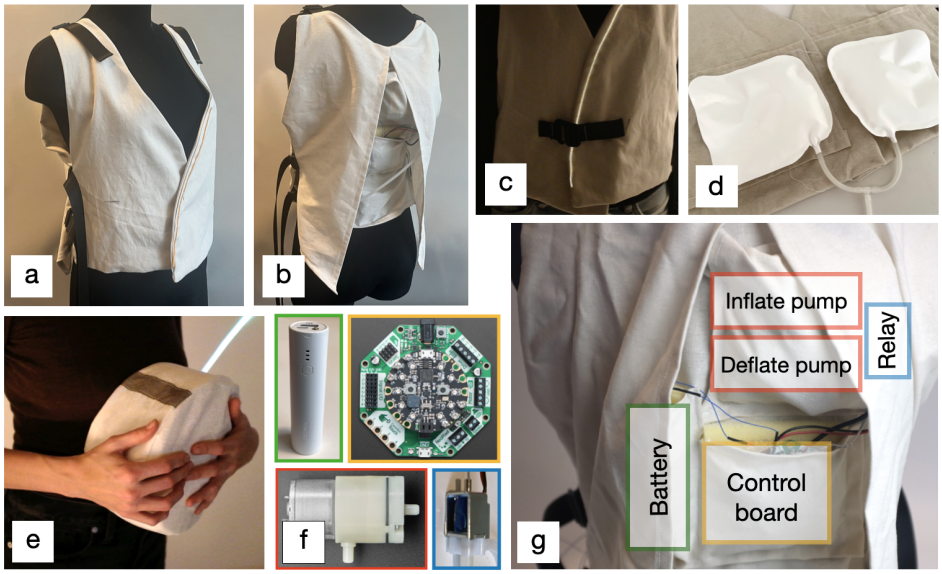

Figure 3: (a,b) Front and back of vest. (c) LED light on the outer closure of the garment reflects the animation of the internal inflatable device. (d) Inflatable pouches are mounted in interior sleeves. (e) Tactile pillows with internal inflatable structures and capacitive sensing mirror the vest sensation to bystanders. (f) Control electronics color-coded to (g) positions distributed across upper back of vest.

The motors are driven by a Circuit Playground Bluefruit microcontroller with a Crickit board extension for motor control (Fig. 3f). A rechargeable battery pack provides power for the control electronics for several hours.

3.3 Mirroring breathing sensation to bystanders with tactile pillows

The breathing sensation of each primary-interaction participant is mirrored in a soft wireless pillow object, which are placed closer to the entry point of the installation (Fig. 2). These tactile pillows contain an internal inflatable pouch, which mimics the inflate-deflate

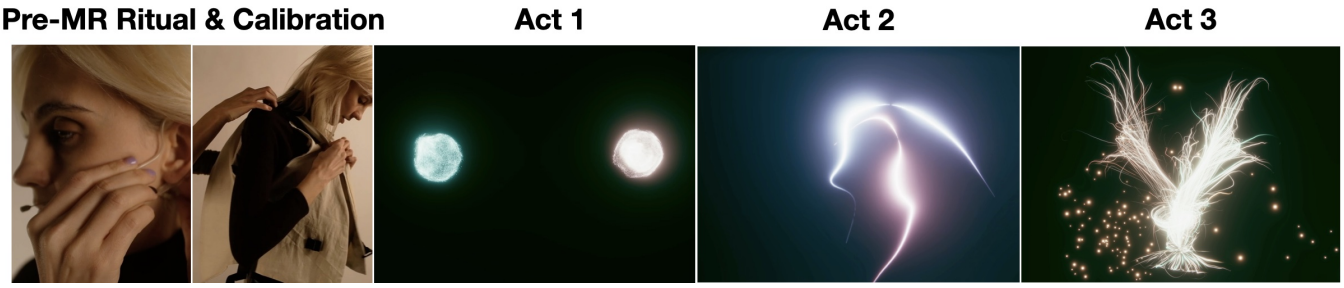

Figure 4: In the entry ritual, the participants are guided to wear and calibrate the mic and vest. In Act 1, the participants' breaths are reflected in projected wave orbs; In Act 2, the participants' breaths are transformed into traces flowing between each other; In Act 3, their breaths are transformed into growing tree branches. A swarm of fireflies appears when the breaths are synchronized.

pattern of the associated garment-wearing participant. These inflatable pillows are designed to be flexibly used, e.g., by hugging them against the diaphragm, or by multiple people touching them with their hands simultaneously. Interaction with these objects will also influence the projection visuals via capacitive touch panels embedded in the object exterior (Fig. 3e). The corresponding orb/trace/branch will glow with a warmer hue when bystanders touch the capacitive panel. Individuals are free to enter the experience and hold the tactile pillows for just a moment or longer, attaining a sensory experience reflective of that of the two full-immersion participants.

4 INTERACTIVITY EXPERIENCE

Each session of the experience will last around 5 minutes, with two primary participants wearing the sewn garment with inflatable pouches, and a constant rotation of bystanders interacting momentarily through the tactile pillows. The primary participants go through three acts, which last for 70-90 seconds each. The setup and calibration are designed as a ritual to ease the participants into the mindset of the experience [Kitson et al. 2020].

Entrance and Calibration Ritual. The two primary participants enter the interaction area with dimmed lighting. Standing in the interaction area facing the projection wall, they can hear ambient music in the background and see two low cushions on the floor. Two facilitators invite the participants to imagine their breath as glowing energy, and guide them to put on the wireless microphones for breath sensing. A glowing orb (one red, one blue) appears immediately when one breathes into the microphone, allowing for calibration and adjustment. The two participants will then put on and adjust the vest garments as a ceremony connecting to their breath. As they inhale, the inflatable pouches are filled to a predefined limit, and the participants will feel a sensation of gentle pressure at the diaphragm. They will then be asked to slowly exhale, and signal the facilitators when they barely feel the pressure. This calibration process sets the upper and lower threshold limits of the inflatables. The calibration process takes approximately one minute per participant pair; the participants are then seated on the floor cushions to begin the three acts.

Act 1: Waves. In this act, the two vests inflate and deflate in a unified breathing pattern. The intensity of the sensation is designed to be noticeable but not distracting, guiding the participants to synchronize their breathing. Participants watch their projected orb expand and contract according to their breath cycle with a wave-like motion (Fig.4), to help participants connect with their own breath first [Stepanova et al. 2020b]. Throughout the three acts, the flexible LED on each garment pulses with the inflatable rhythm, providing a visual cue of the connection between the participants; the inflation pattern of the vests is also mirrored in the pillows, which bystanders can pick up or touch.

Act 2: Traces. The breath exchange begins; each participant feels the inflatable pattern of their partner's breath, continuing through Act 3. The intensity of the sensation is designed to be only noticeable with focused attention, but most of the time should rest in the background at a barely-conscious level. A projected light trail comes out of the light orb with each exhalation, and flows gracefully toward the other participant (Fig. 4). The trail's length and movement change in response to each breath. This is designed to draw participants' attention slowly from their own breath toward their partner's breath.

Act 3: Trees. The inflation strength of the inflatable pouches is at its highest level, nudging participants' attention toward the sensation of their partner's breathing. Each participant's breath is represented as a tree branch on the left or right side of the projection. As they breathe in and out, they jointly grow a tree of light. A swarm of fireflies will appear whenever the breaths are synchronized.

5 PILOT FEEDBACK AND CONCLUSION

We conducted several pilot studies for user feedback on comfort, ease of setup, breathing awareness, and overall interaction experience. Pilot participants reported that they felt a unique sense of playfulness related to the dynamic control of their own breath. Participants noted that they found themself actively reflecting on their own breath in connection with their predictions of their partner's breath, to trigger the synchrony-induced animations in the projection (e.g. swarms of firefly sparks), and expressed an overall sense of pleasure and connection from the experience.

InExChange aims to further explore embodied breath as an interface for interpersonal synchrony and connection, with an easy-to-wear device that can be integrated with a mixed-reality experience

to foster social play. By combining embodied sensations and projected metaphorical representations, we hope to cultivate a genuine feeling of social connection between participants in the experience, and to contribute to the broader discussion on combining soma design and mixed reality within the HCI community.

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