Embrace the Distance: Exploring the Impact of 'Lobit' on Connectedness and Enchantment in Long-Distance Relationships

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ABSTRACT

As communication technologies become ubiquitous, research on digital interpersonal connections grows. While text-based apps are common in daily life, emerging affective or phatic technologies aim to make digital interaction more meaningful. Such technologies leverage the mimicry of physical closeness over a distance and promise to deepen our interpersonal relationships. We propose a technology with enchanting qualities, to elevate interpersonal and emotional connection. However, research on how enchantment achieves such goals remains limited. We introduce "Lobit" – a lounging hoodie designed to connect people in long-distance relationships. With the ability to send virtual hugs and voice messages, Lobit enhances digital intimacy beyond conventional methods; there's no screen time involved! Our research delves into how these enchanting qualities enrich emotional bonds compared to conventional digital communication. Through this exploration, we aim to use technology to enrich social connectedness. Results demonstrate that Lobit significantly improves feelings of social presence and enchantment compared to traditional smartphone-based communication methods, highlighting its potential to revolutionize long-distance relationships.

KEYWORDS

Affective technology, Connectedness, Interaction design, Enchantment, Social Presence, HCI

1 INTRODUCTION

In many ways, digital communication has drawn people closer and made the world more connected [25, 10]. However, most popular communicative technologies are primarily designed to make communication more efficient, and not necessarily more meaningful [9]. Extensive smartphone usage is found to be associated with lower psychological well-being and lower interpersonal connectedness, increasing feelings of isolation [2]. To challenge this pattern of 'connected but not connecting', research and innovation on how digital connection can be made more meaningful, continues to expand [3].

Similarly, technologies designed for social presence, mimicking physical closeness remotely, are surfacing [18][36]. These technologies, for example, transmit virtual kisses, hugs or heartbeats [36, 9, 37, 39, 30, 13, 34]. Correspondingly, Gibbs et al. [18] proposed the term *phatic technologies* to describe such affective technologies, which aim to make interpersonal connections more meaningful.

With this objective in mind, it is valuable to expand the scope of research to include how these technologies can integrate enchanting attributes to improve user experiences [21]. Enchantment means the feeling of being amazed and emotionally moved in a good way [21, 38]. Thus, enchanting qualities integrated into technology hold the potential to elevate interpersonal interactions. There is still a relatively sparse understanding of both the role enchanting technology plays on user experience and social connection and how technological modalities play on invoking enchantment [28]. The current study aims to develop this understanding, specifically on how enchanting technology can increase connection within close social relationships.

With the core themes of social presence and enchantment, we created the "Lobit" - a lounging hoodie which sends virtual hugs and voice messages to mimic physical closeness. Users can pair up with a significant other through another hoodie. Hugs can be sent to the other by hugging oneself, where, in turn, the other hoodie provides a few seconds of vibration to the heart, generating a feeling of intimacy. Additionally, users can send voice messages to their partner through the hoodie itself, which plays through speakers in the partner's hoodie. We brought this design to life in order to increase emotional connectivity between two people. Therefore, we analysed the primary research question:

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(1) How can our enchanted everyday object encourage connectivity in a close relationship compared to smartphone communication?

    From here we derive two sub-questions relevant to the intended modalities:

(2) How can the physical sensation(s) of the hoodie effectively increase emotional connectivity?

(3) How can voice interactions of the hoodie increase emotional connectivity?

2 RELATED WORK

2.1 Socio-Emotional Connection and Social Presence

In this paper, we intend to improve emotional connectedness between individuals. To investigate this, we first aim to develop an understanding of the dynamics responsible for this interpersonal connection. Interpersonal connectedness is the feelings of relatedness and belonging in accordance with the salience of the relationship and its appraisals [3]. Designing for interpersonal connectedness can benefit users as this is known to contribute to mental and physical health, and general well-being [16] [40].

Measuring connectivity at an individual level differs from assessing it on a collective basis, underscoring the importance of comprehending one-on-one dynamics. [3]. There are various scales designed to measure interpersonal connectedness, which typically considers social support and emotional salience [32]. Some measures, such as the scale of Perceived Interpersonal Closeness (PICS) capture both the ideal and actual emotional closeness to specified individuals to understand connectedness [32].

To measure interpersonal connectedness, social presence can be more suitable for understanding the impact of immediate connection. Social presence refers to the experience of feeling emotionally connected to another [19]. Both interpersonal connectedness and social presence consider emotional salience, mutual understanding, and behavioural engagement, but social presence goes further and considers sensations such as how 'real' the interaction with another feels, co-presence, mutual awareness and immediacy [40] [5] [26].

Notably, there is no globally accepted measure of social presence [5] [26]. Instead, careful analysis of the attributes within each measure is necessary for reliable research. One study which investigated social presence to understand and improve socio-emotional connectedness with others through haptic feedback used two measures of social presence to research this [19]. As we are also focused on instant remote feedback, we considered the best way to measure moment-by-moment interactions. Thus, we found the Networked Minds Social Presence Inventory to be an appropriate measure for understanding interpersonal connectedness in close relationships via multimodal interactions [7]. This scale focuses on co-presence, perceived psychological engagement, and perceived behavioural interdependence. Through the analysis of these scales, we're also able to understand the subjective interpersonal symmetry, and inter-subjective symmetry [6][7]. Subjective symmetry is how the individual perceives how similar the social presence of them self is to their partner [6]. Inter-subjective symmetry is the similarities between an individual's and their partner's rating of social presence, which is especially interesting for appraising emotional connection [6].

Furthermore, understanding social presence to increase socio-emotional connection, can also help to understand social behaviour within different modalities, interfaces, and mediated environments [5].

2.2 Digital Connectedness

As the use of technology for immediate and frequent social communication increases, there is a demand to understand changes in interpersonal connection through internet-mediated communication (i.e., mobile communication and social media networking) [3]. This is especially important, as many communication platforms specifically aim to foster social connectivity with others [3] [5]. For example, some internet-mediated communication platforms facilitate face-to-face interactions which can increase feelings of community [11]. Likewise, the use of electronic devices, such as smartphones and computers, for interpersonal communication has been shown to enhance the sense of connectedness among youth (age 12 - 18), indicating a positive impact of digital technologies on social bonds [41]. Therefore, the creation of a digital device can contribute to the sense of connectedness.

However, the impact of smartphones on interpersonal connectedness varies. Research shows that smartphones can create a deeper level of personal connections, as they introduce a novel form of intimacy and continuous contact [28]. For example, the exchange of phone numbers has become a gesture of trust and friendship, thereby redefining personal relationships in the digital era [28]. When smartphones are used to strengthen existing relationships and create new ones, they can reduce feelings of loneliness [31]. Additionally, smartphones can both enhance romantic relationship dynamics and introduce tension [14]. Specifically, the increased usage of mobile voice calls has been associated with reducing uncertainty between partners and a heightened sense of love and commitment highlighting the importance of voice communication [24].

In contrast, some studies show a decrease in interpersonal connectedness by smartphone usage [27, 2]. This can happen when smartphones are a distraction in social situations, as they can interfere and cause the loss of full attention on the ongoing social interaction [27]. Anderl et al. also showed that longer smartphone usage causes a feeling of being less socially connected, which can lead to more smartphone use, causing a vicious cycle [2] [33]. The contrasting impact of smartphone

usage on connectedness shows that we need to leverage an understanding of consistent and deeper connection through the possibility of continuous communication.

2.3 Distanced Communication

Interpersonal connectedness, and the role that internet-mediated communication can play in increasing this, can especially be challenged within long-distance relationships. These are any relationships in which there is physical, emotional, or psychological distance. Such distances make it so creative means (i.e., communication technology) is of utmost importance to maintain the relationship [15].

One of the most researched areas in the field of psychology is how geographical distance affects love relationships. For example, Belus et al. focused on the difficulties that arise from distance in relationships and the specific relationship maintenance behaviours (RMBs) that couples use to stay connected even when they are separated by a large distance [4]. The RMBs mentioned in their paper represent the behaviours of couples before, during and after separation [29]. Examples of such RMBs during separation include sharing positive stories about the relationship or communicating through different modalities while at a distance. However, the paper does not address specific RMBs concerning the use of technology to maintain relationships, which represents a significant research gap that our research seeks to address. The results of their research did indicate that higher RMBs were positively related to the satisfaction of a relationship. In turn, this satisfaction plays a crucial role in determining how RMBs impact the well-being of individuals.

Additionally, multiple studies have expanded the investigation of distance beyond geographical separation, including emotional and psychological distance. Jimenez, investigated the adaptive processes used in long-distance relationships to regulate the psychological distance [23]. The paper emphasizes how long-distance relationships might cause attachment anxiety and highlights how people's attachment styles influence their communication styles, which can help or hinder intimacy and connection with their partners, as well as how they perceive closeness and distance in their relationship. While the use of texting and calling is mentioned in Jimenez's paper, it does not delve further into the use of interactive technologies within long-distance relationships.

Moreover, the analysis of the effects of distance on relationships covers not just romantic partnerships but also platonic and familial ties. Research on the dynamics of long-distance friendships by Finchum showed how important technology is for preserving relationships and adjusting to distance [15]. Comparably, Abel et al. investigated how geographic distance affected family ties, highlighting the significance of common rituals and communication styles in maintaining family ties [1].

The challenge of expressing intimacy in long-distance relationships is often met with innovative solutions, such as the desire for haptic experiences and unobtrusive "emotional pings" that offer a sense of closeness without the immediacy demanded by traditional communication methods [30]. Likewise, internet-mediated communication is also used to improve feelings of closeness [28]. Notably, as previously stated, there are mixed results on the efficacy of this [28, 2, 33, 31, 24, 14]. More research is needed to understand these dynamics specifically in distanced relationships [19].

These studies deepen our comprehension of distance as a complex concept that affects connectedness perceptions in a range of relational contexts, encouraging more research into the intricate processes sustaining relationships in the face of psychological, emotional, and physical separation.

2.4 Phatic Technologies

Physical interfaces for interpersonal connection are relatively common nowadays (I.e., [13, 19, 30, 36, 37, 39]). Illustrating this, various technologies designed for strengthening and maintaining interpersonal relationships have appeared on the market and in research in various modalities [36]. In the context of affective or phatic technologies, Sadaatian et al., (2014) propose a distinction between such technologies which revolve around physical intimate behaviours and those that leverage non-physical dimensions of intimacy [36]. Our design falls in the former category, based on the mimicry of physical closeness of people.

The second category, technologies attempting to recreate physical closeness, is exemplified by the "Kissenger" (2014), a haptic device which transmits a kiss between two remotely connected individuals [36]. The 'Empathy Amulet' (2018) is a touch-sensitive necklace which sends and receives heat signals to strangers [9]. In a similar vein, "Mobile feelings" (2011) exchanges heartbeat and breath sensations using blinking lights and a micro-ventilator [37].

Likewise, phatic technologies are not uncommon in the form of wearable technologies. For example, the "Huggy Pajama" (2009) is a wearable system that uses air pressure to simulate hugs over a distance, designed for parent-child relationships [39]. The "Hug Over A Distance" (2005) similarly uses an air-inflatable vest to receive hugs, designed for and tested on couples [30]. The 'Robo Hug' (2003) [13] and the 'Hug' (2010) [34] are similar concepts.

Another branch of wearable intimate technologies is those that leverage heat for receiving digital hugs. One example is the 'Hug' (2010), which is a thermal belt warming up in the lower back area [19]. Interestingly, Gooch and Watts (2010) found that thermal stimuli give rise to higher perceived levels of social presence. Whether this is due to the thermal stimuli or the mimicry of a hug, is unclear [19]. Lastly, the 'Sending, Feeling' scarves leverage heat to mimic closeness between people [20].

Moreover, there are several shortcomings to these existing technologies. Firstly, most often, such 'hugging technologies' revolve around pressure, disregarding other sensory aspects of a hug, such as warmth [39, 30, 13, 34]. In the few instances where warmth is incorporated to mimic closeness, the product often lacks the design of being comfortable and intended as lounge-wear [19, 20, 9].

2.5 Enchantment

We aim to increase emotional connection by incorporating aspects of enchantment. Enchantment is often defined as the subjective experience of being amazed and emotionally touched in a positive way. Our design aims to evoke feelings of enchantment in one's everyday life [38][21]. Moreover, enchantment has a strong impact on individual emotions in general, thus, it is suitable to implement for emotional connection [35]. We focus on "situational enchantment" where one feels a connection with a higher power or reality [21]. To measure this experience, the Enchantment Adjective Checklist (EACL) is a reliable way in which the positive emotions related to this theme may be identified [21]. This defines enchantment as 21 positive experiences such as delight, beauty, surprise, and connection [21].

To truly understand enchantment, we can look towards traditional artistic mediums that can be observed in our everyday lives creations such as music, storytelling, and film-making, which are typically designed to evoke feelings of enchantment in those experiencing them [28][38]. This is because these encounters captivate us in a way where perception and attention are heightened [17].

Typically, through aesthetics and functionalities, everyday technology (i.e., laptops and phones) can evoke abstract positive feelings towards the device and the user experience [35] [28]. For example, the interface aesthetic of a computer can provoke reminiscence of cinematic imagery, or the lightweight hardware can create a sensation of lightness and weightlessness of the experience [28]. With this lens, enchanting technology is viewed as an active engagement eliciting allure, fascination, and charm with the experience. However, many users would not explicitly define these experiences to be enchanting [28]. In other words, feelings of enchantment, although recognizable on paper, are often unrecognizable to the user [28]. Thus more research is needed on how to create recognizable feelings of enchantment in human-computer interaction. It is recommended that technology creates feelings of uniqueness, wholeness, engagement, ambiguity, and transformation to create enchanting experiences [28]. However, measures such as the Enchanted Adjective checklist exist to understand subjective feelings of enchantment within an experience [21]. Investigating these feelings can aid in understanding how to implement enchanting experiences within innovative technology for connectedness.

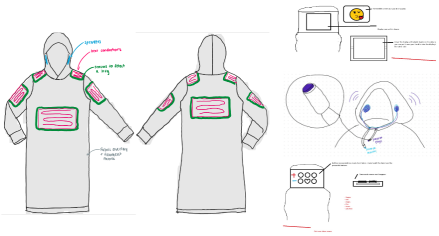

Figure 1: Lo-Fi Prototype V1 - Sketches

3 DESIGN

3.1 The Hoodie

Initially, we researched and brainstormed observations and insights regarding interpersonal connectedness to formulate a comprehensive concept map. This allowed us to determine the preliminary version of our design. We then created user personas and a research plan to better understand how individuals may experience using our design. We engaged in fundamental synthesis by first doing user research to discover how users engage in distanced communication, what their experiences are with wearable technology and what their likes, dislikes, and comments are regarding this design. This led to our initial sketches of the first draft of our design.

With these sketches, we determined the core and complementary features of the design. The core features were to send and receive virtual hugs (to be received as heat) and voice messages and have configuration through a phone application. The complementary features were to have a detachable and changeable microphone and playing encasements and be able to send and receive emoji messages on the sleeves (figure 1). To get from the original idea to our final design, many rounds of user research and continuous iteration were conducted to ensure that our design was sound according to our goals, but to also make sure that it was practical and feasible. First, we did preliminary user research by observing people when hugging themselves. From this, we determined the placement of the sensor pads in order to detect the hug of a user.

We created the physical version of the lo-fi prototype with the new placement of the sensors (figure 2. With this, we continued to reiterate the placement of the heating based on unstructured user research, the encasement of the buttons, and the wiring of the modalities. With this prototype, we engaged in structured user research to determine the enchantment, usability, and interest of the design of both the hoodie and the application. From this, we were able to gather opinions from four potential users. We synthesized improvement points to implement for the final version of the lo-fi prototype. The main things we found were to place the heating on the front and back of a person and be able to see when your partner is wearing their hoodie. Additionally, we removed the emoji feature due to feasibility concerns, as well as user feedback which considered this feature to not be as important for connectedness. Thus, the

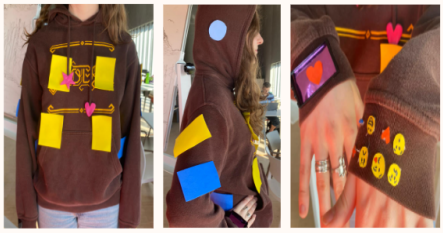

Figure 2: Lo-Fi Prototype V2 used for user testing

Figure 3: Final Lo-Fi Prototype

features present for the next fidelity of the prototype were the sensors and heating (correctly placed), inner hood speakers, buttons which controlled the heat, recording voice messages, sending voice messages, and the configuration application (figure 3. To move from the lo-fi to the hi-fi prototype, we first chose a comfortable and soft hoodie designed to evoke optimal comfort. Additionally, we engaged in computational thinking to bring the design to life to see if the final product would reach our goals of enchantment and social presence. Due to implementation concerns, we changed the design to include vibration instead of heat and had to separate the reception and sending features of the voice messages of the prototype. More of the information can be found in the implementation section.

In line with the placement of the heat reception, we chose the chest area to receive vibrations. Additionally, we designed and embroidered part of the Lobit logo onto the chest. The symbols chosen, two hearts, were designed to emphasise closeness despite different locations (figure 4). Additionally, we implemented this to improve enchantment due to its beauty [21].

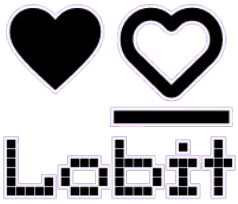

Figure 4: Lobit Logo

3.2 The Configuration Phone App

Alongside the design and implementation of the hoodie, we created a prototype of an app that would be used to configure the hoodie for usage. Notably, our final prototype does not yet include the technical elements which make distanced communication possible. However, we decided to design and research an application that could potentially support the implementation of this feature with a higher fidelity of the design.

First, we created a low-fidelity prototype, which was based on existing smart technology connection techniques [12]. We then tested the usability of the application alongside the lo-fi prototype of the hoodie, by observing users pretend to configure their own and their partner's hoodie and asking open-ended questions. We wanted to make sure that the whole process was intuitive, and that all the features were as expected.

We found that users were able to configure the hoodies intuitively with no guidance. However, users wanted the amount of connections possible to be clearer and be able to see when their partner is wearing their hoodie. Another improvement opportunity identified when testing the hoodie was to include a point in the app where users could learn more about the hoodie. We continued to iterate the app based on these findings while taking into account:

- The inclusion of necessary iconography to depict the process effectively.
- Design conventions and standards for consistency and usability.

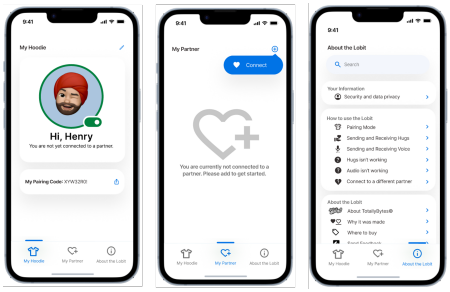

Figure 5: Select Hi-Fidelity Wireframes from the configuration app

- Simplicity, cleanliness, and aesthetic appeal to enhance user experience.

From this, the high-fidelity prototype of the app was made (figure 5). We conducted a short usability study with four participants to validate the design (Mean age = 22, Average tech literacy = advanced, mixed use of wearable technology). An overview of the study protocol and the full hi-fi wireframes can be found in appendix **??**. All participants found the configuration of their own hoodie and their partner's hoodie straightforward and intuitive. However, the addition of an onboarding would be beneficial as some participants found that guidance prior to configuration would make it easier. Furthermore, more research with diversity in age and technical literacy is needed to validate the global usability of this application if the hoodie functionalities support true distanced communication.

4 IMPLEMENTATION

The conceptual design of the Lobit includes two hoodies which are both able to send and receive (heat and voice messages). Due to time and money constraints, the creation of two hoodies was not feasible. However, we were determined that we could demonstrate the core functionalities of the Lobit sufficiently without creating two fully developed Hi-Fi prototypes. With this in mind, we decided to build one sending device and one receiving device, with the receiving device being integrated into the modalities within a hoodie. The hoodie chosen was loose with a soft velvet material on the outside and a fleece inner lining for comfort.

4.1 Wireless Communication

Both devices need to be able to communicate remotely. Two programmable microcontrollers equipped with WiFi modules were required. We found the Arduino ESP32-S3-DevKitC-1 to be suitable due to its lightweight, its built-in WiFi module and the wide array of documentation available. To prepare it for use, we soldered through-hole pins to the board. The use of a breadboard allowed us to try out various connections with the electronics that we had.

The most essential part of the implementation was to connect the two microcontrollers to each other so that they were able to communicate wirelessly. There are various ways to connect two microcontrollers to each other, one of them being Message Queuing Telemetry Transport (MQTT). MQTT allows fully symmetrical connection and it allows for efficient communication between devices across any distance, especially over constrained networks like WiFi [22]. Therefore, we found MQTT a logical choice. Using MQTT the microcontrollers are connected to an external WiFi source, for example, a hotspot of a phone. An existing server provided by Utrecht University then hosts an MQTT broker, which acts as an intermediary for routing messages between the microcontrollers. This way, the controllers can publish (send) and subscribe (receive) to specific topics on the broker, therefore sending and receiving messages from other devices.

4.2 Sending a Hug

The core feature of the Lobit was intended to mimic physical closeness via a hug to mimic a feeling of connectedness with a partner. A touch-sensitive pressure sensor was required. The sensor was to be placed on the upper arm, near the shoulder. The sensor was embedded in an adjustable armband, and the user needed to hug themselves for at least 2 seconds (to avoid accidental firing). The sensor then outputs a signal to the connected Arduino, which in turn activates the virtual hug in the receiving prototype.

4.3 Hug Reception

The greatest challenge we faced was to find or create a heat source that could reach a noticeable temperature (~70-80 Celsius) in a very short time frame (ideally, this was intended to be instant, but due to obvious constraints, we went for anything under 1-2 minutes instead). Likewise, generating heat in such short time frames requires a lot of energy, and can become dangerous when the energy supply is not controlled [**cherz2006practical**]. Due to the loose-fitting design of the garment, the heating pads must be able to project enough heat to its surrounding environment, without burning the skin.

We quickly found that our heating pads did not meet our requirements. After administering various voltage and amperage levels to the heating pads using a variable power supply, we found they maxed out at 70 degrees Celcius, with an average temperature of about 33 degrees Celcius, which on the skin was almost unnoticeable. This urged us to try alternative heating sources, ones which were specifically designed to handle a higher voltage and amperage, yet not exceeding safe ranges. However, because they were not delivered to us in time, we continued the development of our prototype with a vibration motor as a supplement for haptic sensations.

Vibration is a common haptic modality in technologies designed for connection. Implementing this, we used a simple 8mm enclosed vibration motor, which was strong enough for our prototype. We tested out different resistors to reach the desired vibration strength, eventually settling for 100 Ω. Directly connecting the motor to the Arduino resulted in the motor

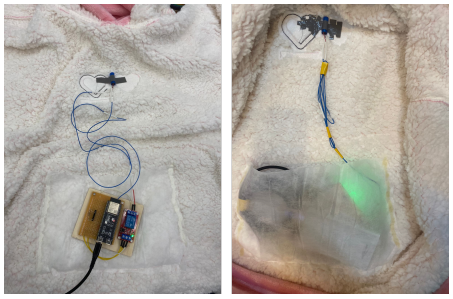

Figure 6: Vibration motor and microcontroller attached to perfboard

never completely turning off, but rather remaining vibrating softly, even when seemingly being supplied with 0 Volt. To solve this, we controlled the power supply by using a relay module. The last step was to transfer the circuit to a perfboard, making it permanent and ready for implementation. Additionally, we screwed the board and relay module to a piece of wood. Finally, the electronics were placed in a pouch inside of the hoodie. The motor was attached to the chest area of the hoodie (see Figure **??**). Once activated, the vibration stays on for 3 seconds.

4.4 Voice Messages

Initially, the voice message feature was designed to be controlled by the wearer. The sender would be able to record audio that would be played by the speakers embedded in the receiving hoodie. However, the recorder module that we were supplied with was not suitable for this specific purpose. The module was intended for voice recording, allowing both recording and playback of messages on a single device, facilitated by its 16MB of internal storage. Due to this configuration, audio recordings were inaccessible to us, as there was no way to retrieve information from the internal storage. Consequently, while messages could successfully be recorded, they could not be sent to the MQTT broker. To mitigate this issue for the user research, the audio recordings were stored on the laptop of the researcher instead of playing directly from the hoodie. This was done by connecting the module to the laptop using a USB-C cable. For user testing and demonstration, a pair of wireless headphones were connected to the laptop for wireless playback of the audio messages.

Voice messages were recorded on the module by pressing the 'rec' button until the corresponding light stopped blinking. After the user produces their message, pressing the 'play' button sends the audio file to the laptop. From there, the voice message could be accessed and played back.

4.5 Aesthetics

Finally, we 3D printed button encasings which were initially meant to hold a microphone, play button and temperature controls. Given our decision to split the prototype into a sending and receiving device, these buttons were non-functional. Therefore, the microphone encasing was not placed inside the hoodie. Additionally, the buttons to control the audio and heat were not connected to the Arduino, due to the unforeseen technical difficulties described in sections 4.4 and 4.3. However, the encasings were included for their visual effect and utility in user testing and feedback. Lastly, we embroidered the Lobit logo onto the chest area.

Even though the final Hi-Fi was not entirely in line with the initial design (e.g. two fully functional hoodies), we ensured the level of functionality met the requirements for evaluating the user experience and interaction.

5 EVALUATION

This study explores the impact of Lobit on feelings of enchantment and social presence using a within-subjects mixed methods study. We used the Lobit as-is (i.e., vibration, and separate functionalities) but also gathered information and perceptions about the idealized Lobit. Participants, who were platonic or romantic partners, were exposed to two conditions: one where the product was used (experimental condition) and the other where smartphones were used (control condition). Each condition simulated distanced communication between a pair of participants, during which they were asked to consider their emotional experiences. Subsequently, participants were given a checklist and semi-structured interview designed to measure the social presence and the enchantment evoked by each condition.

Alternatively, we considered conducting an online vignette study with only the idealized version of the prototype to remove the constraints of our current prototype. Similarly, a provided scenario and an interview were proposed. However, we decided to opt for observational methods using the prototype to ensure a naturalistic setting.

5.1 Participants

We chose to recruit pairs of platonic and romantic couples to ensure that distanced communication may occur regularly. This was done using a convenience sample of peers and a partner of their choice whom they felt emotionally close to. Our sample consisted of 3 pairs (mean age = 22, mean duration of relationship = 2.3 years, mean distance from each other = 1.5 hours, romantic = 1, platonic = 2). Each pair was assigned a number, and each individual in the pair was assigned a letter to ensure anonymity in analysis (i.e., Participant 1a or 1b).

5.2 Materials

5.2.1 Participants. Participants were given the information form and the digital consent form to e-sign. Participants were also asked to bring their smartphones for the control condition.

5.2.2 Environment. During the study, all participants were given snacks and drinks to improve comfort. The phones of the researchers with access to movies were present for the

Figure 7: Reception and Sending Prototype

experimental condition. This was implemented to provide background entertainment for the participants.

5.2.3 The Prototype. The experimental condition required both the reception prototype and the sending prototype (Figure 7). The researcher's laptop was connected to the sending prototype (microphone module and sensor armband) via a USB-C cable. Alongside the reception prototype, participants were given wireless headphones (connected to the same laptop as the microphone) to mimic speakers within the hoodie itself as per the original design. Both prototypes used the phone hotspot of a researcher for a functioning wireless connection.

5.2.4 Checklists. Each participant got a physical copy of the enchantment adjective checklist and the Networked Minds Social Presence Questionnaire for each condition [7] [21].

5.2.5 Data Collection. Voice memo phone apps were used to record the experimental session and the interview sessions. Otter AI was used to transcribe the recordings to be later coded with Microsoft Excel.

5.3 Procedure

First, participants were given the information sheet and consent form to sign. They were then given a verbal debriefing of the purpose of the study and an overview of the timeline. Demographic data was collected at this point. To control for the order effects of the conditions, some pairs (2) were given the control condition first and the other was given the experimental condition first. The duration of the experiment was about 1 hour.

5.3.1 Control condition . Participants were asked to use a text-based communication app of their choice to discuss how their day went with their partner. The pairs were then separated to complete the task for 5 minutes. They were also each given a phone of the researcher to play a movie or TV series of their choice. They were reminded that researchers would not request to view their conversations.

5.3.2 Experimental condition. Participants were given a presentation of the functionalities of both the sending and receiving prototypes. The ideal design (with sending and reception within one hoodie and functioning control buttons) was also explained. One participant was given the sending prototype, and the other was given the reception prototype. Participants were told that when they hugged themselves while pressing the armband, it would be like sending a hug. Additionally, the participant was taught how to send a voice message when they wanted to.

Participants were separated into different rooms where one researcher went with each participant for guidance, observation, and ability to answer questions. A background movie was played for both participants by the researchers. The participant with the sending hoodie was told to send a short message telling their partner about how their day went. The participant with the reception hoodie was told to press the button on the heart when they were ready to hear the voice audio. The researcher with this participant sent a text message to the other researcher to play the audio from the computer. After 5 minutes of usage, participants switched which prototype they were using. Researchers took notes while observing the participants during this procedure.

5.3.3 Checklist and Interview. Between both conditions, participants were first asked to fill in the Networked Minds Social Presence checklist. Then, they were asked to complete the enchantment adjective checklist for either the control or experimental condition. After filling out each checklist, they were given a joint semi-structured interview regarding their answers to gather further insight into specific emotional experiences of enchantment through traditional methods of distanced communication and our design. We chose a semi-structured interview, where we created questions regarding the overall experience, insight into the functionalities, social presence, and enchantment. We chose this method to evaluate the experiences of both communications in depth while leaving room for diverse and unrestricted responses [8]. Additionally, participants were instructed to imagine receiving heat instead of vibration and were asked how they thought they would experience this. We used open-ended questions to be able to compare and contrast the aspects which contribute to feelings of enchantment.

5.4 Measures

5.4.1 Manipulation Check. In the control condition, one post-task question served as a manipulation check. Participants were asked what they talked about and which app they used to communicate. This was done to ensure they completed the task of communicating with their partner using their smartphones. Participant feedback demonstrated that all participants successfully completed the condition.

5.4.2 Social Presence. The Networked Minds Social Presence Inventory was used to quantitatively assess social presence

alongside the qualitative data [7]. This was presented as a balanced scales checklist where participants ticked each box with which they agreed that a statement applied to the condition. +1 was assigned to all items indicating social presence, while +0 was assigned to items indicating the absence of social presence. For example, "I hardly noticed my partner in the room", was assigned a 0. The max social presence score is 24. This approach was chosen to emphasize the presence of connectedness and to simplify the interpretation of results. Within this measure, there are individual scales of social presence. There were 8 items for co-presence (max score = 4), 18 items for perceived psychological engagement (max score = 14), and 6 items for perceived behavioural interdependence (max score = 6). Half of each set of items pertained to the participant's perception of their own experience (max score = 12), and the other half of the experience of their partner (max score = 12). For example, an item for the perception of self was, "I paid close attention to my partner," and the corresponding perception of the partner statement was "My partner paid close attention to me". The full checklist can be found in Appendix **??**.

In addition to the quantitative measures, follow-up questions in the interview were included to understand why participants experienced social presence in the way they did, the intensity in which they experienced each statement, and which modalities contributed to their experience. For example, we asked, "Can you briefly go through the list and explain how you chose the phrases you felt?".

5.4.3 Enchantment. Likewise, we use the Enchanted Adjective checklist, where participants check off the adjectives they perceived to describe the condition (agree = 1, disagree = 0) [28]. At the bottom of the checklist, is a question asking participants to rate their likelihood to recommend the prototype to a friend on a scale of 1-10 (0 = not likely, 10 = likely). The full checklist, containing 21 items, can be found in Appendix **??**.

Additionally, follow-up questions in the interview were included to understand why participants experienced enchantment, the intensity in which they experienced it, and which modalities contributed to their experience. For example, we asked, "Why did you experience [comfort]? Are there any specific features that made you feel this way?".

5.5 Data Analysis

We evaluated the overall design and how the different modalities contributed to the feelings of social presence and enchantment. We compared these results to emotions evoked by traditional text-based communication.

5.5.1 General Observations. General observations of the study were made by analyzing the research notes from the experimental condition. This was beneficial for understanding the overall satisfaction and general experiences of the user.

5.5.2 The Networked Minds Social Presence Checklist. Each phrase was observed for its frequency distribution between both conditions. Values assigned as zero were ignored to exclusively capture the existence of social presence. Additionally, we calculated the subjective and inter-subjective symmetry in accordance to the validated guidelines of the checklist [5]. Subjective symmetry was analyzed by calculating the correlation between the perception of self and the perception of the partner for the social presence score. Inter-subjective symmetry was obtained by calculating the correlation between the ratings of the social presence of the self and the other's rating of their partner.

5.5.3 Enchantment Adjective Checklist. Similarly, each adjective was observed for its frequency distribution between both conditions.

5.5.4 Interviews. Interview transcripts were analysed specifically for the modalities of both prototypes and the communication methods of both the control and experimental conditions. Once the transcripts were coded, we formulated our observations for each adjective of enchantment and each modality. We identified various patterns by analysing the quotes and frequency of codes. This allowed us to compare modalities with feelings of enchantment and obtain our research objectives.

5.5.5 Visualisations. We used visualisations in our data analysis to synthesize our data into comprehensible observations. By supporting our frequency analysis and qualitative analysis with visual depictions, a clearer understanding of the data made it easier to compare our design to traditional text-based communication.

6 RESULTS

In this study, using 'Lobit' in distanced communication within close relationships provided insights into its ability to provoke enchantment and connectedness in comparison to mobile, text-based communication.

6.1 Social Presence

The overall perception of social presence, revealed by the average total score out of 24, was 12.0 with the phone condition (Range=11, Median=11, *SD* =3.87) and 15.3 with the Lobit (Range=6, Median=15, *SD*=2.13). Thus, the Lobit evokes more social presence than the phone condition. One participant explained why they usually don't feel this connected when texting: "*[in the control condition]-I mostly felt their presence metaphorically, but like, in real life when we aren't on our phones at the exact same time I usually don't*" (P1b). Likewise, distraction plays a role, "*I felt distanced. I can tell that I'm speaking to someone, but "I was kind of carried away by [the movie] I was watching"* (P2b). This contrasts how some participants experienced the Lobit, "*If someone's far away the only real way to speak to them is on the phone, but here, because it's on you, like physically on my body, I'm just kind of amazed and feel more connected*"(P2b). This further illustrates the disparity between the sense of presence experienced during regular phone communication, where one must be present at the same time, and the continuous presence provided by wearing a hoodie.

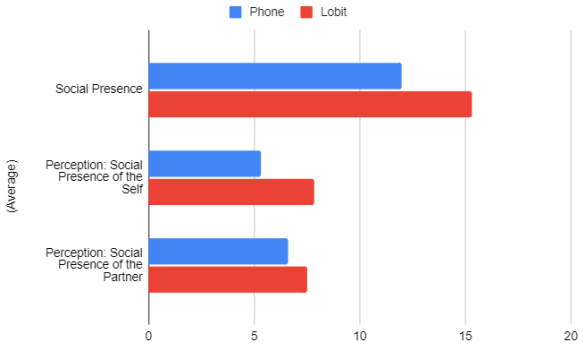

Figure 8: Social Presence and Perceptions of the Self and Partner

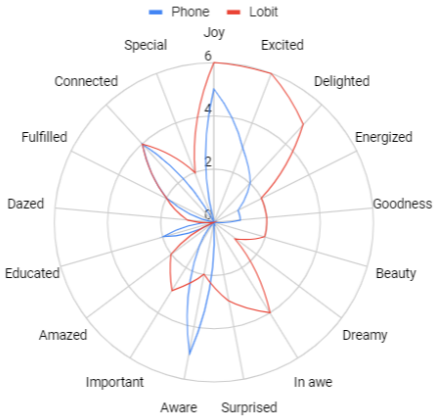

Figure 9: Experiences of Enchantment: Lobit vs. Phone Condition

Specifically, the average perception of the social presence of the self, with scores out of 12, indicates how each participant felt about their partner. When using phones, the perception of self was an average of 5.83 (Range=6, Median=5.5, *SD* = 2.11) and using the Lobit was 7.8 (Range=3, Median=8, *SD*=0.98). Using the Lobit, the user felt they were better able to attend to their partner.

Similarly, the average perception of the social presence of the partner of each participant was 6.16 in the phone condition (Range=5, Median=6, *SD*=1.90) and 7.5 for the Lobit (Mean=7.5, Range=3, Median=7, *SD*=1.11). Users perceived their partner attending to them more using the Lobit.

The symmetry of the user's experience and the perception of their partner's experience further illustrate the perceived connectedness in both conditions. The average subjective symmetry, indicating the correlation of each participant's perception of themself and their partner, was r=0.70 (*SD* = 0.35) for phone usage and r=0.86 with the Lobit (*SD*=0.86). Using the Lobit, the user experienced that the way they felt and how their partner felt was more connected.

On the other hand, the inter-subjective symmetry, representing the correlation between how the participant rated themselves and how their partner did was r=0.81 (*SD*=0.14) for phones and r=0.36 (*SD*=0.18) for the Lobit. The differences in conditions of feelings of social presence are visualised in figure 8. This represents how users were actually able to understand themselves and their partners. In both conditions, this is lower than the subjective symmetry, indicating that users' actual perceptions of themselves and their partners were not as aligned as they thought. Noticeably, this is higher in the phone condition: *"Perception of self and perception of the other was pretty identical for me. I was aware of the conversation and imagined if it was an in-person relationship how it would feel like. I think that's mostly where it comes from; being aware and understanding the method of communication and how we communicate"*(P2a). The lower inter-subjective symmetry in the Lobit could be explained as users in close relationships are used to understanding their partners through text.

An elevated perception of social presence using the Lobit can be explained by the perception of its specific modalities. Specifically, users appreciated the reception of voice messages: *"Also the voice message. It almost felt like there was a presence. Especially if you had the hood on it's like a whole experience"*(P2a). Additionally, the reception of the hug was well received. One user explains, *"Feeling the vibration didn't exactly feel like a hug, but it was a nice little buzz that reminded you that the person was thinking about you and like, wanted to virtually share their presence with you which was cool"*(P3a). However, one user commented that the vibrations may get annoying over time. Regardless, the modalities were mostly well-received.

6.2 Enchantment

Important implications for the design of wearable technology, aimed at improving distanced communication experiences, were also offered by the frequency analysis of the 'Enchantment Adjective Checklist', revealing useful information about the occurrence of enchanting experiences. Participants checked off an average of 10.8 adjectives of enchantment for the Lobit (Range=8, Median=10, Standard Deviation=2.62). This was in stark contrast to the score in phone condition which was 4.5 (Range=2, Median=4.5, Standard Deviation=0.95). Notably, the most common experience was joy and excitement. Many participants felt it was easier to select the adjectives on the list: *"Using the hoodie felt more interesting and fun so it was easier to relate to what was on the checklist"*(P1a).

No participants found the experience to evoke feeling stunned, lost-in-the-moment, in awe, or humbled. We visualised the differences in experiences per condition in figure 9. Additionally, coding the interview transcripts for the modalities of the Lobit revealed their individual and joint impact on enchantment. When describing how they analysed the enchantment,

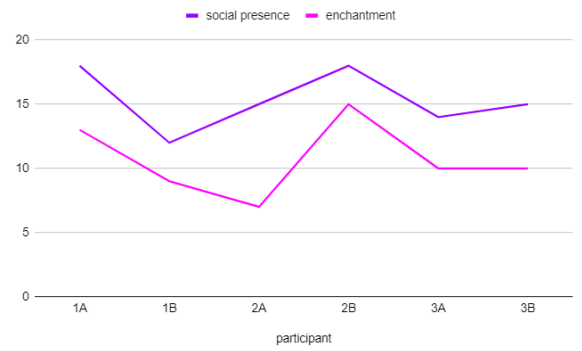

Figure 10: Social Presence and Enchantment Scores for the Lobit

they referred to receiving vibration and voice messages as contributing factors to how they chose the enchantment adjectives. One participant expressed, *"[When choosing the adjectives] I thought of the vibrations because someone is thinking about me I felt special. I could hear [the partner's] voice so I felt connected, and then excitement because of the product itself "*(P2b). Furthermore, users relate to feeling enchanted more using the features of the Lobit than their phones.

6.3 Enchantment and Social Presence

These results steer us to investigate the potential relationship between enchantment and social presence. Using the Lobit, participants who scored higher on social presence also scored higher on enchantment (see Figure 10). One user mentioned that they chose "special" because of their perceived partner's attention to them: *"There was a lot more to pick this time for sure. It was more in line with [the Lobit]. I chose joy, excitement, goodness, connected, and feeling special because you feel more seen"* (P2a).

However, in the text-based condition, there was no relationship to be found; social presence varied, but enchantment appeared as a flat line. This further supports the idea that feelings of enchantment are indeed positively related to social presence.

6.4 Reception of Vibration and Voice Messages, and the Perception of Receiving Heat

Based on observations of the participant wearing the reception prototype of the Lobit and post-interviews, we were able to understand individual experiences of receiving vibration and voice messages. We found that participants enjoyed both modalities. Specifically, many enjoyed the reception of the vibration. Additionally, participants stated that they thought that heat reception would be less suitable for mimicking the experience of a hug, *"I kind of prefer the vibrations. I think the vibration is more obvious, you have the sense immediately like that someone's thinking about you. Also, you might have not noticed the heat because you might just feel like you're getting warm. The vibrations were way more obvious and stood out a lot more. I really liked it "*(P2b). Likewise, users were concerned by the discomfort that heat may cause.

During observation, participants received the voice audio quite well, enjoying the illusion of instantaneous reception. Some users enjoyed pressing the buttons: "*Pressing the button was way more fun than pressing play on voice audio on like WhatsApp*" (P3a).

Overall, users appreciated the combination of the modalities: *"Usually the way you communicate with people far away is like typing and seeing but this one is more like feeling. So more senses makes it better"*(P2b).

Thus, hug reception and voice messages contribute to the overall satisfaction of the Lobit.

6.5 Adopting the Lobit

The general experiences of participants and satisfaction with the product were observed. Alongside enchantment and social presence, comfort played a role in the overall satisfaction with the Lobit, *"I would wear that all day like it's super comfortable"* (P2a).

The average likelihood of recommending the Lobit as a method of communication to someone was 8, whereas phone communication was 7.8. For the Lobit, most recommendations were positive: *"I would recommend this, especially in long-distance relationships with someone you don't usually get to see"* (P1a).

However, one user in a romantic partnership mentioned, "*I wouldn't recommend this to anyone unless it was romantic. It's a little weird between friends I think*" (P3b).

Overall, the adoption of the Lobit was well received by users.

7 DISCUSSION

Our results have shown that participants were particularly intrigued by the novelty of vibration being embedded in a garment, and sending the audio messages. People felt more enchanted and socially present when using the Lobit compared to the control group, using text-based communication. Interestingly, we found that integrated heating technology may even be undesirable and less resembling a hug compared to vibration, according to our participants.

Overall, the Lobit's features are highly favoured by participants, where joy and excitement are among the most often mentioned experiences. Similarly, participants' feelings of connectedness and attentiveness while using the Lobit were well-captured by ratings on the social presence checklist. These findings have important design implications for future technologies that aim to improve the quality of communication between people who are far away by adding characteristics that create a sense of enchantment and connection.

The interviews provided insights into the overall satisfaction and views on the modalities themselves. We found that the prototype was well-received by the participants, who also strongly remarked that they would recommend it for usage in long-distance relationships. Furthermore, the interviews highlighted the thought processes of the participants when rating their feelings of connectedness and enchantment, revealing a potential connection between the two.

Although users claimed that using the Lobit device made them feel closer to their partner than using a phone did, objective measurements show that there is less agreement between the users' assessments and those of their partners. In particular, the inter-subjective symmetry was higher for communication through a phone than for Lobit, which may indicate a gap between perceived and actual comprehension in close relationships.

7.1 Limitations and future research

Despite the insights of our study, there are limitations in our methodology. First, our prototype was not fully functional before testing, and some of the modalities we wanted to test were not functional. This led us to ask the participants to imagine the hoodie was self-heating and had built-in speakers. Looking back, in this aspect our research design could benefited from a vignette depicting the idealized prototype. We think this could have benefited users' imagination of the intended features. For future research, having a final and fully functional prototype would provide a great benefit, as a more naturalistic version of our prototype would likely yield more accurate results.

Additionally, our study treated both platonic and romantic relationships equally. Though we do not have reason to think this may have impacted our outcomes significantly, we do think this could have been an interesting research endeavour. Therefore, in future studies, comparing groups based on relationship type may yield interesting results.

Next, this study provided reasons to believe feelings of enchantment are positively associated with social presence. However, with our current design, we do not have solid ground to make such claims. In this study, we were studying social presence and enchantment in the context of our prototype, which may act as a mediating factor between the two. For future works, it might be useful to investigate this particular relationship, for example in more controlled experimental design settings. Alternatively, large datasets can be analysed for intricate patterns among these factors and many more, in aid of a better understanding of enchantment as observable behaviour.

Finally, researching enchantment and social presence was confined to a single time point, restricting us to surface-level measurements capturing only participants' immediate reactions to the prototype. Additionally, though social presence is important to relationship satisfaction and we do not have concrete reasons to think otherwise, our data does not allow us to infer that Lobit actually increases relationship satisfaction or deeper emotional connections, considering we did not test for these. Rather, Lobit has the potential to do so. Therefore, exploring the long-term benefits of meaningful connection technologies, such as Lobit, would provide deeper insights into how they can support and perhaps even improve our relationships.

7.2 Ethics

From an ethical standpoint, ensuring usage of Lobit requires consideration of data security, permissions and privacy. This includes implementing robust encryption measures to safeguard private messages and biometric data collected through the prototype's tactile features. Prioritizing user consent is important to us, therefore if we were to implement a technology such as Lobit, we would stimulate clear and honest communication about data collection procedures and obtain express consent for each use case.

Another important point we would like to express is that our design is not meant to *replace* social presence, but rather serve as a more meaningful addition to digital communication for two long-distance individuals. Additionally, we cannot foresee the impact that extensive adoption of affective technologies might have on relationships. Therefore, the societal impact of such technologies should be studied more broadly to make sure they enhance human connection rather than diminish it.

Lastly, Lobit should be made to suit a variety of users, including those with disabilities who might have particular accessibility requirements, in order to foster inclusivity. In order to guarantee that Lobit's design and functionality are inclusive and accessible to all users, regardless of their relational settings or technological skill, researchers should actively engage with varied populations. Researchers may promote user confidence and trust as well as the responsible and ethical use of Lobit on a larger scale by proactively addressing these ethical issues.

7.3 Tangibility, Materiality, and Embodiment

Lobit is designed in such a way that it enhances distanced communication through tangible interactions. These include vibration modules and touch sensors, which get activated when the user hugs themselves, providing them with a more immersive experience. Furthermore, the buttons on the Lobit should be able to record and play voice messages when fully developed. In the context of our design, materiality refers to the physical properties and textures of Lobit that contribute to the user's perception and experience, such as the fabric which creates a comfortable and cosy feeling. The design choices that we made were based on the enchantment checklist from the literature (Appendix C), emphasizing adjectives like 'beauty', 'connected' and 'lost-in-the-moment'. These adjectives can be found in multiple parts of the hoodie's design such as the embroidery, the ability to feel a physical connection through vibrations and the ability to send each other voice messages without

the need of a phone. By prioritizing these tangible elements, Lobit provides a novel feeling of presence and connectedness between its users.

8 CONCLUSION

In summary, this article has shed light on the potential Lobit has to improve the quality of long-distance communication within close relationships. Our primary research objective was to understand how our prototype affected feelings of social presence and enchantment in distanced communication, compared to conventional text-based communication. We conducted a mixed-methods investigation to examine Lobit's effects on these dimensions. According to our results, Lobit can indeed have a significant positive impact on feelings of enchantment and social presence, outperforming text-based communication in these aspects. Participants reported feeling more connected than before, and Lobit's tactile features — like voice messages and vibrations for hugging — turned out to be important factors in this regard. Interestingly, inter-subjective symmetry was higher for the phone condition, indicating that users' actual perceptions of themselves and their partners were not as aligned as they thought. These results underline the importance of incorporating tangibility and enchantment into communication technology, deepening emotional bonds, especially in long-distance relationships.

In this era of rapid technological evolution, designing technologies that foster meaningful interactions between people become more important, and our research underscores this importance while enhancing our understanding of technology-mediated communication.

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