



# Always with Me: Exploring Wearable Displays as a Lightweight Intimate Communication Channel

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## ABSTRACT

Simple and low bandwidth communication on computers has been found to promote intimacy between couples. In this work, we further explore this minimal communication in the form of wearables. This pictorial presents an in-the-wild concept study of low bandwidth ambient wearable displays as a communication channel between couples. The goal is to understand the contexts in which the technology might be used and provide benefit. Our findings show that simple communications through a wearable device could provide an additional channel for communication. The wearable form factors also creates the feeling of being always connected. We highlight the importance and influence of form factors, contexts, and activities towards user experience. We discuss the opportunities this study opens for the future design of wearable ambient displays.

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## Authors Keywords

Wearables; wearable display; relationship; lightweight; communication; concept evaluation; in-the-wild; prototype.

## INTRODUCTION

The ubiquity of smartphones allows people to stay connected through text messaging, phone calls, or social networks. While these are rich means of communication, they demand attention and can be distracting from other ongoing activities at hand [23]. Minimal communication is proposed as an alternative communication approach. Minimal communication on computers has been found to promote awareness between remote couples. Kaye et al. [13] demonstrated that the change of colour on a small circle located on a small corner of a computer screen that is triggered by a simple click from a remote partner could efficiently maintain intimacy between a couple in a long-distance relationship. Recently, lightweight and implicit communication has gained more attention as its simple interaction could better support mobile and wearable technology [2]. For example, Yo [24] is a mobile application for smartphones that only sends a one-word message, i.e., “Yo”, along with the sender’s location. Similarly, Animo [15] is an application on smartwatches that allows two people to share their mood through an abstract representation. The representation is a geometric shape that changes its colour and motion based on the user’s heart rate.

Tapping on the representation sends it to the user’s partner.

Previous work has illustrated a trajectory of lightweight communication on different mediums from computers to smartphones, and smartwatches as technology matures. While smartwatches offers a straightforward way for communication, jewellery-like wearables are considered as a new potential (note that smartwatches are usually not considered as a jewellery, but rather form their own category [21]). Jewellery is worn close to the body, thus, naturally creates the feeling of intimacy. Furthermore, it also contains symbolic meanings related to identity and memories, creating a multi-layered experience, which are often considered lacking in technology-driven wearable gadgets [22]. Hence, jewellery serves as a potential design space for lightweight intimate communication between a couple. Nevertheless, they are little explored. In this pictorial, we further explore jewellery-like wearable devices. We present snapshots of our participants’ experiences using low-fidelity prototypes, built based on their own designs. Through this we aimed to gain a better understanding of expectations from minimal, but dedicated, communication in the forms of jewellery-like wearables.

## BACKGROUND AND RELATED WORK

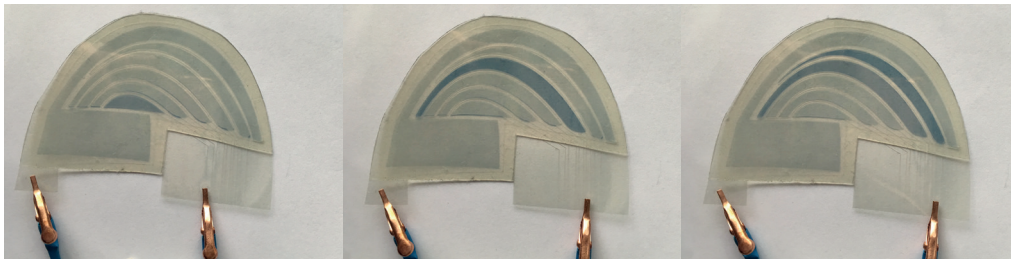
HCI research has explored the potential of computer-mediated communication using everyday objects for maintaining



An electrochromic display is flexible.



An electrochromic display is a dynamic free-form shape-based display. The shape and patterns are defined at the time of their creation.



A single electrochromic display can show more than just two patterns.

intimate relationships over distance. For example, LumiTouch [3] is a pair of picture frames for emotional communication. The picture frame illuminates when the remote partner touches the paired one. Lover's Cups [4] are two paired cups that enable remote drinking-together interactions by showing the liquid level of the paired cup and illuminating when the paired user is drinking. Connected Candles [7] are a pair of candle stands, each including an authentic candle and an electronic one. The system is designed to promote emotional connections using the electronic candle to mimic the light in the connected partner's authentic candle.

In the era of smartphones, video calls, voice calls and text messages are available communication channels to help a couple to stay connected. While these channels could offer efficient communication channels, they are considered generic and lacking in emotional and intimate experience [6,12]. Research efforts have aimed towards making mobile communication between a couple more intimate and special. For example, CheekTouch [17] enables sharing touches over phone calls synchronously by transmitting touch gestures applied on the sender's mobile phone touch screen to the receiver's cheek using vibrotactile stimulation. Dedicated mobile and wearable devices have been designed to enhance intimate communication between a couple. For example, Kissenger [19] consists of two paired devices that enable remote partners to send and receive kisses simultaneously. Ring U [18] is a pair of ring-shaped wearable devices that promote emotional communication - squeezing the ring sends a light and vibrotactile signal to the paired partner. Several designs of novel intimate communication devices have

been introduced. However, most of them, especially ones that present novel form factors beyond applications on smartphones or smartwatches, are presentations of concepts and prototypes [14]. In this study, we are inspired by Kaye et al. [13] to use of a lightweight visual element on computers as a medium for intimate communication. We extend the previous work and explore the potential of wearable displays with minimal visual elements as a medium. We also take a further step and test our concepts and prototypes in the wild to explore how different form factors of wearable displays could be used to communicate intimacy between a couple in different activities and contexts.

## OUR APPROACH

To explore the potential of wearable devices as a medium for minimal intimate communication, we conducted co-design workshops with 16 participants (all in a romantic relationship) to identify the desired design of wearable devices. Electrochromic (EC) displays were selected as the main display technology in our workshops. EC displays are graphical segment-based displays. Unlike pixel-based displays that can display anything within their resolution, the dynamic graphics of EC displays are fixed at the time of their creation. EC displays undergo an opacity and/or colour change, when a small voltage is applied to them [11]. This constraint helps in framing and encourages the workshop participants to develop a design that provides minimal communication, but is still meaningful to them. EC displays are non-light-emitting [16], which better suits wearable items for daily wear [5]. As EC displays are free-form and flexible, this gives freedom for the participants to design wearable devices of any form factor.

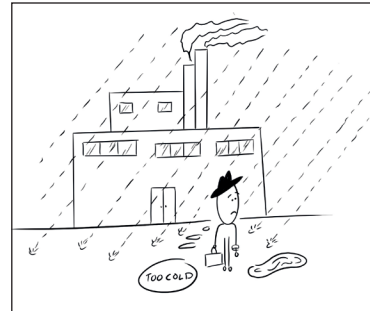
Four concepts and four wearable form factors were developed as the outcomes of the co-design workshop. Then, we constructed a lo-fi prototype of each concept and had the eight participants use the prototypes for two days. Each participant was given a lo-fi prototype of the concept they designed and had to imagine how they would use it to communicate with their partner. This aimed to further explore the concepts and gain a rich understanding of their potential to serve as an intimate communication channel as part of day-to-day activities. This method was inspired by Hawkins and his Palm Pilot wood prototype [20] and experience prototyping [1]. We adopted experience sampling [8] as a technique to capture a snapshot of the participants' experience in different activities and contexts. Over the course of two days, we sent out six triggers through WhatsApp messenger, three each day: morning, afternoon, and evening. The participants also responded to the trigger using the same channel. On the first day, we asked the participants to imagine using the prototype to send messages to their remote partner. On the second day, they imagined receiving messages from their partner. On receiving the trigger message and tasks, the participants were asked to respond immediately. The tasks included: 1) explain the context and activity they are doing; 2) how do they feel about using with their prototype in the context; 3) how would the prototype work in the context and activity; 4) describe what would not work.

## CONCEPTS AND STORYBOARDS

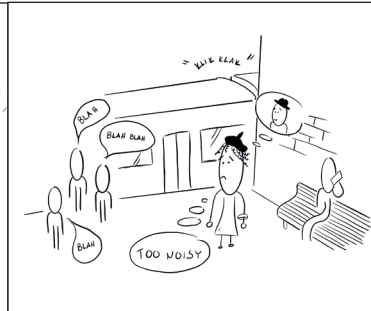
**The bracelets** feature with 4 different visual symbols. Changing from one symbol to another on a bracelet could be done by directly touching the symbol. The same change would also appear on the remote bracelet belonging to the partner. The visual change would be accompanied with haptic feedback to simulate the sensation of touch from the partner. The participants suggested that this form would be more visible than a smartphone, and wearing the device on the wrist, i.e. close to hand, would resemble holding hands with their partner.



Touching on one of the symbols would make the symbol visible. The touch would also activate the same symbol on the remote bracelet.



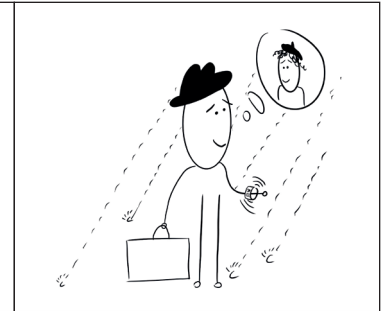
Eric is going home from his busy work day. It's raining and cold. There is no point in reaching for his phone in his trousers and fighting the harsh weather to make a phone call.



Amy is at a noisy train station. She cannot make a phone call to her beloved Eric either.



Instead, she gives a gentle touch on [the Netflix symbol] on the bracelet.



Eric feels a gentle touch from the bracelet and notices that Amy sent him an N symbol, meaning calm down it will be Netflix time for us soon.

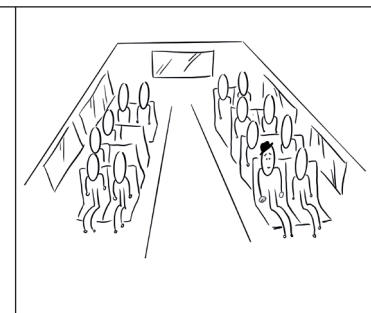
**The rings** are featured with only one visual symbol to visualise the emotional state of the partner. Two emotional states are represented using two different colours depending on how hard the ring is touched/squeezed. The interaction would trigger a change in the partner's ring. The participants who designed the rings suggested that the rings would be always visible to them. Furthermore, ring as a form factor is commonly associated with being a symbol of love.



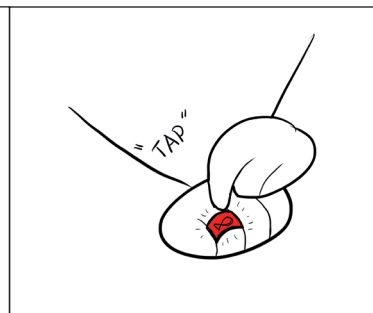
The symbol could be triggered by the remote ring. Gently touching the ring would trigger the visual symbol in blue. Squeezing the ring would show the symbol in red.



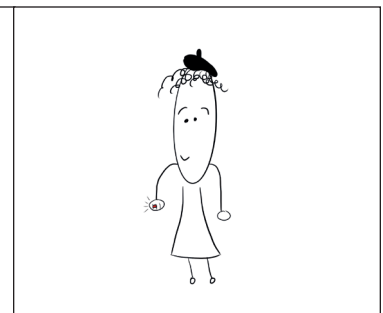
Eric is sitting on a bus. His ring is turning red. This means that Amy wants to talk because she is stressed.



The bus is very crowded and he cannot really talk. He has to wait until his destination so that he could make a phone call.



Eric gently touches the ring to send Amy a message that he got the message, but will get back to her as soon as possible.

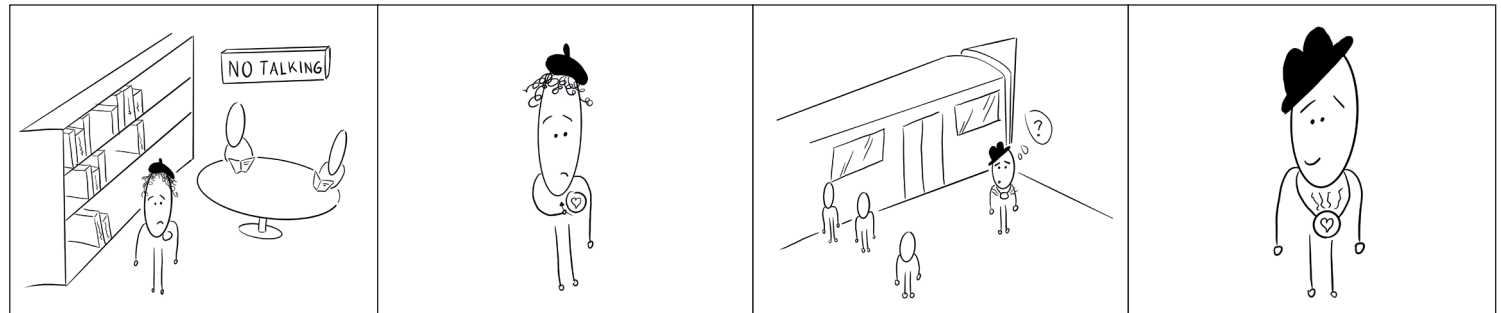


Amy notices the change on the ring. She understands that Eric cannot talk now. She will wait for him to call later.



The pendant showing a different pattern triggered by the movement of remote dial. The chain could be removed and be worn as a pin.

**The multi-wear pins** were designed with the intention that the device could be worn on different parts of the body, depending on the user's preferences. The pendant has a display that shows an abstract pattern, which represents the partner's emotional state. The pendant has a component at the back of the neck that will produce heat to notify the user when receiving a message. An emotional state can be sent to the remote partner by moving the dial in a certain way. This aimed to create a thoughtful form of communication, cherished due to the effort, instead of an easy throwaway message. The participants' reasons for designing the device in a multi-wear format was that they would like to be able to wear the device on different occasions. In addition, the design enabled hiding the device when they did not want others to see it.



Amy is in a quiet library. She cannot really talk.

Amy turns the dial on her pin to send an emotional message to Eric.

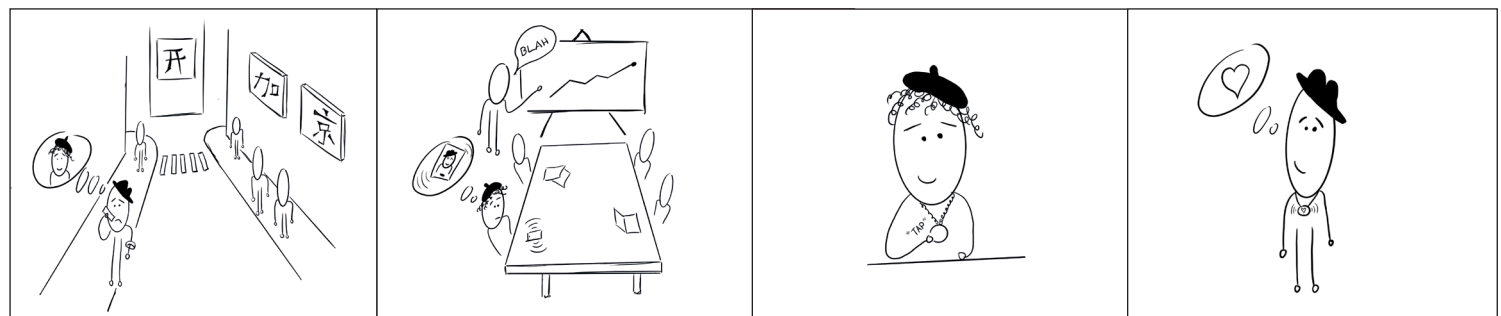
Eric is at a train station. He is wearing the device as a necklace. It warms up.

Then, Eric notices a message from Amy. He will respond to her when he has a quiet moment.

**The necklaces** could display different colours and patterns on the pendant. The pendant has a small switch, which the wearer could use to change the pattern of the pendant on the remote partner's necklace. The change of pattern would also be accompanied with a subtle vibration. The participants explained their reason for designing the necklaces such that they would always be visible to them, but would not stand out too much for others. The necklace is believed to be worn close to the heart, thus, giving them the feeling of closeness and connectedness with their partner.



The pendant shows a different pattern and colour triggered by a small switch on the remote necklace.



Eric is trying to reach Amy through a phone call.

Amy is in a meeting. She notices the phone call, but cannot answer.

Amy uses her necklace, flipping the switch on the pendant to say that she noticed the call, but cannot answer at the moment.

Eric receives a response via his necklace with a pattern, and understands that Amy is occupied and will talk later.

## USING THE PROTOTYPES

In this section, we present the participants' photos of themselves using the prototypes in different situations along with their speculated experience of using the prototypes in those contexts. The participants reported using the prototypes in different contexts, from home, their neighbourhood, commuting, to public places. Two participants went on a trip with their friends during the study. We report the participants' experience of using the prototype in relation to their context and activities, messages that they would send to and receive from their partner, and meanings behind the messages. As the participants went about and engaged in their activities, the way they imagined themselves using the prototypes as an intimate communication with their partner changed depending on different contexts. They considered that they would be more comfortable using the prototypes to send messages when they were alone. Receiving messages would be considered to be alright in most of the contexts, even when they were engaged in other social situations, like a church service or chatting with friends.



"The size is nice and I like the shape. I could wear it in combination with my existing jewellery."

## At home

Waking up



"It would be very nice to see this little message first thing in the morning. I don't have to stress my eyes. Plus, my partner is already at work, so calling or texting wouldn't be an option."

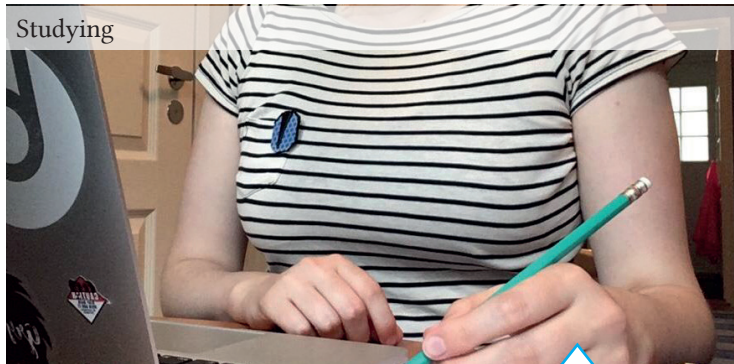
I noticed the message from my partner. He sent me a heart. He woke up earlier and this is a way of wishing me a good morning.

Getting ready for the day



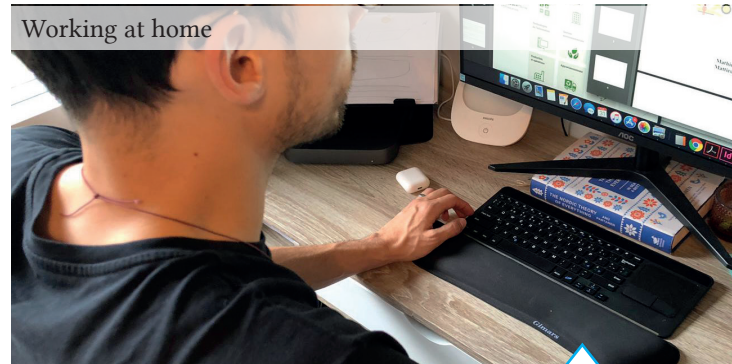
"Getting ready takes attention and time, but with this device, I can still see her message, without the pressure of responding immediately."

Getting ready: It's a good moment to send a message. I don't know if my partner is awake yet, sending something to let her know would be nice.



Studying

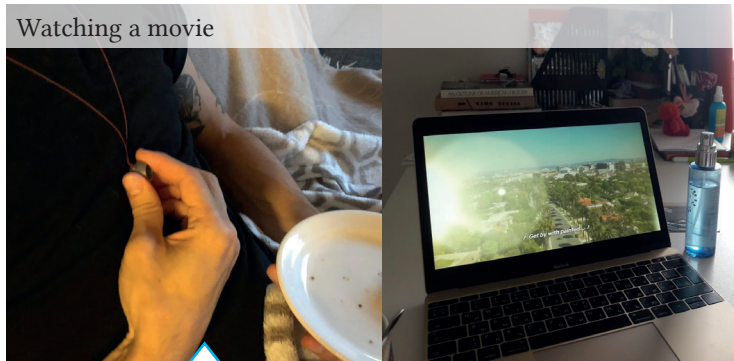
“It would be nice if I notice the message immediately when it is sent. Then, I can look at the display to see the colour change to, what my partner would have chosen.”



Working at home

“This makes me feel good that I could reach my partner at any time without disturbing her or without needing an answer back from her.”

Working at home: I would just send her a message to remind her that I'm thinking of her.



Watching a movie

“It feels great being able to do normal daily things and still be able to communicate feeling and share a moment with my love one.”

I know that my partner is doing morning jogging right now, so he can't talk. I miss him and I want to send him a sign that I'm thinking about him. Also, I press a button with N, which means I'm watching Netflix right now. We can synchronise later and watch it together on a distance.

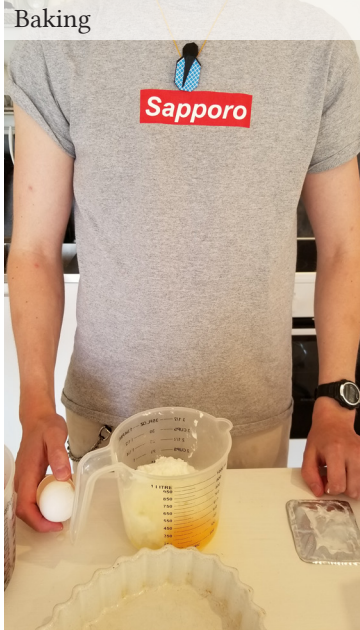


“I feel great because I'm letting my partner know I'm thinking about him without interrupting his morning exercise routine, but by probably making him smile at my message.”



Talking with a relative

“I'm in a group setting. If I want to send a message to my partner, in middle of all this, I would choose to go to another room. Find a quiet spot and then send a message. It's not easy to be mindful in this context.”



Baking

Here a text conversation would be in the way of baking. During a busy time, the device could deliver a simple message quite efficiently. This would also remind me to chat with her later during eating, for example. It's better than the alternative communication methods.



Sauna

I had my device with me but didn't bring it in the sauna. I could use it in the chilling time between sessions. If I'm alone and missing my partner, whom I usually go to sauna with. Then, it probably would be a good context to send a little message.



Exercise at home

"Looking at any devices during exercising is far from my first priority regardless who's on the other end, but if I only see the device in my peripheral vision, then I feel it would do its job nicely."

The device is on the wrist. It's in my peripheral vision.



Booking a holiday trip

"I'm excited to share good news in such an unusual way and see if he will understand the message!"

My partner is asleep now. It's night at where he lives, but I want him to get the exciting news as soon as he wakes up and puts on his bracelet. I pressed sun symbol to show on his device. I hope he gets the meaning of the message that our beach vacation is coming.

### In the neighbourhood

“I feel like this is the only way I can tell my partner how I feel. He is not able to talk to me right now. And he also can't write messages in the middle of the business meeting. But he might quickly press a button on his device to let me know that he's with me mentally even though he's unreachable now.”

Waiting at a public laundry



I press the bracelet to show the rain symbol on my partner's. It's our secret code, which means that I'm feeling down and would like his support when he has time.

Walking a dog



“I felt good performing the action since I was able to use it, share a feeling while taking a walk with my dog.”

### Commuting

Sitting on a bus



“I feel fine getting the message on the bus; even if someone saw me getting the message, they wouldn't know what it means.”

### In a public place

I would notice the message immediately because the thing [message notifier] on the necklace would get warm [...]. But others won't know about it because I'm not even looking at my phone.

Shopping at a supermarket

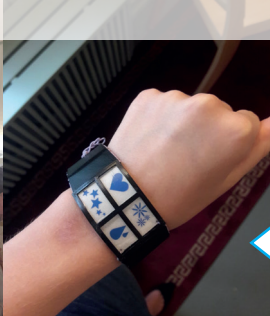


At a gym in a group exercise class



I was able to have it with me, but I'm occupied for the whole class. It's hard to have any interaction with the device. For visual, it would be hard to notice the message. I could see it after the class.

At a church for a service



I get the touch feeling from my bracelet. I know exactly when it means. I quickly glance at the prototype, a symbol of the cross shown.

“A symbol of the cross sent by my partner on the device makes me feel emotional. It makes me feel as if my partner is close to me, like we used to be, standing together in church.”

### On a trip with friends

In addition to the 6 participants who spent their typical weekend with the prototypes, two participants went out on road trips with their friends. The participants were mostly occupied with different activities on both days. The participants reported being more passive and did not wish to send messages to their partner, rather they would like to use the prototype to feel passively connected with their loved one. Furthermore, they highlighted that interactions with the wearables to send messages should be simple and unnoticeable by others.

Going to a supermarket



I'm in a car with 4 others on the way to a supermarket. I would like to send my partner a thought because I miss him.



Waking up



Going to sleep



I would try to send and receive messages without having others notice. It feels more comfortable using the ring when I'm alone, like a good night message before going to sleep.

"I'm a bit uncomfortable because I'm surrounded by others and the ring is very visible."

Hiking



"I would be glad to receive a message. I'm having fun with my friends and wouldn't want to receive a 'distress call' at this moment."

Getting ready for a trip



On a road trip, I would slightly press my ring to express that I'm happy and well. I would maybe wait for my partner to get back to me.



Visiting a husky farm



"It might be a bit uncomfortable as others might notice the ring and the change. I would feel uncomfortable."

I received a message from my partner. The display on the ring changed to blue. Our guide saw the ring and looked a bit confused.

Picking berries



I am in the forest, a bit further away from the others. I receive the message. I would probably see it right away as I am using my hands. I would send her a message that I received the signal. Later, I may take out the phone and write to my partner to call her.

Eating dinner



While my friends are talking around me, I'm thinking about my partner, so I would send her a message. I just press my ring and watch it under the table, so no one else can see it.

Relaxing after sauna

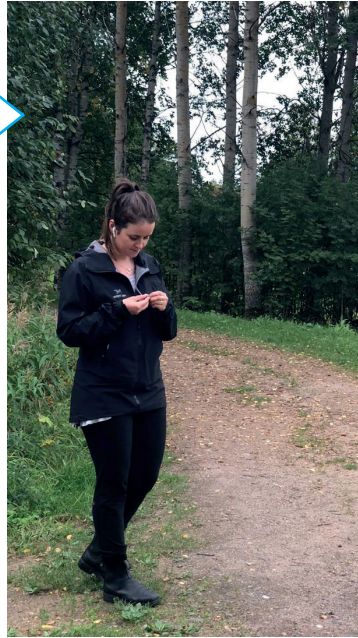


The ring turns strongly blue and my partner seems to need me. I could send her a feedback over the ring, but since she needs me, I will check the phone or call her.

### Emerging Usability Issues

Using the prototypes in-the-wild raised the participants' concerns related to the form factor and interactions with the prototypes. Low-bandwidth communication has the potential to communicate intimacy between a couple, but the participants would prefer to have a broad variety of messaging options to express their feelings and emotions, not just an on/off display. Among the four prototypes, the participants with the necklace raised concerns related to not noticing a message their partner sent. For example, the necklace would not be easily accessed or visible if used outside in winter. This could potentially decrease the feeling of being passively connected, which would make the wearable less distinctive from a smartphone. Usability issues with the ring were related to its interactions. While intuitive interactions are important and maybe preferred, the ring shows that it should be different and specific enough that the interactions could be identified as intended.

“If it’s really cold outside, I will have to open my coat to use it and remove my gloves. This might not be the best context to use this design outdoors during cold months.”



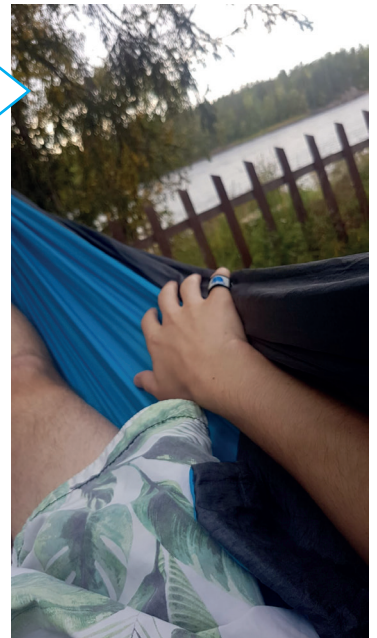
“If I wear a coat, I won’t see the display. It’s better to have something like a vibration.”



“If the device could have, maybe 5 option gears. Let’s say on the device that would activate 5 different patterns and colours.”



“I’m playing with the ring often. Random messages might be sent. Maybe my girlfriend wouldn’t bother with my the message anymore.”



## Importance of visuals

The participants further commented that relying only on themselves to notice the change of visual elements on the display could be problematic. They would not always pay attention to the devices. Although, the participants considered this channel of communication to be passive and less stressful, they would not want to miss or not knowing that their partner had recently sent them something. Furthermore, the participants reported that they would appreciate seeing changes that happen on the display as well as all previous messages their partner had sent. Additional notifications, such as vibration or heat, were considered beneficial. When we asked the participants what they would get from seeing visual content from the display, their responses highlighted the importance of visual and tangible aspects of the prototype.



“I’m a visual person. I like visuals and things that I can see. Warmth, vibration are a nice addition, but they are invisible. Visual is tangible.”



“The visual reminds me of my partner. It’s some symbol that represents him. Other outputs are just to notify me that I get a message from him.”

## DISCUSSION AND CONCLUSION

The four prototypes presented the concepts our participants came up with for using wearable displays as minimal communication mediums between a couple. Although the prototypes were low-fidelity and non functional, we solicited early feedback and first-hand speculative experience of using such lightweight communication concepts in their day-to-day activity. The participants reported feeling comfortable wearing the prototypes in different contexts, from being at home, in the neighbourhood, while commuting, or when engaged in a group or social activity. The participants commented that the prototypes would have made sending a message to their partner easier. However, interacting with the prototypes to send a message was preferred to remain minimal. The participants reported that they would feel more comfortable to be alone when sending a message. This may be based on the fact that the prototypes were a dedicated device used to communicate with their partner. The participants preferred to keep their interaction and communication private. With the prototypes, others could easily tell that the participants were sending or receiving a message to their partner, whereas it would be more ambiguous using a smartphone to do the same [9].

Balancing the visibility of the prototypes is a challenge we noticed when designing wearable devices for intimate communication. While we could not compare the experience of the participants using different form factors, we noticed that the four prototypes had different levels of social exposure, i.e. visibility to others. This led to the participants having different concerns for their prototypes when being in a public place or a social activity. The participants reported the ring was rather visible to others when they were doing different activities with their hands, whereas the participants with the necklace showed no concern about this issue, but were worried about them not noticing or seeing message from their partner at all. The bracelets and the multi-wear pins have a moderate social exposure and were relatively visible to the participants themselves. The bracelets were partly hidden under the sleeve but still in the participants line of sight when they were engaged in different activities. The multi-wear pins allowed the participants to adjust how they wanted to wear the pins based in different situations as they felt comfortable, thus visibility was not a big concern for the form factor. The future design of wearable devices for intimate communication should consider flexible form factor, such as the multi-wear pin, or body locations that are less socially exposed. If it is in a socially exposed location, such as a ring on a hand, the display of the ring could be located on the palm side, or a bracelet with a display on the inner wrist.

The wish to not disturb anyone is another expectation we noted from the participants’ self-report. While wearables might offer an opportunity for

the participants to be always connected with their partner, they would prefer that they could still be fully engaged in any activities they were doing. Similarly, the participants reported that they would send a message through the prototypes because they did not want to disturb their partner, knowing that s/he might be busy with other things at the moment. Lightweight communication in the form of wearables was considered to complement the use of smartphones, as a peripheral interface. It could offer a minimal way to say “I’m thinking of you”.

In addition, we noticed that the participants also considered the lightweight communication as a channel to provide support or to request for an assurance from their partner. While the communication could remain light and low bandwidth, the participants preferred to have broad communication spectrum. Kaye et al. [13] employed colour changing of a small circle over time as a minimal communication medium. Meaning of colour and the change were left open for an interpretation by a couple. Animo [15] uses colours and motion of a shape as a way to convey mood and heart rate between two users with a close relationship. However, as a smart jewellery and accessories, strong and energetic changes and movements are usually not preferred [10], changes of a pattern, symbol, or level of opacity could be considered as an alternative. Our study shows that the participants would naturally assign different signals as they would see fit with their relationship and personalities. They would also consider their partner’s general schedule as they interpret the meaning of a message. A further study is needed to establish a suitable form of visualisation and communication spectrum that is minimal, but yet expressive and open-ended enough for a couple to communicate their thoughts and emotions.

## ACKNOWLEDGEMENT

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