

# **Connection Crystals: Initiating Spontaneous Online Interactions through Ambient Design**

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**STUDENT REPORT**



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## **STUDENT REPORT**

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**Title:** Connection Crystals: Initiating Spontaneous Online Interactions through Ambient Design  
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### **Abstract:**

The purpose of this study was to create spontaneous online interactions and a sense of togetherness in a friend group of six friends during the COVID-19 Pandemic, where social interactions have mostly been moved to online environments. The approach of this study has been research through design, using an exploratory prototype to investigate how to initiate a conversation through an ambient display. The deployment period lasted for one month, and data was gathered through interviews, diaries and data logging of the prototype. The exploratory prototype, Connection Crystals, created more online interactions in the friend group and created a shift in who initiated the interactions. Furthermore, the online interactions created using the prototype were mainly voice communication, whereas they would usually use text before the deployment. The prototype helped people who self-identified as shy and introverted to initiate spontaneous online interactions. The participants perceived the prototype as not disruptive as it operated sufficiently in the background during working hours.

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## Summary

For this project, we have been working with the change in interactions between people due to social restrictions and started investigating different topics and issues. When we had the groundwork for our project, we focused on spontaneous interactions and the lack of these during the pandemic. Since the interactions could not be physical, the focus was on creating spontaneous online interactions by using an ambient display as an exploratory prototype. To understand the problem area, we built on research about togetherness, connectedness, friendship dynamics and ambient displays that we used as a basis for our approach and evaluation.

The approach for our project has been a combination of Research Through Design (RTD) and Reflective Agile Iterative Design (RAID), where we have created an exploratory prototype to deploy in a real-life setting, to obtain insights into how it would affect social interactions. RTD uses an artefact to gain knowledge about a specific context, where the artefact or prototype can be used to observe. RAID is a framework consisting of the stages “*deployment*”, “*use*”, and “*reflection*”, which all revolve around the exploratory prototype created. The design of the prototype is created through considerations of the goal and the use context. The use of the prototype is then observed and probed to collect data, which later can be analysed. Finally, the analyses and reflections are conducted with methodologies that the designer or researchers find appropriate.

To start our ideation process, we brainstormed possible solutions with a focus on creating ambient devices that could be used in friend groups. Afterwards, we used sketching techniques such as crazy eights to quickly form different design ideas that were then discussed and evaluated. The final concept, Connection Crystals, was made to use ambient lights connected across different prototypes to encourage and create spontaneous online interactions. To create the prototypes, we needed to work on several different parts. We molded 64 epoxy resin crystals for spreading the light, which would be split up to eight prototypes. A base for the crystals was also created using the epoxy resin, which was placed on top of a small wooden box. For controlling the lights and connecting the prototypes, we placed an Arduino development board inside the box. The code was developed and tested during the first month of prototyping. Finally, to connect the prototypes, we used Google Firebase, an online database, which would also enable us to collect log data from each prototype when used.

For the evaluation, we chose to have the prototype deployed with six participants for a month to get insights into everyday use and avoid the novelty effect. The prototype was distributed with two different diaries, instructions and a diagram showing each person and their respective colour. One diary would be filled out each time the prototype was used, and the other would be filled out every Sunday. The weekly diaries were more in-depth than the usage diaries and gave us insights into improvements, design considerations and group dynamic changes. To understand the participants and their group dynamics, we had a pre-study interview with them individually. Furthermore, we had a post-study interview which was also individual. Midway through the deployment period, we had a focus group interview with all of the participants. When the deployment period was over, we collected the prototypes and analyzed the data from the interviews by transcribing each of them. From the diaries, we gained insights into the usage of the prototypes and the participants initial thoughts when using them. All of the data was analyzed using Affinity diagrams to sort and get an overview of the data. The log data from the database was used to create graphs and calculate the standard deviations, which could substantiate the interviews.

The findings showed an increase in interactions and a change in group dynamics, as the group started using more voice communication and initiated more conversations with friends they would not usually talk with. The participants agreed that the prototype created a sense of togetherness in the group and worked well as an icebreaker for interactions. Furthermore, the prototype was used most by participants who had described themselves as introverts because they felt less concerned when initiating interactions.

# Connection Crystals: Initiating Spontaneous Online Interactions through Ambient Design

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## ABSTRACT

The purpose of this study was to create spontaneous online interactions and a sense of togetherness in a friend group of six friends during the COVID-19 Pandemic, where social interactions have mostly been moved to online environments. The approach of this study has been research through design, using an exploratory prototype to investigate how to initiate a conversation through an ambient display. The deployment period lasted for one month, and data was gathered through interviews, diaries and data logging of the prototype. The exploratory prototype, Connection Crystals, created more online interactions in the friend group and created a shift in who initiated the interactions. Furthermore, the online interactions created using the prototype were mainly voice communication, whereas they would usually use text before the deployment. The prototype helped people who self-identified as shy and introverted to initiate spontaneous online interactions. The participants perceived the prototype as not disruptive as it operated sufficiently in the background during working hours.

## Keywords

Ambient displays; Awareness information; Togetherness; Connectedness; Research Through Design; Online Interactions; Peripheral Displays; Exploratory Prototype.

## 1. INTRODUCTION

Social interactions are essential for human beings to prevent loneliness [1]. Since the breakout of the COVID-19 Pandemic, encouraging online social interactions is even more important now that physical interactions are very limited [2]. The consequences of these missing interactions have been seen across different age groups [1], [3]. As it is strongly advised against, and sometimes even illegal, to meet physically, it can have a negative effect on people's mental health [1].

Furthermore, loneliness during the Pandemic is worse in some age groups than in others [3]. For example, a study from the United Kingdom showed that adults in the age of 18 to 30 have been more lonely before and during the COVID-19 Pandemic than adults in the age of 60 and above [3]. Students are also at a greater risk of feeling lonely during the Pandemic, especially if they live alone [3]. These facts show the importance of focusing on young adults and adolescents to ensure their mental health.

Instead of meeting physically, people can meet online and continue having social interactions. People who typically use the internet for social interactions also tend to be more social in general [4]. However, this can be a struggle for people who are

not very social and therefore create challenges when most of their social interactions have to be online [4]. There is also a difference in the way people conduct their social interactions when it has to be online. Most of them are at home when interactions are held online, whereas face-to-face interactions are most likely to be held away from home [4]. Therefore, it can be a problem that people are missing their face-to-face interactions and the possibility to meet their friends outside the home. It can be difficult to be social and take the initiative for an online conversation when being at home most of the time and not seeing friends regularly [2].

Our work aimed to make it more accessible to initiate online social interactions, to create more spontaneous online interactions and decrease the likelihood of social isolation during the COVID-19 Pandemic. Based on the above statements, we wanted to support people in initiating spontaneous social interactions.

This design could also be used beyond the COVID-19 situation. Since online social interactions have been increasing in the past decade [5], this design is also suitable for everyday life without a global pandemic.

As the majority of the Danish population uses social media to interact with friends and acquaintances [6], [7] we aimed to create a concept that was helpful in initiating conversations. The goal was to create a prototype that can also be used by people who want to keep the social relation with their peers that they do not see daily. This could be due to distance or busy lifestyles.

We have deployed the Connection Crystals for a month with a friend group of six young adults, all located in Aalborg. We have created Connection Crystals as an exploratory prototype since we investigated emergent aspects of use and not the prototype itself [8]. The prototype was built as an ambient display, making it possible for the user to obtain the information when it fits them. Our goal was to 1) investigate if these Connections Crystals support young adults in spontaneous interactions online; 2) understand if an ambient display can create a sense of togetherness or connectedness; 3) explore if these prototypes encourage people to take the initiative, where they usually would not.

## 2. BACKGROUND

This section will present the importance of friendship, address designing for togetherness and present similar projects, which has been the basis for our project.

## 2.1 Understanding Friendship

To address why it is important to encourage social interactions among friends, we have to understand the importance of friendship and its relation to mental wellbeing.

Friendship is a fundamental part of mental wellbeing, and adults that describe their friendships as positive and satisfying also report fewer feelings of hostility and anxiety [9]. Young adults who describe having been in close friendships showed greater enjoyment, emotional support, sensitivity, loyalty, mutual affection, intimacy, and overall higher life quality than peers that did not [9]. Furthermore, individuals with more and better relationships are associated with having better physical health and higher life expectancy [10]. Friendships contribute to self-esteem and often provide affection, warmth, nurturance and intimacy [9]. In addition, friends provide social support, which has been found to buffer stressors and provide comfort and positively affect health [9], [10].

Having friends in a stressful time, such as a pandemic, can positively impact the ability to cope and give the support needed to overcome the stress. For this reason, it is important to maintain friendships throughout hard times and understand how to make them last.

Oswald and colleagues found four key elements of maintaining a relationship: *supportiveness*, *positivity*, *openness* and *interaction* [11]. “*Positivity*” covers being nice to each other and not engaging in antisocial behaviour [11]. “*Supportiveness*” includes assurance and being supportive towards a friend and their voices [11]. “*Openness*” covers having intellectual conversations and behaviours related to self-disclosure [11]. The last factor is “*interaction*”, covering activities and behaviours that are being done jointly [11]. When having to avoid physical meetings, the most significant shift in the four elements of maintaining a friendship is in the “*interaction*”, which we try to encourage through our design.

Spontaneous interactions are less frequent now that people have to work at home and no longer randomly meet in person. This has created a shift from interactions happening spontaneously to the need for people to initiate conversation [2]. As we are not used to this, it may feel unnatural and awkward [2]. Reasons for struggling to reach out to people may be the lack of knowledge of whether the person will be interested and the worry about the conversation being uncomfortable [2]. A further struggle can be choosing suitable media, as phone calls can feel intrusive and emails impersonal [2]. It has been shown that scheduled social interactions are exhausting and do not work for everyone [2]. Sandstrom states that spontaneous and informal meetings can help us stay connected while reducing the risk of burnout [2].

## 2.2 Togetherness and human connectedness

To maintain a friendship, we aimed to create a sense of togetherness through our concept. Hamelink describes the feeling of togetherness as a part of a spectrum, as individuals are part of multiple societies and relate to them to a stronger or lesser degree [12]. Togetherness describes the feeling of being connected to others, not the necessity to exclude others from this community, but rather embracing each other’s individuality [12]. Hamelink suggests that human togetherness should be explored through deep dialogue [12].

As the current Pandemic prohibits physical meetings, many corporations, institutions, and individuals resort to web conferencing [13]. These online interactions have shown to give a sense of togetherness, where video calls in private interactions can be a way to share daily routines [13]. Video calls are a more natural way of communication than voice or text-only media, as it is a synchronous media and makes ‘show and tell’ possible [13], [14]. Sport clubs and groups of volunteers have used video calls to establish a sense of togetherness and avoid social isolations [13]. In the absence of meeting co-workers and peers in hallways or the coffee machine at work, school and social organisation, proactive measures must be taken to keep up with these interactions [13], [2].

Connectedness is defined as “*a positive emotional appraisal which is characterised by a feeling of staying in touch within ongoing social relationships*” [15]. Social connectedness is also described as the experience of belonging and the relatedness between people and is an important concept when understanding and evaluating communication media [16]. It is important to capture both the individual and group level to evaluate human connectedness, although human communication is a sensitive dimension and hard to measure [16], [14].

To decrease the likelihood of social isolation while social distancing, our goal was to create a design that can encourage spontaneous online meetings, similar to meetings at the coffee machine at work.

## 2.3 Designing displays for Human connectedness

To create connectedness-oriented communication, there is no need to transmit large amounts of data; a small amount of data is sufficient [17]. Receiving large amounts of data might create cognitive overload and prevent the sense of connectedness [17], [18]. When designing for human connection, implicit information is a significant factor [17]. By exchanging status information at all times, it is possible to symbolise individuals’ presence and status information [17]. The goal of connectedness-oriented communication is to make the user aware of the presence of one or multiple people and thereby create a sense of community [17].

A way to create greater levels of connectedness and awareness is through presence displays [15]. Presence displays typically indicate online presence information, whether a person is on the internet or not [15], [19]. These online presence status change from available when using the device actively to idle if online but not active and unavailable when offline [15]. This kind of presence information can often be seen in instant messaging applications and is often limited to a screen [19]. This limits the user to see their friends’ status only when they are in close proximity to this display [19]. Furthermore, the sounds that may be used to indicate the presence of a friend could be a distraction when working on another task [19].

When designing displays that create a sense of community and the feeling of togetherness, Agamanolis proposes nine “*design nuggets*” to consider [20]. These nuggets should not be viewed as established design principles but rather initiate discussions and exploration [20]. The first nugget presented is “*Think beyond the screen*”, which questions how the display fits into the surroundings and which in- and output devices or sensors are the most effective to achieve the interactive goal [20].

The second design nugget mentioned is “*Engage the periphery*”, where Agamanolis recommends using peripheral awareness to avoid perceptual overload [20]. One way to make use of peripheral awareness is through ambient displays [20].

Ambient display, also known as peripheral display, is a display moved off the screen and into the physical environment, where it shows subtle changes in colour, sound, smell, light or temperature [18]. Ambient displays typically only communicate one piece of non-critical information [18]. The goal is to convey information without distracting or burdening the user [18], [21]. Peripheral displays convey information in a lightweight format that does not demand the user’s full attention. Instead, it gives the user the freedom to attend to the information when passing the prototype or when they desire or need the information [18], [21].

The third design nugget, “*Instill a sense of reciprocity*”, highlights the importance of equal access and mutual benefit. Ensuring that all participants should have the same benefits and ability to participate [20].

The fourth nugget, “*Transcend time*”, emphasises that collecting data over time, for analysing later, is essential to understand the long time collaborative activity [20].

The fifth design nugget presented is “*Motivate interaction*”, which questions the motivation to interact with the concept and how to invite interaction [20].

The sixth nugget, “*Design for investment and growth*”, addresses the question of how to motivate continuous use after the novelty factor has worn out. This nugget addresses that it is important to consider how the concept displays what is gained through the use of the concept. One way of doing this is through tracking and reflecting on the history of use [20].

The seventh design nugget, “*Balance togetherness and uniqueness*”, highlights that although people enjoy being a part of a community, they also desire to maintain their own identity within the group [20]. Accordingly, it should be possible for the user to display their uniqueness, as they desire to be different from the rest.

The eighth design nugget, “*Embrace the creativity of your users*”, states that the design team should embrace how the users typically invent new ways of using the display. Encouraging freedom of use can give ideas for operational improvements or inspire ideas for new elements and applications [20].

The last design nugget presented is “*Be patient*”, which states that behaviours are not changed or created overnight [20]. For that reason, it is essential to study the display in the context for more than just a few days. It is important to give time for the novelty factor to wear off and see how the users integrate it into their life [20].

## 2.4 Similar projects

When investigating our problem, we discovered related products and projects which have similar research goals and follow the ambient design concept.

De Guzman and his colleagues explored the use of Peripheral Displays of Awareness information and discovered that the lightweight information of the other person’s status often led to a cue for initiating a conversation using a more heavyweight method, such as a phone call [19]. Friendship Lamps [22] is another concept which utilises ambient lights that are connected over Wi-Fi, to people who are in long distance relationships [23].

It uses colour to convey a specific message to the connected users [23]. The product’s purpose is for users to communicate through the lamp to show whoever is connected that they are thinking about them [23]. The design consists of a single light, which changes colour depending on how long the user holds their hand on top of it [23].

From their own blog, the creators describe that friendship lamps can “(...) give its users a sense of closeness even when they’re separated by great distances.” [23]. It is not clear, however, what research has been done to claim these effects. With our work, we hope to find results that correlate with their claims. More specifically, find the effects on the number of interactions between the users, facilitated by a device similar to Friendship Lamps.

Another project that focuses on availability and facilitating interactions is CoasterMe [24]. Researchers made an interactive coaster that showed when co-workers took a break from work and were open to socialise [24]. This project is similar to Valeria Lezzi’s work, where she designed a coaster to interact with a close friend or family member in the Covid 19 pandemic [25]. This prototype gained overall positive feedback when testing the prototype with two pairs for 30 minutes [25]. The field trial of CoasterMe showed positive improvements to the understanding of work routines and connectedness between co-workers, which have been part of our motivation to test a similar solution on a different group of individuals. Their results also showed how spontaneous moments of interaction can be initiated through digital means and that the participants feel that their time is not being wasted on continually checking when their co-workers are available [24]. As part of their suggested future work, we use these observations as a premise for part of the evaluation, analysis and discussion.

## 2.5 Exploratory Prototype

To evaluate our concept, we have created an explorative prototype. Exploratory prototypes are deployed in a real, natural setting over a long-term basis to understand the emergent aspects of use [8]. The prototype investigates how the artefact is implemented in everyday life and which impact it has on the life of the participants [8]. The purpose of an exploratory prototype is not to understand the particular use of the artefact or its specific form, shape and texture, but rather gain new insight [8].

### 3. PROTOTYPING

Creating the prototypes started with a brainstorm of potential problems and opportunities within creating spontaneous online interactions. This theme was chosen in the context of the Pandemic, the related work, and our interest. When possible, problem areas were identified we did sketching sessions to find a design for the prototype. We focussed on creating ambient displays during the sketching phases. As our concept hopes to create spontaneous online interactions when it fits the user's everyday life, the ambient design gives them the freedom to react when it fits their schedule and mood. After the design was refined several times, we chose a light installation for the explorative prototype, as sound might be disturbing [19]. Another possibility would have been to use movement or shapeshifting, which is hard to do on a prototyping level without making a sound.

The exploratory prototype consisted of a wooden box, which acted as a base for eight epoxy crystals that sat on the top of the box, as seen in Figure 1. Each crystal and colour was a representation of a person in a group. The crystals were held in place by a mold with holes fit for the four different sizes of crystal. Each crystal contains an LED which would light up in one of eight different colours to help differentiate each user. The most central and forward-facing crystal represents the current user of the prototype and could be lit up by pushing a button on the right side of the box' lid. The brightness of the light could be controlled by a turning knob, which is on the left side.

The remaining crystals were turned on by the other seven connected prototypes, which completed the full set of our prototypes.

The design took inspiration from natural crystal formations. It is meant to give a sense of novelty and stand out as something both fun and artistic that one would want to place in their home. Equally important for the concept is adherence to ambient display guidelines [18], where we aim to avoid disturbing the user and add to their home environment. The concept should be used and seen on the users' own volition and should also be easily movable to wherever the user seems fitting.

The information being conveyed to the user must be easy and quick to understand [18]. That is why there are only two variables that the user needs to remember: Light and colour. If a crystal is lit, another user connected to the device has pressed their button.

Depending on the colour of that light, the user would know the specific user who interacted with it. A diagram of the colours was created so the users could identify each person by colour. Furthermore, the users could use the turning knob to account for different lighting situations or in case they found the brightness distracting.

The inside of our wooden box contained a NodeMCU Arduino development board with Wi-Fi, as seen in Figure 1. This controlled the crystals and connected them to an external database for communication with the other prototypes and data gathering for our research and evaluation. Several wires went through drilled holes in the box to give power to each crystal, as well as the button and the turning knob. A USB power cable was also connected to the board by a hole in the back of the box.

The prototype was designed to be used when the user wants to interact with one or more of the other connected users. By pressing the button on the device, the user activated his or her central crystal with a specific colour. At the same time, the device would send a signal to the database, updating the status of the specific crystal. The other connected devices would then read the updated status and subsequently turn on a crystal of the same colour.

Then if the other users wanted to respond, they would also press their button, and the same effect would happen in reverse. After two or more users had noticed the change, they could then get in contact by using other online platforms to communicate while still signalling to the remaining users that they are interacting.

When the prototype was first plugged in, it would try to connect with the specific Wi-Fi SSID that had been manually entered into the code of the device. To help the users understand when the prototype could be used, each crystal would light up in sequence when the Wi-Fi connection had been established. This also worked as an indication that all the lights were working and the prototype was responding. From then on, the NodeMCU board checked the database every five seconds to see which crystals should be turned on or off. That means that there is almost no lag between one user activating their crystal and another user seeing the same crystal light up on their device. This made it possible for almost immediate feedback and a more satisfying experience. A visualisation of the communication between our prototypes and the database can be seen in Figure 2.

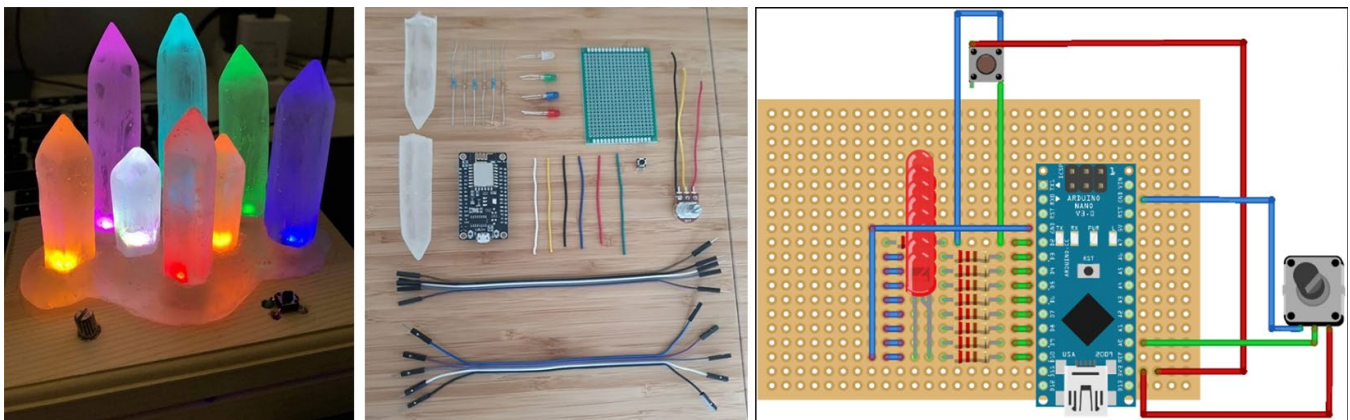
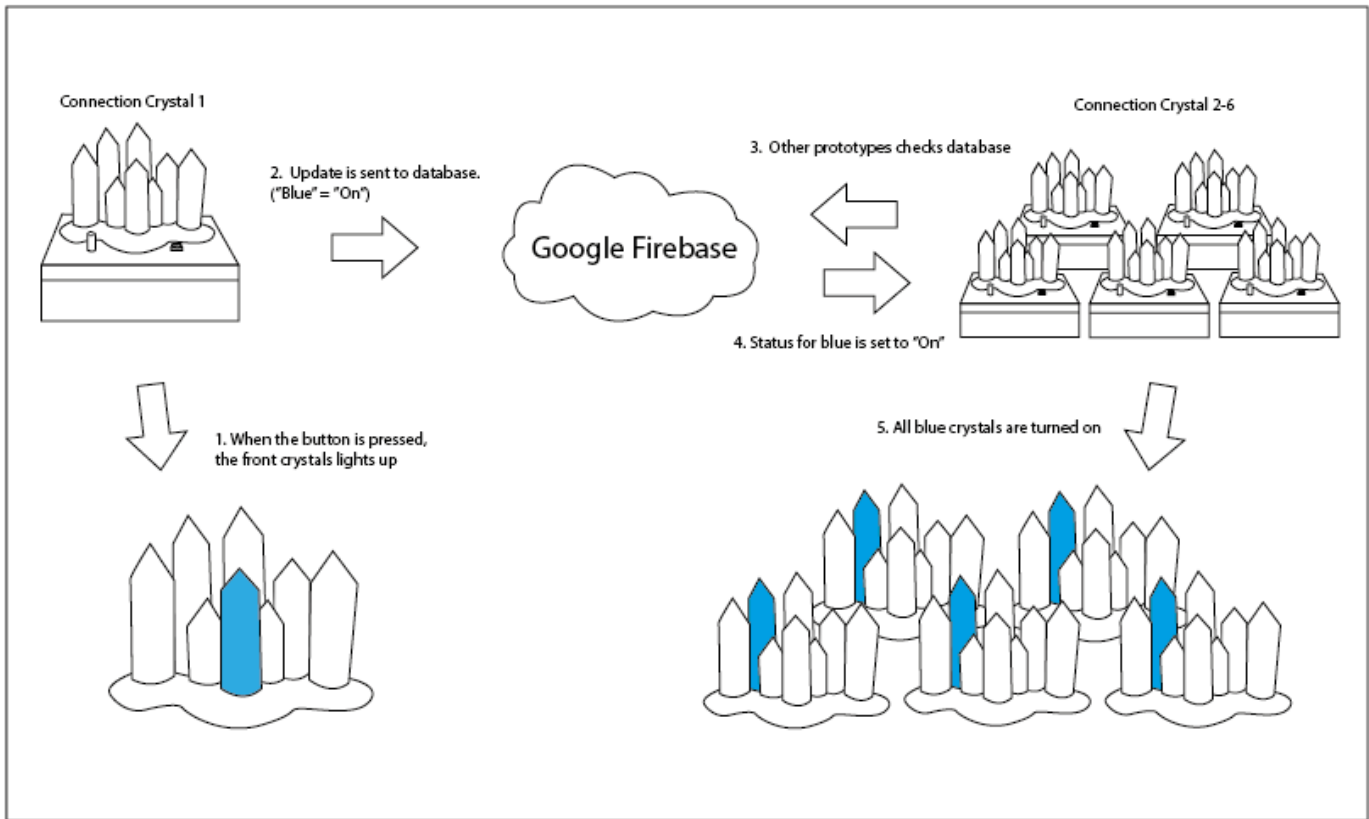


Figure 1: Left: Finished prototype where all crystals are turned on. Middle: Parts of prototype before assembling. Right: Diagram of how the components are connected.



**Figure 2: Diagram that shows how a single prototype connects with our Database and the other prototypes.**

## 4. METHOD

This section will present the methods used for evaluating our prototype. Furthermore, the analysis methods of the data will be presented.

### 4.1 Approach

Our approach is grounded in Research Through Design [26] and Reflective Agile Iterative Design [8], as we use an exploratory prototype to obtain knowledge. We have created a research-oriented design to gain insights into whether our concept can help to create spontaneous online interactions. The exploratory prototype was deployed for a month in a real use setting to get insight into long term use. The main goal of the prototype was not to understand the particular use, but rather to see what issues or possibilities might emerge.

We collected usage data through the database the prototypes were connected to. These logs contain data on which prototype was used, including time and date. In addition, two diaries serve to obtain knowledge on how and why they used the prototype and if the prototype led to an online interaction.

### 4.2 Participants

We deployed the Connection Crystals with a friend group of six men between 24 and 32. They all knew each other through their studies at university and had been friends for five and a half years. They described themselves as very close friends and messaged each other a couple of times a week on Facebook Messenger and Snapchat, as they worked at different companies. This group were

friends throughout the years of their studies and would meet at the university daily. However, since they graduated, they no longer have spontaneous meetings at the university and now had to initiate contact in different ways. Our goal was to make it easier for them to have spontaneous online interactions by using the prototype. When interviewed, only one participant stated that he took initiative to socialise with the group often, whereas the others stated they rarely did. Before the Pandemic, they would meet each other at university multiple times a week and have dinner together once a month. Since the beginning of the Pandemic, they had all graduated and now see each other less in person. We chose this friend group as it shows the struggles of not being able to meet physically and the shift from studying together to working at different companies.

As they do not meet spontaneously at the university anymore, their interactions have decreased, which we hope to increase with our concept.

The participants received one 600 DKK gift card to share that applied to stores, pubs and entrance to attractions in Aalborg for their participation.

### 4.3 Pre-study

Before the evaluation began, we had individual semi-structured interviews with the six participants. We asked questions about how they perceived their friend group, how long they had been friends and their social activities (see Appendix A). The reasoning for using semi-structured interviews stems from having a clear goal with the interview but still having the freedom to address interesting points that might emerge [27]. At the beginning of the



study, we listed the participant instructions for when to fill out the two given diaries and how to navigate and set up the prototype.

As we handed out the prototypes, the participants gained access to an individual Google Drive folder which contained the two diaries, a diagram for the prototype (see Appendix B) and the instructions given to them during the first interview.

#### 4.4 Home Trial

The exploratory prototype was deployed for a month in order to obtain insights into long term use. Since the exploratory prototype follows the ambient display guidelines [18], it was important for us that the participants placed it somewhere it would be seen without being disruptive. Therefore, we asked the participants to place their prototype somewhere that fulfilled these guidelines. At the same time, we made it clear that they could move it around if necessary. However, there were restrictions to where they could place it since it needed to be powered by cable.

The participants were given two types of diaries which they had to fill out. One had to be filled out every time they had used the prototype and included questions about whom they interacted with and which media they used (see Appendix C). The second diary had to be filled out every Sunday and included questions such as how many people they remembered just by the light and whether the prototype changed their way of interacting (see Appendix D). We chose to make the participants fill out diaries as they were scattered, and it did not require any special equipment [27]. In addition, the diary gave us insights into their thoughts when using the prototype and if interactions through the prototype led to online gatherings.

Midway through the deployment period, we facilitated a focus group interview with the participants (see Appendix E), as it allowed us to understand the diversity of opinions in the group and spark new topics between the participants. This interview focused on how the study was going and questioned the recent use of the prototype.

At the end of the study, we conducted semi-structured interviews (see Appendix F) with each participant to understand how they used the prototype and how it affected their friendship and perceived togetherness. During both sets of individual interviews, there was a facilitator and one or two taking notes during the interview. Furthermore, the interviews were recorded to ensure the data could be accessed at a later point.

#### 4.5 Analysis

We transcribed the pre-, midway- and post-study interviews and combined them with the six participants' weekly and usage diary entries. To analyse the data, we used affinity diagramming [28] to construct themes that described the use of the Connection Crystals. In addition, we cleaned up the log data from the database and created graphs showing the frequency of interactions based on time of day, the colour of the crystal and which week to get a clearer understanding of when the prototype was used.

### 5. FINDINGS

In this section, we will present our findings from the data we gathered. As all interviews and diaries were conducted in Danish, we have translated the quotes. The themes presented here emerged from affinity diagrams [28] which were created for each interview. Furthermore, an affinity diagram was created for

insightful statements from the weekly diaries. The diagrams (see Appendix G) were created with new knowledge and improvements for the prototype in mind. When each diagram was created, the main findings were discussed and merged into these themes presented here.

#### 5.1 Theme 1: Change in interactions

One of our findings was that the friend group had multiple changes in their interactions before and during the prototype deployment. One of the changes was the shift from mostly text communication to also use voice communication. P4 stated in the post-interview that they had changed their way of interacting online. *"Yes, we would actually not talk together online normally. We either text or meet physically. So, as we got this, we began to actually talk together online. So that is new, that we talk together instead of texting."* They organised their voice interactions through the online platform Discord [29], designed for gaming and online communities. P3 mentioned in the post-interview: *"We had a Discord server. Every time a person had turned their light on, they would sit there (in a call) in this Discord server and wait for someone to join. It was actually very pleasant."*

The prototype also led to the participants talking to other people in the friend group than they normally do. P1 said: *"I would say that there are certainly some people I have talked more to through this process, than I would talk to normally."*

Furthermore, the prototype led them to talk more often, and it did not interfere with normal interactions. The participants mentioned that they wanted to interact with it when the others in the friend group turned on their lights.

#### 5.2 Theme 2: Icebreaker

The prototype served as an icebreaker and a foundation for initiating contact to four of the participants. Two of these participants defined themselves as shy and introverted, and they found the prototype helpful to initiate contact with the rest of the group. P5 mentioned in the post interviews that *"(...) I have experienced that some of the others, if the light has been lit, then some of them have been very quick to answer. It is like they were missing this to figure out when they can initiate contact."* This participant was often the one initiating conversations before deployment but sees the benefit of the prototype for the more shy and introverted people. P6 mentioned that he found the prototype beneficial for him, since he could have problems initiating a conversation without a real purpose: *"For me it has been a lot easier when I have seen a light being lit to contact them and try to start a conversation. So I think it is way easier to do it this way than unsolicited."* He thought the prototype worked better for him than their normal way of interacting with each other: *"No, I prefer the prototype. That works better for me."*

The other participants in the group also thought it was easier to initiate contact with the rest of the group through the prototype. For example, P4 mentioned that: *"Well, it was easier to initiate contact when you only had to click on it, I think."*

Furthermore, it facilitated a way to initiate interactions in a non-intrusive way for the participants. P1 said the following during an interview: *"Yes, it gives a bigger incentive to, that you at least have a better idea about, that they actually have the time to have contact."* This quote indicated that he might have problems finding out when it was fitting to contact his friends and when they had the time for it. The same participant continued in the

same interview: “(...) by using the crystal, it gives a better idea if people are available (...) So it feels like you do not interrupt if you contact them. I think that this could be the case sometimes if you just contact them.” This statement substantiates his earlier comment and shows his beneficial use of the prototype. Furthermore, the participants mentioned that it was a positive aspect of the prototype that they know when they could contact their friends and expect a relatively quick answer.

### 5.3 Theme 3: Togetherness and human connectedness

By using the prototype, the participants felt more connected or closer to each other; as we can see from some of their statements, P2 said that “*There is something nice about having it on my table when you sit and work (...) There is not that much distance to the others in some way (...) There is more of a feeling of presence with the crystals, even when they are off.*”. When asked directly about feeling more connected with the other participants P1, P2, P3 and P6 said they felt more connected through the deployment period. Some of the mixed responses mentioned the current lifting of the pandemic restrictions that also connected them. P6 clarified, “*yes, definitely yes, but there are also other factors... Other social interactions that did not have anything to do with the prototype, as the corona restrictions have been lifted. but I would say that yes, a bit is contributed by the prototype.*” Overall, the prototype provided a sense of community to P1, P4 and P5, which seemed different from their normal interactions as mentioned by P5: “*I think the feeling of community occurred because it was something which we had together. So, it was something which we all could be a part of. We have had something to talk about.*”

### 5.4 Theme 4: Ambient display

The participants mentioned that they valued the prototype being an ambient display. P2 said: “*I would say that it is (the prototype) less interrupting than a notification that flashes on a phone as an example. I actually think it is very nice. It is somewhat anonymous enough, but still noticeable enough that you can see it*” This indicated that the interaction was less intrusive and obligatory compared to a message on Facebook. The prototype’s functionality was enough for 5 of the 6 participants, as the simple interface was one of the concept’s strengths. P2 mentioned: “*I think it is really good that you keep the interface very simple. If you begin to add too many options, then I think one of the really good things about it, the simplicity, disappears.*” P5 wanted to have more functionality, such as Facebook integration, before he would consider using it. The participants were positive about using an ambient display to signal intent but had trouble with the placement of the prototype so that it would be visible throughout the day.

### 5.5 Theme 5: Practical issues and Improvements

During the evaluation, the participants also experienced some issues. P5 clarified that “*The primary thing is that it is super hard*

*to see when the crystals are glowing.*” Others also mentioned problems with the brightness of the crystal lights, as they found it hard to see in different situations. For example, P4 said, “*It would be nice to have a way of seeing it when the sun shines right on it (...) sometimes I would only notice it when it got dark.*”

Another relevant problem was the portability of the prototype, which several of our participants mentioned in the interviews and diaries. P3 said, “*I think maybe that it could be battery driven (...) because it was difficult to find a good spot for it, because it needed a cable and an outlet and stuff like that.*” P5 also agreed, “*I am not moving it around, so I forget to keep an eye on it. Connecting and moving should be easier.*”

However, our participants did have a couple of suggestions on how we could improve the experience and design of our prototype. P2 and P6 specified that the need for a button to turn off the prototype would have been preferable. P6, in the post-interview, mentioned, “*The only thing was that maybe it could use a.. turn off button, that turned off the lights completely.*” “*...it would be easier if there was a.. I am not interested, and don’t want it to light up and disrupt me or whatever.*” P1 and P2 also suggested making the prototype crystals more customisable. P1 said, “*Then you could think about making representations of the people that are using it. So it is more clear what colour belongs to what or what placement fits with what.*” P2:s “*It’s like, it would be nicer if you had six circles or something else.*”

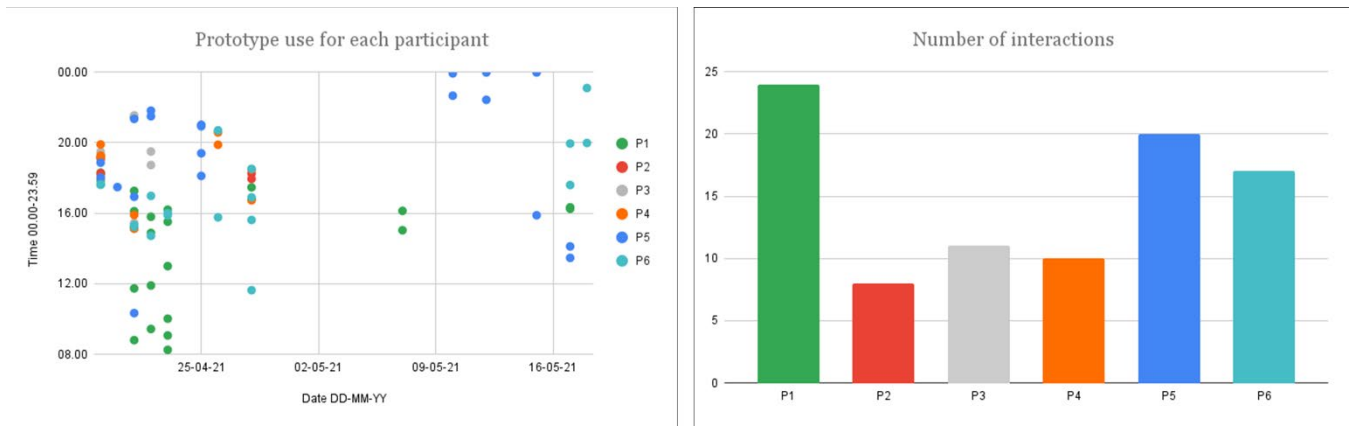
Furthermore, P1 suggested that adding sound to the prototype could help make it more noticeable when other people were turning on their crystals. “*It could maybe make some kinda sound, when there was someone who turned on or something, and then of course make it optional. Maybe it would not be that great for some, if it makes noise all the time.*”. Lastly, P4 questioned if they even needed to have different colours, “*(...) personally I didn’t care that much. The only thing that was interesting was if there were one or more people that joined the conversation.*” Even though he could see who was available to talk, he just joined the conversations without checking the colour diagram.

### 5.6 Log data

Throughout the deployment period, we gathered data logs about the interactions in the group, which we could use to validate and compare with the statements from the participants. From our data seen in Figure 3, the number of interactions stopped for approximately a week, which could be explained by the following statement by P2, “*I have not been using it very much recently. it is not because. It has nothing to do with the prototype in itself. It just says that we have had some social occurrences scheduled already, and then we did not want to contact each other, because we had been together already.*”

Also of interest was that P1 stated, “*I also think that I was one of the more active users of it, at least in the first part.*” We can see from Figure 3 that P1 indeed was the most active user, followed by P5 and P6.

Furthermore, by using the dataset from Figure 3, we can calculate the average number of interactions per user, 15, with a standard deviation of 6,32.



**Figure 3: Left: This graph shows when and how many interactions there were in the deployment period. Right: This graph shows the distribution of interactions between the participants.**

From these results, we can see that the number of interactions per participant has quite large differences in use over the course of one month. We touch on the possible reasons for these differences in our discussion.

## 6. DISCUSSION

In this section, we present our limitations, findings and how they relate to existing literature. From the study, multiple themes emerged that addressed human connectedness and friendship dynamics. These findings could inspire future research regarding the theme and spark discussions about taking the initiative for spontaneous online interactions. Finally, we reflect upon these findings and address participant-suggested improvements of the prototype.

### 6.1 Discussion of findings

From our findings, we constructed themes that could be the focus of other similar studies into ambient displays, togetherness and how to create spontaneous online interactions. The participants, P1 and P6, who interacted with the prototype the most, see Figure 3, self-identified as shy and introverted. They found value in having an icebreaker to initiate conversation; this assured them when it was good timing for their friends. This is similar to the results in the study that explored using peripheral displays to show awareness information, where the status often was perceived as a cue to initiate a conversation [19]. Having the information of the other participants' availability made a shift in the friendship dynamic where the more introverted people in the friend group took the initiative and did no longer rely on P5 who usually contacted the group. The shift in taking the initiative also led to the participants talking to people in the friend group they usually would not talk to as much.

As our project started in the times of a pandemic, we designed the concept to replace some of the spontaneous interactions that, under normal circumstances, would happen at work or school. Sandstrom and her colleague address the shift from randomly meeting someone familiar to initiating conversations [2]. This shift has created struggles with reaching out due to the lack of knowledge of whether the other person is interested or not [2]. Sandstrom also states that finding the suitable media can be difficult, as a phone call can feel intrusive and an email

impersonal [2]. This was the struggle we wanted to address, to encourage people to take more initiative and have more interactions throughout the day. Since the project's beginning, there has been a shift in the COVID 19 situation, as the participants could meet at work at the end of the deployment period. This has had an impact on the amount of spontaneous online interactions needed throughout the day. P4 addresses this in his post-study interview: *"But I think that when you meet people at work every day, then it (the prototype) is not something you would use all the time."*

This change also meant that when asking the participants about the future use of the prototype, they did not see themselves using it every day but still felt that it could be a nice addition for occasional use. However, in other social groups, where distance is a more significant hindrance for physical interactions, this may not be the case.

The participants thought the prototype created more interactions and did not intervene or hinder any interactions they would typically have. As the prototype showed availability, we were unsure if it would discourage or replace their normal interactions. However, this was not the case; they just had another expectancy for when they would receive an answer.

### 6.2 Ambient display for human connectedness

When designing displays for human connectedness, it can be valuable to take Agamonolis *"design nuggets"* into consideration [20]. As for our project, our design takes six of the nine nuggets into account.

The first two design nuggets, *"Think beyond the screen"* and *"engage the periphery"* [20], are fulfilled through our display being an ambient physical artefact. For a design to be ambient, it should not disrupt the user in their current task [18]. P1 stated in the midway interview, *"I feel like I have not experienced problems with it disturbing me. I have it placed here on my desk, next to where I work and things like that. I would not say that it has been interrupting me at all."* Followed by the rest of the participants agreeing on this statement. P2 mentioned, *"I would say it is actually less disturbing than a notification on a phone, for example"*.

The third design nugget, *"Instill a sense of reciprocity"*, addresses how all users should have equal access and mutual benefit [20]. As all participants had similar prototypes with the same

functionalities and the mutual goal to have more interactions with each other, this design nugget was taken into account.

One of the design nuggets we have not incorporated in our design concept is *“Transcend time”*, which should further the long-time collaborative activity by collecting data over time [20]. As we see that the prototypes are used less in the last couple of weeks of the deployment period, see Figure 3, it could be valuable to address this design nugget. In an effort to maintain a long-time collaboration between the users, we should consider making the users aware of their interaction patterns. It might be beneficial for them to get an understanding when the other users typically have time for interactions.

The fifth design nugget, *“Motivate interaction”*, addresses how the design should motivate and invite users to interact with it [20]. P1 stated in the post-study interview that *“If you just had a glance at it (the prototype). Then you have thought about if you had time and then, at least a couple of times, I used it.”* P3 mentioned in his post-study interview, *“My experience with the prototype was that you turned on the light and then someone wrote or called instantly. (...) It was very nice that you just had to press a button and then people knew you were up for interaction”*. This gives the impression that the prototype motivates the user to interact with the prototype to gain the experience of having an online interaction with their friends.

Another design nugget we have not yet considered is *“Design for investment and growth”*, which addresses how to motivate continued use [20]. Agamanolis suggests a way to reflect on the use history or having a changing character based on the growth of a relationship [20]. We could incorporate this into our concept by creating an application that shows growth or a bond getting stronger based on the use of the prototype. However, Agamanolis states that not all design nuggets fit every situation [20], which might not be necessary for our concept.

The design nugget *“Balance togetherness and uniqueness”* has been addressed by our participants as they ask for more customisation, making the representations of each individual more unique. They stated that this would make it more personal and make it easier to remember which crystal belongs to whom. However, this should be done in a way that still retains the sense of togetherness of the prototype.

The way we took the design nugget *“Embrace the creativity of your user”* into account was to give them the freedom of where they wanted to place the prototype and which online communication media they wanted to use. Even though we gave them the freedom to place the prototype anywhere and use it for any interaction they preferred, they had all placed their prototype by their desk. Furthermore, they all used the prototype to signal availability for conversation.

The last design nugget, *“Be patient”*, which states that changes do not happen overnight, addresses that the concept should be placed in the natural setting for more than just a few days [20]. We have taken this into account by building an exploratory prototype [8], which we had deployed for a month.

All participants stated that they felt either a sense of togetherness or felt more connected through the deployment period but also addressed that they had been meeting with each other more regularly due to the COVID-19 restrictions being less strict. Because of the changes to restrictions regarding COVID-19, it could have been beneficial to have a longer deployment period to understand the use outside the Pandemic better. Throughout the deployment period, a lot of changes occurred due to the COVID-

19 situation being more under control. At the beginning of the deployment period, the participants did not have the same amount of physical interactions as at the end of the deployment period. This could have had an impact on how they used the prototype, which they also stated themselves.

The prototypes created a feeling of togetherness by being present, reminding them of each other, which correlates with the findings of Kuwabara and his colleagues [17]. In order to get the sense of connectedness, only a small amount of data is needed; large amounts of data can create a cognitive overload [17], [18]. Our participant stated that one of the positives of our prototype is the simple interface and its anonymity. P2 addresses this in his post-study interview: *“I think it is really good that you keep the interface very simple. If you begin to add too many options, then I think one of the really good things about it, the simplicity, disappears.”*

### 6.3 Improvements

Even though the participants liked the overall idea of the prototype, several improvements could be implemented for future iterations. One of the participants mentioned during the post-interview that he would like the addition of existing technologies. For him, the prototype should connect with Facebook and Messenger to show availability through these media. In relation to Dey and his colleagues’ beliefs, these presence displays could add a sense of connectedness to the user [15]. It should be noted that this article was published in 2006, and there might be a difference in how we perceive presence displays in 2021. P5 would change the lighting in relation to who was online on Messenger, which would change the purpose of the prototype and the project. If this scenario were implemented, the intent of the prototype would not be indicating availability to talk but rather an indication of where someone is online or not. This could raise some problems since the issue of whether people are available to talk or not will still arise.

Another point the participants discussed during the post interviews was the feature of a *“time out”*. Some of the participants mentioned that it could be difficult to differentiate if people were just available for a long time or if they had forgotten to turn off their lights. One of the participants mentioned the time out as a drawback for the prototype since it could be a source of irritation if the user had to turn the light on every hour, for example. Another improvement the participants suggested for the prototype was improved movability. During the evaluation period, all of the participants never moved their prototype due to technical difficulties. This could be solved by powering the prototype with batteries instead of plugging it into a computer or socket. This could also make it possible for the participants to move it around their apartments as they change rooms during the day, always being able to see it. One last point the participants wanted to change was an on/off indicator on the prototype. One of the participants mentioned that he sometimes was unsure if his prototype was powered, so he had to click the button to see if his light would turn on and then quickly turn it off again. This could be prevented with a small LED which would discreetly light up when the prototype is powered.

All of the improvements mentioned above should be implemented so that it does not interfere with the initial goal of the concept. Some of the ideas are easier to implement than others, but all

points mentioned in the interviews should be considered. Our goal with the prototype was to create a simple and ambient display, which can be a challenge with social media integration and the time out function. The social media connection point would be very similar to the existing presence display used on various instant messaging platforms [15], [19] and would not have the same intentions as our current design. Furthermore, the time out could be an irritation to some if they need to click it once in a while to show they are still available.

## 6.4 Limitations and challenges

Our study encountered several limitations which could have affected the results. The most relevant limitations include time restrictions, sample size and choice of participants. Challenges included lack of diary entries, technical difficulties, and misuse of the prototype.

Our evaluation lasted for a month, which usually would be enough time to see the actual use patterns of the participants. However, because of changes to COVID-19 restrictions, it would have been preferable to have a longer evaluation to see these effects. The participants also stated in the post-interview that they would probably use it less frequently in future use than what we observed for the first two weeks. Due to limitations on how many of the prototypes we had available during this study, it was only possible to work with groups of up to eight people. Our chosen group started with seven people, but at the start of the study, one participant decided to cancel due to workload at his job. This means that our evaluation started with suboptimal conditions from what we would have wanted, but with time constraints, we could not delay the study to find a bigger group.

During the evaluation, the participants were asked to write diary entries to log their use of the prototype. The diaries also helped us construct the mid- and post-interviews if we saw the need to address specific concerns or emerging use patterns. However, there was a considerable lack of diary entries in the first weeks of the evaluation, which did not match with our database logs. After motivating the participants with reminders to fill the diaries, we ended with a decent amount of entries that we could use. Nevertheless, for the majority of the analysis, we have had to rely almost entirely on the interviews, where we could extract more nuanced and fulfilling answers for our study.

Unfortunately for the evaluation and the other participants, P5 had a significant other who misused the prototype on several occasions. The misuse caused some frustration from other participants, who felt that they had wasted their time responding to the “fake” signal, which eventually led to them sometimes ignoring the specific participant’s crystal.

Furthermore, the prototype of P2 was broken for a week before we got notified and had the chance to replace it. This might explain that he has the least interactions with the prototype.

To avoid some of these limitations and problems, future studies with a similar focus on multi-person ambient displays should test with multiple groups over a longer period to avoid participant drop off, motivation issues and the novelty effect [30]. In addition, the groups should have a clear understanding of how much time is needed to fulfil the requirements of the study and be sufficiently self-motivated to accept participation for the entire duration of the study.

## 7. CONCLUSION & FUTURE WORK

The result of the study showed that the friend group had more interactions than before the deployment period. Furthermore, the responsibility of initiating contact was distributed to multiple people, which created a change in the dynamic. The participants stated that they talked more to different friends in the group than they usually did due to the prototype. Several participants found the prototype to be a good icebreaker and a reason to initiate contact, which they were missing before the deployment. The prototypes created a sense of togetherness across the friend group by reminding them of each other. When using the prototype, the participants felt more sure about when they could contact their friends and perceived that they did not waste time by waiting for text responses. The lights did not disturb or irritate but worked as an ambient solution, which all participants placed on their work desks. We found that the prototype made it effortless to initiate interactions, especially for shy and introverted people, as it eliminated some of the concerns. This topic should be further investigated to better understand the beneficial aspects of the prototype with different groups of people.

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