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Citation for the original published paper (version of record):
Cabrio, A., Hashmati, N., Rabia, P. et al (2023). HighLight: Towards an Ambient Robotic Table as a Social Enabler. ACM/IEEE International Conference on Human-Robot Interaction: 146-150. http://dx.doi.org/10.1145/3568294.3580061

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HighLight: Towards an Ambient Robotic Table as a Social Enabler

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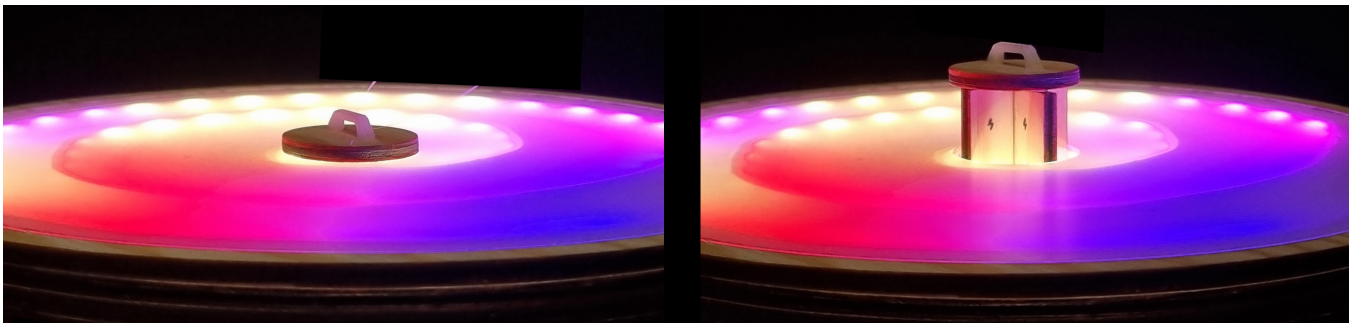

Figure 1: The ambient surface of the robotic table 'HighLight' with its smartphone compartment.

ABSTRACT

With smartphones becoming more commonplace in our daily lives, they often take up more time and space than we would like them to. Research shows that using smartphones during social interactions does more harm than good. With this in mind, we set out to create the first prototype of an ambient robotic table that will support social interactions and discourage digital distractions. Through a rapid prototyping process, we present HighLight, a prototype of a socially enabling robotic table that has a smartphone compartment in its center and ambient features reacting in real-time to conversations taking place around the table. We report on our contributions to the research community by investigating the design of an ambient robotic table as a social enabler that encourages social interactions through ambiance, thus exploring future directions of non-disruptive technologies that support social interactions.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**.

KEYWORDS

Robotic Table; Social; Ambient; Smartphone Sacrifice

ACM Reference Format:
Alessandro Cabrio, Negin Hashmati, Philip Rabia, Liina Tumma, Hugo Wärnberg, Sjoerd Hendriks, and Mohammad Obaid. 2023. HighLight: Towards an Ambient Robotic Table as a Social Enabler. In *Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (HRI '23 Companion), March 13–16, 2023, Stockholm, Sweden.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3568294.3580061

1 INTRODUCTION

From their first introduction, smartphones quickly became a crucial tool in our daily lives. However, along with this came a disruption to social norms around interruptions that are still not fully resolved, and recent research confirms that phone usage risks affecting social interactions negatively [21]. While engaging in a social environment, phone usage is often a distracting parallel activity, hindering people from fully engaging in conversation.

The prominence of this problem is made explicit in social and public settings such as bars, cafes and restaurants. For instance, an empirical study on smartphone usage within several social dinner settings outlines five future design directions that could potentially help to mitigate socially problematic usage of smartphones [22]. One of these design directions is to design artifacts that are non-disruptive but still facilitate social interaction. As tables are commonly found pieces of furniture in social settings such as bars, cafes and restaurants, we see the potential for interactive tables to take on such a facilitating and socially enabling role. The form of a table could be used to draw the attention of everyone around the table towards a shared interface as opposed to everyone looking

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HRI '23 Companion, March 13–16, 2023, Stockholm, Sweden

ACM ISBN 978-1-4503-9970-8/23/03.
https://doi.org/10.1145/3568294.3580061

at their individual smartphones. Some researchers have explored new ways to promote focus or table conversations by using robots. For instance, Micbot [20], is a microphone shaped central robot placed on a table to improve conversational dynamics and team performance. Flexi [2] is a robot that keeps the phone away from the user in order to motivate and help them to focus on other tasks. However, to the best of our knowledge, designing a robotic table as a tool to reduce smartphone distractions and to promote social interactions at the same time has not been researched before. Thus, this has motivated us to initiate research investigating the design of a robotic table for this purpose.

The aim of this ongoing research is to develop a prototype of a robotic interactive table that is responsive to its environment with the purpose of facilitating social interactions. We call the table HighLight, a table that will enlighten conversations. Furthermore, to avoid the usage of smartphones and their negative consequences on social interactions, we propose that the table should require a "smartphone sacrifice" to be used. In this work, our contributions to the research community are: (1) through a prototyping process, an investigation into the design of an ambient robotic table and possible attributes that can support social interactions by reducing the use of smartphones around it, (2) the possibility of social interaction through an ambient feature that provides a visualisation of the conversation flow and its evolution, (3) exploration into future research directions on how technology can encourage social interactions in a non-disruptive way.

2 BACKGROUND

Paradoxically, smartphones can make us feel less connected to each other [10]. Research in the area shows that smartphone usage during real-world social interactions undermines people's enjoyment of the interaction [6], and further, can exacerbate the problem of social disconnectedness. Candiotto [4] claims that loneliness can arise from an abundance of unsatisfying unfulfilling online connections, making the case that digital hyperconnectivity undermines the potential for meaningful social relationships. Some researchers have also concluded that excessive phone usage is affecting the emotional state of the users, leading to stress, social anxiety and depression [17].

To mitigate this issue, researchers have explored several solutions, such as games that reward players for putting down their smartphones while socialising [1]. On the other hand, to our knowledge, none have used existing artifacts in our environment to combat the usage of smartphones while people are in social settings. Considering how socially destructive smartphone technology has proven to be [4], we believe it is a worthwhile effort to explore how technology can act non-disruptively as social enablers instead.

Robotic tables in the past have been researched as social enablers. For example, one such solution is "TurnTable" [7], a tangible table interface that encourages fair turn-taking in conversations by signalling when an individual talks excessively. The purpose of "TurnTable" is to enhance group discussion dynamics via a non-disruptive reactionary interface. Another example is "SociaBowl" [12], which utilises a moving centrepiece to influence social dynamics and improve turn-taking. By tapping the surface of the table, the user is able to tilt the centrepiece towards them, giving them an alternative to verbally interjecting when they wish to speak. Moreover, there are several examples of designs where a combination of an interactive table and a smartphone are connected to function as one interactive system [5, 16, 23]. However, we have not identified any works that actively discourage smartphone use.

In this ongoing research, we aim to combine the proven effectiveness of tables as social enablers and facilitators of conversations with the idea of a "smartphone sacrifice" to reduce the negative effects of smartphones on our interactions in social contexts. We foresee that an actuated robotic table with these capabilities has the potential to enhance social interactions to make us feel more connected to each other. The following sections describe our approach and the prototyping activities associated with investigating the design of a robotic table that enables social interactions and eliminates smartphone activity around it.

3 TABLE DESIGN AND FUNCTIONALITY

The presented robotic table mock-up in this work, HighLight, is meant to be placed in social settings such as a cafe or a bar with the purpose of facilitating social interactions without smartphone distractions. In this section, we describe our approach, the overall prototyping process and functionalities for an ambient robotic table.

In particular, we follow a rapid interaction design prototyping process by iteratively building and refining mock-ups based on input gained during a series of workshops. In total, four consecutive workshops were carried out by five interaction design master's students at Chalmers University of Technology. The process began with a workshop on conceptualisation of the design idea through simple sketches and a paper prototype. Later workshops focused on generating a low-fidelity prototype and a semi-functional mock-up of an ambient table. The following subsections outline the details of the table design and decisions made in the process.

Ideation and Initial Prototypes: To explore what the table's design could look like, we used the AI tools DALLE-2[1] and Midjourney[2] to generate images of wooden tables containing spirals (Fig. 3), using text prompts such as "glowing spiral of light on a wooden table surface". The AI-generated pictures were used as inspiration for the look and feel of the design. Alongside this, the paper prototype (Fig. 2 (a)) was also used to explore the design space. The purpose of these ideation steps was to get an understanding of our design concept and what an implementation could look like.

Refined Prototypes: Following the initial prototype, a more refined version was created using foam boards, a LED strip connected to an Arduino, and a frosted plastic layer for the top (Fig. 2 (b)), to explore how the functionality of the table could be implemented. In this prototype, we explored how the LED strip should be positioned.

Semi-functional: The refined prototype assisted us in developing a more defined mock-up that was semi-functional (Fig. 2 (c)). In the process, we discovered a simpler way of integrating the LED strip into the table, thus better mimicking the wooden table aesthetic we were going for. The wooden parts of the table, including the table leg, were laser-cut into the desired shapes. The leg was created by laser-cutting a hinged pattern into the wood to make it

[1]Website https://openai.com/dall-e-2/
[2]Website https://midjourney.com/home/?callbackUrl=%2Fapp%2F

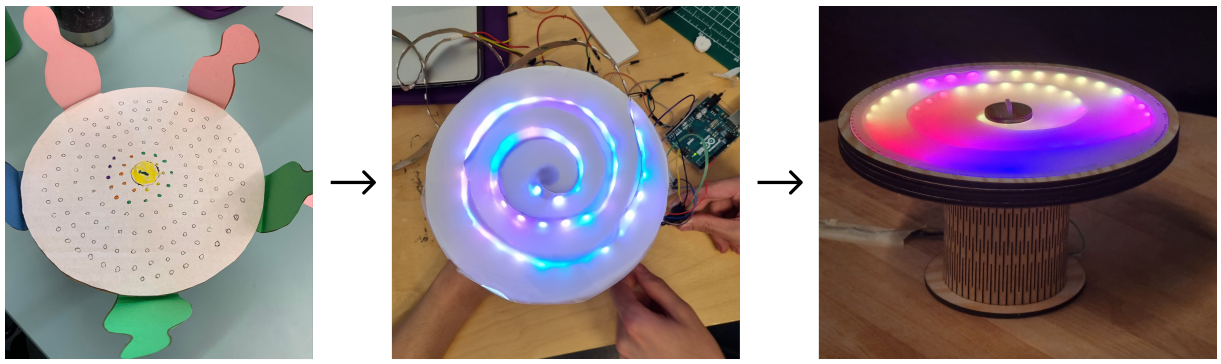

Figure 2: Examples of the prototyping outcomes that were generated through the iterative prototyping process during the workshops. (A) an initial paper prototype, (B) a refined mock-up version, and (C) a semi-functional mock-up version.

Figure 3: AI generated concept images used in the initial phase to inspire the conceptualisation of the initial ideas.

bendable. The topmost transparent layer was created by sanding down plastic to achieve the frosted look.

The table consists of multiple layers of wood and one layer of plastic. We opted for a round table design as round tables generally encourage more social interactions [9, 19]. The LED strip at the centre of the table, consisting of 47 lights, was connected to an Arduino UNO, and its features were coded in Arduino IDE. For the purpose of this prototype, the lights were hard-coded to show the different colour options. In a real-world implementation of the table, we would use microphones connected to the sides or underside of the table to capture the conversation and perform real-time speech emotion recognition [11] which can be represented by lights.

Ambient Surface: The frosted and transparent surface of the tabletop features an ambient actuated interface consisting of a colourful spiral that originates from the centre of the table and advances outwards. The spiral responds in real-time to conversations taking place around the table and progresses by gradually getting lit up in different colours, depending on the emotional content of the conversation. As the conversation takes place, the spiral turns into a colourful visual timeline representation of the emotional content of the conversation. The tabletop's colourful mosaic-esque representation of the conversation will hopefully encourage users to be more present in social interactions.

3.1 Mock-up Functionalities

To use the table a "smartphone sacrifice" is required, meaning that users must place their device in the hatch at the centre of the table for the duration of the conversation. This little compartment will wirelessly charge the users' smartphones (Fig. 1). We chose to add a simple handle to the hatch to visually communicate that the hatch can be interacted with. This purposefully leverages the ambiguity of not knowing what is underneath the handle as a strategy to spark curiosity and exploration [8]. Once the hatch has been closed, the spiral is initiated. If it is opened before the spiral has reached its end, the spiral is destroyed. The colours of the spiral are determined through speech emotion recognition. Nonverbal aspects of the speech, such as acoustic-prosodic features are most commonly used to train such emotion models [11, 13, 18]. These will be the only attributes used as input to determine the colours of the spiral, without recording the content of the conversation. The colour yellow was chosen to represent a neutral conversation, purple for laughter, blue for a sad or serious conversation, red for a heated conversation, and green for an exciting conversation.

Once the spiral has progressed throughout the entire table, each user is provided with an AI-generated picture on their phone representing the spiral and its colours. Just like the spiral, the AI-generated picture also becomes a visual representation of the conversation. This representation is created with more creative freedom and might have the ability to capture the conversation in an impactful way. The picture considers the number of LEDs lit up, their colour and their order. Consequently, the AI-generated picture displays the overall tone of the conversation both in terms of feeling and pace. We imagine this to be a nice way for the users to remember the conversation they had while using HighLight.

4 ENVISIONING FUTURE DESIGN

With the prototyping process described in this paper, we have investigated the design of an ambient robotic table and gained knowledge of what a non-disruptive social enabling technology could look like. This prototyping work should be seen as an initial exploration of a vast design space on how ambient robotic tables or other similar technologies can decrease smartphone usage and act as social enablers. In this section, we shed light on some of the discussion points, and future directions that are envisioned from the initial steps taken. In this context, we hope that this work can be further explored and elaborated upon.

HighLight as a Social Enabler: HighLight aims to encourage social interactions in two ways, by creating a smartphone-free environment, and by its supporting ambient features. In this context, to enable the design and creation of an ambient robotic table several future directions are envisaged from our initial steps. One limitation to the presented prototyping work is that the design has not been built to full scale. Hence, we were not able to conduct a proper evaluation, and the social enabling effects remain hypothetical. Future work in the area should aim to iteratively evaluate the design to understand its effects on social interactions. Both the "smartphone sacrifice" and the ambient features of the table should be evaluated to understand how users feel about them. Giving away your smartphone for only a brief amount of time might prove difficult for some. Furthermore, it would be interesting to see how users would understand the table. We hope the ambiguous nature of the table would encourage exploration and interaction, allowing the users to figure out its usage through trial and error. Evaluations of these aspects will illuminate the design space further and provide guidance for future designs. In this regard, possible evaluation methods with a higher fidelity prototype could include field studies to observe how the design is received in its intended environment.

Functionality: The implementation aspects of the design are constructed as low-fidelity semi-functional mock-ups. One could say that the prototype described in this work is mostly focused on the look and feel of the design, with the purpose of clearly communicating the intended vision. However, this has the consequence of the prototype ignoring many of the technical aspects that would need to be considered for implementation. For example, how the table will analyse the conversational input and translate it to create the desired output is only superficially explored. Future work could explore possible ways of implementing the desired functionality.

Interaction Modalities: The presented design relies predominantly on light as its main interaction modality. It would be worthwhile to explore other interaction modalities, such as sound, haptic feedback, gestural interaction or shape-changing [15]. For example, sound such as music has been proven to positively affect social interactions and relations by providing a sense of euphoria [14]. Adding sound effects to indicate that the spiral is increasing or that it reached its maximum extension might give the users a higher incentive to interact with the table. Furthermore, creating a theme song based on the tone of the discussion similar to the AI-generated picture might also further incentivise the users.

Actuated Expressivity: In a similar fashion to providing audio feedback, the table can provide actuated feedback as expressive movements. For instance, shaking or subtle movements when it is idle, or being used wrongly, or when the spiral reaches its maximum state. Physical actuation could be another enrichment to the interactivity of the table. The benefit of having a physical actuating interface in the table would be that is not prone to noise in the environment, similar to TurnTable [7].

Ambient Expressivity: Another improvement could be changing the ambient expressivity of the table. Instead of having a spiral, there could be hundreds of small LEDs on the surface of the table that could produce more complex and visually interesting shapes. Having such granularity could, as an example, also add the ability to show lit-up shapes close to the person that is speaking at the moment and then dynamically move toward the others as the conversation evolves. This version would be able to display how much each person has talked based on the area of the light originating from that specific person. However, this could have unwanted implications, such as the users feeling the need to adjust their talking if their lit-up area becomes too small or large.

Natural Language Processing: Lastly, the data analysis of the conversational input for the table could also be improved by using natural language processing approaches. Instead of focusing on prosodic and acoustic parameters to determine the emotions throughout the conversation, the content of the conversation could also be explored. For example, using keywords that are frequently used during the conversation. This would improve emotion recognition accuracy [3, 24] which will lead to a more accurate colour coding of the spiral. Furthermore, this feature could be utilised when creating an AI-generated picture. For instance, if a specific topic is being brought up frequently in the conversation, it would result in an AI-generated picture that is influenced by that topic. However, this entire feature has a very serious ethical implication since it actively listens to and registers conversations. Considering this, the addition of NLP should be considered carefully.

5 CONCLUSION

We have described the process to create an initial prototype of an ambient robotic table that supports social interactions, named HighLight. Through a rapid prototyping process, the problem domain was explored, and a design solution has been proposed. HighLight aims to encourage users to put their smartphones away while in social settings around a table by providing a robotic hatch to store their devices. It also aims to encourage social interactions with a colourful spiral reacting to and growing with the social conversation. These features are intended to motivate users to converse, which results in the table acting as a social enabler that assists in creating meaningful connections between people. This prototyping work can be seen as a stepping stone for further research on how non-disruptive robotic technologies and ambient interfaces can act as social enablers to help connect people. Future direction will mainly aim at up-scaling the proposed design by iteratively involving users in the design process. In particular, carrying out user studies that include both objective and subjective evaluations to incorporate their feedback in the design of the robotic table.

ACKNOWLEDGMENTS

This project is partially funded by the Swedish Research Council (VR), Project ID: 2020-04918.

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