

Through the Glance Mug: A Familiar Artefact to Support Opportunistic Search in Meetings

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ABSTRACT

During collocated meetings, the spontaneous need for information, called *opportunistic search*, might arise while conversing. However, using smartphones to look up information might be disruptive, disrespectful or even embarrassing in social contexts. We propose an alternative instrument for this practice: Glance Mug, a touch-sensitive mug prototype that listens to the conversation and displays browsable content-driven results on its inner screen. We organized 15 pairs of one-to-one meetings between students to gather user reflections. The user study revealed that the mug has the potential for supporting instant search and affords sufficient subtlety to conceal user actions. Yet, it provoked some anxiety for the users in maintaining eye contact with their partners. Our main contributions are the context-aware mug concept tested in a real-life setting and the analysis through Hornecker and Buur's Tangible Interaction Framework that discusses its design space, and its impact on the users and social interaction.

Author Keywords

Computer-mediated communication; tangible interaction, smart mug; collocated interaction; subtle interaction; impression management.

INTRODUCTION

Today, everyday objects can incorporate several technological components and become interactive devices while still looking like ordinary artifacts. This offers designers the opportunity to exploit the users' familiarity with the form factor, affordances and cultural aspects of these objects in exploring novel interactions. These aspects make everyday objects resourceful instruments by which we



Figure 1. The Glance Mug prototype and system components

can approach various design challenges regarding our interaction with the information.

In this paper, we talk about one of these challenges: the need to perform instant search in meetings. During a meeting, we occasionally come across unknown words or subjects and feel the need to look up a piece of information. This phenomenon is called *opportunistic search*. Although previous works addressed design issues related to opportunistic search, they are limited to the use of smartphones and tabletop systems [8,23]. However, in some contexts, especially in one-to-one meetings, reaching one's smartphone or tablet might be perceived as a rude or disruptive act as a certain level of attention, interest and participation is expected for the social interaction [2,22]. Moreover, interlocutors might not want to expose themselves while using their mobile device or doing online search during a conversation. The reason for this can be that of concealing their ignorance or weakness on the subject matter; or their ability to access information, which makes them feel personally empowered [10,23]. As a result, in addition to the need for opportunistic search, a demand for subtle interaction with the artefact also emerges.

In order to address these issues, we propose the Glance Mug, a novel, touch-sensitive mug prototype with an inner display

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which converts speech to text (Figure 1). Nearly all previous work on augmented mugs addressed well-being issues such as informing the users on their liquid consumption [28,29]. The difference of our research is that we consider the mug as an intelligent companion for social interaction, especially during meetings. The Glance Mug listens to the conversation and, once triggered by touch, it performs an online search based on the actual conversation content. Wikipedia summary and images from Google are displayed as search results on the inner screen of the mug. It allows the users to look up and view information instantly on the artefact itself without using another device.

In order to see the user response to the Glance Mug in a real-life setting, we conducted an exploratory study with the prototype by organizing 15 pairs of one-to-one advising meetings with university students. The users were expected to interact with the mug, in a subtle or open way according to their preference, and subsequently share with us their thoughts on the experience in semi-structured interviews. This study enabled us to gather user reflections on the augmented mug concept, its gestural and visual interface, its support for subtlety, and its influence on opportunistic search and the flow of conversation. On the other hand, we analyzed the Glance Mug by using Hornecker and Buur's Tangible Interaction Framework [19] to reveal its potential for enhancing social interaction and identify, by the help of the user reflections, challenges and opportunities for the design of augmented mugs. This framework has been previously used to explore several tangible experiences in social settings [5,12,24,27], including augmented everyday objects [1]. It is composed of 4 different themes that are related to understanding embodied and social aspects of tangible interfaces: (a) *Tangible Manipulation*; (b) *Spatial Interaction*; (c) *Embodied Facilitation*; and (d) *Expressive Representation*. Each theme is explained separately in the Discussion section.

RELATED WORK

Opportunistic Search

In their theoretical paper Bruijn and Spence [8] introduced the term opportunistic browsing, which refers to “the continuous but largely unconscious monitoring and filtering of information with the potential to trigger more purposeful behavior” (p. 363). They suggested that this kind of browsing is ubiquitous in everyday life and new systems and artifacts supporting this kind of browsing should be studied. In relation to this concept Li and Dillenbourg [23] coined the term opportunistic search and explained it as a phenomenon occurring in meetings where “people may spontaneously seek information for certain terms that they encounter unexpectedly either from meeting conversation or resources (paper documents or other objects in the surroundings) available in the meeting environment”.

In their paper, they explored opportunistic search meeting support systems by testing touch-sensitive tabletop designs for brainstorming settings. In place of speech recognition,

these designs used Wizard of Oz to transcribe conversations. They found that the search results based on the conversation context showing the related Wikipedia pages and images seemed to be working better as it presented a simple interface for results and offered visual representation of the conversation. Although, the Glance Mug adopts a similar approach to present the search results, our research differs as our aim was to understand what kind of experience a tangible interface could offer for opportunistic search.

Subtle Interaction

Anderson et al. define subtle interaction as “providing input to, or receiving output from, systems without being observed” [2]. The researchers implemented four device prototypes that enabled users to perform some actions during meetings without exposing themselves to the attendees. One of these prototypes was a coffee cup with a flat display placed on the bottom, which enabled users to read messages. In a limited way, the study of Anderson et al. shows that the coffee mug form factor has potential in encouraging subtle interaction. However, the mug was a phone-controlled device. Our Glance Mug differs as it offers both input (touch-sensitive surface) and output (inner display) in a single device, which presents a direct and unified interaction. In this way, we intended to explore the potential of an augmented mug as a tangible interface for subtle interaction.

Augmented Mugs and Tangible Interaction

Although coffee mugs are well-known social artefacts, few studies or products explored the mugs' potential as interactive devices. The earliest effort is The Media Cup developed by Gellersen et al. which is an augmented ceramic coffee mug prototype with diverse sensors placed on the bottom part [4]. It was able to sense its motion, perceive the temperature of the liquid it held and share these data with nearby devices. The researchers' main aim was to design a cup that would be able to connect to a network of devices and to communicate with them. Although they tried to capture human gestures with the cup (drinking and fiddling), they did not explore or discuss its potential to support collocated social interactions.

Interactive mugs designed specifically for social interaction are rare. One of them is the Lover's Cups that allow two people in different places to communicate with each other [9]. The prototype of the device could sense the liquid level, sipping and shaking action, and it used LED illumination as an output method to display information. Although this project considers the cup as a potential interface for interpersonal communication, its focus is on supporting remote social interactions. In this sense, our study differs from others as we examine the role of an augmented mug in a face-to-face social setting. Another noticeable artefact is the Paulig Muki, a coffee mug with a flat e-ink display on its outer surface which was designed for both direct and remote social interaction [30]. This mug allows people to send each other images via its app. These images are shown on the mug display as fresh coffee is poured in the cup. This project is an

example of how an ordinary mug can propose novel forms of interaction with/between people by using gestures that are intrinsic to the use of the mug, such as pouring coffee. However, unlike the Glance Mug, it is limited in terms of direct contact as it does not exploit hand gestures performed on/with the mug (drinking, grasping, tilting, revolving), which could introduce novel ways of manipulating the content for social interaction.

Mugshots is another salient project that focuses on both remote and collocated interactions [21]. This work is inspired by Goffman's theory in which he uses the theater metaphor to explain why people act differently in public and private spaces, defined respectively as the front and the backstage [16]. The researchers' aim was to facilitate the switching between public and private performance by proposing a mug interface for communication. In private mode, this mug shows images sent from friends and family in the small, flat LCD display on its outer surface. When the user passes to the public space, the display shows an image preloaded by the user via web/smartphone interface. The researchers also mentioned how these displayed images triggered conversation. Although this project explores how an augmented mug displaying images could affect social interaction, it does not provide any input method on the mug itself like the Glance Mug. Our study also differs from the Mugshots as it addresses the subtle interaction potential of the mug in social encounters.

Coffee Cup Reading Paradigm for Mug Interactions

We previously studied how the cup and saucer were used by fortune-tellers and examined the cup reading phenomenon from an HCI perspective [6] as this centuries-old socio-cultural experience is tightly related to nonverbal interaction and physical manipulation of handheld artefacts. We argued that the cup and saucer could be considered as tangible interfaces to explore interactive handheld systems for enhancing social interaction. In line with this perspective, we also conducted a comprehensive investigation on how fortune-tellers physically engaged with the cup during the sessions. As a result, we derived 11 characteristics that could be a reference for user interactions with handheld cylindrical devices with an inner display [7]. In designing the Glance Mug, we were inspired by this study as it provides a base for exploring the design of augmented mugs in terms of form factor and tangible interaction. Although the Glance Mug differs from the coffee cup mentioned in the study, in terms of purpose and various aspects such as visual content and dimensions, we took into consideration three of these characteristics: *Touching*, *Contact with the Cup* and *Interrupting Contact with the Cup*.

Touching referred to the participants' continuous tactile interactions with the outer surface of the coffee cup. These included rubbing or poking, or tapping gestures. In the Glance Mug, we created touch-sensitive areas around the mug that would enable users to perform gestures with fingers. *Contact with the Cup* and *Interrupting Contact with*

the Cup referred to the participants' tendency to hold the cup in one hand most of the time during the practice. Inspired by this finding, we arranged the touch-sensitive areas close to the mug handle to make single-hand interaction easier and allow users to still perform communicative gestures with their free hand during a conversation. According to the study, the participants also tended to hold the coffee cup with both hands if they were examining its inner visual content. Keeping this behavior in mind, we employed two touch-sensitive stripes to cover the entire brim of the mug. In this way, the users were able to employ both hands to perform touch-gestures, by positioning them on the sensors around the mug. Our main aim was to propose a simple yet interactive tangible prototype that would enable us to see an augmented mug concept in action and gather initial user reflections on this novel experience. Therefore, at this stage of the research, we limited our study to the mug interactions that were the most feasible for us to prototype with our available resources.

GLANCE MUG

The Glance Mug is a 3D printed augmented mug prototype equipped with a small flat display on its inner wall as well as touch-sensitive areas around its surface (Figure 1). The mug continuously listens to the conversation during meetings, which consequently enables the mug holders to look up information related to the content (e.g., name, concept, location). When needed, they tap on the mug to trigger search. The mug then rewinds 9 seconds backwards [31] and converts the audio recording into text by using Google Speech API [32]. Once it has received the speech-to-text output, the mug processes this textual data as query with an algorithm to search the web. In the end, the screen displays the related title, description and Wikipedia summary received from Google Knowledge Graph Search API [33] and presents the first five image results from Google. The Glance Mug allows users to see and browse these search results instantly on the inner surface of the mug. Users can browse through the results by performing swipe gestures on the outer surface of the mug. Triggering another search updates the display to show new results. At this stage of the research, the mug is not suitable for drinking and cannot contain any liquid as the material we used for 3D printing was not food safe and the electronic components might get damaged. It was also the case in [2] in which the researchers obtained fruitful results in their study on subtle interactions. Likewise, in our study this configuration was sufficient for us to gather user reflections on the mug concept.

Touch-sensitive Interface for Search and Navigation

We placed the touch-sensitive areas as stripes on the outer surface of the mug: two of them are horizontal around the brim and one is vertical on the user side, close to the handle. These are used for swipe gestures. The horizontal stripes are responsible for browsing through images and Wikipedia summary. In addition, tapping/pressing gestures applied on the edge of the stripe that is close to the handle triggers

search. The vertical stripe is used to browse different search terms derived from the conversation.

Graphical User Interface

We placed a small and low-resolution flat display on the inner surface of the mug. A simple GUI was designed to minimize the information load, showing only the most essential elements: title (query), description, Wikipedia summary and one image for each frame (Figure 2). The title was shown in the gray stripe while the textual/visual content was displayed below. The interface also shows feedback messages in this gray section when a search is triggered or when there is no result. We used Verdana typeface as it was designed to increase the readability for low-resolution screens. The GUI uses a slide animation to show the transition between one content and the other (e.g., from the Wikipedia description frame to the frame with the coffee cup visual in the Figure 2). This movement-based transition, intended to stimulate also peripheral vision [13], notifies the users whenever there is a change in content on the screen.



Figure 2. Glimpse Mug GUI. Wikipedia summary on the left and an image from Google on the right.

USER STUDY

As our inspiration was the previous research we conducted on Turkish coffee fortune-telling, a traditional advice-giving practice, we chose an advising setting to test the mug. We designed a study at the university in which two students came together to talk about the experience of going abroad as an exchange student, in 15 minute one-to-one meetings. We issued a call for participants for students who wished to apply for an exchange program (advisee) and for students that had already had such an experience (advisor). We believed this setting would provide a suitable context to look up some information (such as countries, places, universities) to make conversation, answer questions or extend arguments. In this regard, our main aim in conducting this user study was to understand what people would think of the interaction mechanism and opportunities the Glimpse Mug offered, and whether they could use it while interacting with another person in a social setting.

Although touch-gesture recognition and GUI components of the mug performed well in the pilot sessions, speech recognition results failed most of the time to correspond to

the actual content produced during the conversation. However, this did not prevent the participants to have hands-on experience with the augmented mug concept and they were motivated to give feedback. Following these preliminary sessions, we preferred the Wizard of Oz (WoZ) method to solve speech recognition issues. This way, we were able to provide a more stable system and continued with the second series of sessions. The main difference between these two series of sessions was related to the duration and frequency of interaction with the mug. However, as we did not change the mug concept in between the two sessions, and did not aim to measure task performance, we considered the data sufficient for initial user feedback about a novel concept. Therefore, we grouped the user reflections from both series together.

Participants

In total, 30 right-handed participants took part in our study. Fifteen of them were the mug users (4 males, $Age=23.33$) and 15 were their conversational partners (5 males, $Age=21.6$).

Experimental Setup

For each session, a mug user and a conversational partner were asked to sit facing each other at a round table in a room. We placed two cameras to frame the face of each participant, their body movements and the Glimpse Mug. Although we could not put coffee in the Glimpse Mug for technical and safety reasons, we still provided coffee to the conversational partner to maintain a balance in terms of mug presence on the table. We gave an informed consent form to all participants but we did not present the details of the user study as it might have created a bias. We however provided debriefing right after the sessions. All sessions were conducted by two researchers and were video recorded. As thank-you gifts, we offered vouchers for a coffeehouse on the campus.

Procedure

We wanted the mug users to play and familiarize themselves with the Glimpse Mug concept for a while before the sessions. Therefore, we invited the mug users to the study room 15 minutes earlier than the others. After giving the informed consent form, we introduced our prototype to the users. We explained what the Glimpse Mug would do, demonstrated how it worked, and asked them to try to use it during the meeting. We also mentioned that the other participants, the conversational partners, did not know about the Glimpse Mug, yet we did not guide the mug users to conceal or expose the mug. After this briefing, we let them play with the mug until the partners arrived. Upon arrival, we offered them coffee/tea and asked them to converse for about 15 minutes. During the meetings, there was no researcher in the room. After the sessions each researcher held a semi-structured interview with each of the participants.

FIRST SERIES: PILOT SESSIONS

We conducted these sessions by using the speech recognition system implemented in the Glimpse Mug. We organized 6

sessions in which 12 students participated. We conducted the first half of these sessions by giving the mug to the advisee students, and the other half by giving the mug to the advisors. This allowed us to observe whether one group tends to use the mug more often. However, we could not find any visible differences. As we based our research on the previous work on Turkish coffee fortune-telling, we proceeded with this traditional advice-giving setting, in which the advisor uses the cup. Therefore, following these preparatory sessions we gave the Glance Mug to the students with an exchange experience as they represented the advisor in these meetings.

SECOND SERIES: WIZARD OF OZ SESSIONS

These sessions were conducted following technical issues with speech recognition results. Eighteen students participated in this series and we organized 9 sessions. The Wizard of Oz (WoZ) is a method to manually operate some features of a system that cannot be implemented at an ideal level, or are currently technologically impossible. By using the WoZ method we imitated the desired speech-to-text output and did the search operation manually for the Glance Mug. These sessions allowed us to create a more stable experience with the mug and thus helped us obtain more reliable user feedback.

USER REFLECTIONS FROM BOTH SESSIONS

In this section, we report the user response gathered from the semi-structured interviews. We took into consideration the interviews conducted with all the mug users in 15 sessions. In 3 sessions, we were informed that the partners were aware that there would be an augmented mug involved in the study, but did not know about the mug's functions or what it was used for. We still involved in our analysis the users of the mug in these sessions as the subtlety the mug provided was not our only interest; we were also interested in its overall user experience.

Interpersonal Communication and Subtle Interaction

An interesting aspect of the Glance Mug was its influence on the language employed by the user. One participant (P13) believed the mug changed her style of speech. Instead of using generic nouns such as "city", "home", or "school", she tended to use more proper nouns such as city or university names. She also repeated the words of her partner when she wanted to search for them on the mug. It is inspiring that an augmented mug demonstrated a potential of creating new forms of conversation. One participant (P14), who had shared the contents of the mug with his partner at the beginning of the session, believed that this created a momentary bond among them and acted as an ice-breaker. Interestingly, his partner reported the same feeling when asked about how the conversation went. Adding a sound system to the mug was suggested by four participants so that the mug could play videos and sounds or read the search results out loud. For example, one of the participants (P7) who had lived in Australia reported that he would like to play some Australian accent videos for his advisee so that she could get a grasp of what to expect. The same participant also stated that he would not need such a mug as he would use his

smartphone to look up information. Yet, he added that the mug would be helpful when there is a need for secrecy. Overall, we see that the mug was considered as an artefact that could contribute to conversations in different ways.

The 3 conversational partners, who knew there would be an augmented mug involved in the study, did not notice an unusual or suspicious activity on the users' side. In the remaining 12 sessions where the partners were oblivious to the mug, only 3 of the users declared to the partners that they were using an augmented mug. Two of the mug users (P9, P14) reported that they wanted to be honest and talk about the mug they had. Another participant (P15) said that she felt the need to try and involve the mug in the conversation because of its mere presence. One other participant (P7) reported that he was planning to share the contents of the mug with his partner, in this case pictures from the city where he studied in Australia, yet the right time never came. The remaining 8 participants kept the mug's function a secret. Although they had the freedom to share the mug's actual content with their advisees, these users chose to keep it to themselves. The reasons for keeping it secret were that they wanted to see whether they would be able to use it secretly, or that there was no need to involve the mug in the conversation.

As a result, secrecy was introduced into the dialogue where one party withheld the information from the other. In these sessions, none of the partners became aware of the mug use during the meeting. However, seven participants reported it was hard to maintain eye contact with the advisees while trying to use the mug covertly and this made them feel uncomfortable. Since they were sitting alone in a room with their advisees with whom they had just met, they did not have much opportunity to direct their gaze elsewhere during the conversation. They found the mug attracted too much of their gaze and attention, and they struggled to focus on the dialogue they were engaged in. In this sense, the mug seems to be more comfortable to use in crowded contexts where the users would be more comfortable with their gaze direction. Yet, a distracting mug might still be helpful in one-to-one encounters. For instance, one participant (P12), who is energetic by nature, started playing with the mug triggering random search to erase her boredom and divert her attention from the conversation that felt stuck at a certain point. This is an example of how the experience presented by the mug could change depending on the personalities.

Opportunistic Search and Use Cases

The majority of the participants appreciated the concept and tried to use the Glance Mug during the conversation. Our mug prototype did not always yield the desired search results during the user studies, nonetheless this did not always result in negative outcomes. In one instance, while trying the Glance Mug for the first time before the session, one of the participants (P8) was pleased to see unrelated results as she gained knowledge. Users performed opportunistic search for different reasons. One participant (P11) indicated that the

mug helped her concretize her thoughts and retrieve her memories during the conversation. Similarly another participant (P7) reported that he did not search for things he did not know, but rather for those he already knew and remembered. Two participants (P7, P10) mentioned that they did not feel the need to use the mug for facts since they talked about their personal experiences, so searching the net was not a priority for them. One participant (P14) said it was not easy to understand which words the mug would pick. He expressed the wish to see on the display all the words for each search so that he could navigate and choose the ones he needed most. Similarly another participant (P13) expressed the wish that the mug recorded and displayed all the search results so that she could navigate through that information after the conversation. She said she would put “bookmarks” on the search results she liked in order to come back to them whenever she wanted to. Another participant (P14) said he wished the mug could hold liquid which would make him more enthusiastic about it.

By closely examining the use-cases suggested by the participants, we found that they referred to its potential to support interaction in formal encounters: business meetings, seminars, and academic discussions were among the most common suggestions. Users believed the mug could enable them to easily look up small pieces of information they missed in such encounters without creating social discomfort. Another use-case suggestion was presentations, where the mug would be helpful to quickly retrieve needed information, to answer questions from the public, as well as to control the presentation slides via their mug.

Physical Structure and Gestural Interaction

The form of the mug was appreciated by almost all participants. They reported finding the mug’s shape, weight and appearance appropriate to its purpose. The most common criticism regarding the form was directed towards the placement of the screen: eight participants reported that it was hard to see the lower end of the screen while the mug was on the table. Participants either had to lean over the mug or tilt it towards themselves to get a better view. To overcome this, participants suggested to incline the screen upwards towards the user’s eye level. An interesting comment pointed out the fixed position of the screen; one participant (P15) reported that she normally holds mugs with her left hand, thus making the Glance Mug feel reverse to her. She expressed the wish to have the screen on the opposite side of the mug in order to be able to use it with her left hand. Almost all participants found the positioning of the flexible sensors convenient. Most of the participants believed swipe gestures felt natural and comfortable. However, they believed the swipe sensors and touch-sensitive search spot did not provide enough feedback to notify the user that they have been pressed. Five participants reported that they could not understand whether they had pressed on the search spot correctly as there was no physical feedback to communicate whether they had done it correctly. Moreover, four participants suggested that the search spot could be moved to

the side facing them or to the top of the handle, where pressing on it would be easier and more seamless.

DISCUSSION

Below we analyze and discuss the current and potential design space of the Glance Mug, and the user reflections through Hornecker and Buur’s *Tangible Interaction Framework*. We explain the themes of the framework briefly in the beginning of each section.

Grasping the Opportunity for Search

The first theme of Hornecker and Buur’s framework is *Tangible Manipulation*. It refers to the bodily interaction with physical objects equipped with computational resources, that is the users are able to control the computation by directly manipulating objects [19]. The Glance Mug presents the information gathered from the conversation context to the users. The users see the digital representation originated from the ongoing conversation in the space where the coffee is poured. When holding a mug, the users’ fingers are in direct contact with the outer surface as well as the handle. The touch-sensitive stripes around the Glance Mug take advantage of this bodily relationship to provide access to the content inside. To trigger a search, or manipulate the textual and visual content represented on the mug’s inner display, the users do not need to handle any other device, as they can control these actions from the mug itself. In this way, the Glance Mug couples the intrinsic physical function of the mug (holding liquid) with a new one (holding information). In a similar way, the daily interaction with the mug’s surface is transformed into meaningful gestures to instantly search and navigate the digital representations of the conversation content.

We believe that this coupling, together with the concealing form factor of the mug, enables users to perform opportunistic search and engage with the Glance Mug without provoking any doubt in their partner. Even the participants who knew about the mug did not notice the mug user’s movements nor did they understand how the mug worked. Although in some sessions the mug did not work in a stable or continuous manner, our user study enabled us to have an understanding of the degree of subtlety the mug could offer. We found the results encouraging as we conducted the study in a real-life setting and did not dedicate much time to polish the 3D printed mug case. Conceived as an everyday object, the Glance Mug should also be considered as a personal object that can be customized and individuated [1]. For instance, with a knitted mug sleeve it can reflect different styles and identities, and could thus be distinguished among others. Although the current prototype does not allow using any liquid, using drinks would add another layer to the tangibility and expressiveness of the Glance Mug. For example, triggering search can be coupled with the drinking gesture and the level of coffee can reveal the representations on the display sip by sip. Similarly, the movement of the liquid inside the mug can be controlled by

hand gestures (e.g., fidgeting, revolving, inclining) for navigation or selection purposes [15].

Ambiguity Enables Privacy and Subtlety

Spatial Interaction refers to the fact that tangible interfaces occupy real space in the world and that users interact with them by moving in real space [19]. The Glance Mug is an object that can be moved freely in space. We can talk about two main physical spaces for the Glance Mug. The first one is the surrounding space in which the users handle and move the mug. This mobility allows users to adjust the view of the content inside according to their head and body posture, which helps them reduce the physical effort to follow the textual and visual output presented. Moreover, this handheld object mediates the transition between the private spot (where interaction with the artefact occurs) and the public spot (where interaction with the interlocutor occurs). These two spots can occasionally coincide when users share the content of the mug with others. In this case, the private becomes public and the digital content is enjoyed as a shared element of the conversation. In the Mugshots study, this transition is performed digitally by the users through the mug interface (switching to public/private mode) in separate places [21]. In the Glance Mug case, this transition occurs in the same place and time, and is performed physically by the users through their behavior (showing the mug display to the interlocutor). In this regard, the privacy or disclosure of the Glance Mug depends on the users' bodily interaction as the interlocutors cannot know exactly whether the users are looking at visual information, a blank screen, or simply the coffee. This gives room for users to perform opportunistic search with subtlety. The Glance Mug introduces an ambiguity that allows both sides to maintain the social interaction without feeling interrupted or disruptive. Ambiguity has been discussed extensively in HCI and is considered as a powerful design element. In this case, *ambiguity of context*, originating from the obscuring mug form factor, creates a meaningful space of uncertainty. This proposes an alternative to the activity-exposing smartphone interaction for opportunistic search [14].

The second space, which is also related to the first one, is the inner space of the mug, which is normally used to hold liquid. Because of technological limitations, we currently present the mug's content on only one side of the mug. This prevents the users to freely revolve or tilt the mug, unless they want to expose their activity. With a flexible or embedded screen the entire inner surface of the mug can become a visual space for displaying the content [34]. This would help solve the handedness issue mentioned by one of the participants (P15). In such a circular display, the visuals can reposition themselves around the inner surface according to the hand in use so that the content is not exposed to the interlocutors and it can easily be used with the preferred hand.

Privileged Access to the Search Content

Embodied Facilitation refers to the physical and procedural structure of tangible interfaces that influence user actions and

behavior, and consequently shape social configurations [19]. We can say that the Glance Mug presents the digital representations in an unconventional way, that is, on the inner surface of the mug. The form factor of the Glance Mug enables people to have privacy in meetings when needed as the interlocutors cannot precisely know whether the user is looking at a piece of information or the liquid inside. As opposed to the use of a smartphone in a meeting, which can be perceived as rude or associated with working on tasks irrelevant to the meeting, handling a coffee mug refers in the first place to the act of drinking [20,22]. When considering this in line with the subtle interfaces framework [2], we can describe the Glance Mug as an artefact that (a) provides functions beyond its appearance (*device visibility: disguised*); (b) enables interactions observable but perceived as normal behaviors (*interaction observability: disguised*); (c) prevents others from noticing the ongoing task (*task transparency: opaque*).

These design and form factor qualities allowed us to explore how users would behave with such an artefact in social interaction. Users are given the opportunity to keep the content for themselves or to reveal and share it with their interlocutors. In this regard, the mug's form factor is marked by a level of privacy and access threshold. The mug users have privileged access to the content for two basic reasons: they own the mug (in case it is a personal artefact) and they are physically the closest person to the mug. While this proximity eases the access for the users, it also limits the access points for the others to the content presented. The movement of the mug in space regulates the privacy and access points as this can manipulate the proximity too. In any case, the Glance Mug has a single and narrow access point by nature as the mugs are not designed to be used by two people at the same time. The access threshold can be lowered only by the user's intention to expose the mug's content. Thus the interlocutors might only know about the content if the users express it verbally or show them the mug display. As it happens in the fortune-telling practice, the mug can be shared between the interlocutors for communication purposes. The users can share the content in order contribute to the conversation (see the account of P7 on Australian accent videos and city images).

Impressions and Extensions of a Conversation

Expressive Representation refers to how digital functions and data are physically represented in tangible interaction, often implemented by combination of materials and digital elements [19]. The Glance Mug transforms the voice input (physical form) into textual and visual output (digital representation) and offers impressions and extensions of the conversation. These are displayed on a flat screen placed on the inner surface. Topics and concepts produced verbally during conversation might not always stimulate our senses and appear in front of our eyes. Yet, by displaying textual and visual representations of these conversational elements, the mug plays a stimulating role. In this way, the mug provides the user with textual and visual material to learn

about an unknown concept, to extend a known one, to share these with the interlocutor, or simply for distraction. As the users can trigger search at any point in the conversation, the Glance Mug opens the way to being stimulated by doing random search for unexpected results. This serendipity adds playfulness to the conversations and might be a trigger for people to talk or learn new things. (P8, P12). User reflections also indicated that the support for opportunistic search does not have to be only limited to displaying information instantly. A suggestion was to keep the log of search results and make them available after meetings as well (P13). Therefore, access to the search history at a later time is expected as opportunistic search results cannot be exploited in a comprehensive manner at the moment of search. In this way, the Glance Mug could extend the momentary impressions beyond the meeting into new spaces of the user, both physical and virtual (e.g., social media, personal archive etc.). In this sense, it is also interrelated with the *Spatial Interaction* theme.

Although most participants preferred to keep the mug's functions and content to themselves, trying to use it for subtle interactions, they had difficulty in maintaining eye contact with the partners while interacting with the mug. As mentioned previously, the distracting visual attraction of the mug is not always a negative aspect as it also has the potential to prevent boredom during the conversation as indicated by P12. However, when this is not the intention, communication problems might arise. The most challenging part of an augmented mug for face-to-face interaction is that it divides the user's attention between the visual content (re)presented inside and the conversation in progress. The visual representation on the mug screen is designed to have as little elements as possible to lower the cognitive load during the social interaction. However, the user reflections demonstrated that this was not sufficient to maintain a smooth and flowing conversation. Multisensory Data Representation, that is employing various senses and media for representing data [17], can be a suitable approach. Although, one sensory channel alone might not be sufficient to communicate the desired information (e.g., understanding by taste where a certain building is located in the city), vision can be supported by other senses. In relation to touch gestures, using vibrations or temperature change as haptic feedback might also reduce the attention required to notice whether search and navigation gestures have been triggered.

Ethical considerations

The subtlety and secrecy the Glance Mug offers also raise ethical questions. Some users might consider this device concept as a potentially dishonest instrument (P9, P14) as it creates a way for deception, can compromise privacy as well as decrease social engagement by making eye contact difficult. Yet, whenever such an artefact becomes popular, it also has the potential to change people's habits and privacy expectations, as was the case with the first Kodak cameras [18]. Similarly, first-time mobile phone users demonstrated within a few weeks a positive change in behavior towards a

technology initially perceived as annoying [25]. Therefore, in the future such adaptation can make us employ IoT devices similar to the Glance Mug as a support for our daily online/offline or context-specific face-work [3,26].

CONCLUSION

We designed the Glance Mug, a 3D printed ordinary-looking mug that listens to conversations. When triggered by touch, it performs an online search based on the conversation content and displays related textual and visual results in its inner screen. Our aim was to explore the potential of the Glance Mug in supporting opportunistic search and subtle interaction during meetings. We conducted an exploratory user study with the mug to gather user reflections about the experience it offers and to identify challenges and opportunities for the design of augmented mugs.

The user study revealed that the participants appreciated the augmented mug concept and the mug allowed the users to subtly perform opportunistic search whenever wanted. Furthermore, we noticed that, although users had not been guided by us to hide the mug's functions, they still tended to keep the mug and its content to themselves. We interpreted this as a result of the mug's form factor which implies secrecy and subtle use because of its concealing physical structure. These outcomes indicate the Glance Mug's potential to be used during meetings without attracting much attention or suspicion. However, the users found it difficult to maintain eye contact in social interaction while performing search and navigating the results. This challenge can be addressed by employing different sensory channels to provide feedback on the users' actions (e.g., triggering search) and to represent search results.

Our two main contributions are (1) designing and prototyping the Glance Mug and testing it in real-life setting; (2) analyzing it through Hornecker and Buur's Tangible Interaction Framework to discuss the current and potential design space of the Glance Mug, and user reflections. The analysis revealed 4 salient traits of our mug prototype: (a) *Grasping the Opportunity to Search*; (b) *Ambiguity Enables Privacy and Subtlety*; (c) *Privileged Access to the Search Content*; (d) *Impressions and Extensions of a Conversation*. These traits indicate the challenges and opportunities that would inform the design of similar augmented mugs for supporting collocated social interaction. In addition, the design directions we shared in the Discussion could also be helpful in reflecting on the behaviors of augmented everyday objects in social contexts.

As a next step, physical mug affordances (e.g., sipping, squeezing the handle etc.) can be further explored to couple them with different input methods for subtlety such as EMG-based motionless gestures [11]. For future work, we plan to deploy the iterated prototype in a group meeting setting with other mobile devices for a comparative study in terms of opportunistic search and subtle interaction experience as well as social acceptance.

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