HCI Design and Evaluation during Social Confinement: Reflections and Techniques

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Abstract. The pandemic brought a number of challenges that provoked a major impact on almost every human activity. In this new context, designers of technologies aimed at supporting mental or physical health are faced with a lack of principles and guidelines for successfully evaluating them, since health authorities impose social confinement as a standard safety measure. Moreover, mental health technologies become even more important and more challenging in such context of constrain and anxiety. We discuss the design and evaluation of (i) a system for helping university students avoid smartphone overuse; (ii) a mobile system to support informal caregivers of dementia patients; and (iii) a VR-based system aimed at improving mental well-being. The design and evaluation of these systems was entirely performed during social confinement. We present a list of risks, challenges and lessons learned, as well as the techniques we employed to effectively overcome these limitations. Incorporating motivational or persuasive factors into the solutions was the key objective and we organize our reflections around reliability, usefulness and intrusiveness.

Keywords: Interaction design, social confinement, pandemic, human-computer interaction, mental health, mobile systems, well-being.

1 Introduction

The COVID-19 pandemic has made a significant impact in our lives, and affected how we approach life and work. Since the beginning of the pandemic, most of us were forced to change the way we live and work. Mental health services are struggling to meet the needs of patients and fail to reach large proportions of those in need of care in most countries. The pandemic also brought several new challenges and concerns to the way some research activity is conducted, depending obviously on the nature and the context in which it is performed. This impact has been much more severe in scientific fields where one or more in-person contacts are fundamentally needed, as is the case with HCI.

In this new pandemic context, designers of technologies aimed at supporting mental or physical health are being faced with a lack of principles and guidelines for successfully evaluating them, since health authorities impose social confinement as a

standard safety measure and in-person contact is forbidden. Moreover, mental health technologies become even more important and more challenging in such a context of constrain and anxiety.

In this paper, we discuss the design and evaluation of (i) a system for helping university students avoid smartphone overuse; (ii) a mobile system to support informal caregivers of dementia patients; and (iii) a VR-based system aimed at improving mental well-being. The design and evaluation of these systems was entirely performed during social confinement. We present a list of risks, challenges and lessons learned, as well as the techniques we employed to effectively overcome these limitations.

2 Background

HCI has had an important role on fighting the pandemic, but the pandemic has also impacted the way HCI research is performed. During the past year, several studies have already been published inter-relating these different issues and bringing up new opportunities as well as introducing new concerns. Recognizing that fighting a pandemic is as much a social endeavor as a medicinal and scientific one, some authors collected a multitude of data that includes longitudinal trends of news topics, social distancing behaviors, community mobility changes, web searches, and other descriptors of the COVID-19 pandemic's effects on the United States [1]. The potential of HCI for issues such as producing meaningful social insights and have them presented in an interactive dashboard to aid further exploration is immensely useful in a pandemic [1]. But what has been the impact of the pandemic on HCI itself and how does it shape the current design and evaluation methods and techniques?

The most common technology medium to conduct HCI research during social confinement is the use of videoconferencing. It had been studied before, as late as 2009 [2], and its challenges have been discussed, but under the perspective of geographically-dispersed researchers. For instance, Sedgwick et al. [2] presented the experience of using videoconferencing technology to collect experiential data from undergraduate nursing students and preceptors who were dispersed over a 640,000 square kilometer area in western and northern Canada during a rural hospital-based preceptorship.

A similar pattern happens with recruitment. Online recruitment methods had been studied by the HCI community for quite some time. For instance, Lane et al. presented a review of the literature on using online recruitment methods for web-based and mobile health studies [3]. But again, this and other studies were performed in non-pandemic times and were consequently analyzed under different lenses.

In a 2020 paper, Dupuis and Renaud presented the results from a longitudinal HCI study which was interrupted by the pandemic [4]. Significant challenges were encountered in modifying the original design of the study so that it could continue during the middle of a pandemic. However, the authors reported that those challenges were overcome and even added some advantages to the manner in which the study took

place in the online environment, for instance the fact individuals generally had greater availability since many were already working from home; participant drop-out was low; and regarding participant compensation, by using electronic payments, the research team did not have to have large sums of cash on-hand at specific physical locations. One can presume that under social confinement and lockdown contexts HCI research does not necessarily become hampered in a critical way, and there may even be positive outcomes of such research endeavors.

3 Design and Evaluation during Social Confinement

In this section, we present three case studies revolving around technologies for physical and mental health. Their common aspects include the fact they were all designed and evaluated during the pandemic and under lockdowns and/or social confinement. Consequently, they presented us with many opportunities for fine-tuning and reflecting on the current state of HCI practice.

3.1 Technology for helping students avoid smartphone overuse

Smartphone overuse can lead to a series of physical, mental and social disturbances. This problem is more prevalent among young adults as compared to other demographic groups. Additionally, university students are already undergoing high cognitive loads and stress conditions; therefore, they are more susceptible to smartphone addiction and its derived problems. In this project, we presented a novel approach where a conversational mobile agent uses persuasive messages exploring the reflective mind as a way to raise users' awareness of their usage and consequently induce reduction behaviors.

Since conversational agents were not widely used as personal digital wellbeing assistants, our novel approach intended to develop an Android app that collects real-time smartphone usage data, sends it to the conversational agent (via Dialogflow API) and, according to the usage data, triggers alerts to the user in the form of messages. These alerts intend to minimize the usage levels of the participants since self-tracking has a vital role in the behavior change process [5].

Besides the conversational agent's messages, the developed application also has a floating widget that indicates when the user received a new message from the chatbot, in order to avoid vibrations, LEDs or sounds and, consequently, interrupting the user (since push notifications may compromise students' focus and attention [6]). When the user surpasses specific percentages of the defined goal, the application triggers a message that intends to minimize the smartphone usage, accordingly with the defined goal. The conversational agent's messages, instead of sending push notifications to

alert the user for it, were shown through a black dot in the corner of the floating widget.

We conducted a four-week study with 16 university students undergoing stressful conditions - a global lockdown in the course of their semester - and evaluated the impact of the agent on smartphone usage reduction and the perceived usefulness of such approach. Results show the efficacy of self-tracking in the behavior change process: 81% of the users reduced their usage time, and all of them mentioned that having a conversational agent alerting about their usage was useful. Before this experiment, only 68% of them considered such an approach could be useful. In conclusion, users deemed essential to have an engaging conversational agent on their smartphones, in terms of helping them become more aware of usage times.

This study reinforced the notion that the users tend to underestimate the total time they spend per day, on average, on their smartphone, as was previously discussed by several authors [6, 7, 8].

In short, it was possible to conclude that, since subjects were more aware of their smartphone usage data, they were more realistic about their smartphone use. When comparing the perceptions of their usage with the real values, after using this mobile system, it was revealed that the real value was only higher in five subjects out of the sixteen, i.e. only five subject underestimated the time spent on their smartphones. This constitutes a decrease in half the number of subjects underestimating their usage, from the results of the pre-questionnaire (from eleven to five).

The sudden global lockdown did not hamper the original research plan, as we were using the smartphones of the participants as the means to gather all data. But it did bias the results, since the anxiety levels (and other related metrics) were obviously influenced by the social confinement measures.

3.2 Technology for supporting informal caregivers

The unprecedented growth of the elderly population around the globe [9], coupled with the desire of most elderly people to remain in their own homes for as long as possible, results in a growing number of family caregivers (i.e., family members or acquaintances who provide unpaid assistance to seniors).

Most family caregivers work either full or part-time and the caregiver role represents an added responsibility. The extent of the required assistance from an informal caregiver depends on the care recipients' needs and the amount of available professional help. Their workload may vary from episodic care to a daily substantial time commitment [10]. However, family caregivers often lack formal training to perform these tasks and are unaware of the available resources in place to support them. The range of demands that caregivers have to deal with often translates into negative psychological consequences [21]. This is one of the many reasons why researchers have been designing and evaluating novel technological solutions for supporting the

mental health of caregivers. However, technology-mediated interventions to support caregiving present some limitations and their design is not a trivial task.

In this project, we designed and evaluated a mobile system for helping improve informal caregivers' mental wellbeing and reduce their burden [13].

After the initial iterations, we recruited 20 participants at [anonymized for double-blind review] between October 2020 and December 2020. Two of the participants dropped out, meaning that data was acquired from a total of 18 participants (13 females and 5 males) with ages ranging from 72 to 94 years old (mean=82; std. deviation=7.42). Due to the pandemic, the nurses and formal caregivers at the health institution acted as proxies and they were actually more effective at the experiment's execution. Firstly, they made the participants feel more comfortable, since they were already well-acquainted with every one of them - if an unknown researcher had performed that role, the entire interaction would have been biased by the mere presence of an outsider. Secondly, they removed the need for a pilot-test of the experiment, as they already knew what would go wrong and what would work properly.

Five major conclusions were withdrawn from this experiment:

1) the vast majority of research focuses on patient-centric solutions, aiming to help provide more efficient and effective care, rather than to directly mitigate caregiver burden and related caregiver distress. Ubiquitous systems can even add to the burden that a caregiver already experiences [10]. Therefore, technology interventions should consider interactions with every person involved, and avoid being solely centered on the patient;

2) the success of any assistive technology that is meant to be used by the elderly depends greatly on its acceptance. As the elderly are often resistant to the use of new technology, it is important to explore how assistive technology can be perceived by them as appealing rather than intrusive;

3) current solutions do not accompany disease progression, leading to frustration and ultimately abandonment; solutions need personalization over time, as well as seamless integration in the lives of both patients and their caregivers;

4) current instruments to measure the impact of interventions on the health and well-being of caregivers do not adequately address the fact that caregivers' burden, needs, and their quality of life change significantly as the condition of the dependent person progresses. Therefore, researchers should develop instruments that are sensitive to the evolving nature of the caregiver's and dependent person's status;

5) there is a need for the development of an evaluation scale to characterize existing mental health technologies for caregivers according to their reliability, usefulness and intrusiveness.

3.3 Virtual Reality Technology for Improving Mental Wellbeing

Feelings in Virtual Reality have also been researched into a more therapeutical component, as demonstrated by Baus et al. [12] who reviewed an approach of running exposure therapy, specially phobias, from the more expensive Virtual Reality to the less costly, but still effective Augmented Reality. In this third example, the goal was to deliver a VR-based system that leveraged on the power of nature-contact (something that became more relevant during the lockdowns) in order to improve mental wellbeing.

Two scenarios were produced and evaluated: a beach, i.e. a golden-sand beach, near the ocean, and a forest, a calm, tree-filled forest. In the beach scenario, some palm trees paint the sand dunes behind the subjects. Assorted beach props are spread around the subject. There are two time-of-the-day settings that the subjects can experience:

(i) At midday - a very high strong sun;

(ii) At sunset - a romantic sunset.

In the forest scenario, the subjects are in a small sunken glade with a fire built nearby. Just like in the beach, there are two time-of-the-day settings that the subjects can experience:

(i) During the afternoon - the sun is comfortably midway in the afternoon creating some longish shadows while keeping good visibility;

(ii) During the night - the sun is long gone, giving space to a starry sky and the moon.

We used the HTC Vive Pro as the Virtual Reality headset. No controllers were used since there is no direct user interaction, other than looking around. We used a MUSE S in order to sense the level of relaxation of the user. We also used a generic Heart-Rate sensor band to measure alterations on the subjects' heart-rate.

To complement the data gathered by the sensors, we exposed the subjects to the following standard questionnaires: 1) the AD ACL and 2) the SAM. From all the questionnaires that we explored, we found these two to better evaluate the more positive and calm feelings that we are trying to research. The other related questionnaires are more focused on active and negative feelings.

We also exposed the subjects to another two non-standard questionnaires. One at the beginning of the experiment and another at its conclusion.

Our tests confirmed, with a very high degree of statistically significance (best p = 0.0024; Beach at Sunset), that Nature Scenes in Virtual Reality can induce a sense of *Calmness* in the subjects who were exposed to it. The effect is considerably strong: the subjects report an average increase in *Calmness* of 0.5214 points (Beach at Sunset) in a scale ranging from 1 to 4 (AD ACL). This effect is felt even in sessions of very short duration (1 minute). There is also a decrease in the sense of *Energy*, consistent with the current literature [11], with a high degree of statistically significance (p = 0.0043; Beach Sunset). This effect is even stronger than the *Calmness*, with a decrea-

se of 0.67 points (Beach at sunset). The *Tired* feeling is only statistically significant for the Beach at sunset ($p = 0.0078$) with an increase of 0.5143 points. The *Tension* feeling has no statistically significant except for the Forest at Night ($p = 0.044$).

An unforeseen and unfortunate conclusion is that our subjects did not enjoy being in a Forest at night, despite it being under the full moon with a fire going nearby. There is a big decrease in *Valence*, even if not statistically significant, and a statistically significant ($p = 0.044$) moderate increase in *Tension*. The subjects corroborated this verbally. Unfortunately, this may have reduced the relaxation capabilities of the experiment as a whole, especially for the subjects who felt fear.

All of this confirms that Virtual Reality with nature scenarios, can be used to effectively induce a strong feeling of relaxation in people. The effect seems to be strong enough to even affect the circadian cycle. However, very little work has been done in offering an individualized VR experience to improve mental health.

4 Reflections and Techniques

The reflections that arose from approximately one year of HCI design and evaluation during pandemic times can be useful for any kind of research that involves serious usability testing when users are not physically available, but rather need to participate remotely in sessions with the design team. In this section, we provide an overview of those reflections and systematize the techniques that worked most effectively.

Not surprisingly, of all the projects, the VR-based system was the hardest to evaluate during the socially-confined pandemic times. A workaround included a UV-based disinfection and cleansing of the hardware used, informed consent where we explicitly asked COVID-tracking information, and social distancing rules.

Overall, there were three different setbacks stemming from the pandemic, which influenced the experiments: need to adapt equipment (VR project); inaccessible users (the elderly population of the caregivers' project); and the bias inherent to the sudden global lockdown measures (in the project about smartphone overuse by students).

In the second project, the fact that the target population of the caregivers project was a particularly vulnerable segment of the population (the elderly) was also a stressful situation. Overall, there were both positive and negative aspects of HCI research under social confinement, which we highlight below.

Positive aspects. Despite the well-known constraints, there are a number of positive aspects regarding HCI design and evaluation in social confinement: for instance, most of the time participants are in their natural environment working on their own devices; it is actually cheaper and faster to setup a remote HCI evaluation session; and quite frequently, participants will find more time and be more available than under normal circumstances.

Negative aspects. However, limitations and risks do exist. It is much more difficult to keep participants focused. They will be less likely to pay attention and stay cooperative for longer. More over, the participant(s) may not show up at the arranged session(s). The lesser engagement and lack of personal contact sometimes results in a loose approach to the arrangements. It is also much more difficult to assess usability aspects that would normally be easily discovered during live sessions, subtleties abound and they will most likely not be detected during a videoconference.

4.1 Participants' recruitment

Recruitment is a central aspect of any HCI research experiment. When it is not performed properly, biases can occur and validity is threatened. In a lockdown or social confinement context it becomes a complex situation: no physical contact with people implies that a personal face-to-face conversation is not possible. Recruiting people to participate on a remotely-conducted experiment needs to be done using digital media, and this reduces the motivation as it narrows down the persuasive abilities of the research team.

At the same time, however, flexibility is vastly increased: performing remote HCI research makes it easier to recruit a varied and representative sample of participants. People are well-acquainted with digital videoconferencing tools and feel comfortable using them. But a myriad of other technological solutions has emerged and is becoming more mainstream.

4.2 Experiment execution

There are a number of interesting conclusions regarding the pitfalls and caveats of performing HCI experiments under social confinement.

In the caregivers' project, it was not possible to directly access the users due to the lockdown and given we were dealing with a risk population (the elderly). Their own nurses had to act as "proxies" and this led to an overhead of having to provide clear instructions for conducting user observation, semi-structured interviews and physiological data collection: this had to be entirely performed by nurses. However, this ended up running quite smoothly and it was actually advantageous given that no external influence was made: users were observed in their normal living conditions, meaning less bias to the experiment. Intrusiveness is a critical component of performing remote HCI research: as it gets more difficult to obtain data, more concerns emerge around the intrusiveness of the approach. Other research [14] explores activity prediction models as a tool to build an efficient collaboration between the elderly and care-

givers. They aimed to successfully predict an elder's next activity and its occurrence time in order to detect behavior anomalies and promote prompt-based intervention. While sophisticated sensors may reliably alert the caregiver of any relevant changes, they come at the cost of the privacy of the dependent person – one of the major factors for the acceptance of such technologies [15].

There is an increasing recognition that caregivers and care recipients reciprocally affect each other. This perspective has led to the development of interventions targeted simultaneously at the caregiver and at the care recipient, serving the needs of both. Interventions should adapt to the pandemic dynamics of the elderly-caregiver relationship and augment current tasks rather than create new ones.

Regarding the smartphone overuse project, and even in a remote context, students considered the execution of their UX assessments as quite positive, since it allowed them a greater self-awareness and reflection about the actual time they spent using their smartphones during lockdowns. But again, a clear script and good instructions were critical to the actual execution of the HCI research involved in this project.

5 Conclusion

Global crises such as the current pandemic bring endless HCI design challenges and problems. This also creates exciting novel design opportunities. Delivering usable, useful and satisfying user experiences is now more important than ever. A significant percentage of users will continue to be available remotely, even after the pandemic is over. In this sense, HCI designers and researchers need better asynchronous collaboration tools but they also need practical guidance about best practices. Existing literature about remote HCI research is ample and well-grounded, but was performed during non-pandemic times. Novel scientific knowledge should continue to be created, based on case studies and project post-mortem analyses, and condensing lessons learned in the formed of usable principles.

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