5th Asian CHI Symposium

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Title Page

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Preface from General Chairs

Welcome to Online Asian CHI Symposium 2021!

For the fifth year, Asian CHI Symposium has attracted the world's leading researchers and practitioners in the field of Human-Computer Interaction (HCI) and User Experience (UX) in Asia and beyond. The symposium showcases the latest ground-breaking research and innovation from Asia and beyond by the Asian diaspora and focuses on incorporating Asian sociocultural factors in research and innovation related to how humans interact with technology. This year, we received 69 submissions, with 58 presentations over the 2-day events, with 2 prominent Asian keynote speakers: Gierard Laput from Apple, and Hiromi Nakamura from the University of Tokyo, and 94 registered participants.

As the Asian CHI Symposium virtually returns to Asia since the first symposium in Seoul in 2015, many have changed. In terms of diversity, the number of countries represented in the Asian CHI Symposium has grown from several countries to many countries, including outside Asia, e.g. New Zealand and the United States. In terms of equity, we have provided fairer treatment, access, opportunity, and advancement for both academics (researchers and students) and practitioners to submit, present, and attend the event through General Chair Election, Blind Review, Shepherding, and Registration Grant. In organizing the event, we have also included various dedicated people from different backgrounds to have power, voice, and decision-making authority to make the symposium a success through many town halls, chairs, reviewers, and ambassador meetings.

While we miss the physical engagement, the fully online symposium has provided us with a better understanding of how to collaborate with others online. We look forward to fostering social ties among the academic community and practitioners, growing and nurturing the research community in Asia.

Sincerely yours,
Josh (Adi Tedjasaputra), Briane Sampson, Masitah Ghazali
5th Asian CHI Symposium 2021 General Co-Chairs

Preface from Paper Chairs

Presenting a high-quality Asian HCI Research collection for the 5th Asian CHI Symposium 2021 is a considerable effort. We want to acknowledge the valuable contribution of HCI research community members to make this journey a success. The journey starts with promoting this symposium to a broader audience, including the Asian researchers and diaspora, mid to senior researchers, and young and first-time-to-SIGCHI-conference researchers to share their work with the international HCI community.

Our special appreciation goes to CHI 2021 General Chairs - Professor Aaron Quigley and Professor Yoshifumi Kitamura, who has given the 5th Asian CHI Symposium Committee Members tremendous opportunity to publish selected research works as an extended abstract collection under CHI 2021 conference.

This year, we welcome two types of submissions, i.e., Original Works and Showcases. The Original Works are the original research works that have not been published elsewhere. Meanwhile, the Showcases are high-quality research works published at CHI or other family ACM SIGCHI conferences. The purpose of the Showcases on Asian-related research works or works published by Asian researchers is to inspire the Asian HCI research community.

In this symposium, we accepted 48 papers that consist of 34 original works and 14 posters. Accepted papers are from the field of Human-Computer Interaction with an intersection to Energy, IoT, Smart Cities, AI and social impact, and sustainability. The proceeding collectively provides an overview of the ground research conducted in or by Asian researchers with implications that will benefit society globally.

Each paper followed the rigorous double-blinded peer-review process by an international board of reviewers. Forms with minor revision were conditionally accepted and shepherded to improve their quality. Many young and first-time authors submitted to this symposium and got accepted.

We publish the papers in both ACM Digital Library and Asian CHI Symposium Special Publication, each with its ISBNs. For the ACM Digital Library publication, we are required to

use the TAPS system to process the publication. While this is a high learning curve for the paper chairs and the authors, we would like to acknowledge the support from the TAPS team to make this happen.

We hope you enjoy this curated publication and we look forward to having your submissions next year.

Sincerely yours,

Eunice Sari, Sayan Sarcar, Dilruksi Gamage, and Yohannes Kurniawan

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Hancheng Cao, Zhilong Chen, Mengjie Cheng, Shuling Zhao, Tao Wang, and Yong Li. 2021. You Recommend, I Buy: How and Why People Engage in Instant Messaging Based Social Commerce. Proc. ACM Hum.-Comput. Interact. 5, CSCW1, Article 67 (April 2021), 25 pages. DOI:https://doi.org/10.1145/3449141

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Zhicong Lu, Chenxinran Shen, Jiannan Li, Hong Shen, and Daniel Wigdor. 2021. More Kawaii than a Real-Person Live Streamer: Understanding How the Otaku Community Engages with and Perceives Virtual YouTubers. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 137, 1–14. DOI:https://doi.org/10.1145/3411764.3445660

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Kazuyuki Fujita, Aoi Suzuki, Kazuki Takashima, Kaori Ikematsu, and Yoshifumi Kitamura. 2021. TiltChair: Manipulative Posture Guidance by Actively Inclining the Seat of an Office Chair. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 228, 1–14. DOI:https://doi.org/10.1145/3411764.3445151

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Zhilong Chen, Hancheng Cao, Yuting Deng, Xuan Gao, Jinghua Piao, Fengli Xu, Yu Zhang, and Yong Li. 2021. Learning from Home: A Mixed-Methods Analysis of Live Streaming Based Remote Education Experience in Chinese Colleges during the COVID-19 Pandemic. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 348, 1–16. DOI:https://doi.org/10.1145/3411764.3445428

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Chang Siang Lim, Pin Sym Foong, Telehealth Core, National University Health System; Adrian Yeow, The Business School, Singapore University of Social Sciences; Gerald CH Koh, Telehealth Core, National University Health System.

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Kyle-Althea Santos, Ethel Ong, Ron Resurreccion, De La Salle University

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Xiyue Wang, Kazuki Takashima, Tohoku University; Tomoaki Adachi, Miyagi Gakuin Women's University, and Yoshifumi Kitamura, Tohoku University

Xiyue Wang, Kazuki Takashima, Tomoaki Adachi, and Yoshifumi Kitamura. 2021. Can Playing with Toy Blocks Reflect Behavior Problems in Children? Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 540, 1–14. DOI:https://doi.org/10.1145/3411764.3445119

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Maryam Mustafa, Lahore University of Management Sciences; Kimia Tuz Zaman, North South University; Tallal Ahmad, Lahore University of Management; Amna Batool, University of Michigan; Masitah Gazali, Universiti Teknologi Malaysia; Nova Ahmed, North South University

Maryam Mustafa, Kimia Tuz Zaman, Tallal Ahmad, Amna Batool, Masitah Ghazali, and Nova Ahmed. 2021. Religion and Women's Intimate Health: Towards an Inclusive Approach to Healthcare. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 232, 1–13. DOI:https://doi.org/10.1145/3411764.3445605

Special 2021 Asian CHI Symposium Publication

“I Didn’t Know Until I Saw Siri on Reels”: Studying Gen Z Users’ Voice Assistant Navigation

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Gen Z users have the highest penetration rate for adopting voice technology, but statistically, they engage less with voice technology. Our findings from the evaluation of Google Assistant and Siri usage reveal that reduced engagement is due to lack of information retention. Broken interaction while performing tasks, communication breakdowns, lack of prompts for extended learnability, and limited design scope that focuses mainly on usability and conversation design hinders user navigation. This paper analyzes empirical data on how users interact with smartphones’ voice assistants through a survey (n=74), interviews, and participatory design activities (n=8). While Voice Assistant studies focus on children, adults, and low literate users, we extend the analysis from the Gen Z perspective. Finally, we articulate design insights that shape existing usability challenges and further explore the scope for auditory and visual design.

CCS CONCEPTS • Human-centered computing • Empirical studies in ubiquitous and mobile computing

Additional Keywords and Phrases: Voice Assistants, Gen Z, Google Assistant, Siri, Voice User Interfaces, User Experience

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* Both authors contributed equally to this research

1 INTRODUCTION

Voice is an intuitive mode of communication for people [20]. Due to their emerging popularity, voice assistants are being rapidly integrated into our daily lives [25]. Speech and language interfaces that become more conversational will potentially enhance both usability and user experience [4, 34]. However, the lack of foundational guidelines for voice, with it being an emerging technology, has led to many usability challenges reported by users [23]. Studies that have evaluated Voice User Interface (VUI) heuristics have not been commercially tested, applied, or included designers and experts through the development phase [29, 35]. Hence, there is scope to improve VUI design [5, 24, 35]. This research paper complements heuristic evaluations of voice user interfaces by delving deep into user expectations associated with voice assistant engagement on smartphones.

Smartphones are ubiquitous personal devices. Additionally, smartphones prove to be a rich medium to study voice assistant engagement due to their multimodal interface, which provides alternate control modalities [21]. These devices also render accessibility to a wide range of user groups [7]. Data shows that voice assistant use on smartphones has significantly grown from 51.5% to 56.4% (2018-2020) in adult users with an 11% increase in user base [15]. With the rise in popularity of voice assistants, there is reason to believe that spoken dialogue interfaces will take their place at power with graphical user interfaces [34]. The voice assistants picked for this study are Google Assistant and Siri, as the relative market share (for smartphone voice assistants) of Siri is 46.1%, and Google Assistant is 29.9% as of 2020 [15]. Reports show that the demographic of 18 to 24 years have the highest penetration rate for adopting voice technology.

In contrast, studies on voice assistants have shown that user demographics of 18 to 24 years are statistically less likely (59%) to engage with voice than the users in the age group of 25-49 years (65%) at least once a day [27]. There is limited research to understand the Gen Z expectations and usage of voice assistants. Hence, a need arises to understand user expectations within voice assistants to complement research and inform design patterns on improving voice technology catering to this demographic. Additionally, the usage of voice assistants on smartphones by Gen Z has not been researched extensively in the Indian context. So usability challenges like learnability, discoverability, repair strategies and expectations within this group are unknown.

This paper targets this demographic to uncover deep insights into their user expectations through exploratory research. The key questions addressed are:

RQ1: How does Gen Z currently navigate through voice assistants in the context of performing command-event-based tasks on smartphones?

RQ2: What are Gen Z user expectations and resulting design insights that can enhance user interaction with voice assistants on smartphones?

2 RELATED WORK

Many existing works on voice assistants focus on improving usability through understanding user expectations. For instance, Lipford et al. analyzed user preferences and expectations for *"always-listening voice assistants"* (they will work without being explicitly invoked by users [31]) among adults 18 or older in the Global North [30]. Research shows that users prefer the personification of voice assistants or the *"human-like"* nature when the users experience the system with influences like spoken feedback from the assistant[36]. Myers et al. and Pan et al. had demonstrated a wide range of adaptive interactions to allow users to navigate according to their user preferences and user goals [18, 26], suggesting that voice assistants are more effective when adapting to user

characteristics and preferences. Hiniker et al. investigates various communication breakdown interactions and repair strategies exploited among families [3]. Research conducted by Cassidy et al. surrounds understanding ideas and expectations of teenagers in relation to smart home voice assistants. Studies highlight the difference in modalities for music search considering gender differences [14]. A study focused on improving assistance for low-literate adults explored using assistive tools through the graphical interface of a mobile [22]. A study in the Global South by Shrivastava and Joshi found that emergent users in developing regions engage better with visual interfaces as compared to audio interfaces [28].

The studies validate that research within voice has empirical data. As technology advances, there is a need to improve voice and speech technology beyond their current capability and address their visible shortcomings [23]. Gen Z, as a user group, has had high adoption rates for voice technology and smartphones. Although they are leveraging upcoming technology to fit their needs, relatively less work has been done to understand these users' needs to better design for them. Studies have argued that it is essential to develop VUI guidelines by understanding diverse group's engagement with the voice assistant at a foundational level to meet this growing demand [5].

3 METHODOLOGY

The goal of the empirical exploratory research was to seek the usage patterns and expectations that emerge through Gen Z interaction with smartphone voice assistants such as Google Assistant and Siri. A combination of methods was used to collect data. This included in-depth surveys with male and female participants and semi-structured interviews with participatory activities. The participants encompassed Gen Z, who are in the age group of 6 years to 24 years. For the research, participants in the age group of 18 to 24 years were recruited. These included those pursuing their higher education and those who had recently graduated and entered the workforce.

The research was conducted in two phases. Phase one consisted of the web-based survey where we analyzed 74 responses. Phase two was a series of semi-structured interviews and three participatory design activities. For this phase, participants (n=8) were filtered based on survey responses, such as their frequency of use of voice assistants on smartphones. The data was analyzed based on emerging themes and patterns and duly validated across the survey and interview.

3.1 Web survey

An in-depth survey was designed to understand the motivation of voice assistant usage of Gen Z over Graphical User Interface (GUI). The survey consisted of 21 questions, which included multiple-choice questions such as those about the participants' smartphone usage pattern and interface preference (between VUI and GUI). Others were more open-ended such as personal experiences and feedback on voice assistants. The third type was presented as a series of statements where users expressed their response through the Likert Scale [19]. These consisted of statements that described their frequency of use of voice assistants, ease of performing tasks through it, and listenability, among other parameters.

The survey was distributed through LinkedIn and WhatsApp. It was developed and administered in English. A note at the beginning of the survey explained the objective of the research. Responses were received from 75 participants (equal parts male and female). Among them, 74 of the participants agreed to participate in the

research and one of them denied consent. Hence, the one response was discarded. The survey was analyzed using google forms data visualizations.

In addition to this, the participants were assigned markers. For example, (a) iOS-F-001 indicating that the participant is a female iOS (Siri) user whereas (b) AN-M-002 indicates that the participant is a male Android user (Google Assistant). After this, based on the set parameters that were followed while designing the questionnaire, the data was coded.

To filter participants (who were not beginner users) for the interview and participatory activities, the users were color-coded depending on their frequency of use of voice assistants - blue for participants who used it often and pink for participants who used it sometimes. Emphasis was laid on users that engaged “sometimes” and [?] (deciding factor for proficiency within this research). This was done because the next phase of the research was designed to gather insights from proficient voice assistant users (in smartphones). The set parameters acted as the starting point to build the semi-structured interview and participatory activities.

3.2 Interview and participatory activities

Eight semi-structured interviews were conducted with participants recruited through the survey. The selection criteria for recruitment were the frequency of usage of voice assistants (those who selected “sometimes” and “often” on the Likert scale) and participants’ consent to be contacted for the second phase of the research. The consent of all participants was collected before the interview and participatory activities. They were sent a digital invite explaining the goal, benefits, and risks of participating in the research, along with the choice of voluntary participation. The purpose of the interviews and activities was to understand the engagement and expectations of participants familiar with the voice assistants on their smartphones. This phase was conducted using two remote tools, the Zoom (for interviews) and the Miro board (for participatory activities).

To understand how participants navigate through their voice assistants, the initial questions in the interviews focused on various tasks users performed through their voice assistants. Subsequent questions were framed to unpack factors that contributed to their interactions, for example - “Do you think there is more potential to your current usage of Siri/Google Assistant?, What do you think a good/intuitive voice assistant should be able to do? and Do you usually have an end goal in mind while engaging Siri/google assistant?”

As part of the interviews, three participatory activities were conducted with each participant (n=8) on the Miro board. The goal of these activities was for the participants to design a conversation keeping in mind their idea of an “intuitive” (offer more cognitive abilities) voice assistant. The first activity required the participants to pick adjectives that they associate with voice assistants.

The second activity involved participants being shown artifacts in the form of two screens with conversations between a user and a voice assistant in a given context. These two screens were designed based on the conversation guidelines of Siri and Google Assistant [13], wherein one adhered to the guidelines and the other did not. Participants were asked to exercise the think-aloud approach [25] to draw insights on the differences in the conversations indicated to them. The first two activities were planned to aid participants in thinking about the kind of interaction they wanted to design. In the last activity, participants were provided with different situations and prompt questions. These facilitated them in developing their “ideal” (their definition of ideal) conversation with a voice assistant.

All the interviews were conducted on Zoom in English. They lasted for 40-50 minutes per participant. The data was subjected to iterative, inductive analysis. Firstly, the interviews and activities were transcribed and

coded line by line. Subsequently, based on the patterns that emerged through this coding, clusters of findings and insights were mapped through affinity mapping.

4 FINDINGS

In this section, we present our findings from Phases 1 and 2 of the research in the following categories : (a) Duality for Information Retention, (b) End-to-End Interaction, (c) Communication Barriers, (d) Learnability and Discoverability, and (e) Associating feelings with Voice Assistants.

4.1 Duality for information retention

One of the observations put forth by a participant described how the bifurcation of cognitive load through the GUI and voice assistant makes it easier to process information. When probed further, the participant brought up the fundamental limitations of a purely voice-based interface compared to the multimodal interface. Their view is that:

"a purely voice user experience has a fundamental limitation of not how fast we can say things but how fast we can hear and understand things and process them sufficiently. . . when the voice user interface is augmented with a visual, like say when it is inbuilt into your phone or in an app, the visual part of it delivers the information load whereas the voice user interface can actually keep it conversational and relevant and going. . . almost like having a presentation." - (AN-M-074)

The participant noted that juxtaposing the visual load with the voice-based interaction to keep the conversation going helped them comprehend the interface response better. This was supported by another user quote:

".....let's say when I ask Google Assistant if my flight is on-time, being presented with the flight details like the gate number and other details on my phone screen while the assistant tells me if it's delayed or not helps me break down the information better." - (AN-M-074)

Another participant (AN-F-034) mentioned that when they were cooking or baking and asked the assistant to read out the recipe, it was challenging to remember everything the voice assistant said. They suggested that if the voice assistant could somehow break down the information load to present it on the phone screen while providing complementary aural feedback, it would improve their engagement with the voice assistant. The participant here voiced the need to engage with both the interfaces simultaneously through the length of the task for improved retention.

4.2 End-to-end interaction

Participants had reported their primary use case for interaction with voice assistants to be for performing hands-free tasks. This means performing the task without having to interact with GUI. In scenarios such as mentioned, we found that participants faced the challenge of not being able to complete their task, in an end to end manner, just through interaction with the voice assistant:

"....So when I tried booking a table at a restaurant through google assistant, to see if it would work. It just searched for "restaurants" on google search instead and that's it. I was expecting the assistant to book a table in a restaurant for me not to search. That I can also do myself, why do I need a voice assistant for that" (AN-F-045)

Similarly, a common challenge reported by participants stated that once the voice is activated, they wanted their interaction with the voice assistant to end only after the task was completed and not before (mid-task). Similarly, another participant (AN-M-053) explained their concern by stating:

"If the voice assistant (Google Assistant) was leading me to the Amazon e-commerce app asking for smartphones of a price range, I could do that myself. So it would be better if the voice assistant was able to guide me specifically till I make my purchase based on my needs."

Participants expressed feeling discouraged to engage further with voice assistants on their smartphones in cases where switching to third-party applications did not provide continued engagement with the voice assistant. They mentioned that their intention to engage in an end-to-end interaction with a voice assistant fell short on this account.

4.3 Communication barriers

Many instances in the interview process involved participants stating that they often encountered challenges while trying to communicate with their voice assistant. One such encounter was:

"I use Siri a lot to navigate while I'm driving and although it takes me to my destination, it has a tough time understanding area names. Like the other day when I was traveling to "Doddaballapura," I had to stop the car and manually type the name because Siri did not understand me....this word could be misinterpreted even if said by an American you know. So over here it was the word itself, not the accent. From then I decided not to use Siri for navigation" - (iOS-M-005).

In addition to this quote, multiple participants have reported their experience with encountering communication barriers [3]. These included (a) misinterpretation due to differences in accents [20] and dialects (as reported by users), (b) failure on the part of the voice assistant in distinguishing between homophones; for example, a participant (AN-M-074) described instances when he was unable to play the song he wanted because many songs have the same name and the voice assistant did not probe to narrow down on the song the participant wished to play and (c) misinterpretation of *"difficult"* words (like, ("Doddaballapura"). The instances mentioned above forced users to repeat commands, which led to reduced usability and frequency of engagement. In addition to this, the voice assistant's response to open up google search (a feature of the multimodal nature of smartphones) when it is unable to perform a task frustrated the participants. This also contributed to the reduced engagement.

4.4 Learnability and discoverability

Participants claimed their primary engagement with voice assistants to be when they had an end goal in mind. The rate of discoverability and learnability (the ease with which new users can begin effective interaction and achieve maximal performance) [7] went down after they figured out fundamental interactions to perform common command event-based tasks (like setting an alarm or reminder). This was highlighted by a participant who went on to say that:

"I wasn't aware of all the uses of Siri. I thought it was only for smaller tasks like setting an alarm or asking Siri for knock-knock jokes until I saw friends of mine use it or reels on Instagram for tasks like dictating an essay" - (iOS-M-072)

Such an occurrence was noted as a common challenge among multi-modal interfaces in previous studies [2, 8, 12, 23]. Participants expressed that current forms of learnability only existed through YouTube tutorials or

visual menus [26] that are either hardly noticeable or get repetitive and boring. For example, a participant (AN-F-045) quoted,

"...Initially, when Google Assistant came out, I played around and explored with it but now the prompts have just become repetitive and I do not see anything new, so I use it only for goal-oriented tasks."

Participants also suggested approaches that would increase their learnability such as:

"I would like an update from Google Assistant where it would not take up too much space as an overlay over everything else while I am doing. All I need to see is if my command is being recorded correctly. This may be a good way to get people to use it, without making it invasive" - (AN-M-074)

4.5 Associating feelings with voice assistants

We found that many users mentioned the need for voice assistant design to focus beyond just usability to make them more eager to interact with it. One participant recognized how their engagement is limited and they surmised that:

"the tone and personality of the voice assistant (Siri) would be a huge stepping stone for me. It would be interesting if I could listen to the daily news in the voice of my favorite newsreader or listen to match highlights with the energy of a sports commentator. I like him (name) because of his energy of picturizing the football field. The same voice of his would be good to listen on Siri while listening to the sports news..." - (iOS-M-005)

In light of such inputs, we uncovered the need for a design that focuses on improving interaction with voice assistants. An example could be, imagining voice assistants whose tone, pitch, volume, or even persona depend on the given task [6]. Participants recognized this as a factor that would increase their engagement with voice assistants. Another participant (AN-F-063) also mentioned,

"...It would be cool if I could build you know, a "relationship" with my VA. I personally feel like it will make me want to keep going back to the VA. Now it just seems like something I can use to finish a task but not have fun with..."

The participant noted a disconnect with the voice assistant, wherein they interacted with the voice assistant to finish the task. They have mentioned a need to develop a personal "relationship" as a requisite to improve their engagement.

5 DISCUSSION

Our goal through this research was to understand how Gen Z users (within the Indian context) navigate through voice assistants on smartphones and uncover insights to enhance their interaction with said voice assistants. Our research provides insights that can be built upon to enhance interaction beyond usability and explicit conversation design.

5.1 Usability

A recurring sentiment expressed by participants indicated the difficulty they face in digesting large chunks of information. This holds true when they are provided with heavy aural feedback during hands-free tasks such as cooking, driving, etc. We question that if a person isn't comfortable grasping large chunks of information purely through voice, how does that affect the way they perform hands-free tasks with a voice assistant? Compared to pure voice-based interactions (no GUI present), the multimodal nature of smartphone interfaces holds an advantage. We find an opportunity for design exploration through creating different mechanisms to leverage

the GUI and the voice assistant in combination. This can be supported by the theory - the “split attention effect” [17], which states that having visual cues along with aural feedback leads to more excellent retention. Voice assistant design needs to address that utilizing visual prompts along with auditory prompts will result in a high recall and engagement with users [11]. By exploring ways to communicate feedback through balancing the cognitive load between Voice Assistant and GUI, we can explore new opportunities for screen and conversation design in the context of smartphone devices.

Another feature of the multimodal nature of smartphones allows voice assistants on these devices to redirect users to GUI, abruptly ending engagement before the task is completed. In particular, the engagement breakdown that occurs when participants enter third-party applications was observed as a challenge. Additionally, the interaction ending abruptly when the voice assistant cannot perform a task discourages users from engaging with the voice assistant again. The opportunity to design for an end-to-end interaction is, thus, crucial to increase usability [7]. When looking at such an obstacle, we found that it is critical to question alternative ways that a GUI could respond in such a scenario. How can we capitalize on the multimodal nature of smartphone voice assistants to better mediate between third-party applications? When interacting with the third-party applications, participants expect the assistant to be present until the task has been completed, with the voice as the primary communication link throughout the engagement.

At times, however, when the voice assistant fails to understand the command issued by the participants, the participants themselves switch to GUI. With increased communication barriers, participants reported switching back to GUI rather than applying repair tactics to overcome the obstacles [33]. Studies have shown that users of smart home devices use various tactics such as code-switching (which involves recognizing different communicative expectations for different communication partners and/or different communication environments [16]) to overcome obstacles faced. For example, teenagers use an altered conversational tone and vocabulary when interacting with their peers than with parents [3]. Conversely, how can we capitalize on the presence of VUI to build aural tactics for users to overcome obstacles faced? This break in the interaction serves as an opportunity for the voice assistant to gather information on why the user chooses to end the interaction before completing the task. The voice assistant instigating interaction to learn more could also sway users to increase their interaction even when facing difficulties. Additionally, studies show that people perceive forms of artificial intelligence (like robots) more positively when it makes “vulnerable statements” than when it makes passive statements or none at all [32]. Voice assistants (also a form of artificial intelligence) can leverage this characteristic and follow a similar approach. This opens up opportunities to traverse conversation design as a means to mend the broken communication between the participant and the voice assistant.

Extended learnability also plays a huge role in fostering continued interaction between the voice assistant and participants. Based on our analysis, we need to consider the decrease in learnability and discoverability after the initial interaction with smartphone voice assistants. Participants noted that once they learned fundamental interactions that equip them to perform common command-event based tasks, the discoverability is minimal to none. Studies suggest alternative approaches to this challenge. Myers (2019) introduced the adaptive approach to increase learnability beyond initial use (extended learnability)[1, 10] using API.AI (a platform used to develop natural language interactions like Facebook chatbots and Amazon Alexa skills) on DiscoverCal [7]. Our research highlights the need to introduce extended learnability within smartphone voice assistants. Consequently, we pose the question: How can the multi-modal interface be used to provide visual feedback that is not missed but at the same time does not feel intrusive to the user? A few possibilities could

be using overlays that indicate that the user feedback is being recorded while not taking up too much space in a manner that allows the user to perform ongoing tasks and even pop-ups that give participants personalized prompts to help them perform tasks. Design opportunities within this landscape could be further explored.

5.2 Beyond usability

Voice assistant design in the present scenario focuses explicitly on conversation design and developing mechanisms to improve the usability aspect. However, there is a need to expand the scope further [9]. Participant expectations to push the envelope with voice assistant design would acquire a new meaning if we try to address them from a sonic instead of the usual conversational paradigm. Their comments hint at the potential present to design sound interactions beyond simple textual content. Thus, expanding the design scope for voice assistants to include more than just usability and current conversational design could increase engagement with users [6]. Exploring possibilities in incorporating sound design elements like auditory icons, emoticons, and musicons [9] could address participant expectations (Gen Z) of bridging design gaps within the current voice assistants. Studies show that auditory elements can be extended in various directions to enhance experiences (voice assistants in this case) [9]. For example, spearcons (sounds obtained by speeding up speech sounds to the point that it is not recognized as speech) are particularly suited to compliment GUI.

6 CONCLUSION AND FUTURE WORK

We conducted an exploration of Gen Z user navigational issues with voice assistants on smartphones that inform design insights to enhance voice assistant interaction to better suit their needs. We gathered perspectives of Gen Z with the aim to extend the literature in designing voice assistants. Our findings indicated that for the improvement of voice assistant design in multimodal smartphone interfaces there is a need to expand on the current focus on usability and conversation design. The multimodal nature of smartphone interfaces provide opportunities to develop a better synergy between visual and sound design for voice assistant interaction. Our analysis provides a deeper understanding of the user expectations to shape the design of the voice assistants. Future work could examine how Gen Z users behave with voice assistants in one context such as when booking a taxi, using a calendar on mobile phones. Further intent (what the user wants to do) and its utterance (how the user says it) need to be studied to make voice assistants contextualized for Gen Z.

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Running or Jogging Together to the Future, Virtually

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Running or jogging is one of the physical exercises that is capable of improving one's healthy lifestyle apart from enhancing social interaction such as running or jogging in group of friends. To run or jog with friends could be fun, enjoyable, and encouraging but to run or jog with compatible friends having the same pace, endurance, capability, same time, same day, and same venue are not easy. At the present moment, there are various types of running applications available that allows running or jogging to be executed; 1) either physically or virtually; 2) either in a co-located or different locations; 3) either individually or group; 4) either competitive, charity, or training; or 5) run or jog for health purposes. However, these applications either have to pay to use its comprehensive functions or have restricted functions to use if available for free. Therefore, a virtual running application is being proposed that allows runners or joggers to use allowing them to; 1) run or jog individually or group; 2) create their own running or jogging events; 3) avatars to show running or jogging positions in group activity; 4) elevation gains; and 5) allowing split run or jog, split venues, split times, and split distances to be displayed. Comparing previous studies to improve what the proposed virtual system are lacking in order to produce Human Computer Interfaces that are friendly, ease of use, satisfying, and enhancing social interaction. The improved features enable initiators to create running events and all running events' status to be displayed within the proposed system. It has avatars feature to reflect runners' current position, have running venues display, and no uploading results to organizer required.

CCS CONCEPTS • Human Computer Interaction (HCI) • Interaction Design • Collaborative and Social Computing

Additional Keywords and Phrases: Virtual Running, Ease of Use, Satisfying, Social Interaction, Friendly

1 INTRODUCTION

A new novel coronavirus (COVID-19) that is caused by SARS-CoV-2 has been announced by the World Health Organization (WHO) as a fatal global pandemic [1]. This deadly infectious disease is mainly transmitted through respiratory droplets and contact pathways. WHO and national health authorities, has recommended social distancing as one of the means to control the outbreak of this pandemic [2]. The Malaysian government has taken proactive action to prevent the spread of COVID-19 and one of the many regulated restrictions is suspending or cancelling all sporting events and competitions, closing all gyms, public swimming pools but one important exception has been made allowing people to practice certain sports and outdoor physical activity, such as running or jogging, provided that social distancing of at least one (1) meter must be maintained. Group running of more than two is prohibited and if two were allowed they must be family members. This ruling thus have a major problem impact on the potential deleterious effects of physical inactivity due to interpersonal distancing. Imposing a social distance of at least one (1) meter has negative impact on sedentary behaviour and physical activity. Barkley et al., 2020, found that sedentary behaviour of university students increase during the COVID-19 pandemic [3] whereas healthy adolescents between the ages of 14 to 18 in Saudi Arabia decreased their physical activities during the COVID-19 pandemic [3].

The WHO targeted in reducing the prevalence of physical inactivity by 15% by 2030 [4] and has established clear guidelines on the minimum amount of physical activity necessary to maintain sufficient one's health and fitness. For example, adults

between 18 and 64 years should engage a weekly training of at least 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous-intensity of physical activity [5]. Limited physical activity or, even more worrisome, inability to do regular walk outside of one's home due to strict quarantine may associate with a kaleidoscope of unfavorable metabolic effects that would dramatically increase the risk of many severe and disabling disorders such as diabetes [6], cancer [7], osteoporosis [8] and cardiovascular disease [9]. Hence, encouraging participation of physical activity such as running or jogging, either individually or within group, should be motivated to live a healthy lifestyle besides avoiding the unfavorable diseases. Currently, Malaysian's MCO rulings forbid running in group of more than two (2) runners and must observe the one (1) meter social distancing. A virtual running apps can be developed to overcome the runners within a group problem. With the virtual running apps, runners can run together whenever, wherever and whoever they want to run with. Previous study had found that 63.51% of respondents were interested to run with friends virtually at any day, anywhere, and anytime and felt that virtual running was interesting, promoting social interactions, and motivates them to stay active [10].

One of the most popular forms of sports that can be considered healthy, relaxing, or pleasant is running [11]. Running can either be done within group or individually [12]. It was found that running in group have extra health benefits as compared to running individually [12] as well as enhancing connectedness, social support, and peer bonding [13]. There are two types of running namely physical run and virtual run. Physical running is where runners needed to be present at the specific venue, day and time to perform the run physically. On the contrary, participants do not have to be on the specific venue, day and time for the virtual run as it can be executed at anywhere, anyplace and anytime. It can also be held indoor such as treadmill or in other countries. However, virtual run requires online platform to record its activities. Generally, a virtual run consisted of three main steps such as; (1) selecting a running activity or race; (ii) run and record the activity; and (iii) submit the results to the organizer via the online platform [14]. However, the details and methods of each virtual run various from one another. The virtual run organizers create the instructions on an online platform [15, 16] and it allows participants to run at any location such as on road, on track, on treadmill, at any time. A participant needs a device to record the running activities that connects to the organizer's platform. For example, participants can record their running history on a mobile or wearable device, as well as by taking a photo of the results on a treadmill screen. To submit the running results, some organizers provide a web based platform where participants can submit their results. Some virtual run activities offer a real-time platform where participants can accumulate the total running distance or time on a mobile application.

However, most of the virtual running apps have limited functions such as only allowing leader in the group to create group running, post it on social media and friends will join the group run only if they check on the web page for suitable running events to join. Some running event organizer allow runners to register and pay then only permit to download the virtual running system to use till the actual event for free. Once the event is over, the virtual running apps can no longer to accessible. Hence, a new proposed virtual running system allows runners to download to their smartphone for free to use unlimited number of run. Runners can take the opportunity to run any day, whenever, wherever and with whomever with this new virtual running system. This proposed virtual running system permits runners to run either individually or within a group, virtually. In view of the current pandemic Covid-19 and government imposing the MCO restricting group exercises to only 2 family members in public places, runners from different geographical locations can still manage to run together at the same time and day virtually as exercising with others may enhance social connectedness, social support, and peer bonding [17] as well as health benefits [18]. Besides, this virtual running systems have persuasive factors to motivate users to participate such as friendly competition, rewarding systems, avatar representing runners in race, communication, calculating energy expenditure, and determine the elevation gain for the running route. The proposed virtual running systems allow any runner to create their own running event either individually or group run. Notification of newly created group events will be sent to all members in the group. Group results will be displayed for public to view. As some solo runner who wants to do secret training and do not want others to know their performances, results can be displayed privately otherwise. Running can either be done in one session or several sessions. Initiator is capable of monitoring group members run. Upon reaching the targeted distance set, the apps will announce the achievement. Avatar agents representing runners will show the runners' position for group running.

The paper is organized as follows: related work; methodology; results; discussion; and a brief description of conclusion and future work.

2 RELATED WORK

Specific application that are downloaded and installed in user's mobile phone is known as mobile applications (apps). These specific apps are specially designed to meet specific category of runners in order to encourage, promote and stimulate physical activity participation [19]. Developing these apps employed new communication technologies and social media interaction to improve the motivation of users to perform exercises [20]. There are a varieties of virtual systems for sports that are available such as running, marathon, cycling, swimming, treadmill, etc. Examples are such as [1]Garmin's Forerunner 745 (swimming, running and cycling), [2]Strava (running and cycling), [3]Sunnto 9 (running and hiking), [4]Runkeeper and [5]Runtastic (running).

Mulas et al. [21] developed a virtual running apps that allow runners to run virtually at a predefined date, time and distance that are set by the any members. The created events will be posted to social network Facebook and other members will have to check for the current running event status. All the runners need to do is to join in the event and just wait for the scheduled event to start. Upon completion, results will be posted to the Facebook for other members to view. However, runners needed to create group run event to be posted on Facebook prior to run so that other interested members can join. The creator of the events can also invite other members to join their group run otherwise members have to check for these information regularly for the latest update on the run events. Upon completion of each run, members have to upload their results to Facebook for others to view. Members must be disciplined to upload immediately otherwise. Again, the process of uploading still needs to be manually, and is dependent fully on the runners to execute.

Zhang et al. [22] developed a similar virtual running apps allowing runners to compete against each other on treadmill. However, competitors must upload results manually to each other via internet at the end of the race. This manual step can be exhaustive and repetitive, and if the step is forgotten, there is no way to compare running results.

Mueller et al. [23] developed the virtual running apps that permit different runners to compete from opposite end of the world wearing special gadget on the body while running. Both runners must start at simultaneously at the agreed time regardless of different time zones. Runners know their partner's position by the sound that appears in front, same lever, or behind their head from their headphone that indicate partner is either ahead, same, or behind respectively. Upon completion, each runner will have to upload their results to each other manually via their handphone. Although no screenshots are needed, the system required runners to have special equipment such as headphone and another special gadget to be strapped on to their chest. Both these extra weight gadgets were cumbersome to wear during running.

Virtual Marathon System [24] was another system that allowed runners to experience marathon races virtually on the smartphone. It made use of an agent, representing runner, to move along the marathon route on the screen. The systems displayed several user interfaces to show the marathon routes on the runner's smartphone. This enabled runners to toggle other runners while moving. However, as it was designed for marathon races, only the organizers can create the race event and monitor the leaderboard, whereas runners themselves could not view the results until the end. Besides, it has too many interfaces allowing runners to toggle and these pages eating up too much memory spaces which might slow down the processing speed. Allowing it to on throughout the race will also drain out the battery power too.

Thus, to overcome the problems associated to above mentioned systems, a new virtual running apps will be proposed where runners need to download the virtual running apps to their mobile phone without special equipment needed. This new apps enable any runners to create individual running event or group running event to post it on the app's running event page. Notification for newly created group events will be sent to runners so that they are aware of new group run events to join instead of checking social media [21]. Upon completion of the run, results will be displayed automatically relieving runners from posting the results manually, solving the hassle currently practiced by [21,22]. Runners just have to download the apps to their hand phone and avoiding spending cost to purchase special gadgets [23]. Both these extra weight gadgets were be cumbersome to wear during running. To save unnecessary memory wastage, the proposed apps will only use one page to have avatars showing

[1] https://www.garmin.com.my/products/wearables/forerunner-745-black/

[2] https://www.strava.com/mobile

[3] https://www.suunto.com/en-my/suunto-collections/suunto-9/

[4] https://play.google.com/store/apps/details?id=com.fitnesskeeper.runkeeper.pro&hl=en&gl=US

[5] https://www.runtastic.com/

runners' current position and to have longer battery usage, the proposed apps will shut off the current screen after a few seconds. This helps to alleviate the situation for system by [24].

Previous studies found that group participation in sports have social benefits such as enhancing social connectedness, social support and peer bonding [17, 25]. A study by [26] found that walking together with someone has value in the form of companionship. A study by [27] found that there has been an increased in emotional social support amount senior citizen performing group exercises. Apart from reducing the risk of physical and mental illness, group exercising improved social relationships among group members [28]. Another study by [29] found that park runners reported superior satisfaction within their community whereby women benefited from improving their mental health whereas men improved their connectedness. In addition, park run within community continue to improve the healthy habits among athletes, and for non-athletes it enhances their activity and social interaction.

3 METHODOLOGY

This study employed both qualitative and quantitative techniques. Users will be asked to run both individually and within group, virtually, using the virtual running apps. Users will then be asked to answer an online questionnaires to obtain their perceptions of the virtual running apps. This will be followed by interview where individual opinion of the virtual running apps will be asked.

3.1 Designing questionnaires

The self-administered online survey questionnaires were conducted in English. The targeted subjects were runners regardless of gender, race, nationality, and all were above 18 years of age. Due to the current pandemic Covid-19 and the movement control operation (MCO) imposed by the government, recruiting subjects will be via social media such as Whatsapp. Duration for data collection was from December 2020 to February 2021.

To avoid typing mistakes, a set of answers were created for respondents to choose. Questions related to respondents' physical activity details, running preferences, easiness of getting friends to run together either in co-located or different venues were defined, (refer to table 1).

Table 1: Physical Activity Details

Defining running characteristics	Questions
Running preference	You enjoy running/jogging _____
Physical activity detail	On the average, how many times do you run/jog in a week? What is the total distance that you run/jog in one session? What is the time taken for you to complete the above distance, approximately?
Perception of getting friends to run together	Do you easily get friends to RUN TOGETHER AT the SAME PLACE, SAME DAY and SAME TIME? Do you think it is easy to get friends to RUN TOGETHER on the SAME DAY and SAME TIME BUT DIFFERENT PLACES?

In relation to the proposed virtual running apps, respondents were asked to evaluate the virtual running apps in terms of usability [30], satisfaction [31], ease of use [32] and sociability [33]. There were 10, 7, 11, and 3 questions being asked in usability, satisfaction, ease of use and sociability respectively. Likert scale of 1 to 5 being used to measure where 1 was equivalent to strongly disagree to strongly agree for 5.

3.2 Sampling method and subject recruitment

There two different categories of sampling methods: 1) probability sampling methods where all subjects in the targeted population have equal chances to be selected in the sample [34, 35, 36], and 2) non-probability sampling – based on researcher's choice, population that accessible & available [37]. In non-probability sample, subjects can be enrolled according to their availability and accessibility [38]. This method is quick, inexpensive, and sample elements can be recruited according to their convenient and proximity [36].

3.3 Participants and setting

All participants were on a voluntarily basis. There were a total of 30 participants for the individual run and 11 participants for the group running. 11 participants agreed to the interview for both individual and group running. Due to the current pandemic Covid-19 and government imposing the MCO restricting group exercises to only 2 family members in public places, this study was

conducted virtually whereby all participants were be required to run at venue that was most suitable and convenient to them. They could either walk or run outdoor as well as indoor via treadmill. Participants were then required to answer a questionnaires on line via a link provided to them at the end of the session. A virtual meet was held with participants to get their opinions and suggestions pertaining to the systems they just used.

3.4 Data collection

Data collection period was from December 2020 to February 2021. Participants were asked to download the virtual running apps via a provided link. For the individual running experiment, participants were required to create their own run events with the flexibility of mileage they want to complete anytime and anywhere. Upon completion of the running event, participants were required to send a screen shot of their results and complete a questionnaires via a provided link too. Questionnaires collected were analysed. Interview was conducted and recorded via a virtual platform. As for group run, an initiator would create a group run event and would invite members to join in at the specific date and time but different venues. The initiator would send in the screen shot of the completed race. The focus group interview was conducted virtually and the interview was recorded after the group had completed their group run activity.

3.5 Statistical analysis

Descriptive statistics are used to describe or summarize the characteristics of sample or data sets, for example variable's mean, standard deviation, or frequency. Inferential statistics used any number of techniques to relate variables in a data set to one another, such as using correlation or regression analysis. A mean is the simple mathematical average of a set of two or more numbers. A standard deviation is a statistic that measures the dispersion of a dataset relative to its mean. A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related in certain features [39]. A percentile is a number where a certain percentage of scores fall below that number [40]. Mean and standard deviation would be used to analyse questionnaires feed whereas mean, standard deviation, t-test and percentile ranking would be used for analysing the virtual running apps. Questionnaires and interviews would be used to explore the collected data. Both descriptive and inferential statistics would be used for data analysis as follows:

- Questionnaire – descriptive statistics & inferential statistics
- Interview – inferential statistics
- Log files - descriptive statistics

4 RESULTS

A total of 30 participants, comprised 11 males and 19 females, volunteered for the running experiments. The average age was 32.5 years old and standard deviation was 12.5 years old. All participants engaged in physical activities regularly either running or walking. 60% of participants enjoyed running alone whereas 40% enjoyed running with friends, (refer to figure 1). On the average, participants engaged 2.3 days in physical activity weekly, covering an average of 3.5 kilometres each session and clocked an average of 33.4 minutes for each session, (refer to table 2). 80% of participants responded that it was not easy to get friends to run together at the same place, same day and same time whereas 67% replied that they do not think it was easy to get friends to run together on the same day and same time but at different places, (refer to figure 2). Participants rated poor for the proposed virtual running app's usability, moderate for satisfaction, ease of use and sociability, (refer to table 2). This suggests that features to use were not sufficiently friendly due to poor navigation and function buttons too textual making it confusing to use. In spite of this, majority of the respondents found it easy to use, suggesting that they were satisfy using it after a few rounds.

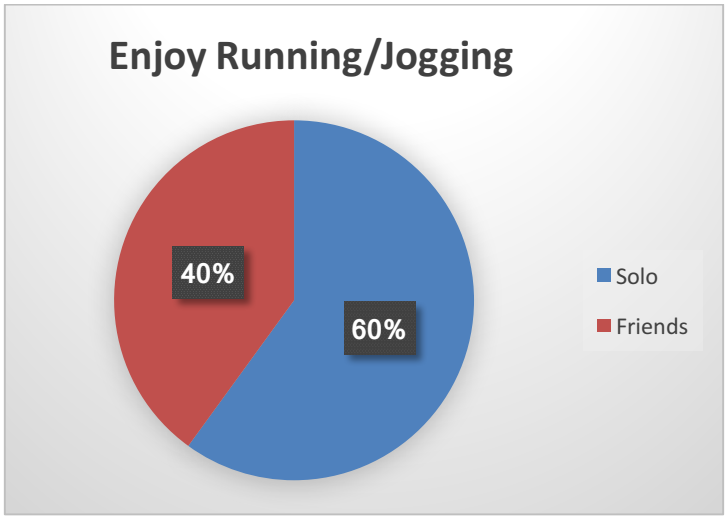

Figure 1 Breakdown of runners preferring running solo versus running with friends

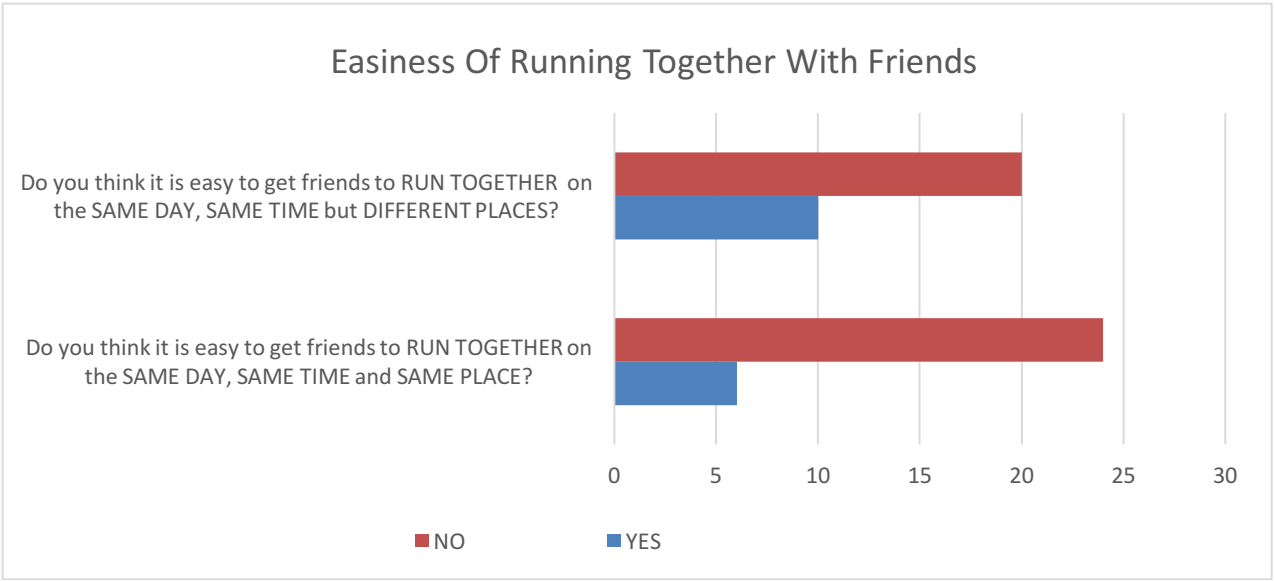

Figure 2 The perception of easiness in getting peers to run together

Table 2: Physical Activity Details

	Mean	Standard Deviation
Weekly running/walking	2.3 days	1.5 days
Distance covered per session	3.5 kilometres	2.6 kilometres
Time clocked per session	33.4 minutes	19.5 minutes

Table 3: Proposed Virtual Running Apps Evaluation

	Mean	Standard Deviation	Percentile Rank	Description
Usability	60.4	17.2	61.3%	Poor
Satisfaction	3.5	3.2	50.0%	Moderate
Ease of Use	3.5	3.2	34.0%	Moderate
Sociability	3.5	3.2	49.0%	Moderate

5 DISCUSSION

The aim of this study was to gain an insight among participants' running characteristics, running preference, and using the proposed virtual running apps. This is an important step toward enhancing the existing proposed virtual apps further based on feedbacks coming from participants. This is to encourage participants to continue using the virtual running apps to improve their connectedness, satisfaction, sociability, and leading a healthy life [28].

The study found the same percentage, 60%, of runners preferred to run individually as study carried by [41]. This is in line with previous studies carried out that running is an activity that is mostly practiced individually [42]. Reasons for not running in groups rather individually could be due to their work commitment, unable to get compatible partners to run together, and the presence of other might affecting their performances [43].

It was found that participants did not find it easy to run with partners on the same day, same time, and either in co-located or different venues and reasons could be due to the pandemic Covid-19 as well as the government MCO allowing not more than two family members to run together. Running with friends could be fun but it is not easy to find compatible partners to pace with the same speed, venue, and distances [10].

For the proposed virtual running apps, it was found that usability was poor with a percentile ranking of 61.3% whereas satisfaction, ease of use, and sociability were moderately acceptable with percentile ranking 66%, 34% and 49% respectively. The not so encouraging feedback from participants could be due to poor navigation, confusing textual message buttons, and unfriendly interface designs. Respondents preferred to use simple and easy to use apps interfaces. Hence, based on the comments from participants, initial set of design criteria for the virtual running apps being proposed as follows:

5.1 Criterion 1: Using avatar or agent to motivate runners

This study found that majority of participants enjoyed running using the avatar. The avatars that appear on the screen of smartphone, reflect the location of other runners using the same system, will motivate runners to do more running [24]. For example, P1, P2, and P3 commented on how they react to the avatar screen.

P1: *I enjoyed running in group as I can see my friends, where are they and if I am behind I can run faster.*

P2: *I prefer virtual run, I think a bit connected because I can see someone I know race for two kilometre something like that and then I also join in.*

P3: *Yes, at least we can motivate each other to run better pace or sometimes we feel like lazy to run, you know at least you have someone or friends who encourage you to run.*

5.2 Criterion 2: Navigation

The study found that navigating from one page to another was complicated as runners have to select too many buttons. Most of the buttons were too textual based and rather confusing with the actions. Runners have to move around and testing the buttons to get the right functions they wanted. Hence, more direct and efficient interface should be provided for runners to use. Efficiency refers to how fast runner can get their job done and can be measured by the time taken to complete a task [44]. Hence, international symbols could be used instead of textual based buttons as what P4 and P5 commented.

P4: *The message buttons in the stopping page was too confusing. I have to click so many times to stop. Should be simple like the Kuala Lumpur Standard Chartered Marathon Virtual Run 2020.*

P5: *Can use international symbols to represent standard functions such as "Start", "Stop", and "Pause" instead of textual message button.*

5.3 Criterion 3: Satisfaction

This study also received negative satisfaction feedback from participants that the announcement of completing the targeted distance to be annoying, frustrating and disturbing [45]. Besides, there is only announcement at the end of the run and no

announcement being made at every kilometer completed, commented P6, P7, and P8. Therefore, a more helpful and entertaining announcement should be made and inform runners on their running distance details.

P6: *I don't know how far I run, so I keep running until the final announcement.*

P7: *When reached the target goal, it keeps on announcing and feel frustrating. I have to stop and close it.*

P8: *Should announce once or twice and then switch it off automatically. I can continue running.*

5.4 Criterion 4: Learnability

Learnability is the time taken to learn a task [45]. This study found that all of the participants did not read or follow the operating manual when they access the virtual running apps as they manipulated the operation by try and error. Feedback from P9, P10, and P11 was that learning the operating procedures were rather confusing.

P9 : *It was confusing initially, but after a few tries, I can manage it.*

P10: *I cannot find the creating event button.*

P11: *Suggest to create a main menu instead, easy to navigate.*

It is important to note that this is a preliminary study. Due to the limited number of participants in this study, ability to draw a more certain conclusion is rather limited. The survey questions design, instructions manual to participants, responses from participants and other factors over the course of this study could affect the results differently. In future, usability, satisfaction, ease of use, and sociability testing of the virtual running apps is necessary.

6 CONCLUSION AND FUTURE WORK

This study found that it was not easy to find partners to run or jog together on the same day, same time, either same or different venues. The study also found that the usability of the proposed virtual running apps was poor, satisfaction, ease of use, and sociability were moderately acceptable.

The future work for improving the proposed virtual running system includes providing runners with necessary precautionary information such as appropriate levels of physical activity for individual, how to prevent injuries, and some warm up guides before run as recommended by [46] and safety issues while running [47]. The proposed virtual running system should make the avatar feature in real-time situation so that runners could feel how far ahead or behind their group members, creating a sense of competitive mood ambience. Letting runners know after each kilometer they ran and notifying runners on the newly created running events by initiators would be recommended as well.

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Review and Prioritization of Accessibility Guidelines for Video Game Development

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Video games are an interactive medium and these interactions are performed by the player through combinations of sensory and motor inputs. As a result, video games are often highly dependent on the functioning of the different senses of the player and ability to perform the required motor functions by the player. This often results in the video game becoming inaccessible to people suffering from various types of disabilities. However, this can be remedied to some extent by adding some accessibility options to a video game that account for some of these disabilities thus, making the game more accessible. The Institute of Computer Science - Foundation for Research and Technology – Hellas, Greece, has created a list of accessibility guidelines that developers should follow to make their games more accessible. They have demonstrated the need for the implementation of these guidelines by creating a universally inaccessible game that ignores all these guidelines and an universally accessible game that implements all guidelines. The aim of our study is to review, highlight and elaborate on these guidelines as well as to provide a priority order that a developer can follow if they are unable to implement all the guidelines. The paper also provides examples of video games and industries that have the effective implementation of a particular guideline. In future, it is recommended that video games should be developed with compliance to all high and medium priority accessibility guidelines discussed.

CCS CONCEPTS • **Human-centered computing~Accessibility~Accessibility design and evaluation methods** • Human-centered computing~Human computer interaction (HCI)~HCI design and evaluation methods

Additional Keywords and Phrases: Game Accessibility, Video Games, Guidelines, Prioritization, Game Development.

1 INTRODUCTION

In recent years, video games have seen a dramatic boost in popularity as a source of entertainment. According to a survey by J. Clement on Statista [1], there were 2.69 billion gamers worldwide in 2020 and this number is projected to rise to 3.07 billion in 2023. Despite this increased interest, a significant number of people encounter barriers when playing games, due to some disability. Around 92% of people with impairments play games despite difficulties [9]. In most cases, developers most often do not take into consideration people with disabilities when they are creating video game applications. Accessibility problems may include not being able to receive feedback, to determine in-game responses and to provide input using conventional input devices. People with disabilities are thus partially or completely excluded from being able to enjoy and experience video games. Games, considered as a field of research, could provide new interaction principles, which can be incorporated into the existing HCI Standards, thereby complimenting, and expanding these standards positively. It is important to ensure that everyone has accessibility to this technology, regardless of abilities or age.

This paper focuses on reviewing and highlighting the accessibility guidelines curated and demonstrated by Institute of Computer Science (ICS), Foundation for Research and Technology – Hellas, Greece (FORTH) with their two games – **'*Game Over!*' (a Universally Inaccessible Game) [3], and '*Terrestrial Invaders*' (a Universally Accessible Game) [2].** These games are perfect examples of the two extremes regarding accessibility in video games and showcase the basic accessibility guidelines that developers should consider implementing in their games to improve the user experience while including a wider group of players.

1.1 ICS-FORTH

The 'FOundation for Research and Technology' - Hellas (FORTH) was founded in 1983 at Hellas, Greece. The Institute of Computer Science (ICS) is one of the eight institutes of the FORTH. Following games are developed by FORTH:

1.1.1 Game Over!

'Game Over!' is a universally inaccessible game developed by the Human-Computer Interaction (HCI) Laboratory at FORTH's Institute of Computer Science (ICS). It is designed such that every level has the same goal to achieve but every level is extremely hard or even impossible to complete as it ignores a very important accessibility guideline. Game Over! essentially serves an educational purpose by highlighting the need for implementation of game accessibility guidelines. Game Over! provides an experience of how it feels interacting with a game that is not accessible due to the exclusion of basic accessibility features. Figure 1 is a snapshot of an ongoing level in 'Game Over!' where enemy spaceships (at the bottom of the screen) are shooting at the player (at the top of the screen).

1.1.2 Terrestrial Invaders

'Terrestrial Invaders' is the by-product of 'Game Over!'. The developers at ICS-FORTH made a Universally Accessible version of 'Game Over!' by showcasing the implementation of every accessibility guideline in its gameplay. Figure 2 is a snapshot of an ongoing level in 'Terrestrial Invaders' where enemy spaceships (at the bottom of the screen) are shooting at the player (at the top of the screen). There are textual prompts for every action.

Figure 1: Gameplay of 'Game Over' [3].

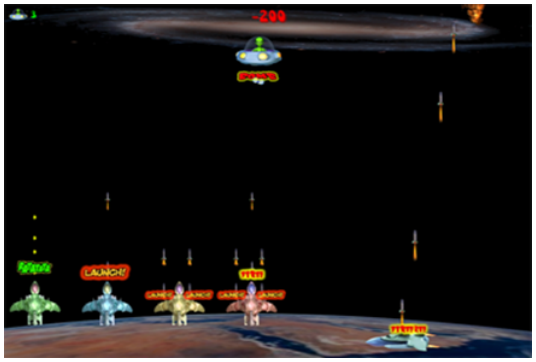

Figure 2: Gameplay of 'Terrestrial Invaders'

2 RELATED WORK

Accessible.Games [4], is an effort by AbleGamers Charity [5] to aid developers make their games more accessible. They have broken down accessible design into three layers represented as the 'APX Triangle' [6].

A research work related with Game accessibility [7], published a full list of game accessibility guidelines segregated into categories viz. motor, cognitive, vision, hearing, speech, and general, with further classification into basic, intermediate, and advanced, based on ease of implementation.

3 PRIORITIZATION OF ICS-FORTH'S GAME ACCESSIBILITY GUIDELINES

While implementation of all twenty-one guidelines proposed by ICS-FORTH [22] in every game would be ideal, developers may face resource constraints that make it difficult for them to effectively implement all of them. Furthermore, due to the situational nature of some of the guidelines, every game might not require the implementation of every guideline as some guidelines might be irrelevant to it or the game may already have mechanics that serve the same purpose as the guidelines.

Our criteria for prioritization of ICS-FORTH's accessibility guidelines for video games, are as follows:

- **High Priority:** Guidelines will be assigned 'High Priority' if either their exclusion makes the game inaccessible to a vast majority of the population or if their inclusion is already Industry Standard and is expected in every game. A guideline could also have 'High Priority' if it is easy and resource efficient to implement while considerably increasing the game's accessibility. Implementation of these guidelines in every video game is a must.
- **Medium Priority:** Guidelines will be assigned 'Medium Priority' if they are situational and do not apply to every game, but they drastically increase the accessibility of the games that require their inclusion. It is highly recommended that, if feasible, developers incorporate these guidelines in their games after implementing the high priority guidelines.
- **Low Priority:** Guidelines will be assigned 'Low Priority' if they are extremely situational and very difficult for developers to include in their game. These guidelines include guidelines that are rarely required in games and require a considerable number of resources to be implemented. It is recommended that developers incorporate these guidelines if they have the sufficient resources.

Figure 3 is an overview of our prioritization of ICS-FORTH's accessibility guidelines.

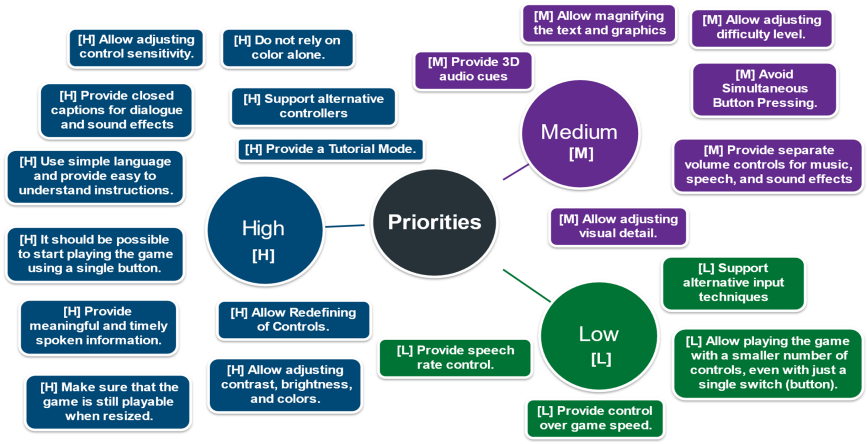

Figure 3: Prioritization Overview of all Accessibility Guidelines

4 APPLYING GUIDELINES

Game Over! demonstrates a need for 21 different accessibility guidelines [22], through its levels that break one or more of them. For better understanding the guidelines, we categorize them into 5 broad categories illustrated in Figure 4.

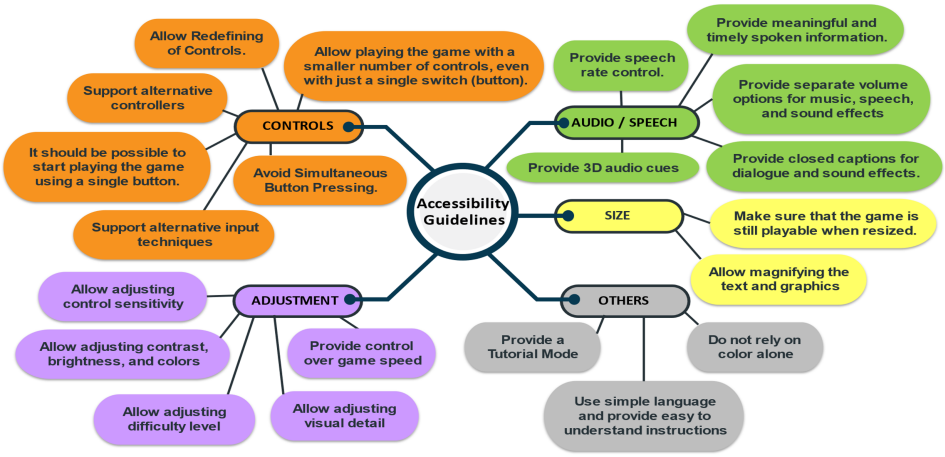

Figure 4: Categorization of Accessibility Guidelines.

4.1 Guideline 1: It should be possible to start playing the game using a single button – High Priority.

While this guideline [22] ensures that most users will be able to proceed ahead of the start screen, developers can provide further options to make it more accessible. For example, adding a voice command that starts the game would ensure that players with motor impairments would not have to make any unnecessary button presses. In case of VR Games and games with eye tracking, a timed gaze pointer could be implemented to

provide options for the button press. Starting a game is a simple task which should not require complex actions. Simple inputs ensure that most players would be able to start the game, which is essential for it to be accessible to players because otherwise the game becomes unplayable before it even starts. Hence, this guideline has high priority. This guideline is implemented in most modern game releases as an industry standard practice.

4.2 Guideline 2: Provide a Tutorial Mode – High Priority.

The tutorial mode should make the player invincible as it would allow the player to experiment with the game's controls and comprehend game's mechanics at their individual pace [22] [24]. This would especially help people with cognitive disabilities as they will not be pressured to learn at a speed that they are not comfortable with.

Tutorial mode is crucial in helping the player grasp the game's mechanic and controls which trains them to be able to play the game. Without a tutorial the player would not be able to get acclimatize with the game's mechanics which might lead to the player getting confused and unable to access the game as intended. Hence, this guideline has high priority. The Witcher 3: The Wild Hunt by CD Projekt Red [10], provides a tutorial which makes the player invincible and allows the user to practice as much as they want.

4.3 Guideline 3: Avoid Simultaneous Button Pressing – Medium Priority.

This guideline [22] serves well in reminding developers about taking into consideration players with motor impairments and joint diseases like arthritis. People with motor impairments can find it uncomfortable to press multiple buttons simultaneously, so, the developers should try to avoid it. However, due to limitations of controllers, sometimes simultaneous button presses might be required to include certain game mechanics. Hence, due to the situational nature of this guideline, it takes medium priority. Super Smash Brothers Ultimate by Nintendo [11], despite being a fighting game, avoids excessive simultaneous button pressing.

4.4 Guideline 4: Allow Redefining of Controls – High Priority.

This guideline [22] not only ensures that players will not get confused by sporadic control schemes designed by the developers but also allows players to design a control scheme that is comfortable for them both physically and mentally. This helps not just players with physical and cognitive disabilities but also players without impairments as they are free to select controls that work in tandem with their previously established mind muscle connections making their gaming experience more comfortable and efficient from the start [25].

Every person has buttons on their controller that they are more comfortable with. Several people might find certain buttons difficult to press which others might find comfortable to press. For people with motor disabilities and joint diseases, certain control schemes might even make a game completely unplayable. Redefining controls is an essential feature as it allows every player to use the controls, they are comfortable with for frequent actions and hence it takes a high priority as it directly affects the comfort level of the player while playing the game. This guideline is implemented in most modern game releases as an industry standard practice.

4.5 Guideline 5: Allow playing the game with a smaller number of controls, even with just a single switch (button) – Low Priority.

This guideline [22] can be implemented by designing the game in such a way that it does not demand complicated control schemes and players with specialized controllers which have limited functionality, can also play the game. It might not be feasible for every developer to accommodate their game for smaller number of

controls as they might require a certain number of controls to implement all the planned mechanics. Since, the implementation of this guideline might interfere with the core mechanics of games, this takes a low priority, and it should be implemented only if the developer deems it possible. Pokémon: Let's Go, Pikachu! and Let's Go, Eevee! By Nintendo [11], is a game that can be played with only 1 button and a clickable analog stick.

4.6 Guideline 6: Support alternative input techniques – Low Priority.

This guideline [22] can be implemented by allowing an option for inputs like voice commands in addition to the traditional button presses [26]. Not all games have mechanics that can work with alternative input schemes like voice controls. Furthermore, inclusion of such input techniques might be costly. Hence, this guideline should only be implemented if a developer can translate their mechanics to alternate input schemes and have the budget to do it. Mass Effect 3 by BioWare [12] and published by Electronic Arts. Inc. [13], had voice controls that allowed the player to say commands like “Open the door”, “Switch the weapon”, etc.

4.7 Guideline 7: Support alternative controllers – High Priority.

Specialized game controllers like the Xbox Adaptive Controller [8] for people with disabilities are available and games should support them as it allows more players to enjoy the game. Furthermore, providing an option to use pointer controls (like mouse and gyro aiming) in the place of analog stick controls can help people with weak hand-eye coordination to aim easily and have better control over camera in 3D games. Certain controllers can be completely unusable by people with specific disabilities making games that rely solely on them completely inaccessible. Furthermore, different players have different controllers that they feel comfortable using and hence it is a set industry standard to provide support for majority of the widely used different types of controllers. As a result, this guideline [22] takes high priority. This guideline is implemented in most modern game releases as an industry standard practice.

4.8 Guideline 8: Allow adjusting difficulty level – Medium Priority.

A quick solution that would not require many resources is to have an easy mode that simply lowers the enemy health and the amount of damage that they do. Developers that want to provide a customized difficulty experience for every player may implement a dynamic difficulty system within their game such that the game automatically adjusts its difficulty according to the performance of the player [27]. Different difficulty levels allow players with different levels of skills and reflexes to adjust the difficulty of the game’s mechanics to a point that they find it comfortable and enjoyable. However, it is not possible to allow adjustment of difficulty in some genres of games as they require a fix difficulty to function. For example, multiplayer games need a set difficulty to account for fair play. As this guideline [22] is dependent on the genre of the game, it has medium priority. DOOM: Eternal by id Software [14] and Bethesda Softworks [15], offer players 4 levels of difficulty that can be interchanged anytime during the game from the game settings.

4.9 Guideline 9: Provide control over game speed – Low Priority.

This guideline [22] can be incorporated by simply providing a game speed slider within the game settings. This would help players that require slower paced gameplay adjust the game to a speed that they are comfortable with. Providing players control over the game speed can only be implemented only if the game is designed to account for different game speeds. As in several games, game mechanics are directly dependent

on a game's speed, it can be very difficult, or even impossible, to incorporate this guideline in such games. Hence, this guideline has low priority. NBA 2K21 by 2K Games [16], provide players with a slider to adjust the game speed.

4.10 Guideline 10: Allow adjusting control sensitivity – High Priority.

For example, in a first-person shooter game, if the sensitivity of the player's mouse is very high, it becomes very difficult for the player to aim precisely and may turn out to be frustrating. A person's ability to play a game is directly corelated with their ability to adjust to the sensitivity of the controls. If a person is unable to adjust to the sensitivity of the controls, they should have an option to adjust the sensitivity to their comfort level otherwise, the game becomes completely inaccessible to them. Hence, the high priority. This guideline [22] is implemented in most modern game releases as an industry standard practice.

4.11 Guideline 11: Use simple language and provide easy to understand instructions – High Priority.

While this guideline [22] can be further elaborated by incorporating multilingual support, thus, providing the players with an option to select a language they are most comfortable with. Furthermore, game developers should not depend entirely on text to convey instructions and provide an option for the instructions to be conveyed in audio form as text cues are difficult to comprehend for dyslexic players. Language and instructions of a game are crucial in making a game accessible because if gamers are unable to comprehend the language or instructions of a game, it hinders their ability to play the game. Hence, it is highly recommended that developers use simple, easy-to-understand language. This guideline is implemented in most modern game releases as an industry standard practice.

4.12 Guideline 12: Do not rely on color alone – High Priority.

This guideline [22] can be implemented by using different media for object recognition like shapes as it is providing a better experience with lesser limitations. To make more accessible to colour blind people, different types of colour-blind filters can be incorporated that automatically alter the colour scheme of the entire game to fit the particular type of colour blindness [28], [29]. People with visual impairments like color blindness may find it difficult to identify indications from the game that rely on color alone. Hence, to account for them, developers should prioritize to accompany every color-based stimulus with an alternative stimulus like audio. Among Us by Innersloth [23], featured a puzzle that relied on color. However, after reviews and suggestions from color blind people, they added shapes alongside the colors to the puzzle to make it more accessible.

4.13 Guideline 13: Allow magnifying the text and graphics – Medium Priority.

This guideline [22] will serve to prevent cluttered menu in a game which might have important information but in very small text size. Additionally, separate options to magnify separate graphic elements (UI, text, etc.) will provide the player with greater control over the game and allow them to adjust different game elements and different sizes thus mitigating the chances of screen clutter. Different players have different text sizes that they are comfortable with and text size that is comfortable for a person could be unreadably small to another. Hence, adjustable text size is a must for games that rely on text to convey important information. However, games that do not rely on text to convey information can give this guideline a relatively lower priority. Assassin's Creed: Valhalla by Ubisoft [17], allows the players to increase the text size.

4.14 Guideline 14: Make sure that the game is still playable when resized – High Priority.

The developers should incorporate this guideline in the game testing phase of the development and ensure that the game is playable in a variety of window sizes as screen sizes can greatly affect player immersion in the videogame [30]. Players have screens of different sizes and resolutions that they play games on (For example, televisions, monitors, smartphones). The games become unplayable if they do not resize optimally to the desired screen size and resolution. Hence, it takes the high priority. Most commercial video games adjust to different screen resolutions offering flexibility. This guideline [22] is implemented in most modern game releases as an industry standard practice.

4.15 Guideline 15: Allow adjusting contrast, brightness, and colours – High Priority.

This guideline [22] can be implemented by displaying an image and asking the player to adjust the brightness till the image is barely visible. This ensures that the contrast in the game works well with the screen brightness of the player as well as their surrounding lighting. Players with visual impairments might not be able to differentiate the contrast between different game objects making it difficult for them to play the game. Moreover, different people have different sensitivity while identifying contrast. Therefore, developers should prioritize adding settings for the adjustment of contrast, color, and brightness in the game. This guideline is implemented in most modern game releases as an industry standard practice.

4.16 Guideline 16: Allow adjusting visual detail – Medium Priority.

This can be implemented by displaying a warning at the start of the game, informing the player about such content, and an option should be provided to turn these effects off. Flashing lights in visual effects may cause discomfort or even epileptic seizures in some players. Hence, the inclusion of seizure warnings and the option to disable these effects should be a priority. While games that do not include flashy effects do not need this settings, developers of games that do, should prioritize this guideline [22]. This guideline is implemented in most modern game releases as an industry standard practice.

4.17 Guideline 17: Provide 3D audio cues – Medium Priority.

This guideline [22] can be implemented by having any projectiles or anything that can cause the player's in-game character any damage clearly indicated using audio and visual cues. This would result in better immersion of the player in the game [31]. Players with visual impairments rely heavily on audio cues to understand the events in the game's environment. Without appropriate audio design, the game becomes inaccessible to them. Developers should prioritize adding 3D audio cues for as many events as they can in the game. The Last of Us: Part 2 by Naughty Dog [18], provides several accessibility options including 3D cues for informing most action in the game.

4.18 Guideline 18: Provide separate volume controls for music, speech, and sound effects – Medium Priority.

Several games provide separate voice sliders for music and different types of audio effects. Games with pre-set volume levels may be inconvenient for the players. If the volume is too high, it might be uncomfortable for the players, and if it is too low, players might miss out on important information conveyed through audio in the game. This guideline [22] is implemented in most modern game releases as an industry standard practice.

4.19 Guideline 19: Provide meaningful and timely spoken information – High Priority.

This guideline [22] can be implemented by providing the player with a small sidekick character that provides necessary information throughout the game. Players can get easily confused while playing a game if the required information is not provided at the appropriate time which may halt their progression. Furthermore, if the information is only provided in text format and not in a spoken manner, it would not be accessible to players with visual impairments, making the game unplayable for them. Hence, it has been allocated a high priority. Genshin Impact by miHoYo [19], provides player with a sidekick that provides information when the player is stuck or confused.

4.20 Guideline 20: Provide speech rate control – Low Priority.

This guideline [22] ensures that people with hearing and cognitive impairments can listen to the audio cues comfortably. This guideline should be prioritized by developers whose games heavy utilize speech in the implementation of their game mechanics. However, if a game does not rely on speech for its functionality, then this guideline can take a low priority. Lair of the Clockwork God by Size Five Games [20] and Ant Workshop [21], allow the players to control the rate at which the text speech proceeds.

4.21 Guideline 21: Provide closed captions for dialogue and sound effects – High Priority.

Voice narration and dialogues play an important role in game design as they contribute to the story of the game which keeps the player engaged in the game. If the player is not able to comprehend the dialogues or if the player suffers from hearing impairments, it becomes very difficult for the player to continue playing the game. Subtitles with readable and clear font are very important in games in order to make the dialogue comprehension more accessible [32], [33]. Hence, developers should offer options to customize the subtitles according to the player's requirements. Closed captions are crucial in providing a visual stimulus for dialogue and audio effects to players with hearing impairments. Moreover, closed captions are also important in providing subtitles in different languages different from the one in the voice acting, which is essential for making the game accessible for players from different countries. Hence, this guideline [22] should have a high priority. This guideline is implemented in most modern game releases as an industry standard practice.

5 CONCLUSION

Game Over! proves, through its deliberate design, that accessibility is a pivotal feature that needs to be implemented while designing and developing a video game. Terrestrial Invaders follows the guidelines that Game Over! deliberately neglected in order to create a juxtaposing effect to showcase how much accessibility can transform a gaming experience for the better. Accessible video games not only provide a superior gaming experience but also ensure that these video games are playable by a wider audience. In future, it is recommended that video games should be developed with compliance to all high and medium priority accessibility guidelines discussed.

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Social Affordances of Digital Technologies: A Tentative Framework for HCI Research

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The concept of "social affordances" is commonly used in HCI research. However, the advantages and limitations associated with employing the concept are yet to be fully understood. This paper presents a critical examination of "social affordances", which includes a discussion of current uses of the concept in HCI and a comparison of "social affordances" with more traditional interpretations of "affordances". We argue that making full use of "social affordances" as an analytical tool in HCI requires an unpacking of the relationship between *perceiving a potential action*, supported by the environment, and *utilizing the potential* and actually carrying out the action. We also argue that in case of "social affordances" it is particularly apparent that the perception of an affordance does not automatically result in a problem-free execution of the respective action, and needs to be integrated with other processes within the overall structure of action regulation. We propose a tentative framework for the analysis of the interplay between perception and action in the enactment of social affordances. Implications of the framework for employing the concept of social affordances in HCI research are discussed.

CCS CONCEPTS •Human-centered computing~Human computer interaction (HCI)~HCI theory, concepts and models

Additional Keywords and Phrases: Affordance, Social Affordances, Disaffordance, Social action, Instrumental action, Digital technology

1 INTRODUCTION

In the last decades the concept of "social affordances" has become rather common in HCI and interaction design. A rough indication of the relatively widespread use of the concept is that searching for "social affordances" in the ACM Digital Library produces hundreds of hits[1] . Recently, authors of this paper turned to "social affordances" when planning a cross-cultural study of users' perception of digital technologies in Malaysia and Sweden. An initial exploration of the concept led us to conclude that the meaning of social affordances in HCI needs to be further examined and clarified. The aim of this paper is to take a step toward such an examination by discussing the potential and limitations of "social affordances" in the context of HCI research.

The remainder of the paper is organized as follows. In the next section we discuss the notion of "social functionality" of digital technologies. We argue that social functionality is an increasingly important issue for HCI and interaction design, and "social affordances" is a promising analytical tool for dealing with this issue. After that we present a brief overview of how the concepts of "affordances" and "social affordances" have been used in the field of HCI. In the section that follows we discuss "social affordances" with a special focus on direct perception, learning, and the relationship between perception and execution of an action. Then we present a tentative framework for social affordances, which builds on existing HCI research. We conclude with discussing the implications of our conceptualization of social affordances for analysis and design of digital technologies.

2 SOCIAL FUNCTIONALITY OF DIGITAL TECHNOLOGIES: A NEED FOR FURTHER HCI RESEARCH

In recent decades, digital technologies, such as email and social media, emerged as a crucial infrastructure for social interactions in the modern society. Arguably, the importance of digital technologies for supporting various types of social interactions is going to further increase in the years to come. There are several reasons why such an increase can be expected. First, more and more communication activities, which have traditionally occurred "in

[1] dl.acm.org; 214 hits as of January 30, 2021.

real life", such as business or community meetings and social events are taking place online. This transition has been significantly accelerated by the covid-19 pandemic, but the overall trend was clearly evident even before that.

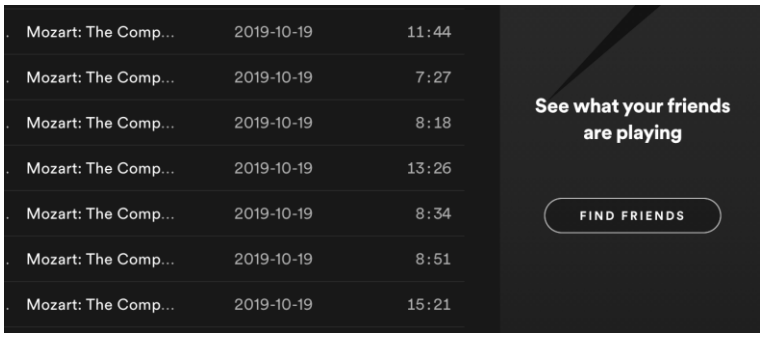

Figure 1: A screenshot of the Spotify streaming service user interface.

Second, the Internet of Things (IoT) and the related proliferation of connected devices, provide ample opportunities for transforming individual activities, such as listening to music, making tea or even reading a book into social ones. For instance, Spotify, a leading music streaming service, offers its users the option to find friends and watch what music they are listening to (Fig. 1). The Messaging Kettle device [1] is an electric kettle, which can be connected to another kettle and support communication with the other kettle's user. The communication is supported by indicating that the other kettle is on, and providing a surface (the top of a tea box) for exchanging messages. Sharing reading parts of a religious book in a WhatsApp group via the mobile phone is not new in countries such as Malaysia. In case of all these three examples Spotify, the Messaging Kettle and Whatsapp, the technology in question offers two types of functionality, namely: (a) instrumental functionality, such as playing music, boiling water or simply writing text messages and (b) "social functionality", such as sharing the music playing experience or communicating with friends and family.

Third, emerging types of interactions that can be regarded as "social", even if in a metaphorical sense, are interactions between people and digital agents. Such agents, e.g., social robots [7], autonomous cars [34], digital voice assistants [28], or objects with intent [27] may engage in communication, and even negotiation, with their users, and can therefore be considered communication and collaboration partners.

Since digital technologies are essential to our social interactions, it is critically important for the users to be able to understand the "social functionality" of the technologies. In particular, the users should understand what social actions are made possible by a certain technology, how to perform the actions, and what consequences, both positive and negative, the performed social action would have. The common instances relate to technology that facilitates social interactions in wikis, blogs, social networks, and media. Other instances may refer to the case of competently and responsibly using the "social functionality" of music app such as Spotify. One needs to understand, what exactly it means to "watch what your friends are playing" in Spotify (does it mean observing their actual use of the service? are you going to do that with or without their knowledge?) and what happens when "finding friends" is selected. An additional question, which could need to be addressed, depending on the specific context (e.g., the concrete interpersonal relationship, particular cultural norms, etc.), is assessing whether or not it would be polite to ask someone if you could watch them playing their music.

Arguably, helping people make use of the social functionality of digital technologies is a timely issue for HCI research. Understanding how people detect and learn social functionality, as well as designing systems that support the detection and learning in an effective, efficient, and preferably also enjoyable, way, is a challenge that interaction design needs to address. In the next sections we discuss how the concept of "social affordances" may help interaction design deal with this challenge.

3 AFFORDANCES, SOCIAL AFFORDANCES, AND DISAFFORDANCES IN HCI

Originally, the concept of "affordance" was proposed in by James Gibson [11] within his ecological approach to human perception. It was defined as the possibilities for action, which the environment provides to an animal,

"either for good or ill". The notion of affordances, understood as the perceived and actual properties of an object that translate to its usage, was introduced to HCI by Donald Norman [23], and it was quickly accepted by both researchers and practitioners. The history of employing the notion in HCI spans over three decades, during which time a significant effort has been made to specify and elaborate the meaning of "affordances" in HCI (e.g., [2,4,5,8,19, 14,18,19,22,24,29,31,32,33]. While Gibson was mostly (but not exclusively) concerned with "animal-environment" complementarity, physical actions, and locomotion, a key direction of exploring the notion of affordances in HCI was adopting it for understanding and supporting specifically human forms of activity. The interest of HCI researchers in "social affordances" is, arguably, a logical continuation of this development.

Currently, the notion of social affordances in HCI research refers to a wide range of phenomena. One of the first relevant analyses (even though it does not use the specific term "social affordances") is conducted by Gaver [9], who discusses the affordances of media places for *collaboration*. Bradner [3] employed the notion of social affordances when studying the *relationship between social behavior and design features* of computer-mediated technologies. Hanrahan et al. [13] present a method for evaluating social network sites, which includes assessing social affordances of the technology, such as *social browsing, sharing content, and collaboration*. Kavanaugh et al. [20] analyze the support for social affordances, such as *social trust*, in local news aggregation in the US. Kan et al. [17] introduce "social textiles" that provide social affordances for unacquainted, collocated users to *interact with one another*. Isbister et al. [15] discuss social affordances for *physical co-presence*, using examples of several game designs. Shnell et al. [30] reports an exploration of social affordances of mobile apps with motion-controlled sound for *engaging people in spontaneous collaborative performances*. Raja-Yusof et al. [25] investigate the affordances of social media for *cyber-volunteering*.

The uses of the notion of social affordances in HCI research are varied, and suggest that the notion is playing an important role on studies of human-technology interaction. Apparently, the notion is generally understood as possibilities for social action, and there have been some attempts to define it. For instance, according to Hanrahan [13], social affordances refer to "The quality of an artifact in any space which invites and facilitates social actions by the participants in that space." However, in most cases the notion is explained through examples, rather than being defined. In addition. In addition, it is seldom discussed how the notion is related to analyses of affordances by Gibson [11] and Norman [23].

In our view, there is a need to further specify and elaborate the notion of social affordances in HCI research. In the context of social technology, the notion is related to accomplishing the goals of usability and user experience in terms of fulfilling some social goals. Subsequently, the identified entities related to social affordances of the technology, would assist the designers in creating a usable social technology. Goals of usability are related the social technology that assist users in their tasks covering the effectiveness, efficiency, utility, learnability, memorability, and security. The goals of user experience are closely linked to human factors such as emotions and attitudes toward the achievement of valued and relevant experiences to the users.

Related to social affordances is the somewhat not yet popular term "disaffordance". Lockton [21] refers to it as constraints, which are defined as "either products with functionality deliberately removed or with the functionality deliberately hidden or obscured to reduce the user's ability to use the product in certain ways, or a combination of the two". Thus, intentional and strategic design approach to obscure unwanted functionality of artefact designs should also be useful [6], although concealing and discouraging certain functionality may lead to negative user experience.

We further discuss this issue by providing an illustrating example of a social disaffordance of a virtual meeting technology. In the Zoom application where people can meet online for a social networking event, the organizers are able to place the participants in breakout rooms to prevent communication interaction between certain groups of people or individuals with conflict of interest. The *Breakout Rooms* functionality is a social disaffordance used purposely to prevent communication. Another example is the *Remove* functionality in a social chatting application such as Whatsapp. The Admin of a particular group can *Remove* any individual preventing them from socializing with the group members.

4 SOCIAL AFFORDANCES: PERCEPTION, ACTION, AND LEARNING

Some of the key issues in the debates on affordances in HCI have been the relation of affordances to, respectively, perception, action, and learning [10, 19, 22, 25]. In this section we bring these issues to the analysis of *social* affordances in order to discuss the meaning, as well as potential advantages, of social affordances as an HCI concept.

4.1 Direct perception of social affordances

The notion of *direct perception* is a central tenet of the ecological approach to perception, proposed by Gibson [11]. According to Gibson, the complementarity of the animal and the environment, in which the animal exists, makes it unnecessary for the animal to develop a special representation of the environment. Instead, animal's perception directly extracts combinations of perceptual features, which indicate that certain actions are possible in the given environment: e.g., that a certain staircase is *climbable*, that a certain plant is *edible* or a certain cliff is *fall-off-able*.

In the current uses of the concept of social affordances in HCI research, the notion of direct perception usually receives little or no attention. In most cases researchers do not specifically indicate, whether a social affordance, that is, a possibility for a social action, is perceived directly or revealed through a substantial effort. As such, the concept of affordance in many contexts has the general meaning of "functionality", "utility", or "use purposes".

In our view, the notion of direct perception of affordances has a number of advantages, and analysis of social affordances of digital technologies could benefit from employing this notion. The notion emphasizes the importance of having an early intuitive understanding of the possibilities for social action, provided by available technologies, as a precondition for efficient planning and execution of technology-mediated social actions. Explicitly linking affordances to direct perception would also help to distinguish them from other related concepts, such as "functionality".

4.2 Beyond perception: From detecting a social affordance to enacting it

As mentioned, the concept of affordances was introduced by Gibson [11,12] within his theory of perception. Accordingly, the focus of his analysis was on how people perceive action possibilities, rather than how they make use of these possibilities and actually perform the afforded actions. The predominant emphasis on the perception, rather than execution, of actions can probably be explained by the types of actions analyzed by Gibson. Walking on a flat surface, falling off a cliff, or placing a letter in a letterbox are rather simple types of actions: once a possibility for such an action is perceived, its execution or prevention is trivial. In case of more complex actions, the link between perception and action is less obvious and, as argued by several HCI researchers, needs to be elaborated upon (e.g., [2, 19, 18]).

One possibility of bringing together the perception and execution of a potential action, explored in HCI research, is mapping the concept of affordances onto Norman's model of action, Hartson [14] identifies different types of affordances, corresponding to different parts of Norman's model. Vermeulen et al. [31] also map different categories to different parts of Norman's model, but propose another kind of mapping. By focusing on various parts of the model, they differentiate between affordances, feedback, and feedforward.

Exploring the internal structure of Norman's model, undoubtedly, offers a number of valuable insights. However, placing affordances somewhere within the structure of an action is, in our view, appears to overlook the fundamental fact that affordances refer to *entire potential actions,* rather than their component parts. In addition, such analyses are difficult to relate to the notion of direct perception, discussed in the previous section. Therefore, we suggest that the perception of affordances and making use of them should be considered two closely related but distinct processes. Perceiving the affordances offered by an environment is crucial for setting a specific goal that should be achieved. However, actually achieving the goal does not directly and automatically follows from perceiving a certain affordance, that is, identifying a certain action potential. The potential may be real, but, for various reasons, the potential may never come true. It is especially evident in the case of social affordances. Perceiving a potential social action cannot "guarantee" that the action will actually be performed. Social actions involve several actors, and since one person may not control what other potential participants in the social action are going to experience and do, the results are not completely predictable.

4.3 Social affordances and learning

One more controversial issue, related to the concept of affordances, is learning. James J Gibson did not consider learning an important factor [11]. The reason was, probably, again, the specific examples of affordances, which were used most widely in Gibson's [11] analysis. Recognizing that one can walk on a surface or fall off a cliff only requires the most basic perceptual capabilities, and can be explained without conducting advanced empirical and conceptual analyses of learning. However, understanding more complex types of actions, and especially social

actions, can only be achieved by taking learning into account. A number of researchers, including James J. Gibson's wife, Eleanore Gibson, who herself was a prominent psychologist, emphasized the centrality of learning and development [12].

Arguably, learning plays a crucial role in forming the ability of a human actor to discover, perceive, and use *social* affordances. Social affordances are not determined by our biology. In different cultures, and even in different contexts within the same culture, the range of potential social actions, available to actors, could be vastly different. Moreover, people having similar physical capabilities may have dramatically different social capabilities and therefore the same environment may provide very different affordances to different people in the environment. It can be concluded, therefore, that a key issue for understanding social affordances is how the affordances are formed, perceived, and used as a result of culture- and context-specific learning.

5 A TENTATIVE FRAMEWORK FOR SOCIAL AFFORDANCES

The discussion in this section builds on the issues, identified above, to propose a framework for framing and guiding the exploration of affordances in HCI research. First, we make a distinction between different types of social actions, afforded by digital technologies (Table 1). Second, we outline a schematic relationship between affordances, perception, action, and learning (Figure 2).

The role of social affordances in the context of social technology is related to accomplishing the goals of usability and user experience. Subsequently, identification of the entities related to social affordances of the technology, would assist the designers in creating a usable social technology. Goals of usability are the quality attributes of the social technology that assists users in their tasks covering the effectiveness, efficiency, utility, learnability, memorability, and security. While the user experience goals are related to human factors in terms of emotions and attitudes as such to achieve meaningful, insightful and relevant experiences to users.

Social affordances should be tightly related to social behavior. Social behavior depends on many factors such as geographical location, language spoken, history and religion [21]. It is important to take note that social behavior in different cultural settings can fall into four categories; acceptable common behavior, unacceptable common behavior, acceptable differing behavior, unacceptable differing behavior (see Figure 2). For example it is completely acceptable to talk about food and fashion in general. However, the intake of alcoholic beverages would be acceptable for adults but unacceptable for children. In Muslim communities it is unacceptable for both children and adults. In the case of men wearing a hat in Sweden and men wearing a *'tanjak'* in Malaysia are totally acceptable differing behaviors. However, women wearing a mini skirt and women wearing the *'hijab'* may be two unacceptable differing behaviors in certain cultural contexts.

Table 1. Types of social actions afforded in a given social context.

		Acceptability	
		Yes	No
Commonality	Yes	Common acceptable	Common unacceptable
	No	Differing acceptable	Differing unacceptable

Figure 2 places social affordances in the overall context of a technology mediated social action. The right-hand side of the figure shows the social-cultural environment, in which the social action in question is taking place, and of which a certain digital technology is a component part. The person, performing the social action, perceives the range of social affordances, offered by the given environment (signified by a horizontal arrow pointing left, from the environment toward the person). The particular set of social affordances, perceived by the person, depends on the person's social action capabilities. The person also perceives instrumental affordances, that is, possibilities for acting with objects, offered by the environment. These instrumental affordances, which depend on the person's instrumental action capabilities, include the ones provided by the given digital technology. Their perception is signified by another horizontal arrow pointing left.

A social action is initiated when the person sets a goal for a social action. Setting a goal is a complex process, which is shaped by various forces, motivations, and constraints. Two of the main factors shaping the process of goal-setting are (a) the perception of affordances for social action, provided to the person by the environment (the environment is understood here in a broad sense, as including digital technologies, as well), and (b) the current needs of the person. If the person chooses to use the given digital technology to achieve the goal of the social action, then the person should set an instrumental goal of using the technology. For instance, the person may decide to employ an appropriate WhatsApp functionality, which would support a shared religious book reading, or to write a message for a user of a connected Messaging Kettle.

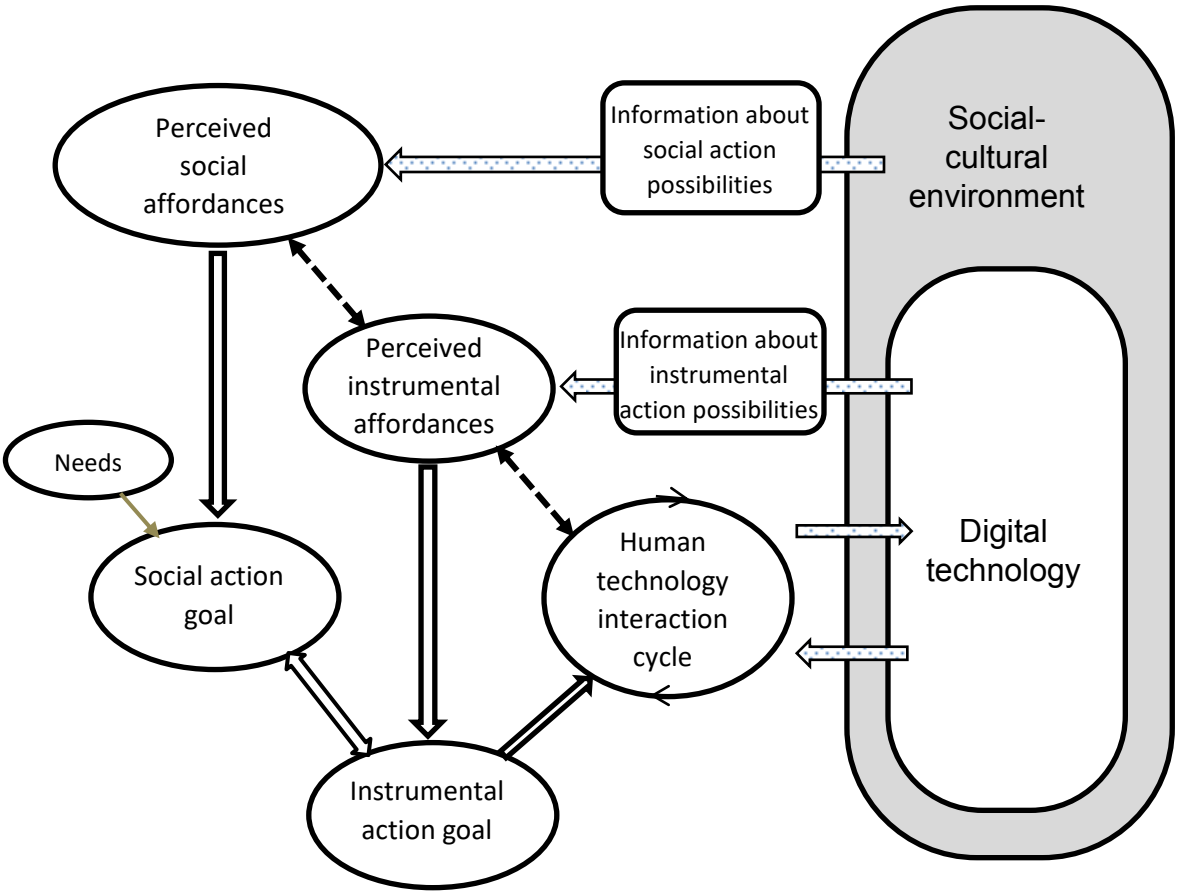

Figure 2: Social affordances within the overall structure of a technology-mediated social action.

Accomplishing the instrumental goal, the goal of using a digital technology to achieve the social action goal of the person, should be achieved through the actual interaction between the person and the technology. This interaction is depicted in Figure 3 as "human-technology interaction cycle". This part of the framework includes planning and execution of a concrete user input to the technology (signified by a horizontal arrow pointing to the right), as well as perceiving the outcome (signified by the lowermost horizontal arrow pointing left), as well as interpreting and assessing the outcome. The "human-technology interaction cycle" component of the framework is similar to the seven-stage model of action, proposed by Norman [23, 24].

The main aspects of the proposed framework can be summarized as follows. First, the framework posits that the same digital technology may have very different social affordances in different cultural contexts and for people with different action capabilities. Second, the perception of social and instrumental affordances, provided by the environment, takes place at an early phase of a social action "lifecycle". When the user has a need, which can be achieved through conducting a social action, setting a concrete goal for the social action is shaped by both the need and the perception of the possibilities for action, offered by the environment. Therefore, affordances may direct and guide an action, but they do not determine it. Third, the framework highlights a close connection between social and instrumental affordances, which may mutually affect one another, both in the context of a specific instance of technology use and a long-term perspective of learning and development.

The framework can be illustrated by an example of using Zoom's breakout rooms at a committee meeting. Committee members are often asked to leave the room, if they have a conflict of interests regarding the issue to be discussed. If the committee meets in a physical room, such people are asked to meet outside and are then invited back. In virtual committee meetings, which have become common during the covid-19 pandemic, it is not possible. According to the framework illustrated by Figure 2, in a digital meeting the issue can be addressed as follows.

First, a concrete **social action goal** should be set. The organizers should decide whether it is, in principle, possible to manage participants' presence as needed, in case of a digital meeting. **Information about the context** (e.g., participants and technology), as well as organizers' **action capabilities** (e.g., skills and experience) led them to conclude that the **social affordance** of temporarily excluding certain participants from a meeting is offered by the available technologies (which means, as mentioned above, a *social disaffordance* to the participants). Therefore, the organizers proceed to setting the goal of the social action. Second the social action goal needs to be implemented through physical actions, which means that an **instrumental goal** should be set. Available technologies may offer various relevant **instrumental affordances**, including for instance, leaving a Zoom meeting, waiting for an invitation message (e.g., email), and re-joining the meeting. The social action goals and perceived instrumental affordances collaboratively determine a concrete **instrumental goal,** in this case, *temporarily placing people with conflicts of interests to a breakout room*. Third, the instrumental goal is achieved through the actual use of technology, a **human-technology interaction cycle**, which comprises executing and, if necessary, adjusting, a sequence of operations with the technology). This process may involve learning, exploration, and discovery, which may involve revealing and using *nested* instrumental affordances [10] (e.g., discovering that it is possible to setup a breakout room so that participants can join it themselves rather than being assigned by the host, or that participants cannot see the chat messages, which are posted during their absence). Fourth, executing the operations achieves the goal of social action, and the experience of initiating and completing the social action affects, through propagation, the perception of affordances, as well as action capabilities of the actors carrying out the action.

The framework can also be used to determine how a specific design based on certain culture norms would affect a group with different culture norms. An example of this is the written and spoken conventions of an individual name. In most part of South East Asia such as Malaysia many do not have a surname. This would also be common in most part of the Muslim countries worldwide. The names are usually written as follows; the individual name followed by the father's name. The individual and the father's name may contain more than one. To illustrate this, if a Malaysian is to register for a conference, the normal design of forms would ask for first name and surname or last name. The conference participants action capabilities led them to conclude that the social affordance of the available technology may be have been deliberately put forward as a social disaffordance. Who would want to spent too much time arguing about how to address a person in the most accurate manner as long as the naming convention is as close as the correct one? So, a Malaysian might feel a little uneasy about the many numerous instances when the so call normal culture of certain groups/community being imposed to them. This implies that the instrumental disaffordance leads to a monotonous social culture standards as oppose to the proliferation of multivarious culture experiences.

6 IMPLICATIONS OF THE PROPSED FRAMEWORK FOR HCI RESEARCH

The aim of the analysis in this paper is to contribute to the discussion and elaboration of "social affordances" as an HCI concept. We identify the main issues, which need to be considered when clarifying the meaning of the concept, as well as appraising its potential, and propose a tentative framework for analyzing social affordances. In our view, the framework can be used in HCI research in different ways.

First, it can be used as an *analytical framework* guiding the analysis of the social functionality of digital technologies. In particular, the framework emphasizes the importance of investigating the effect of digital technologies on how

people generally understand the possibilities for social action in a certain context. It also highlights the need to focus on the relationship between social and instrumental affordances, and on how the perception of social and instrumental affordances develops over time.

In particular, the framework may be employed in cross-cultural studies of how people perceive and use social functionality of digital technologies. As shown by Ishak et al. [16], cultural differences between users, even within the same country, Malaysia, may affect how the users interact with technology. Such differences can be expected to play an even more significant role when different countries (e.g., Malaysia and Sweden) are compared. The components of the model, shown in Figure 2, as well as relations between the components, can inform cross-cultural studies in HCI by identifying the topics to be covered in observation, interview guides, and surveys. Examples of research topics, derived from the framework, include:

1. types of social actions supported by digital technologies (e.g., using technologies when having extended family gatherings),
2. importance and frequency of the social actions,
3. types of technologies used, and how they are used (e.g., in a centralized or decentralized manner),
4. action capabilities (e.g., skills and experience) for technologically-mediated social and instrumental actions,
5. information about the environment, which conveys the presence of social affordances,
6. design, development and testing guidelines for digital technologies involving social affordances,
7. strategies of translating social action goals into appropriate instrumental action goals of technology use,
8. learning and development, resulting from the use of digital technologies for planning and performing social actions.

Second, the framework can serve as an additional conceptual tool, *informing the analysis or design of particular technologies*. In the context of interaction design projects, the framework highlights that different affordances can be mapped to different usability and user experience goals, and that designers may need to employ three different types of perceptual cues, supporting, respectively, the perception of social affordances, the perception of instrumental affordances, and the feedback, provided to the user on a performed action.

Third, last but not least, it can support *thinking about social affordances* and establish common ground in discussions of social affordances, which may involve researchers, who interpret the concept somewhat differently. In particular, the framework can be used when specifying the meaning, in which the concept is used in the context of a certain study. For instance, researchers could indicate whether or not they adopt the notion of direct perception, whether or not they explore the relationship between perception and action, and in what particular cultural context their analysis of social affordances is taking place. In our view, such clarifications would help to avoid potential misunderstandings, and ensure a more efficient coordination of research efforts, related to social affordances.

As mentioned, the proposed framework is a tentative one; it needs to be further developed in several respects. Two of these respects are the long-term co-development of affordances, perception, and action, as well as the engagement of other people in the “human-technology interaction cycle”. We plan to apply, test, and elaborate upon the current version of the framework in our prospective research, including analysis of social affordances of digital technologies in different cultures.

7 CONCLUSION

The term “social affordances” is being widely used in HCI research, which suggests that possibilities for social action, offered by digital technologies, is a key issue for research on human-technology interaction. In this paper we argue that the notion of “social affordances” needs to clarified and further developed, and we propose a framework for analyzing social affordances in the context of the overall structure of technology-mediated social action. The potential application scope of the framework includes a broad range of HCI research activities, dealing with social functionality of digital technologies. One of the most promising uses of the framework, in our view, is employing it when addressing cross-cultural and culture-specific uses of technology.

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Mobile Usage in the Organizational Context

Understanding the factors influencing mobile usage in the workplace

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The number of smartphone users worldwide today surpasses 3 billion and is forecasted to further grow by several hundred million in the next few years. Mobile is an omnipresent device, and we are doing a range of tasks on our mobiles every day. Mobile–first approach, has thus become a great strategy to employ for digital products. However, mobile usage in the organizational context is still not a mainstream behavior yet. There are various reasons why employees are still not using their mobile as a preferred device in the workplace. The reasons range from device capabilities like storage, screen real-estate to contextual factors like a laptop already being a preferred device for heavy software that they may be used for work. Global research was initiated by a technology organization that develops Human Capital Management (HCM) Software in a bid to understand the factors influencing mobile usage in the workplace better. The objective of this global study was to uncover insights, trends and themes that could potentially inform mobile product development across pillars for this software company. The study captures the mobile mental model of the end-user and uncovers moments of friction in the current experience through user journey mapping. It introduces the 3E Model of Mobile Experience- Explore, Enable & Engage. The study also distils the insights into an application-based toolkit called the Mobile Innovation Toolkit that puts together a set of triggers to enable innovation in the mobile product development process.

CCS CONCEPTS • Human-centered Computing • Ubiquitous and mobile devices • Mobile Devices

Additional Keywords and Phrases: User Research, Mobile Usage, Toolkit

1 INTRODUCTION

Employees use their mobile phones for a range of work-related tasks from checking their mail to filling their time records and even accessing their pay slip and tax information. There is a certain complexity to these tasks and by nature, these tasks have a higher cognitive load. Laptops/Desktops are suitable as a device for high cognitive load tasks. They offer a larger screen, the ability to toggle tabs, and a typing keyboard that can enable complex and mentally demanding tasks. However, the scenario of usage on mobile is entirely different. The users are usually trying to accomplish a task while being on the move and have a limited attention span. The nature of the mobile device i.e., smaller screen real estate and low storage also impacts the experience.

The study intended to investigate deeper to understand the user's experience and unearth the primary factors that impacts mobile usage in the workplace. The study aims to add value and bring the user's voice for

the future mobile project across modules for the HCM software and decode how mobile as an organizational device will play a role in Human Experience Management. During the end-user research, the users for example laid emphasize on how there is a certain level of expectation from the HCM applications as they are well versed with the seamless experiences of other apps. Such insights which affect mobile usage in the workplace environment have been captured in the different research artefacts in the study.

2 RESEARCH METHODOLOGY

The methodology of this study was the double diamond process practiced in Design Thinking. The project was initiated with a discovery phase which involved conducting secondary research to identify trends in user experience, technology and workplace behavior. The information gathered through the secondary research was crystallized into trend cards that summarized changes in the behavioral, organizational and technology landscape. One of the important aspects from the existing mobile guidelines was that these frameworks don't go deep into user behavior in the context of HR technology. The internal design guidelines for iOS and Android Design in the organization exists, but they are more specific to material design and not on the behavioral and cognitive factors. The study thus aims to have an integrated approach to understand the mobile experience from the lens of human behavior and perceptions. Also, facilitating collaboration using mobile devices brings new challenges. Some of these challenges are inherent to the nature of the device hardware, while others focus on the understanding of how to engineer software to maximize effectiveness for the end-users [2].

Such insights from the discovery phase were shared across with different stakeholders including Designers, Product Managers, Experts in a workshop setup. The sample size of stakeholders who participated in these sessions was twenty-two. The session included a debrief of the trend cards from the secondary research, post which the stakeholders came up with some How Might We statements which helped us to identify and prioritize the hypotheses. These hypotheses helped construct the primary research artifacts and interview guide. The research team then conducted primary research with end-users to collect data. The users were primarily desk workers in medium to large organizations. The participants were recruited via an online tool called Respondent. It was ensured that there was a good representation of industries – Food & Beverage, Information Technology, Professional Services, Hospitality and Manufacturing.

The mode of interviews was one on one qualitative remote sessions with open-ended questions, followed by two mapping exercises with participants on the mural platform. One for discovering a day in the life of the user which laid focus on user's mobile usage and the other to understand the mobile usage for HR activities in their lifetime in the organization. Since the study was global, there was representation from different geographies- North America, EMEA, APJ. The sample size of the user research was nine participants with adequate representation from different industries and geographies. The participants also had an equal gender ratio between male and female employees. After the research phase, the divergent phase marks the analysis phase in the cycle where all the research artifacts, hypotheses, and materials were referred to synthesize them into potential solutions.

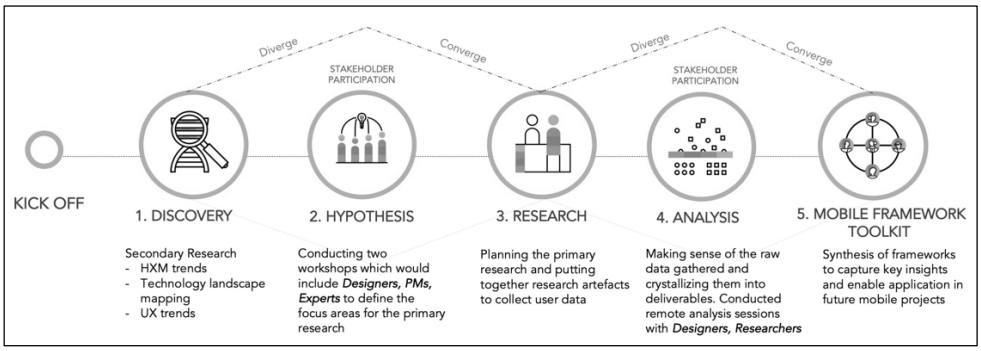

Figure 1: The Double Diamond Process showcases the different phases of the project- Discovery Phase, Hypothesis Phase, Research Phase, Analysis Phase to Mobile Framework Toolkit.

3 RESEARCH FINDINGS

To make sense of the user data collected during interviews, information was then bundled and grouped into different categories using affinity mapping. The patterns are composed of user behaviors, pain points, influencing factors, systems and processes around mobile. Different clusters showcased different relationships between data and were further compiled into a format that would be practical to use.

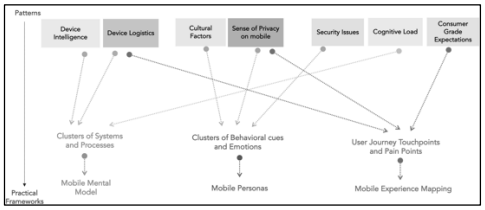

Figure 2: The clustering journey of the user data from patterns to putting them into practical frameworks.

3.1 Mobile Mental Model

Mobile Mental Model is a cluster of mobile attributes highlighting the factors that affect mobile usage. The model is a snapshot of the factors influencing user behaviour and their interdependencies. It showcases the macro-categories that influence the mobile experience-

- User attributes i.e., how technology acts as an enabler, sense of privacy towards mobile as a device.
- Device attributes i.e., inherent capabilities of the device, security barriers for organizational use.
- Task attributes i.e., impact of consumer-grade applications, cognitive load associated with tasks.

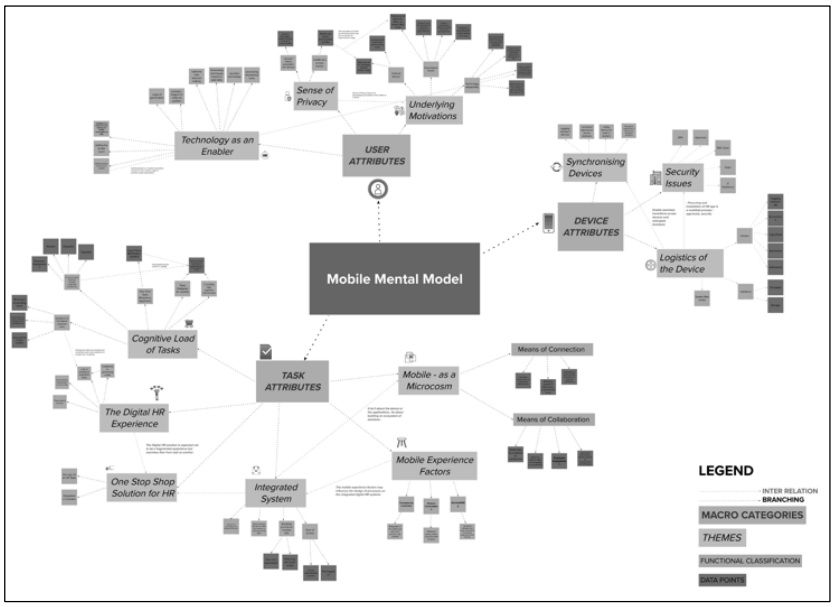

Figure 3: User's Mental Model in terms of Mobile Usage

3.1.1. *User Attributes*

The user attributes capture the essence of the mobile user – their expectations, unmet needs, gaps in experience and throws light upon their innate characteristics. Users are enabled by tech intelligence when it comes to decision-making. From a psychological perspective there are underlying motivations of the users to use mobile like the openness of the organization to let the employees use their mobile in the work environment. There are also some inhibitions for using mobile for HR tasks as mobile is a personal device and there is a sense of privacy attached to it.

3.1.2. *Device Attributes*

The device attributes focus upon the tedious process of procuring the mobile and installing the HR application. Mobile devices provided by organization restricts the user to perform certain actions like screenshots, copy-paste action. These limiting capabilities for the tasks defeats the purpose of providing a seamless transaction for the user.

3.1.3 *Task Attributes*

The task attributes highlight the nature of tasks and how their characteristics themselves impact the user experience. When the users are guided to the task, it needs to be their one-stop solution to all their HR needs, users seek for similar integrated and digital experience provided on other platforms. Mobile has become their channel of communication and collaboration for employee engagement, hence making HR applications go beyond the radar to just perform HR tasks. Some of the key insights that emerge from the user's mental model while using mobile in organizational context are:

- User's sense of privacy towards mobile, their underlying motivations to use the device and the role of technology affect the users thought process while completing a task.
- Mobile as a device is perceived for mobility hence the nature of tasks expected on it are quite different from the nature of tasks on a laptop. They are expected to be designed with a low cognitive load.
- Mobile is no longer just a device; it is a microcosm that serves as a means of communication and collaboration.
- Consumer-grade applications and the ever-evolving systems influence the experience of HR applications that are already available to the users. Users, therefore, seek the same level of personalization, intuitive interaction, engagement, and ease of access from the HR app.
- Synchronization between different devices like mobile and laptop, security issues while logging in the application, and logistics of the device like screen real estate, storage or processor are some of the major themes that affect the user's mental model.

3.2 Mobile Personas

All users are not the same. The assumption that people use their organizational portal only for only transactions seems to be evolving. There are users who come to the system to wander and see what it offers them. They are ideally the personas who are looking for highly personalized and curated content relevant to them.
The mobile personas are mapped across the defining attributes of the frequency of mobile usage & adaptability to the mobile as a device for work. The frequency of mobile usage could range from active to passive usage, where active usage means users are more task-oriented to perform prolonged tasks and passive usage means that the users are content-oriented and access the application to explore more.

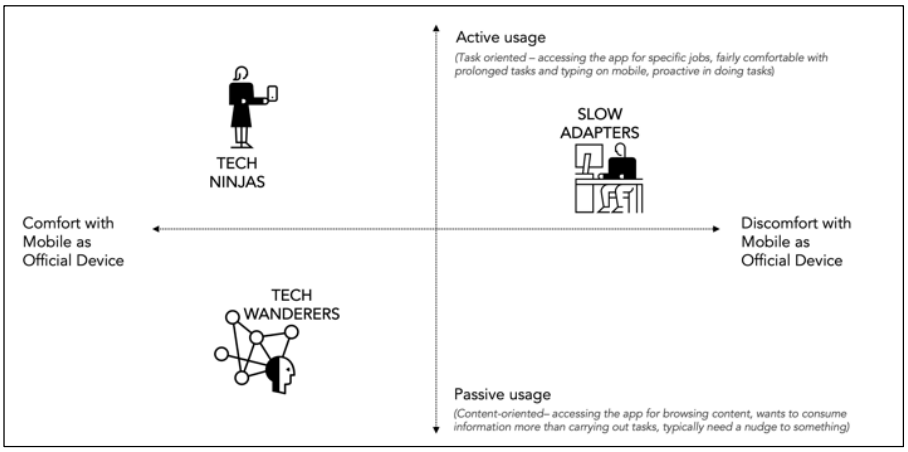

Figure 4: The Mobile Personas mapped on a matrix of patterns of usage and adaptability to mobile as an organizational device.

Tech Ninjas are those mobile users who are well versed with the technology and are comfortable using the device for HR tasks. They have a dedicated task to perform on the device and access it for the same. Tech Wanderers on the other hand are the ones that are driven by content and like to spend time exploring the application. They are influenced by the consumer-grade applications and seek out the same experience in the

HR world. Slow Adapters depict the discomfort in using mobile as a go-to device for their HR tasks. They are more inclined to use laptops for completing tasks because they lack confidence and are uncertain when it comes to using mobile. This representation of the archetypes of mobile users helps to deep dive into understanding the journey they embark on their device.

3.3 Mobile Experience Mapping

There has been a shift in HR technology from a mindset of Human Capital Management to Human Experience Management. As we navigate through this shift, we must design experiences that enable not just transactions but also addresses the user's need to engage and interact meaningfully with the system. The experience mapping charts out this journey right from the log-in to being able to accomplish a task on the mobile and exiting. The research sheds light upon the fact that users face trouble at the initial touchpoint of procuring and installing the HR application itself.

The experience for the personas also differs, the Tech Wanderers expect information and personalized content whereas the Slow Adapters and Tech Ninjas expect seamless access and navigation to the task. As they transition from this exploration phase to the enable phase, they seek out guidance when it comes to performing the desired task. And as they approach the last phase; they have already accomplished the tasks or continue to linger on the platform and expect to be engaged.

This 3E Model of Explore, Enable and Engage phases on the mobile journey illustrates friction points that impact the current mobile experience and help identify opportunities that can craft the future HCM mobile experience. The mobile experience can no longer be an afterthought or a passive transfer of the web experience. There is a need to simplify and adapt processes to mobile keeping in mind the user's needs, the environment of usage and expectations. Some of the key insights that emerge from the mobile experience mapping are:

- The first point of friction is the log-in part where users undergo a multi-fold process to even procure, install, or even use the application.
- As stated, all users are not the same, their journey, their expectations from the app also differ. Hence the challenge lies in decoding the personas that will be using the app and providing them with solutions that caters to their needs.
- Mobile as a device is characterized with low cognitive load tasks, which means that the tasks should be designed in such a manner that it does not overwhelm the user with information and requires less effort for completion.
- It is not just about the transaction, some users want to find ways to engage, explore the application. Keeping this in mind we must build micro engagement opportunities for the mobile users.

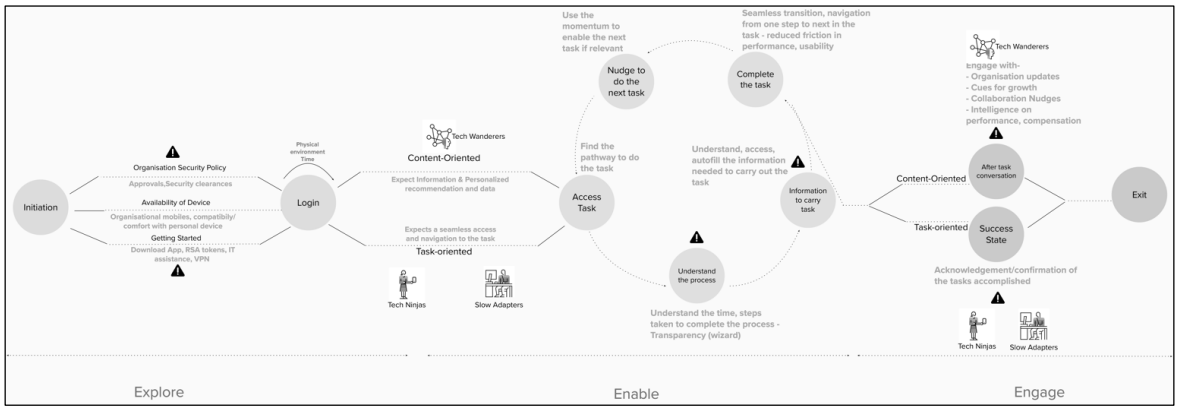

Figure 5: 3E Model of Mobile Experience Map - Explore, Enable & Engage

3.4 Mobile Innovation Toolkit

We live in times of unprecedented technological advancements. One must consider not just the capabilities of the devices today but also have a foresight of how these experiences can adapt to the devices of tomorrow. As we move into a more mobile world, it is important for us to design our products according to the device's capabilities. Although mobile brings in challenges like small screen real estate, it also has some in-built potential like location, camera, Biometrics, NFC, RFID readers. These capabilities can be maximized as we bring out the next generation of products. We have put together some of these triggers that can help bring innovation to mobile designs in the form of a toolkit – Mobile Innovation Toolkit. It provides a 360-degree view of aspects one needs to consider while designing for mobile.

The study distills all the insights of the study into this toolkit that puts together a set of triggers to enable innovation in the mobile product development process. It could be used for brainstorming while conceptualizing mobile products and has more versatile applications in the many upcoming mobile projects for the product.

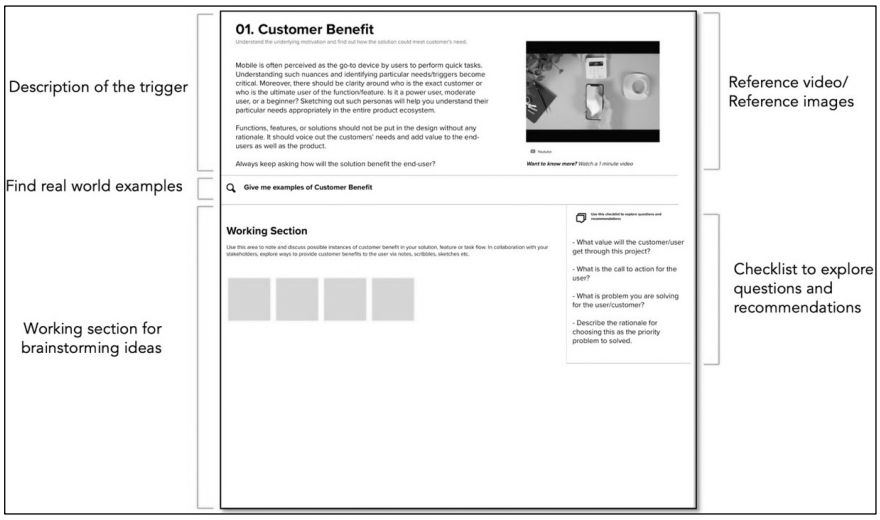

Figure 6: The above image showcases the structure of information in the Mobile Innovation Toolkit cards

The cards provide a description of the trigger, followed by some real-world examples of how different products or services are applying them into their design solutions. A brainstorming area is constructed to jot down all the ideas the team members come up with. The videos and images are put together for reference and a checklist is placed in case the team hits a roadblock while ideating. The 11 triggers that make up this toolkit are as given below:

1) Customer Benefit: Mobile is often perceived as the go-to device by users to perform quick tasks. Understanding the underlying motivations and identifying needs/triggers become critical. Moreover, there should be clarity around who is the exact customer or who is the ultimate user of the function/feature. Is it a power user, moderate user, or beginner? Sketching out such personas will help understand their needs appropriately in the entire product ecosystem. Functions, features, or solutions should not be put in the design without any rationale. It should voice out the customers' needs and add value to the end-users as well as the product. The intention of having this trigger is to realign the product development team's objective with the customer's need or benefit. The reason for this being often we jump into the "how" of product development without having spent enough time on "why".

2) Cognitive Load: Cognitive Load is the number of users' mental load associated with executing tasks efficiently. This theory was developed in the late 1980s by John Sweller. The theory differs from many other instructional theories as it lays emphasis on human cognitive architecture [3]. Cognitive load can relate to the quantity, quality, complexity, or relationship between pieces of information. This effect is more pronounced on mobile devices. High cognitive load adversely impacts user's efficiency and satisfaction, resulting in negative effects on task completion. Cognitive load experience is distinct for all users, people using a product/system for the first time may experience a higher cognitive load than experienced or power users. Let us say the user needs to take any action based on many facets of information. The solution should ask whether the mobile

experience handles this cognitive load in a conscious and meaningful way. Put simply, if the user has to 'juggle too many mental balls' while interacting with the solution, feature or task-flow, it should be re-examined.

3) Design for Touch: It includes understanding the ergonomics and designing for touch as it put information in the user's hand. Unlike the mouse or keypad, fingers are the most used cursors on the mobile. When designing actionable elements for a mobile interface, it's vital to make targets visible enough so that they are easy for users to tap. Mistaken taps often happen due to small touch controls or fat-finger errors. That does not mean that the icons should be always bigger, it is a matter of usability. Understanding the hot spots, the touch targets of the users, the appropriate distance between action buttons, placement of the buttons help in limiting the margin of error that can be caused by the user. The various screen sizes of mobiles and the placement of the call to action in high touch zones need to be considered as well.

4) Emotional Experience Touchpoints: In today's globalized world, mobile is an ecosystem of solutions and encompasses micro-engagement opportunities with society. People are not just dependent on mobile for these engagements but are also emotionally attached to the device. While designing there is a need to understand the feelings (highs and lows) the user goes through when they access the product or service. For example, when there is a payment failure user might not know where the amount has been lost, or while filling out a form they might attach the wrong files. During such instances how can the design assure the user and provide measures that can alleviate negative conditions? Another aspect to it is that design can be used as a mechanism to uplift the mood of the user during their entire task flow. Adding emotional intelligence, providing individualized experiences, or adding visual distractions can be some of the ways to make the emotional experience better.

5) Environment of Usage: Mobile has become an extended part of the human body and its usage is increasing inevitably. People across generations are seen using it all day for multiple reasons like texting, listening to music, doing their office work on the go, and much more. It becomes important to consider the circumstances in which the user is accessing the mobile and the kind of tasks they are trying to accomplish. For example, if an employee is commuting to the office, what kind of tasks could s/he possibly do, and what technology can be put to leverage? Identifying and mapping these opportunities in the user's journey can help address the user's needs and grab their maximum attention. Learning for example, can be designed for commute by adding more audio content. Understanding the context around the users help design better solutions.

6) Maximizing Device Capabilities: In today's world, mobiles are not limited to just connecting people, they have capabilities that make them inseparable from the user. To name a few fingerprint sensors are used for seamless logins in apps, NFC (near-filled communication) is being used for payments and haptic touch is slowly replacing 3D touch in smartphones. It quite interesting how these devices have potential that goes beyond the screen interface. Keeping this in mind, how can we bring these strengths of the device into play and add value to the user experience. Though these devices come with inherent constraints like smaller screen real estate, limited storage capacity, they do provide us with a range of opportunities. Push the thinking beyond "mobile-first" and start thinking about leveraging device capabilities first. For example, in the context of HR tasks, camera can be put into use to upload the various bills, receipts in the system to get them reimbursed.

7) Navigation: One of the main reasons cognitive frictions occurs is because the users struggle to find information when they navigate their way through the page. While performing tasks, irrespective of the devices used, the users slowly adapt to the workflow and build muscle memory for it. Providing that parity in navigation across devices becomes essential for users at this point of time. Some key elements that can help reduce this friction are:
A) understanding the user's mental model to decode their thought process while they use the application.
B) highlighting the essential information and making it visible for users.
C) bringing hierarchy to the information i.e., do not inundate the users with all the information on the landing page.
Give the users reasons to stay on the page and explore more of your application to know the product or service better. If the user can easily navigate through the page the chances of them abandoning the task is less.

8) Synchronize Devices: There is a constant need to enable a consistent experience across mediums and aid them to work in tandem. According to Appticles, 37% of users research on mobile but switch to desktop to complete a purchase [4]. Some triggers that cause these instances are the limited screen real estate of the mobile to fill the form, constant zoom in/zoom out to find actionable icons or information, attaching multiple documents, and so on. The solution needs to provide that flexibility to switch from one device to another and grant access to the saved data from the previous device to make it a seamless experience for the users. This can especially be beneficial for the tasks that carry a high cognitive load. Some tasks like income task declaration, compensation planning is by nature complex and carry relatively high cognitive load. Drop-offs on mobile are possible and therefore there should be an option for the user to pick up the task on a laptop and not lose their progress.

9) Task Flow Transparency: In the context of processes, transparency means creating a system in which the users can understand all relevant steps of a complex task easily and efficiently. Providing such an overview about the sequential steps, reduces user’s cognitive load and imparts a brief understanding of the duration of the steps. It thus becomes easy to identify the bottlenecks in the entire workflow. There is a sense of accomplishment or success state that a user goes through while completing a task. Even providing small cues related to task status like approved, in-progress, delayed, delivered can help in achieving that confidence. Providing relevant details for a complex task can inspire the users to complete the task.

10) User Input: The user input stands for the information that the user needs to feed into the system to accomplish a task. While designing for mobile, the limited screen real estate of the device as well as the nature of the task need to be considered. Understanding such limitations are important while extracting information because the users find it difficult to fill in so many details which would have been otherwise easy on a laptop. Some measures like autofill or automating the system to retrieve data from the existing repository or providing forms that are easy to fill could reduce the workload of the user. The mobile applications should thus ask for the bare minimum amount of information to reduce data redundancy and save the users from the hassle of filling in repetitive information.

11) 3D Assistive Screens: The flat screen of the mobile can be optimized to serve layers of information through them. These 3D assistive screens act as an additional layer that guides the users when they require intelligence about complex or new features, hence guiding the first-time user when they get onboarded onto the app. There are times when users do feel a little lost or anxious while using the platform i.e., transferring funds for the first time on a banking app. Moreover, some terminologies can be difficult for them to comprehend as they might be technical. Anticipating what tasks, the users might want to initiate and ensure that the screen can provide step-by-step guidance helps in mitigating the difficulties and making tasks trivially simple. It would help the users to navigate through the page and understand the new interface elements. To put it simply, there is a need to understand where and when such overlay can be done on screens to provide the users with cues to make them feel comfortable and assisted.

3.5 CONCLUSION

The value of this toolkit lies in the application of these actionable insights in real-time projects. The product team can use these frameworks while brainstorming ideas and catalyze innovation in their upcoming mobile projects. The Mobile Innovation Toolkit can be ideally used with different stakeholders like Product Manager, Designer, Researcher, Product Design leader to collaborate and list out the ideas while designing for mobile. The multi-disciplinary teams can apply this framework during the design as well as concept phase during the product development process. It could also be used as a checklist for teams to verify if they have covered all the bases while designing for mobile. It is not mandatory to use all the components of this toolkit in one go. Rather, the 11 components can be used with modularity and plug & play as per the project's requirements.

The objective of the study is to uncover the nuances of mobile usage in the workplace. The insights gathered bring the user's need to the forefront of product development. It also demystifies the components of a good mobile user experience. Ultimately the study can be used to inform product development in technology organizations so that they can continue to craft products that are relevant and delightful for the end-user.

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Ludic Odor: Designing Interactive Olfactory Experience for Daily Family Routines

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This paper describes an experimental design project *Ludic Odor* which explores the possibilities of designing interactive olfactory experience for parents and children in daily family routines. We propose to bring the affective and evocative aspects of smell to the interaction through digital olfaction. It associates the child's early encounter olfactory experience with the family bonding moments. Here, we take bathing as the instance of daily family routine which is shared intimately between parents and children through the sense of smell. *Ludic Odor* is designed based on the ethnography research method through fieldwork, thick description, and mental models of contextual design. The feasibility of this concept is discussed through the proof-of-concept at the family bathing in the real bathroom setting in Macao. The design components of *Ludic Odor* include the categories of scents associated with daily family life, the selection of scents by parents and children, the bathing artifact along with bather behavior, the emission device setting in bathroom and the interactive olfactory experience through the system connection. This paper discusses the opportunities for the future study in the areas of interactive olfactory experience design for parents and children at daily family routines.

CCS CONCEPTS • Human-centered computing~ Interaction design~ Interaction design process and methods~ Contextual design

Additional Keywords and Phrases: Olfactory experience, interactive olfaction, parent-child interaction, smell, odor

1 INTRODUCTION

Family is treated as a holistic unit rather than discrete individual in Chinese culture. Family bonding and gathering time are placed a higher priority than personal agenda [30]. Canton Chinese parents consider bonding as the quality of the parent child relationship to develop an ideal child [18]. In Chinese culture, family bonding time are always related to different olfactory experience. For example, Chinese New Year is considered as the most important family bonding time in a year. The smell of citrus, narcissus, cooking, firecracker and incense are some of the examples the family encountered together in the family traditions. The smell of white champaca and the smell of Liushen floral water were commonly found in the Canton Chinese family environment in 70s to 80s as home fragrance was not common at that time. The early encountered olfactory experience at childhood ties closely with the family activities in Chinese families.

Mark Greener [12], research pharmacologist, pointed out that the most intimate family bonding time through smell happens at bath time. As the child comes to be naked, the child feels the parents and the surrounding naturally through sensation. Bathing, the process of body washing, offers a rich sensory experience intimately

sharing between parents and child which is hardly provided by other family routines. The smell in the bathing environment not only makes the experience enjoyable, but also promotes the bonds between parents and child. The bonding experience with smell affects the behaviour and physiology of the child for long term. The family bathing is a great sensory experience for parents and child to play and bond in daily life.

People usually describe the olfactory experience beyond the sensation itself, but the memories of activities and associated feelings. For example, one referred "*the smell of baking*" as the pleasant moment spending with the family after dinner at Christmas while another referred a clean laundry smell to the experience hanging out with her aunt in childhood [32]. Olfactory experience should be considered as subjective perspective rather than a neutral object existed in the world. Yet current digital olfaction researches focus on the studies of odor identification rather than its role in daily life [16]. Smell is a process rather than the properties of objects. Olfactory experience is a rich description of the modalities that are dynamic and intertwined [4].

Providing olfactory experience through digital technology is getting more attentions in academics and industries in recent years. Digital Olfaction Society [9] is formed to connect the interdisciplinary researchers to bring the impact of smell to the people in everyday life. HCI researchers have been making attempts to provide olfactory experience to enhance the realism of virtual environment [23], to convert information [28], and to stimulate the gustatory perception [24] for example. The industries also introduced various computer-controlled odor emission devices. *Scentee Machina* [19] is one of the cases in the commercial markets. Yet some scholars argued that the discussion of the interactive design for olfactory experience in HCI community should expand from the focus on meeting tasks and solving problems to the meaning and possibilities behind [25].

2 RELATED STUDIES

2.1 The Role of Smell in Daily Life

The sense of smell is powerful to us in daily life, though unconsciously. We smell with every breath we take. Olfactory experience is richly extended the interaction with the world [8]. It connects people even they are separated apart. Smelling the odors of the partner's clothing brings people comfort and secure. The bonding elicited by odors can be carried through everyday objects [21]. The perceptual and cognitive responses to odors are based on associative learning from the early stage of life. It makes olfactory perception and its associated memories subjective among individuals [13]. The odor-evoked memories were less often evoked by other sensory cues [17]. The odors encountered at the early stage of life triggers an emotion that affects the behavior unconsciously. The meaning of smell is often beyond what the object represents. "*The smell of rotten eggs*" conveys shared experience and similar message among the general public while "*the smell of my childhood playground*" conveys a personal experience and private meaning behind [2]. The value of smell can bring a great impact to our daily life in the digital age through olfactory technology.

2.2 Early Encountered Experience with Smells

Odor-evoked memories were more emotional compared with those evoked by other modalities. If the odor is firstly encountered with a pleasant experience, this odor could bring pleasant emotion to the subject in the future [10]. This makes the encountered experience with smell at childhood becomes very crucial. The odors encountered at the early stage of children's life triggers an emotion that affects the behavior unconsciously. Children experienced a frustration mood when presented with unfamiliar odor [11]. However, if the children

experienced success with the presence of odors, the same odors would exert the positive effect on their next school performance [7]. The value of smell can bring a great impact to children's well-being in the digital age through olfactory technology.

2.3 Designing Experience through Digital Olfaction

In order to provide olfactory experience in digital context, researchers have been focusing on the development of olfactory display. Local odor display [1] is one of the cases. Rather simply clicking to smell, researchers explored different ways of interaction with smell. Kao et al. proposed to interact with smell through manipulating the form of clay [15]. Cao et al. proposed to use pebbles to blend the smell with lighting to create sensorial imagination to engage users' mind [5]. Another recent study proposed to use a necklace to emit the odors to affect people's mood and cognitive performance [3]. Yokokubo et al proposed a gaming system *eGenjiko* which provided olfactory experience in gameplay [33]. While the academics are taking the cutting-edge olfactory technology to apply in different areas, the industries also notice the potential of it. *Sensorwake* extends the digital olfaction into domestic life through olfactory alarm clock [29]. Yet researchers argued that current development focuses on the technical devices rather than how they are used [22]. Psychologists proposed to apply in the clinical virtual therapies to reduce the anxiety of burn victims and to restore the memory of brain injury patients for example [14]. Industrial designers proposed to apply in product evaluation. It enabled the users interact and experience the new product with the sense of smell while it was still under the stage of prototyping [6]. In recent years, researchers put it further on virtual reality application, such as sensory training [26] and motion sickness [27]. Besides, scholars also raise up the concern about how to guide the designers' choices when using smell. Maggioni et al, proposed to design olfactory interaction from chemical, emotional, spatial, and temporal perspectives [20]. All of these have opened up the possibilities of bringing the value of smell in bonding through digital olfaction for everyday life.

3 DESIGN PROCESS

The aim of this research is to explore the possibilities of designing interactive olfactory experience for parent-child interaction in everyday life. In this paper, we propose to design interactive olfactory experience for family routines through ethnography approach. *Ludic Odor* is designed based on the ethnography research with contextual inquiry and fieldwork in Macao. The design components of *Ludic Odor* are based on the fieldwork analysis. It includes the categories of scents associated with user daily family life, the selection of scents chosen by parents and children and the interactive olfactory experience through the bathing artifact with emission device.

The feasibility of this concept is discussed through the proof-of-concept at the family bathing in the real bathroom setting in Macao. This paper contributes in a way to design digital artefact with smell to create first encountered olfactory experience for promoting the family bonding between parents and child at bathing in the digital age, especially in the pandemic. Here we present our experiment project *Ludic Odor* as the proof-of-concept and discusses the opportunities for the future study in the areas of interactive olfactory experience design for parents and children at daily family routines.

3.1 Family Fieldwork Conducted in Macao

Fieldwork is an initial step of contextual inquiry to understand the users in the real context and to uncover the meaning behind. The fieldwork invitation were sent to the families through acquaintance which have working parents with young children living together. Our aim is to observe how working parents and child interact with each other for bonding at daily routines. Three families (Family X, Y, Z, see Figure 1) accepted the fieldwork invitation. They were respectively the X's family who had two daughters aged at seven and three; the Y's family who had a son aged at two, and the Z's family who had a son aged at three. The working parents in Macao usually do their daily routines with their children together after work during weekdays, such as dinner, playtime and bathing. Meanwhile, they treated it as the time for family bonding as well. Hence, our researcher conducted the fieldwork at these three families at weekday evening. The thick description of the fieldwork was later analyzed into five models, including flow, sequence, artifact model, physical and cultural model. Through these families have their own routines and background, there are some similarities found in the family fieldwork through the contextual inquiry with the model analysis.

Figure 1: Family Fieldwork Conducted in Macao (Family X, Y, Z)

3.1.1 Intimate interaction at preschool stage

Through the physical and flow model analysis, it is showed that parents tended to give more intimate interaction in close proximity towards the preschool children compared with the children in primary school. The children in the preschool stage relied on their parents in daily routines. For example in X family, Mrs. X stroked the younger daughter's hair when talking to her. Mrs. X followed the younger one walking in the house. Comparatively, the elder child was more independent. She did her own works even her parents were not nearby. In Y family, Mr. Y gave hugs towards his preschool son when playing the ball with him. In Z family, Mr. Z had intimate interaction with his son throughout the bath time such as the skin contact when scrubbing his son's body.Figure 1 is an example

3.1.2 Daily routine through playing

Through the sequence and cultural model analysis, it is showed that the parents often guide the children to do the daily routine through playing. X family set a to-do list to guide the preschool child to finish the daily task. The child would gain the awards after accomplished all in a week. Y family did roleplay to act like different musicians to guide the son to learn the vocabulary of music. The consolidated cultural model showed that parents take the daily routine as the time to bond with their children too. Z family sang and chatted with their son during the bath time.

3.1.3 Daily artifacts as the medium for interaction

Through the artifact model analysis, it is showed that the daily artifact in parents' perspective could be treated as a toy in child's perspective. In Z family, even though there were bath toys around, the son took the rinsing cup to play the water while his father used it to wash his body. Y's family turned the daily artifact into a toy. They would roll up a piece of paper to treat it like a flute or a violin bow to play. Two daughters in X family love to invite their parents to play the cooking game together. Mrs. X would pretend to be the customer when the girls did the cooking.

3.2 Personas

The personas are defined for the young families with working parents and preschool child. The parents personas need to go through all the daily routine after work while also treasure the time for family bonding in everyday life. The child persona loves to play and have parents accompany together. *Ludic Odor* aims to design for this personas family. It provides a way for the family to create their own olfactory experience with their family preferences. Also it lets the child encounter early olfactory experience in the pleasant context with their parents in daily practices.

3.3 Design Components

The concept of *Ludic Odor* (Figure 2) provides the categories of scents related to family daily life. It lets the parents and child choose the scents for daily bathing based on their family routines and preferences. Family interaction would be detected through the input sensors which are embedded in the artifacts. It triggers the odor emission from the olfactory output device installed at the bathroom. The duration and the sequence of odor emission are based on the interaction between parents and child.

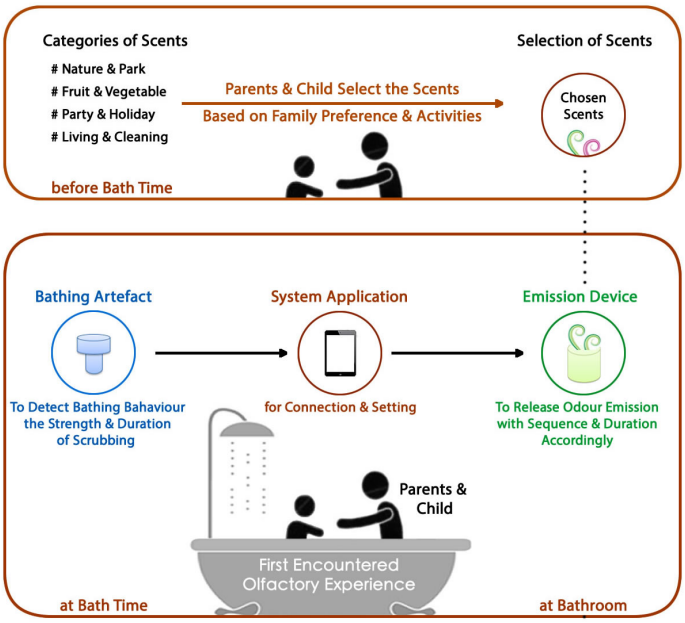

Figure 2: The Concept of *Ludic Odor*

3.3.1 The category of scents

The category is designed based on the model analysis of the family fieldwork. We found that most of the scents they could associate with are those related to their daily scenarios in Macao. Hence, we choose the scenario fragrance from Fragrance Library for our prototype design. The category includes (a) scents of nature, representing those encountered in the park; (b) scents of fruit, representing those encountered at daily food; (c) scents of party, representing those encountered at birthday parties or family gatherings, and (d) scents of living, representing those encountered in home living.

3.3.2 The selection of scents

We adopt the approach of Sugiyama et al. [31] to present the category of scents coded with random numerals (Table 1). It lets the families select the scents based on their olfactory experience itself rather than the label on it. Twenty samples are presented with the scented cotton inside the sealed bags. The parents and children select the scents together which might be associated with their family members, events or places.

Table 1: The category of scents with random numerals

Category	Numerals	Scent	Category	Numerals	Scent
Nature	227	Grass	Fruit	661	Coconut
	776	Bamboo		854	Mango
	957	Jasmine		903	Orange
	558	Lavender		952	Strawberry
	920	Ocean		543	Tomato
Party	189	Popcorn	Living	394	Laundry
	532	Chocolate		961	Baby Powder

Category	Numerals	Scent	Category	Numerals	Scent
	538	Vanilla		877	Paper book
	576	Coffee		852	Leather
	693	Earl Grey Tea		418	Mahogany

3.3.3 The bathing artifact

The interaction between parents and child at bathing is involved a series of behaviors. *Ludic Odor* integrates the bather behavior with the odor emission in the design system. Soap is the artifact coming along with haptic and olfactory sensory at bathing. We turn the soap as the artifact to detect the bather's action. In the initial design, we embed an orientation sensor inside a waterproof container and attach it to an odorless soap. When the bather holds the soap to scrub the body, it detects the orientation and triggers the corresponding odor emission.

3.3.4 The emission device

We adopt ultrasonic atomizers into our emission device. The ceramic piezoelectric transducers inside the atomizer transforms the liquid into mist through the vibratory motion made by high frequency sound wave from ultrasonic nozzles. The duration and the intensity of emission are controlled through the system. The batteries and ultrasonic circuit are all placed inside a sealed container in order to protect from humid environment at bathroom.

3.3.5 The system connection

We use Sony MESH IoT blocks for the system of *Ludic Odor*. It provides the interface for the families themselves to adjust the duration and the intensity of emission. Its wireless connection also fits in the bathroom environment. Sony MESH IoT blocks are compatible with IFTTT connection. It expands the possibilities of combing *Ludic Odor* with IoT applications for further development.

4 IMPLEMENTATION

The prototype of *Ludic Odor* (Figure 3) was deployed in the real family bathroom environment. It helped to reflect the fuzziness of real design problems that lab researches may not reach. It also provided a familiar environment for the children to experience the prototype like the way they usually do at daily bath.

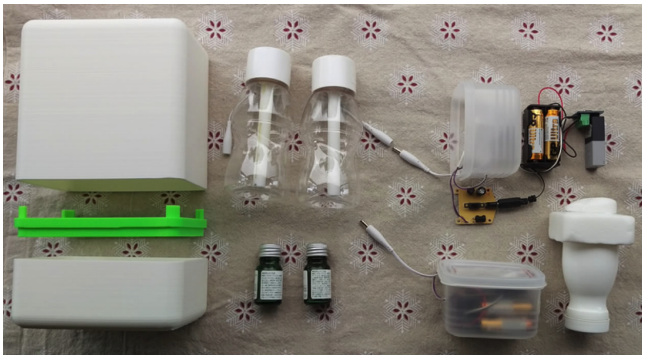

Figure 3: The Design Components of *Ludic Odor*

4.1 The Study

The families in the study were recruited by acquaintance in Macao. The invitations were sent to the families with preschool child aged under six. The purpose and the method of the study were given at the invitation. Four families accepted the invitation for the study. All of them have a child aged under six who is also the first child in the family. Child 1 (C1) is a four years old boy who attends the second year in kindergarten. C1's father and mother take turn to bath the child. Child 2 (C2) is a two years old boy attending child-care centre. During weekdays, C2's grandmother who helps to bath C2 as C2's parents usually come back home late. C2's mother would take the duty at weekend. Child 3 (C3) is a two years old girl. She is afraid of bathing due to previous accident at bath. Her parents take turn to bath her. Child 4 (C4) is a six months-old boy. C4's mother is the one who is responsible to bath C4 every day. The home visit included the setup, the selection of scents, the bath time and follow-up interview took around two hours for each family. The emission device was placed within one meter distance from the bathing area. Once the bath was finished, a follow-up interview would be conducted. Below we summarize and discuss the findings at the study.

4.2 The Findings

4.2.1 The associations of scents

Regarding the scent selection, C1's mother chose 903 scent and 532 scent which smelling alike her child's favorite. C2's mother chose 558 scent and 227 scent which reminded her their first family trip, even though she could not identify clearly what these scents exactly were. C3's mother chose 952 scent as it reminded her the smell of her daughter's skin. Also she related 957 scent and 854 scent to the sweet feeling with her husband. C4's mother related 776 scent as the imagery scenery of the blue sky. She chose 661 scent as it reminded her about her own childhood spending with her mother. She wanted to share this memory with her son. The selections of scents in the four families were mainly from the category of nature and fruit. Yet their reasons behind were different. The scents were chosen as they were associated with their children' favorite (C1), family vocation (C2), specific family members (C3), and the memory of the mother her own childhood (C4). Though the chosen scents indeed evoked their memories during the selection, all the families responded that they did not recall any associations while bathing their child. They simply focused on the action of bathing.

4.2.2 The label of scents

By replacing the original label of the scent with random numerals, it intended to let the families select the scent based on the olfaction itself. It reduced the subjective expectation gap between the name of the scent and the actual perception. However, the families responded that they preferred to know what they would smell before actually smelling it.

4.2.3 The bathing artifact

The children in the study were all under than four years old. It showed that they simply enjoyed shaking or touching the bathing artifact. Sometimes they held the soap upside down. It affected the intensity and the duration of emission. It would be better to design the artifact to match the bathing behavior. The continuity of scrubbing action fits into the continuity of odor emission for example.

4.2.4 The sequence of emission

In the study, the system emitted the odor continuously until the detected orientation was changed. It caused the confusion on the bathers. After all the scents were blended altogether in the air, the families hardly distinguished the scents. Strong scent covered the light one. It showed that it is important to consider the sequence of the odor emission according to the intensity of odor. Also, the parents concerned about the safety of the scent emission.

4.2.5 The interaction experience

The interaction experience with *Ludic Odor* was found to be different according to the age of the child. C1 was the eldest among four children. He was curious about how the interaction worked behind. Once his mother told him there was difference among the odor emission. He tried to find out the sequence patterns and the relationship behind by shaking to different orientations. When the odor emission gradually mixed up, his mother tried to guide him to slow down and played the guessing game to find out which odor was emitting. C2 focused on the bathing artifact itself rather than the odor emission caused. He kept shaking the bathing artifact for fun. His mother simply enjoyed the scents created by her son through *Ludic Odor*. C3 was the same age as C2. Similarly, her curious mainly fell on touching the artifact itself. Her parents let her treat it as a toy to play around. Comparatively, C4 was the youngest. His hands were too little to grab the bathing artifact by himself. His mother mainly focus on bathing him during the time. She took *Ludic Odor* as the background odor and simply changed the odor emission once she finished the bath.

4.2.6 The meaning behind

Ludic Odor provides different olfactory experience meaning to the families depending on the selection they chose. For example, C1's mother used *Ludic Odor* to provide her son pleasant atmosphere at bath by choosing the scent related to C1's favorite item. C2's mother took *Ludic Odor* as the way to bring them the feeling of being somewhere else like in a vocation. She wanted to bring the holiday mood into daily family bath. C3's parents used *Ludic Odor* to prepare the odor atmosphere before entered into the bathroom. They treated it as the attraction for C3 to play during the bath. C4's mother treated *Ludic Odor* as the tool to associate the memories and feelings across generation. She selected the scents brought her back to her childhood with her mother. She wanted to share it with her own son during the bath.

4.3 About the Deployment

Our study showed that the location of the emission device and the direction of the emission are crucial when designing for the domestic environment. Due to the limited bathroom space in Macao, the emission device was often deployed outside the bathing stall. It affected the bathers perceive the olfactory experience. For example, in C1's family, the child perceived the scents better than his mother as she faced backward to the device when she bathed her son. Another limitation that we conducted the study only in one bathing session. It would be good for the future development to study the family olfactory experience across weeks and months in the domestic environment. It helps to examine the outcome of the bonding impact it brings to the families through the daily routine.

4.4 About the Safety

We aims to design for the families with the working parents and preschool children. We found that the parents paid high concerns on the scent materials we used in the design. As the ones we used in the study are originally synthetic fragrance, it might not be good for the children to inhale for long terms. Yet the essential oil designed safe for children are limited to certain herbal essential oils for aromatherapy. On one hand, we suggest that the HCI designers work with the aromatherapists to co-design the olfactory experience for aromatherapy combing the IoT through the daily routines, for example, providing different scent emissions for aromatherapy in daily life according to the family bio data in real time. On the other hand, we might seek the alternatives by bringing the children to experience the scents in the real world through digital technology. It embeds the natural scents in the physical lives into the interaction in the digital lives.

5 OPPORTUNITIES AND CHALLENGES

Based on the findings of our study, we discuss the opportunities and the challenges of designing olfactory experience for parents and children in daily routines.

5.1 Designing Olfactory Experience through the Scenario

The scenario design affects how the families perceive the hostile olfactory experience in their home environment. From the category of scent to the interaction design, it has to match with their daily experience. For example, when we presented the scents with random numerals, the families chose the scents based on their own scenario association such as the scent which evoked their memories of family vocation. Therefore we suggest that designers can design the platform for the users to customize their favorite scents into interaction experience. Alternatively, we can work with the perfumers to create various sets of olfactory scenario to match with different daily routines. For example in the bedtime storytelling, the parents and the children can choose different sets of olfactory scenario to create their own olfactory experience with the stories.

5.2 Designing Olfactory Experience beyond the Moment

The design of olfactory experience can open to the interaction across multiple users in multiple sessions. In the field study, we found that there were some interesting interactions happened between the sibling' olfactory experience. The users can co-create the olfactory experience together within one space in different time sequences. Besides, our study showed that the parents not only related the scents to their children but also related to parents their own childhood. They would love to share these family memories with their children. The

interaction between the odor-evoked autobiographical memories and the present experience is worth to be further explored. We can design the platform which draws the odor-evoked autobiographical memories into the present family experience through digital olfaction.

5.3 Designing Olfactory Experience with the Artifacts

It is crucial to find out the appropriate daily artifact with a corresponding behavior when designing olfactory experience for daily routines. Initially we designed the interaction by mapping the orientations with scent emission. It turned out that it did not make sense to the users at all, especially the children. It only caused confusion for both parents and children. Later we refined the detection related to the bather's action at bathing in terms of the strength and the duration of scrubbing. The result showed that the users feel more enjoyable with the interaction. We thereby suggest that the variety of the artifacts can be designed related to the variety of the interaction as well.

5.4 Designing Olfactory Experience along the Culture

As the early encountered olfactory experience at childhood ties closely with the family routines. It is inseparably from the family cultural background. The perceptual and cognitive responses to odors are based on associative learning from the early stage of life. They are continuously shaped through culture and experience. In this study, we found that each scent has its own meaning toward different people under different culture contexts. Hence, we believe that it is important to take ethnography approach in local culture when designing olfactory experience in real contexts and daily practices.

6 CONCLUSION

In this paper, we present the design of *Ludic Odor* to examine the feasibility of using smell as the medium for daily family routines. It takes the form of bathing artifact for parent-child interaction at daily life to create the early encountered olfactory experience in a family context. It has five design components including the categories of scents associated with daily family life, the selection of scents by parents and children, the bathing artifact along with bather behavior, the emission device setting in bathroom and the interactive olfactory experience through the system connection. It aims to bring the affective and evocative value of smell at family bonding through digital olfaction. We deployed the prototype in the real family bathrooms in Macao for the study. The finding showed that the parents and children had enjoyable olfactory experience with *Ludic Odor* at bath, though there are some limitations behind as discussed such as the deployment, the safety and the cultural issues. Our study implies the opportunities of designing the digital artifact with interactive olfaction for daily family routines in terms of selection, interaction and experience. We hope this study will be benefit to the CHI researchers, especially the Asian community, to explore the possibilities of olfactory experience design in everyday life along with the culture context and the meaning behind.

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Personalized-Persuasive Mobile Exergames Design Model for Older Adults to Encourage Physical Activity

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Aging usually involves major changes in roles and social status. The adoption of a sedentary lifestyle, which causes loneliness, depression, and a variety of diseases, is the greatest health risk for older adult. However, persuading an older adult to participate in daily physical activity is not always an easy task. Exergame is a compelling approach to encourage the physical activity of older adults. With the growing power of mobile devices, Mobile Exergaming can now be used to encourage physical activity as well. This paper presents an outcome of a literature review conducted in SCOPUS, Web of Science and Google Scholar. The review is driven by the PRISMA Statement review method. As a result, this paper also proposes a personalized-persuasive mobile exergame design model to encourage physical activities for older adults.

CCS CONCEPTS • Human-centered computing • Human computer interaction (HCI) • HCI design and evaluation methods

Additional Keywords and Phrases: Mobile exergame, Personalization, Persuasive technology, Older adults, Physical activity

1 INTRODUCTION

As people age, their health deteriorates and they can lose abilities such as auditory, visual, cognitive, and psychological abilities [2]. Physical activity is suggested to delay or slow down the older adults' frailty and vulnerability [1,5]. Physical activity is a movement of the body that is created by contraction of the skeletal muscles and increases energy consumption [10]. According to Penedo and Dahn [25], physical activity is one

of the most effective ways to help older adults maintain their health and well-being as they age. However, older adults often find it challenging to stay motivated and engage in physical activity [21]. Billis et al., [4]once stated that older adults often lack motivation and encouragement to perform physical activities. In order to solve many obstacles that hinder the older adults from doing regular physical exercise, innovative and non-traditional methods can be considered, such as exergames. Exergames is a combination of exercises and game; also known as exercises games or exergaming. In recent years, exergames also have grown significantly in variety areas such as physical health [6,8,11,12], mental illness [14,17,20] and frailty [9,22,27]. However, there is a lack of study related to mobile exergame design models that consist of integrated components that are suitable for older adult users to encourage physical activity. The main objective of this paper is to propose a design model of mobile exergame to encourage physical activity focusing on older adults. To propose the design model, first we need to increase our understanding of the existing research work in exergames, mobile exergames and older adults and physical activity. Several research questions have been derived from our research. Our research questions are;

RQ1: What are existing exergames that focusing on encouraging physical activity among older adults?

RQ2: What are the trends in strategies, model, theories or component of exergames for older adults used to encourage physical activity?

In order to answer our research questions, we began with conducting a background study and literature review to understand the topic and identify possible gap. Hence, the objective of the early research work as well as this paper are:

RO1: To review existing exergame with purpose to encourage physical activity among older adults.

RO2: To highlight trends in strategies, model, theories or component used to encourage physical activity among older adults.

2 METHODOLOGY

To ensure a comprehensive inclusion of relevant studies about this topic, a systematic literature review was conducted. The systematic literature review method was driven by the PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) [23]. PRISMA was used because it provides three specific advantages: (i) it defines simple research questions that allow for systematic research; (ii) it specifies requirements for inclusion and exclusion; and (iii) it seeks to review a broad database of scientific literature at a given time.

2.1 Search strategy

Studies published from year 2008 to 2021 were retrieved through systematic literature searches in the databases. Two main databases, Scopus and Web of Science were used to search relevant papers, as both databases are substantial and cover global research areas. We also performed a manual search in Google Scholar, considering that it contains relevant journals that meet the required paper criteria.

2.2 Selection procedure

In the Identification phase, we used the following title search string (("exergame*" OR "exercise game*") AND ("older adult*" OR "elderly" OR "senior citizen*" OR "retiree" OR "older people" OR "older" OR "aging" OR "ageing") AND ("health" OR "physical activity" OR "fitness")). In this phase, duplicate articles have been

removed after careful filtration. The second phase is screening and the third phase is eligibility, which has access to all the articles. Articles that did not meet the eligibility criteria were omitted. Only articles and journals with empirical evidence are selected, which means that review articles, book series, book chapters, book reviews and conference proceedings are excluded. Second, in order to avoid the complexity and difficulty of translation, the search work omitted non-English publications, and concentrated only on papers written in English. Third, because the research focuses on exergames with encourage physical activity purposes, specific papers written for different or unrelated purposes are excluded. The report on the younger generation as a field is also omitted, that is, under 55 years old. Non-exergames are also omitted.

3 RESULTS AND DISCUSSION

After the implementation of systematic inclusion process, total of 14 articles were derived from three main databases. Two articles have been published in 2021, five papers published in 2020, two papers in 2019 and one published in 2018, 2016, 2015, 2009 and 2008, respectively. There are three main categories of tools and platform used for exergames which are; 1) Kinect Xbox, 2) Nintendo Wii, and 3) Mobile Exergames. There are few strategies or model found including Social Interaction, Co-designed, Behavior Change Techniques (BCT), Dynamic Level Adjustment, Fun and Interactive, Social Support, Custom-made exergame, Persuasive, Pervasive, and Self-efficacy. A review of the literature on exergaming indicated that these types of games have the potential to increase PA and thus facilitate the increase of PA levels in older adults. However, some challenges have been found in exergames' ability to persuade older adults to exercise. Currently, motivation in exergames play is still being researched and needs to be assessed over a longer period of time. Persuasion approaches, according to previous research in this area [12,24, 30], may be a feasible option for motivating older adults to participate in physical activities. The key factor that can evaluate the persuasiveness of behavior change is by creating a personalized or customized experience for each person [13]. Another potential disadvantage of using current exergame is the small amount of space available for video game play. This limitation may be due to the exergame technology's immobility. Therefore, mobile exergames are another way to increase individual's motivation to exercise. Mobile exergames is healthy games on mobile platforms [16], or games in which the mobile platform is the exergame's controlling mechanism [19]. However, there may be concerns about older adults being confused about the content of mobile exergames, such as the type of exercise that is appropriate for them. Since the new technology is unfamiliar to them, they may be doubtful if it is suitable for them. This concern may result in individuals quitting the use of mobile exergames. To address this, we propose that a personalization aspect be included as a key feature in our mobile exergames design model. Personalization is important for a system because the concept of 'one-size-fits-all' is less appropriate since each user's preferences are different, especially older adult users who have their own challenges [7]. The personalization component is essential to achieve transformation [28] and has also been proven effective for behavior change in several independent studies [3,18, 29]. Also, personalization of the game content increases acceptance of serious games [15]. Therefore, the personalization component needs to be considered when developing a mobile exergame design model, especially if it is designed for older adults. Moreover, as mobile devices provide more reliable, affordable, and appealing real-time support, there is an increase in better ways of personalization, which could increase the efficacy of mobile exergames in promoting physical activity. More research should focus on a mobile device such as smartphones, as they are more affordable, more popular than desktop and notebook computers, and

commonly used by older adults. In addition, the mobile usage trend has become the current phenomenon in the market [26]. Following to that, the researchers attempted to propose a new persuasive mobile exergame design model aimed at encouraging physical activity for older adults.

4 PROPOSED MODEL

The proposed mobile exergame design model aims to encourage older adults to exercise while playing mobile games. We have selected three main categories to be implemented in the mobile exergame design model we propose. The first category is the primary task support. The components in the primary task category support the execution of the user's primary task. The second category is the dialogue support between computers and human. This category is to help users to continue move towards their goals or target behaviors. The third category is social support. The components in this category describe how the system uses social influence to motivate users. Figure 1 illustrates our proposed model.

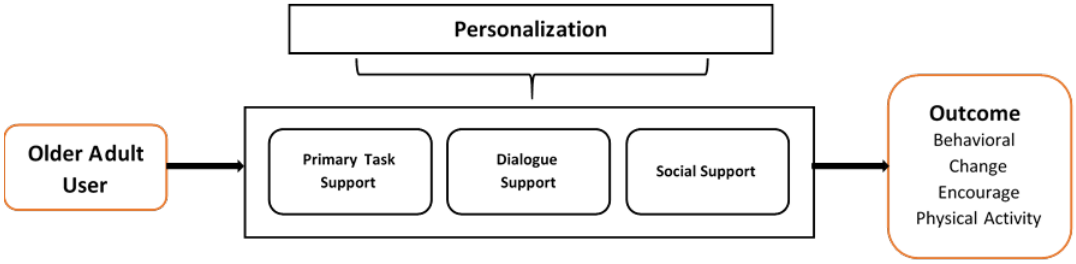

Figure 1: Proposed Mobile Exergame Design model for older adults

5 CONCLUSIONS

The aim of this review paper is to look at the possibility of implementing personalised persuasive mobile exergame solutions to encourage older adults to participate in physical activity. Exergames can help older adults increase their physical activity levels in a number of ways. The personalised persuasive strategy may have even more benefits for increasing levels of physical activity in the aging generation. Based on the review we conducted, we proposed a mobile exergame design model for older adults that included a personalization as a main component. To validate our proposed mobile exergame design model, we intend to conduct an online focus group interview with the older adults and as well as an interview with experts in the field of gerontology and exergames developer. Following that, we will develop a mobile exergame prototype and evaluate it to see the effectiveness of our mobile exergame design model in encouraging older adults to participate in physical activities.

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Relax App: Mobile Brain-Computer Interface App to Reduce Stress among Students

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Students especially at universities undergo a lot of pressure and stress, and mental health is something that must not be taken lightly, especially at the time of pandemic as we are experiencing now. The need for us to look into the mental health is constantly reminded everywhere. There are a lot of ways to reduce stress such as meditation, getting involved in sports and one of the most practiced methods is by listening to music. Music has been indeed proved to have positive effects on humans and that it aids healing process such as binaural beats and Solfeggio frequency. These frequencies of music have impact towards the brainwave. This study reports on how we explored the mobile Brain-Computer Interface (BCI) as an application to know the impacts to reduce stress by studying the impacts of different type of frequencies of music on the human brain. Besides suggesting a generic guideline to develop an application for mobile BCI, this study also provides us insights into the readiness of mobile BCI as an application for common usage.

CCS CONCEPTS • Human-Centered Computing •

Additional Keywords and Phrases: Mobile application, Brain Computer Interface, Design thinking process, Stress level

1 INTRODUCTION AND MOTIVATION

The stress level among students is in alarming state. A recent study by [1] has shown an increased stress and anxiety due to the COVID-19 outbreak. Even before the time of pandemic, in dealing with stress, listening to music has always been seen as a great way to reduce stress as it is proven by neuroscience that it calms nervous system up to 65% [2]. Brain Computer Interface (BCI) is widely known as a technology that is able to detect the EEG signal of one's brain. With the advent of mobile BCI, there is yet an application that could measure the stress level of a person and suggest a way to reduce. The closest applications that are available in the market right now which come with Neurosky Mindwave Mobile 2 are those that measure the focus level and meditation level of a person, brainwave visualizer, study trainer, etc. [3]. This motivates this study to explore

the most suitable design for a mobile BCI application that could work as a means to facilitate in reducing stress especially among students.

Currently, the studies regarding Solfeggio frequencies and binaural beats and their capability to reduce stress among students are limited, let alone the compatibility of Solfeggio frequency music alongside of BCI. Not only that, existing stress detecting methods are they are time consuming and requires an individual's full attention to indicate the level of stress. With EEG that is received from the signals from the electrical activity of the brain, we are able to measure stress level instantly. In this paper, a design thinking process is adopted to create a user-centered mobile BCI application, known as Relax app, to reduce stress by incorporating two different music ;1) Solfeggio frequencies and 2) Binaural beats.

2 DESIGN METHOD

After gathering and eliciting users' needs and insights via online questionnaire on 12 students, a wireframe was first built to illustrate the flow that reflects the needs of users. A series of prototypes was developed to realize the initial design idea. The first prototype (Prototype I) is a low-fidelity prototype, which was to further understand the interaction and the flow of the application to fulfill the tasks.

Second prototype is HFP 1 which is a working prototype developed using Android Studio. User starts by accessing the home page and reading the instructions first then in the activity page, they are required to connect to the headgear first before clicking on the detect stress button. Once the button is clicked, a stress meter appears to display the stress level of an individual. Before a usability test can be conducted, a pilot study was conducted on HFP 1. The purpose of the pilot study was to examine the feasibility of the actual test. Three participants involved to test the Relax application and were asked to complete the SUS and a feedback form. From the pilot test, it was found that they faced some difficulties as they used the app. One of it was, when the user checked the stress level again, the Solfeggio frequency music kept on playing in the background because music was set on a loop. Hence, the correction was made to play the song only once. Some users also needed assistance to make sure the headgear was worn properly. HFP 1 was then further enhanced where the enhancement was mostly done in the main activity screen to ensure the clarity of the flow of the application. Figure 1 illustrates the final working prototype (HFP 2).

The actual usability and performance test on the working prototype 2 (HFP 2). The aim of this test was to measure the performance and effectiveness of the Relax app and its usability. To measure the performance and effectiveness of the Relax app, a within subject design was applied, where the users will be needing to measure their stress level using (i) stress level assessment, and (ii) Relax app. Meanwhile, SUS instrument is used to measure the usability of the Relax app. This session was participated by 10 new participants. They were first asked to answer online stress assessment that is available on the BeMindful website (http://www.bemindful.com). This assessment required the participants to answer 10 multiple choice questions and at the end of the assessment, participant's stress level is stated. The participants were then asked to test the usability of the prototype. The participants were first briefed about the Relax app prototype. The participant was equipped with the BCI headgear; NeuroSky Mindwave Mobile 2, with the Relax app prototype in Huawei Nova 3e smartphone. Each participant was given tasks that instructed them to wear the BCI headgear and navigate through the application to check their stress level and try to reduce it by selecting and listening to music. The session approximately lasted 10 minutes for each participant. At the end of the session, the participants were given the SUS form to review the prototype.

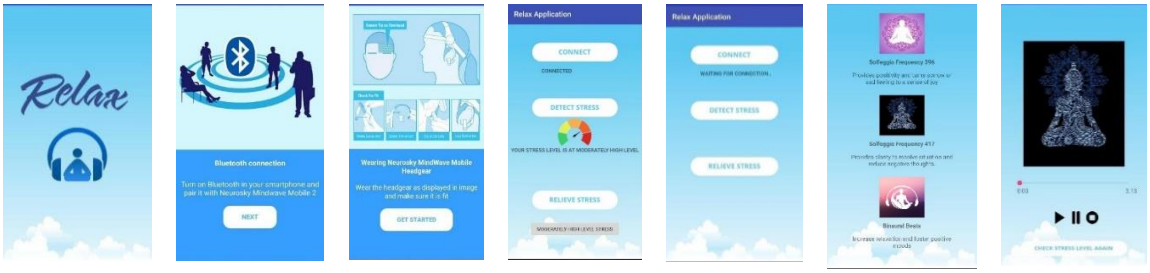

Figure 1: Image Interface of Second Working Prototype (HLP 2) of Relax app

3 EXPERIMENTAL RESULTS

3.1 Performance and Effectiveness

The performance and effectiveness of Relax app were measured against an online stress level self-assessment test. Out of the 10 participants, 60% stress levels were detected the same by using both methods, with 20% the Relax app detected one level higher, and another 20% the stress level self-assessment detected one level higher. See Figure 2. The time to detect the stress using both methods was recorded for each participant. The time taken for the assessment is recorded from the second the participants start to read the first question and as for the Relax app, the time is recorded from the second the participant clicked on the start monitoring button (once the Bluetooth connection is established). Using the self-assessment test, the time taken was ranging from 1 to 3 minutes, while using the Relax app the time was constant at 5 seconds. See Figure 3.

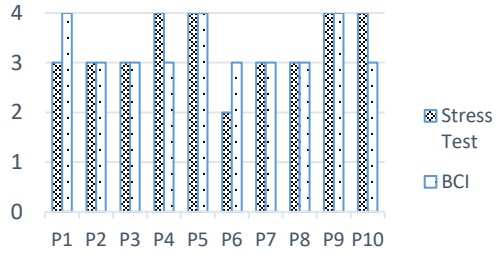

Figure 2: Stress level using Stress Test and Relax app

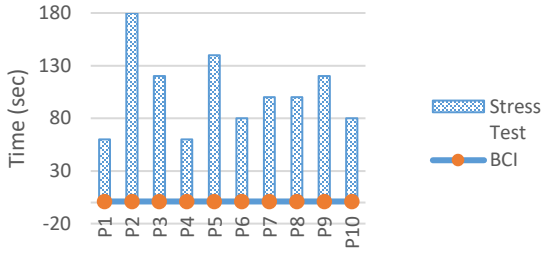

Figure 3: Time Taken to Detect Stress Level

3.2 Usability

The SUS form consists of two sections which has the feedback of the application and the usability scale. Figure 4 shows the SUS response using the average value. The highest rating by participants is confident of using the application which is 3.4 followed by the ability for participants to learn quickly at 3.3 and easy to use at 3.2. There is no factor below the average 2.00 and the lowest rating is at 2.2 which is on the inconsistency. Feedback received stated that the design of the application is minimalistic with an interface that accommodates first-time user. User is able to understand the icons and navigate through with minimal instructions provided. The color and the font of the application is also said to be comforting to relax an individual.

3.3 Comparison between Solfeggio Frequency and Binaural Beats

This study offers two different music which are Solfeggio Frequency and Binaural Beats in the design of the Relax app. Table 1 below shows the stress level before and after listening to Solfeggio Frequency and Binaural beat. According to Table 1, 6 participants were able to reduce their stress levels with Solfeggio frequency and as for the rest 4 participants, 1 participant's stress level is the same before and after, and the other 3 participants' stress level became higher. In comparison to binaural beats, 5 participants were able to relax themselves and for the other 5 participants the stress level increased after listening to the music.

Table 1: Stress Level with Solfeggio Frequency and Binaural Beat

Music	Solfeggio Frequency		Binaural Beats	
Stress	Before	After	Before	After
P1	Moderately High	Moderately Low	High	Moderately High
P2	Moderate	Moderately High	High	Moderate
P3	Moderate	Low	Moderately High	Moderately High
P4	Moderate	Moderately Low	Moderate	Moderately Low
P5	Moderately High	Moderately Low	Moderately High	High
P6	Moderate	Moderate	Moderate	Moderately High
P7	Moderate	Moderately High	Moderately High	High
P8	Moderate	Moderately Low	Moderately Low	Moderate
P9	High	Moderately High	Moderately High	Low
P10	Moderate	Low	Moderate	Moderately Low

4 CONCLUSION AND FUTURE WORK

From this study, we are able to see how the design thinking method could be used to develop a mobile BCI-based application to detect stress level. This Relax App offers two different music to reduce the stress level of an individual. The study result shows that the mobile-BCI has huge potentials in facilitating in reducing stress levels among students. In particular, it suggests that Solfeggio frequency is a better stress-relieving music and detecting stress level using BCI is a much more effective way. The design of the application can be further expanded into other functionalities of smartphone such as connecting it with other music platforms such as Spotify. Overall, this study explores the potentials and readiness of BCI in everyday and common usages and contributes a guideline for the development of similar mobile BCI-related applications for future designers and developers.

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