A Card-based Ideation Toolkit to Generate Designs for Tangible Privacy Management Tools

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ABSTRACT

Effective privacy protection in dynamic UbiComp environments requires users to be able to manage their privacy seamlessly across diverse contexts. To support this, designers need to go beyond GUI-based interactions and utilise tangible and embodied interactions. To help designers in such endeavours, we present the TTP toolkit: a card-based ideation kit to generate designs for tangible privacy management tools. The toolkit translates the Privacy Care framework for tangible-supported privacy management into a game intended to support designers in developing TUI privacy management tools. We demonstrate use of our toolkit through 10 online participatory workshops with 22 interaction designers. Our results demonstrate that the toolkit was effective in supporting the participants to creatively and collaboratively generate meaningful conceptual designs of tangible tools for privacy management.

KEYWORDS

Privacy management; tangible interactions; ubiquitous environments; ideation toolkit

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1 INTRODUCTION

Due to the increased ubiquity of computing devices in our everyday social and physical spaces, the possibility of privacy violations has dramatically increased. These violations can happen in the form of undesired access to an individual's physical space or their information, anytime and anywhere, raising serious privacy concerns [17, 18]. Due to the highly contextual and dynamic nature of ubiquitous devices, automated privacy protection and control is unlikely to be effective. As several researchers have argued, to enable an individual to effectively manage their privacy in environments full of ubiquitous devices, it is essential to raise users' awareness appropriately and provide them with straightforward privacy management controls [2, 17, 19, 31].

The majority of existing end-user interfaces that support privacy awareness and control are GUI based. Due to inconsistencies with our interactions in the physical and social world, these interfaces pose several usability challenges especially when managing privacy dynamically. GUI tools tend to fail to focus on the contextual needs, interaction capabilities and ad-hoc privacy management desires of a user in ubicomp environments, making the entire experience of dynamic privacy management physically interrupting, socially disruptive and predominantly time-consuming. Previous work highlights such challenges and argues that a tangible and embodied style of interaction can improve the user experience of privacy management [23, 27]. Drawing on the literature of user-centric privacy management and tangible computing, Mehta et al. present *Privacy Care*, the first privacy framework that guides designers in the design of effective and seamlessly natural privacy management in everyday settings [27].

Just like many other conceptual frameworks, the Privacy Care framework describes an abstract set of essential qualities that are desirable, but doesn't provide step-by-step guidance on how to creatively develop a design concept, thereby leaving a gap between theory and the practical design process. There is a need to transfer knowledge between design theory and practice that is "more lightweight and accessible" [33]. To bridge that gap, we translate the framework qualities into practical insights for interaction designers and present them in this paper as the Tangible Tools for Privacy (*TTP*) toolkit. TTP is a card-based ideation toolkit that consists of 92 cards, a gameboard and a workshop-based game protocol. Guided by the framework, the TTP toolkit provides its users with creative freedom to generate design ideas for managing privacy in different contexts. It helps users to reflect, iterate and improve their

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designs. The toolkit also facilitates a collaborative approach that is participatory and playful in nature.

The toolkit material is released under a Creative Commons license and can be downloaded at [26].

To demonstrate the efficacy of the TTP toolkit in supporting idea generation for privacy management tools, we conducted 10 online participatory workshops with 22 interaction designers. We present results from those workshops, demonstrating that the toolkit was perceived to support creativity in effectively generating interaction design concepts for tangible tools to support privacy management.

2 BACKGROUND AND RELATED WORK

2.1 Characteristics of Card-based Tools

Card-based tools are widely used as effective design instruments to stimulate creative thinking and support idea generation [37]. They inspire and positively structure the process of idea generation by facilitating free but focused thinking, open ended interpretation and provocative questioning [11]. Fostering a human-centred participatory approach [13, 28], they also promote collaboration by supporting creative dialogue, developing shared understanding, and ensuring multi-perspective input [11, 21]. Collaborators can explore and externalise their ideas, taking risks within the structure of the game [4]. Cards can enable users to iteratively reflect and plan evaluation [11, 20].

Across diverse studies using card-based tools, clear practices for making the best use of card properties have been established, including:

- Cards can be sorted and grouped [6].
- Cards can help to bookmark ideas and steer discussion [11].
- Adding game mechanics such as turn-taking [11], role-changing [4] and time-bounding steps [28], to collaborative design activities further improves idea generation [4].

We incorporate all of these characteristics in the design of our toolkit.

2.2 Translating Theory into Practice using Card-based Tools

Understanding the usefulness of the characteristics outlined above, several privacy researchers have used card-based approaches to teach complex privacy concepts and raise awareness about privacy in general. For instance, Denning et al. presented a card brainstorming toolkit to facilitate the exploration and awareness of potential security and privacy threats for a particular system [7]. The toolkit supported this facilitation in terms of ranking cards on an adversary's motivation, resources, methods and the aspects of human life that could be impacted. Luger et al. used ideation cards based on European data protection regulations to raise awareness among designers, and encourage it's incorporation in the early stages of design process for any technological system [22]. They tested their cards through 4 design workshops with 21 participants and found their participants perceived the cards to be useful in promoting human-centered regulation. Dowthwaite et al. used data cards to stimulate discussion about the sharing and selling of personal data by online companies with 116 young participants (13-18 years old) in 11 workshops, and suggested it's incorporation into the school curriculum [8]. Taking a more gamified approach, Bergen et al. presented their card-based ideation toolkit to involve teenagers in co-designing serious games for improving their general privacy awareness levels [3]. The protocol enabled participants to describe a real domain, play genre, and the game concept. They evaluated the usefulness of their toolkit with 32 teenagers in 9 groups. Drawing from poker and similar card games, Barnard-Wills et al. designed a privacy card game to facilitate exploration and discussion around issues of online privacy [1]. In the game, players are continuously presented with a series of disclosure/privacy decisions to take in a competitive environment. Certain packs also introduce uncertainty and thereby disrupt strategies. The game was tested with 130 players from a wide variety of backgrounds.

While all this work [1, 3, 7, 8, 22] aims to use card-based approaches for improving participants' knowledge on privacy and change their attitudes when designing technological systems or towards their own data sharing practices, we focus on ideation for designing privacy management tools themselves. Our cards enable designers to choose the form-factor of a device they envision, its' input-output interaction modalities and its' desired privacy management functionalities in accordance with a given privacy violation scenario. Our cards also help participants to evaluate and iterate their design concepts according to usability criteria specific to end-user privacy management. The design concepts that originate from our toolkit intend to represent tools that could be used by end-users to manage their privacy in everyday settings.

2.3 Card-based tools for TUIs

Several researchers in the field of tangible computing have gone further and developed card-based tools to effectively translate complex theoretical concepts or specific frameworks into actionable guidelines for designers and help them design technology for different application areas. For instance, Hornecker transformed her "Tangible Interactions Framework" into cards to brainstorm in a game format [11]. They reflect on using the cards in 10 distinct projects, considering the value the cards have had in supporting design. In addition to arguing that the cards have proved effective as an ideation technique for tangible systems, we will also follow the recommended practice of providing an appropriate number of constraints to provide scaffolding without reducing creativity.

Similarly, Mueller et al. transformed their "Exertion Framework" into a set of design cards and examine their utility in the ideation phase of designing exertion games through 7 sessions with 134 design researchers and students [29]. Based on interview and questionnaire feedback, they argue that the cards helped provide team focus, and assist in generating and improving ideas.

Deng et al. translated the "Tangible Learning Design Framework" into Tango Cards to inform the design of tangible learning games [6]. They evaluated the effectiveness of their cards with 24 design students in 12 sessions, who were asked to use the cards to first design adaptations to an existing game, before using them in an ideation session. Based on interviews and observations, Deng et al. conclude that using the cards made design knowledge about tangible learning games accessible to designers. They also highlight the need to minimise the information on the card, and make the

cards visually distinct. Such design properties were carried through into TTP.

These three examples [6, 11, 29] share a common approach in framing design considerations as provocative questions in their cards. The participants either have to already have a design concept and choose between relevant or irrelevant cards to uncover neglected issues and new insights, or adjust their design concepts to incorporate design considerations from as many cards as they consider appropriate. While such cards are useful for stimulating ideation and act as criteria to consider or evaluate with, participants are not provided with any individual cards to support them conceptualise and externalise the input-output functionalities, interaction modalities and form-factor of the technological solution itself. Moreover, there is no structure or guidance provided on how to use the cards and progress, which risks overloading and confusing participants [11].

Mora et al. address these gaps in TILES, a card-based ideation toolkit to support ideation in the design of novel 'Internet of Things' user experiences [28]. In addition to providing cards for design provocation and reflection, they also provide users with the opportunity to first pick cards for conceptualising the design concept in terms of their form-factor, feedback and control modalities, logical operations and data channels. A playbook with time-bounded steps and a game-board for scaffolding use and placement of cards is also provided to the participants to guide them through the game-play. They evaluate the usefulness of their tool through 9 workshops with 32 non-designer participants. Based on interviews, observations, and questionnaire data, they conclude that their toolkit helped participants to design augmented objects, and supported creativity across the ideation process.

The literature reviewed demonstrates the value card games can have in supporting the design of tangible tools. In their review of 71 design-focussed card games, Peters et al. found that for those games that are evaluated, the standard approach is an empirical investigation of how the game is used in design sessions, and questioning the participants on their experiences [32]. A similar approach is taken within the TUI community (e.g. [6, 11, 28, 29]). This is the same evaluation approach we shall take.

2.4 The Privacy Care Framework

The Privacy Care interaction framework is rooted in the literature of privacy management and tangible computing [27]. Keeping users at the centre, privacy *Awareness* and *Control* are established as the core parts of the framework. This is supported with three interrelated interaction tenets that aim to make privacy management *Direct*, *Ready-to-Hand* and *Contextual*.

'Privacy Awareness' stresses the importance of making users aware of relevant aspects of an access appropriately, in order to enable them to decide whether a particular kind of access is a privacy breach or not. These aspects cover dimensions of information on 'who' is accessing the user, 'what' is being accessed, 'when', 'why', and 'how'. It also suggests not restricting the feedback representation to textual/visual means only but distributing the right combination of the multi-dimensional information across different sensory channels through visual cues, sound, haptics or smell as per users' context and available attention. 'Privacy Control' describes three different types of controls that a user could choose from when trying to manage their privacy: *allow and block*, *confront* and, *record and report*. The control actions can be exerted *re-actively* or *proactively* by the user. To achieve seamlessly natural and ad-hoc control interactions for privacy management, it also advises designers to go beyond touch interactions and support privacy control with direct haptic manipulation [12], spatial interactions or full body movements [12].

To achieve sensory embodiment, the framework suggests integrating elements of privacy awareness and control into the everyday objects and environment around the user, thereby supporting augmentation as a design strategy [16]. 'Direct' refers to leveraging the inherent physicality, familiarity and embodiment offered by tangible computing systems to design metaphor-based interactions that are meaningful. 'Ready-to-Hand' suggests design interactions that are ad-hoc (always available as and when needed) but neither intrusive nor buried. The interaction modalities should be suitable to support coarse-grained privacy management at the periphery of users' attention (requires minimum cognitive or physical resources), and fine-grained management at the center of their attention (more focused and precise). 'Contextual' stresses the importance of the properties of a situation in a user's perception, implication and mitigation approaches for privacy management. It supports design for versatility, flexibility and extensibility so that the system can be integrated across different contexts.

We instantiate these principles in the design of the content and categorisation of our toolkit material.

3 DESIGN OF THE TTP TOOLKIT

The toolkit consists of 92 cards, a gameboard and a workshop-based game protocol. The toolkit is intended to be used as a collaborative game, that encourages playfulness and creativity during the ideation process of developing tangible tools for privacy management. The objective is to generate ideas on how an everyday object can enhance awareness of an unexpected privacy violation and enable control for the central character of a given storyboard in real-time, also fulfilling various usability criteria. To play the game, designers need to use scenarios which represent the problem space they are working in. In this paper we contribute an initial set of scenarios for illustrating the utility of the game.

3.1 TTP Cards

The 92 cards are divided into five packs where each pack is color coded for easy discernibility. The front is different for each card, showing a representative image of an object or a concept specific to that card, the card's title, a short role description, and a footer with the pack's name and the card number. The back presents a representative image for the pack, the pack's title, the pack's role and a footer with the project title. Two blank cards are also provided for each pack to encourage free thinking and give toolkit users an opportunity to design their own cards if they wish to do so. Figure 1 illustrates the front and back sides of one representative card from each pack. See [26] for the full set.

Each of the 5 card packs represents a distinct element of the Privacy Care framework [27].

Figure 1: Front and back sides of representative cards from each of the five card packs.

3.1.1 Pack 1: OBJECT. These cards (n=22) refer to common objects (e.g., clothing, furniture) that can be augmented with technology and made interactive. As people are familiar with the forms and use patterns of such items, augmentation extends their existing capabilities, keeping the effort to learn how to interact with the object as low as possible. The selection of objects was made by the authors, drawing on previous explorations of suitable objects augmented for IoT functionality [28].

3.1.2 Pack 2: FEEDBACK. These cards (n=23) describe changes in the physical properties or motion of the object that can cause stimulus and metaphorically communicate required information to the user. The information can be perceived through haptic, aural, smell or vision senses. The change in the object's physical state could be caused by an external service when it senses a privacy threat, or when a user interacts with the object to trigger a digital input. The cards in this pack were based on our previous work on establishing user-preferred image schemas in the context of privacy management [25].

3.1.3 Pack 3: ACTION. These cards (n=20) describe a set of physical modalities in which a user can interact with the augmented object and trigger a digital input. The modalities are in the form of direct physical manipulation of the object, spatial movement of object or its parts, or full body movement of the user themselves. The user action can either happen as a reaction to a stimulus (or prompt) from the object, or as pro-action without any external stimuli. The cards in this pack were based on our previous work on establishing user-preferred image schemas in the context of privacy management [25].

3.1.4 Pack 4: GOAL. These cards (n=19) are divided into Feedback GOAL (n=9) and Action GOAL (n=8) cards. As with every other pack, this pack also includes two blank cards. While the former represents the purpose of feedback from the object, the later represents the purpose of users' action on the object. The goals are tied to the set of elements that are required for privacy awareness and control as described in the Privacy Care framework. The cards in this pack were directly derived from the privacy care framework [27].

As described in the Awareness element of the privacy care framework [27], the main purpose of feedback from a tangible privacy management system should be to communicate relevant aspects of an access appropriately to the user. These aspects could include information in different granularity on dimensions such as who is accessing, what is being accessed, when is the access happening, why and how, or the overall status. Such feedback is digitally triggered when an external service senses an access that could be a potential privacy violation to the user. Feedback GOAL cards represent these aspects of access.

As described in the Control element of the Privacy Care framework, the main purpose of users' input action is to re-actively or pro-actively control the access to their physical self or personal information. A user should be readily able to allow, block, confront, record, or report the access. Action GOAL cards represent such input actions to digitally trigger the required functionality.

3.1.5 Pack 5: CRITERIA. These cards (n=8) help participants to reflect on, evaluate and iteratively adjust their designs. They represent the usability features (e.g. intuitive, granular, ad-hoc) or criteria that should be satisfied through their design concept. Again, these are tied to the properties of the three interaction tenets of the Privacy Care framework [27] that a Tangible UI for privacy must possess for effective privacy management in UbiComp environments. While the first four packs foster divergent thinking, this pack helps in reflecting and converging upon the design outcomes.

The front of the cards in this pack do not follow the common template. The information is divided into: the card's title, the concept description, the provocative questions to ask when judging the design, and the footer with pack's name and card number.

3.2 TTP Gameboard

To provide a spatial layout for placing cards and to enable effective collaborative brainstorming, a scaffolding board is also provided (see Figure 2). The board consists of six sections: storyboard, interface, awareness, control, reflection and playbook. Teams are required to put the storyboard they are working on, and the chosen cards in respective section, as the game progresses. A playbook (present at the bottom of the gameboard), details steps about the gameplay along with the time limit for each step. The gameboard was designed once the selection of card packs had been finalised.

3.3 TTP Playbook

Game-play is divided into five time-bound steps and helps to guide participants through the session. Each step requires teams to go through a particular set of cards and pick up to three cards that they think are best fit for the purpose. The authors developed the playbook, reflecting on the findings of the literature review, and an understanding of the privacy care framework.

- Step 1 (~5 minutes): *The Scenario*, asks teams to go through the given storyboard, notice the central characters' (user) context and understand the privacy violation scenario that they face.
- Step 2 (~8 minutes): *The Object*, asks teams to go through the object cards, meaningfully pick up-to three objects to be augmented that they think are easily accessible to the user as per the storyboard context, and discuss their choices.
- Step 3 (~13 minutes) and 4 (~13 minutes) asks teams to think about input-output modalities and map them to privacy management functionalities. They are divided into 2 parts each:
  - 3a. *What to Inform*
  - 3b. *How to Inform*
  - 4a. *The Purpose*
  - 4b. *The Human Action*

  and can be done in any order.
- Step 5 (~10 minutes): *Reflect to Improve*, asks teams to go through all of the cards in the Criteria pack, discuss and adjust (if needed) their design concept as per those cards. They are allowed to leave any criteria out if they think is not suitable for the given storyboard.

Adding time constraints to the steps of ideation have helped participants to progress efficiently through the process and generate a design concept [28]. Hence, we too add a time constraint for each step.

To design for a specific scenario, one round of game play per team is likely sufficient. However, to design tools that can cover broader contexts, a group can be provided with two or more privacy violation storyboards one after the other.

Each storyboard takes around an hour to play. Based on our user-study, we recommend no more than two storyboards per session, with two rounds of the five-step game-play, taking 2-hours.

3.4 Summary

The TTP toolkit can be mapped onto existing frameworks of card games. Clearly positioned to support combinatorial creativity (through the selection of multiple cards) and collaboration (through multiple players), the toolkit draws on characteristics that support design [21]. Focusing on the framework from Wölfel et al., our game is context-specific as it is focused on a clear design context [39]. The implications are that it is suitable for early use in the design process, provides specific instructions, with little customisation of cards or gameplay, and the cards use both text and images. All of these properties are clearly present in our description of the TTP toolkit.

All of the materials described in this section can be found at [26].

4 USER STUDY

We demonstrate the efficacy of our toolkit through 10 participatory workshops with 22 interaction designers. While our workshop protocol was inspired by the works of Mora et al [28], due to the ongoing Covid-19 pandemic, the workshop sessions were conducted online rather than in a physical setting.

We used Skype to video conference with the participants. The toolkit was shared on an online visual collaboration whiteboard platform called Miro (www.miro.com), that enables distributed teams to work effectively together during brainstorming sessions and design workshops. This combination of technologies was sufficient to support the key characteristics of card games. The card decks were setup as images layered on top on one another. Players could sort and group the cards by moving them around the infinitely scroll-able Miro space, and then move the cards onto the gameboard when wanting to benchmark ideas and steer discussion. Skype provided sufficient cues for participants to discuss their solution, while recording the resulting decisions on the Miro space.

4.1 Participants

After receiving approval from our institution's ethics panel, we conducted two pilot workshops, each with two participants. These pilots helped us to refine the toolkit imagery, language and session approach. They helped us to fine-tune the visual placement of toolkit elements on MIRO and improve their visibility and navigability. We also adjusted the time limits for playbook steps, checked the efficacy of the overall study, and validated that the key gameplay features could operate online.

10 workshops were then conducted with 22 participants (age mean=34y, SD=8.54y) who were a convenience sample recruited through HCI mailing lists and a social media platform. All had some experience working as interaction designers in academia or industry. 12 had some form of prior experience in designing for tangible computing while only 4 had experience in designing for privacy. Groups were formed on a first-come first-served basis and the availability of the participants. Except in three groups (G1, G2 and G10), none of the members knew the other member(s) of their team prior to the session. Table 1 presents basic participant details, the group they were in and the storyboards they worked on during the workshop.

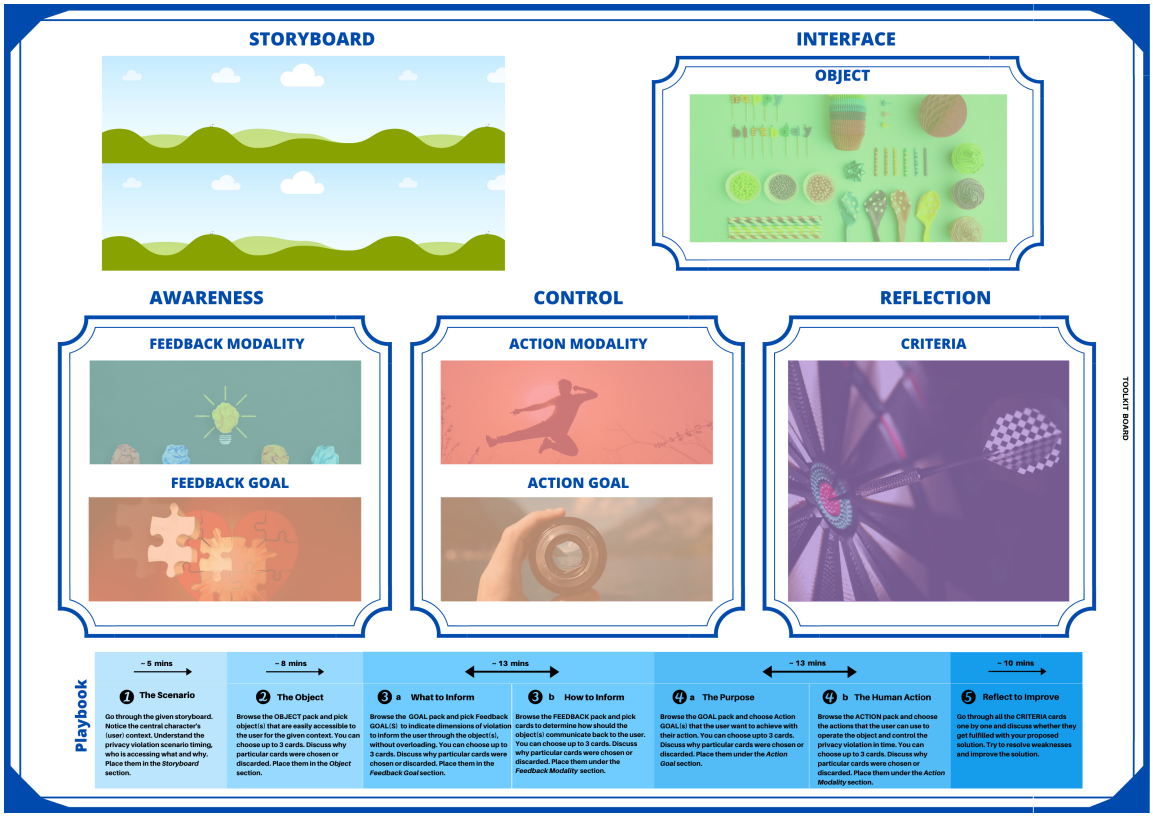

Figure 2: TTP Gameboard.

4.2 Storyboards

For our design workshops we used six storyboards used previously by Mehta et al. in studies of privacy management in UbiComp contexts [25]. These storyboards are inspired from consultations with different stakeholders (privacy experts, ordinary users) of different age groups. All (except S6) are based on real-life accounts of privacy violations experienced across the cyber-physical-social worlds that people inhabit. S6 is based on hypothetically futuristic technology. S1, S3 and S5 are based in a personal space or inside the home. S2, S4 and S6 are based in public spaces. The storyboards also highlight a variety of contextual adversaries (observers and disturbers) such as company employees, family members, spam agents, acquaintances and drones. Along with the physical environment and adversaries, the central characters' main ongoing activity (and available mental and physical resources), also vary across the storyboards. An example storyboard can be seen in Figure 3.

4.3 Protocol

The first step was to prepare a shared work-space in Miro for each team. The toolkit elements were structured in Miro frames. Keeping the Gameboard at the center, the cards were arranged around the board for easy accessibility. The frames were kept locked prior to the session to avoid any accidental moving of the elements.

Participants were then sent the consent form and workshop information sheet prior to the online session and were requested to send back the signed copies of their consent form before the session. Once confirmed, they were sent a link to access the password protected shared work-space of their team on the Miro platform. To get participants up to speed in using Miro on the day of the session, all participants were also sent a link to a short introductory videos on how to get started with Miro, and asked to go through the video if they hadn't previously used Miro.

The first author facilitated all of the workshops. The Skype call was audio recorded and the workshop activity on Miro was screen recorded. Notes were also taken by the facilitator. Each session on average took around 120 minutes. For their time, participants were rewarded with a £15 shopping voucher.

4.3.1 *Online Session with the Toolkit.*

As an ice-breaker, each workshop began with a round of brief self-introduction by all the attendees. The facilitator then provided participants with a brief introduction on the concept of personal privacy, its violations, and the need for awareness and control for its management. This was followed by a brief overview of the toolkit elements, clarifying the aim of the collaborative workshop and making sure that all the participants were able to remotely access the toolkit elements on Miro. The aim was also posted on the Miro shared work-space on top of the toolkit board, so that it was available to the participants whenever they wanted to refer to it during the session.

Group	Storyboards	Participant Id	Gender	Age	DE in Privacy Management	DE in Tangible Computing
G1	S5, S6	P1	F	37	X	✓
		P2	M	31	X	✓
G2	S3, S2	P3	M	29	X	✓
		P4	M	39	X	✓
G3	S1, S4	P5	F	27	X	✓
		P6	F	30	✓	X
G4	S5, S2	P7	M	29	X	X
		P8	M	32	X	✓
G5	S4, S3	P9	F	33	✓	X
		P10	F	41	✓	✓
G6	S6, S1	P11	M	52	X	✓
		P12	F	45	X	X
G7	S6, S3	P13	M	29	X	X
		P14	F	28	X	✓
G8	S2, S1	P15	F	42	X	✓
		P16	F	27	X	X
		P17	M	24	X	X
G9	S4, S5	P18	M	29	X	X
		P19	F	37	✓	X
		P20	M	24	X	✓
G10	S3, S2	P21	F	55	X	X
		P22	M	29	X	✓

Table 1: Participant details, DE=Design Experience.

Figure 3: Scenario S5: Physical access to a personal device by an acquaintance/friend, leading to leakage of sensitive information.

Participants were required to go through the playbook steps in the TTP Gameboard one by one to conceptualise the form factor and interactions of a privacy management tangible tool suitable for a given TTP Storyboard. They were required to pick a limited number of TTP Cards from the respective categories for each step, and place them in appropriate sections of the TTP Gameboard (using the drag and drop operation on the Miro shared work-space). The facilitator moderated the workshop sessions by (a) introducing the card packs corresponding to each step one by one, (b) managing the timer for each step in the playbook while participants worked through them, and (c) clarifying any doubts throughout. The timer (a feature of the Miro platform where one can set and share the remaining time for each step with all members of a session) was also visible to the participants on their screens. At the end, participants were asked to briefly pitch their design concept to the facilitator. This was recorded by the facilitator on MIRO and written under the gameboard.

Each group was required to design for two storyboards, one after the other. The two storyboards were pseudo-randomly selected, one from an indoor setting, and one from an outdoor setting. After the first round with the first storyboard, participants were asked *not* to clear out the cards from the TTP Gameboard space. To mitigate the

effects of fatigue, particularly given the online interaction context, the second round started after a 10-minute break. Participants were presented with a second storyboard and given two options, either (a) to adjust the design concept they had came up with for the first storyboard and design an integrated solution applicable to first as well the second storyboard, or (b) to treat the two storyboard scenarios independently and come up with a second design concept suitable to the second storyboard only. To execute this, the participants again went through the time-bounded playbook steps and presented their design pitch briefly at the end.

The moderator used two screens; one for the Skype video conferencing and the other to monitor the Miro shared work-space. To encourage equal participation, the moderator facilitated turn taking by assigning a lead for each step. Which participant was to lead which step was decided prior to the session in a pseudo-random manner. Participants were asked to be respectful to each other's view and have a friendly discussion. They were also encouraged to think-aloud during the session.

4.3.2 *Feedback.*

After the toolkit session, a 10-minute group feedback discussion was conducted. Participants were also reminded that each of them would be receiving a post-study questionnaire and were requested to complete it and send it back within a day. This questionnaire had ten 5-point Likert scale (Strongly Agree, Somewhat Agree, Neutral, Somewhat Disagree, Strongly Disagree) questions asking participants about their experience with the toolkit (covering elements such as creativity, supporting reflection and supporting ideation). It also had two open questions asking them about the most liked feature and one thing they would like to change in the gameplay to gather further suggestions for improvement. The questionnaire can be found at [26].

4.4 Data Collection and Analysis

The Skype call was audio recorded and the workshop activity on Miro was screen recorded. Participants' interaction with the toolkit were observed and hand-written notes were taken down throughout the workshop. These notes also included participants' feedback during the post-session discussion. Data was also collected through the post-study questionnaire.

The focus of the analysis was not on comparing or quantifying the quality of design concepts that the groups came up with, but on how the toolkit facilitated the creative ideation process for generating those design concepts of tangible tools for effective privacy management. Given our research interests, our focus was on: (1) effectiveness of the toolkit in satisfying the qualities of the Privacy Care framework in generating tangible tools for privacy management, (2) general support that the toolkit provided in collaboratively generating creative ideas for tangible privacy management, and (3) the overall visual appeal of the toolkit. Within these themes, the qualitative data was analysed using inductive thematic analysis [5].

The analysis process started with the lead author familiarising themselves with the hand-written notes, and watching the workshop recordings. Time codes for conversations related to our areas of enquiry were noted, for later use in the generation of themes. Answers to the open questions from the post-study questionnaires were collated on to the Microsoft spreadsheet software. A process of thematic analysis turned this data into a collection of themes, which are reported in the next section. These themes were further supported with the descriptive statistics obtained through aggregated responses of the individual participants on Likert-scale based questions from the post-study questionnaire.

We decided not to analyse the design concepts that participants generated. The inherent connection between the storyboards and the resulting design concepts would have conflated our principle research objective with our participants responses to the storyboards. As we wanted to demonstrate the efficacy of the TTP toolkit in supporting idea generation for privacy management tools, our focus was on analysing the gameplay data. We return to this issue in our limitations.

5 RESULTS

The response to the overall workshop was positive with the collaborative element particularly highlighted: "*enjoyed the highly collaborative nature of the workshop, the fact that the design and the dynamics really favoured communication between participants and building on each others' ideas. This makes it both more interesting as well as more fun*" [P13]. Eight participants emphasised that they liked the visual appeal of the toolkit, particularly the combination of imagery and text on cards (P1, P5, P7, P8, P10, P15, P18, P20).

In total, the six storyboards were collaboratively seen and taken through the ideation process 20 times (two storyboards per session), resulting in 20 design concepts. All of the developed design concepts used some form of tangible interaction to address the privacy concern expressed in the storyboard.

A completed gameboard is shown in Figure 4. The solution for storyboard 1 was described as "*Phone being accessed by children, breach. Wristband, accessory or wallet can give notification through vibration on band or alert text on band or glass. Who is accessing what data is accessing. Possible spam. Pull the jewelry, touch band, scratch glasses. Could be more discreet. You want to block, or before set the settings. Balance to get good things allowed and bad things block or divert*". The storyboard 2 solution was "*Privacy intrusion in home. Escalating situation. Walker, eyewear/jewelry, ambient furniture. Colour pattern discernible to her, vibrate, smell (multi-sensory) in case low vision is challenge. To inform who, what they want, and that they are physically trying to access. Action could be pull, touch, or scratch. Pre-set access info, resisting to slow down, log and report to police or neighbour*".

Our results are structured around the two key themes we wanted to investigate: whether the toolkit supported designing interaction concepts for privacy management; and whether the toolkit stimulated creativity.

5.1 Supporting designing tools for Privacy Management

Across our diverse data sets, 21 participants agreed that the toolkit was effective in designing interaction concepts for privacy management. As demonstrated through the proposed solutions, participants were able to make sense of the privacy violation storyboards, generate meaningful tangible design concepts, and reflect on their solutions through the lens of criteria specific to the user-centred privacy management.

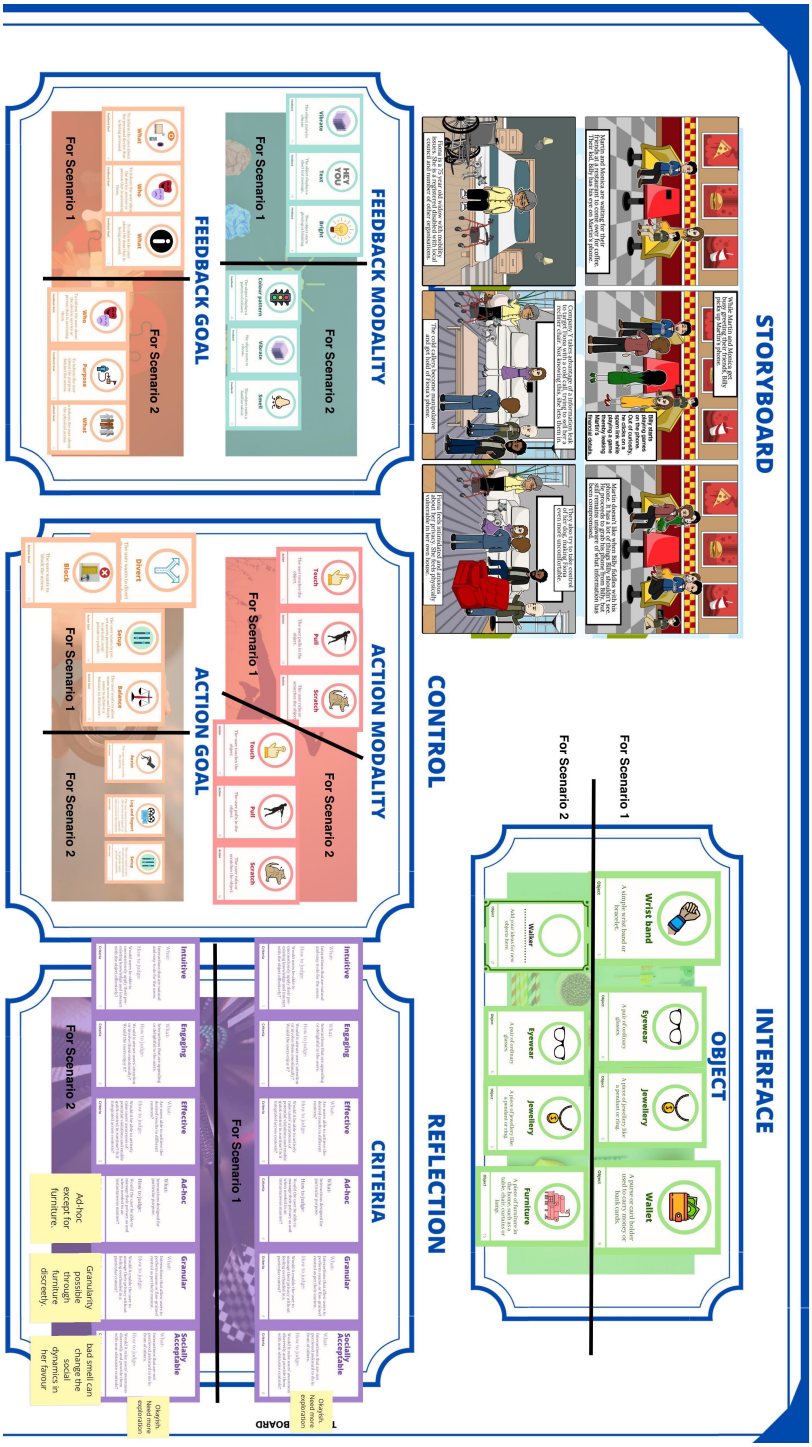

Figure 4: The Completed Gameboard and Design Concepts by Team G8.

Three prominent themes influenced the nature of design concepts that the teams came up with, which we discuss in the remainder of the section.

5.1.1 Ad-hoc and Granular Interactions.
Our storyboards did not explicitly describe the persona of their central characters. Nonetheless, they largely inspired participants to consider a specific persona and consider the personal needs, age,

abilities, comfort and the overall context of the central character they were designing the interactions for. This influenced discussions on what is suitable and what is not, helping the teams to choose between different objects, feedback and action modalities. For example, while designing for S2, team G10 picked 'emoticons' as a feedback modality as they felt it to be more child friendly. Similarly, when designing for S1, team G3 picked voice interaction as one of their preferred action modalities as they considered it to be highly intuitive and easier for an older adult. Teams largely considered the need for their proposed tools to be easily and quickly available (ready-to-hand) and offer coarse-to fine grained management options as needed.

Wearable form factors (e.g. wristband, jewellery) were chosen by all the teams for mobile or outdoor scenarios due to their portable nature and the ability to be with the user all the time. For indoor contexts, objects surrounding the storyboard character were commonly considered.

The flexibility to choose up to three cards (from the first four packs), enabled the teams to distribute the aspects of privacy awareness and control across different form-factors and interaction modalities. This enhanced the customisability of the solutions and helped to support different granularity in interactions. For example, justifying the choices of cards for their team, P2 argued, "*someday you wear watch with display, or shoe or belt. Watch can be used to setup basic rules, shoe and belt for more coarse, dynamic or real-time management*". Team G7 divided the awareness component into two parts and picked feedback modalities that were suitable as (a) attention pullers (coarse), and (b) information givers (fine-grained). Their action modality choices also differed with the granularity in control interaction they wanted to achieve (e.g., squeezing for binary input, scratching with direction and intensity parameters for multi-point input, and rotation for more fine-grained input). Team G10 setup a mantra of 'alert, explain, mitigate and share (educate)' and designed coarse and peripheral interactions for the 'alert' and 'mitigate' phases, and fine-grained and focused interactions for the 'explain' and 'share' phases.

From the existing FEEDBACK pack, 40 cards were chosen in total across all the sessions. Out of these, only nine of the selected cards involved providing feedback through text. These modalities (e.g., vibrate, colour pattern, sound pattern and emoticons) were predominantly picked for providing coarse feedback. From the existing ACTION pack, 34 cards were chosen in total across all the sessions. Out of these, 26 cards involved some forms of direct haptic manipulation (e.g., scratch, squeeze) or spatial movement (e.g., location change). These modalities were predominantly chosen for enabling quick and coarse control.

The data was not always clear on which FEEDBACK GOAL card was considered to be under coarse information category and which of those card combinations were considered under fine-grained category, even with the description of how the designed technology worked.

5.1.2 *Embodied Metaphors.*

To improve intuitiveness, many privacy UI researchers have used metaphors as conceptualising tools when designing interactions for privacy management (e.g. metaphor of eyes [34], faces [19] , walls [15], mirror [31], itch and scratch [24]). Our toolkit triggered the participants to creatively and collaboratively consider several analogies or interaction metaphors pertaining to their privacy perceptions for a given context, and externalise them by picking from a wide range of card choices (from the first four packs) or adding their own cards.

For example, for raising awareness of a potential privacy violation for S6, team G1 came up with the analogy of "*tightening the belt like how it happens in a blood pressure device*", (P1). To design the 'block' control action for S3, team G2 conceptualised the interaction as "*hitting a desk is forceful action. It is like saying NO. Feels like natural thing to do*", (P4). Team G4 picked biological metaphors of "scratching the itch", (P8) to raise awareness of a potential privacy breach through a physical 'itch' and allowing user to 'scratch' to block the access, for both S5 and S2. For S4 and S3, team G5 suggested to have a "privacy screen skin" to protect unwanted access to a digital device, while team G10, came up with the metaphor of "*stamping the foot*" to block access to their phone in S2.

5.1.3 *Contextually Versatile.*

As seen in the results so far, our toolkit enabled participants to design for a context. The second round of gameplay further stimulated them to design extensible and more versatile solutions that were applicable to more than one context. Teams were given an option at the beginning of the second round to choose between *building an integrated solution or two independent solutions* for the two storyboards. Nine teams choose the first option and extended the design concept they had come up with for the first storyboard, to suit the second storyboard. Such integrated solutions provided a common collection of chosen cards (particularly the objects, feedback modality and action modality) from which two different combinations could be derived, one more suitable to scenario 1 and the other more suitable to scenario 2. The higher the commonality between the cards of the two storyboards, the higher was the versatility. For some participants, this feature actually made solutions more effective and the entire exercise all the more interesting. "*I liked the combination of goal and medium brainstorming, and projecting the solution for the first scenario to the second scenario*", said P6. "*I liked how you gave us the option of keeping the same things or changing it because when we did the first one, I was like I am not going to carry around something just for this drone [in S6], but then adding the second layer where you can actually have the same thing and adjust it to use in a different scenario that kind of really filled in the gap*", argued P14.

5.1.4 *Other Usability Criteria.*

The reflection step helped the participants to discuss the features of their concepts against the six usability criteria and adjust their designs if needed. For instance, reflecting after the first round of their respective sessions, three teams (G1, G4 and G8) replaced a previously selected card.

The reflection step also stimulated the teams to reasonably discard or even develop their own criteria. Four teams (G1, G2, G5 and G9) discarded 'engaging' as a criteria because the prime focus of their design concepts was to have instantaneous and reactive interactions, something that are not needed to be enjoyable, learned or used over longer periods of time. Five teams (G1, G3, G5, G9 and G10) added six new criteria cards. These were: *Non-intrusive, accessible, aesthetics, comfort, intentional/deliberate* and, *inclusive.*

In addition to other criteria, team G4 stressed the importance of having interactions that are private, personal and discreet. They modified the 'social acceptability' criteria card to reflect such features. These additional cards demonstrate the flexibility TTP offers in terms of adapting solutions to fit designers' knowledge, and the context of the storyboard presented. Further work could explore whether the same criteria are widely generated, suggesting their inclusion in the main card pack.

5.2 Support for Creativity

Similar to many other card-based ideation toolkits [6, 28], the collaborative nature of the workshop sessions appeared to spark creativity. Such sessions with the toolkit resulted in divergent and convergent thinking among the participants.

Participants found the toolkit inspired them to "*think outside the box*" (P12) and provided them with "*an opportunity to explore*" (P4). It appears to have provided participants with the right mix of structure, constraints as well as creative freedom. Overall, participants found the information on the cards to be useful for ideation (21/22 agreed) and had ideas they would not have had without the cards (17/22). P11 felt that the "*options and assortment of cards were well thought out and reasonably diverse. Did encourage thinking about potential options*". Focusing on the FEEDBACK and ACTIONS pack, P10 commented that "*the modalities, makes you think up interesting ideas*". CRITERIA cards particularly helped teams to reflect, converge, and improve their solution (18/22). For example, P15 found them to be a "*good opportunity to deep dive in some usability issues and see areas that might need more discussion or see things that are not that obvious*".

5.2.1 *Gameplay: Progression and Playfulness.*

While a large majority of the participants (20/22) agreed that the collaborative gameplay was fun, it wasn't considered to be gamified enough. Some participants provided interesting suggestions on how to improve the gamification, focusing particularly on competitiveness and challenge. P2 suggested having a "*reward based system to have a sense of competitiveness*". Focusing on the part where a team was given the option to choose between building an integrated solution or two independent solutions for the two storyboards, P13 described how their team decided to challenge themselves by thinking to build an integrated solution. P13 went on to suggest gamifying such challenges within the toolkit by having "*certain card combinations like having 1 point for easier cards, two points for more challenging cards or allowing players to grab a third card randomly as an added challenge*", and comparing with other teams.

5.2.2 *Flexibility vs constraints.*

Participants enjoyed the flexibility of adding/discarding their own cards. For P2 and P3, this was the most liked feature. P2 stated "*we often started by discussing the existing cards, which became a stimulus for us to create cards tailored for our solutions*". Every team added at least one card of their own. In total, 26 new cards were added by the teams during the workshop sessions (10 in the OBJECT pack, 6 in the CRITERIA pack, 5 in the ACTION pack, 4 in the GOAL pack and 1 in the FEEDBACK pack). For instance, a 'Walker' card was added as an OBJECT by team G8, team G9 added 'Hologram' as a FEEDBACK modality, team G10 added 'Stamp foot' as an ACTION modality and 'Educate' as a feedback GOAL. 'Pause' as an action GOAL was added by team G7.

While for the first four steps the teams were asked to choose not more than up to three cards per step, they were allowed the flexibility to group cards if needed, based on similarity or those that formed opposite analogous pairs. For example, team G6 and G9 grouped 'hot' and 'cold' FEEDBACK cards together and considered them as one unit. G8 combined 'eye-wear' and 'jewellery' OBJECT cards and put them under an accessory or wearable category. Team G3 grouped 'allow' and 'block' ACTION GOAL cards.

Time constraints helped to keep teams on track and effectively progress through the gameplay. Group 7 particularly liked being able to see the timer for each step and found it "*good to have time pressure*" (P13). For P14, the most liked toolkit feature was "*the playbook telling how long each section would take and the timer to keep us on time*". P13 argued, "*the aim in such workshops is not to come up with ideal solution but to make a a rational choice relatively quickly*".

Picking up to three cards, was considered to be a useful constraint. This helped participants to keep their choices practically focused to the context. P15 found it to help their team "*deep dive and think hard about what is needed*".

6 DISCUSSION

Our work contributes to the broader research agenda of usable privacy and security. With the aim of fostering a human-centred approach to privacy management, we have translated the principles of the Privacy Care interaction framework into an easy and fun to use collaborative toolkit. Our results show that our toolkit made participants curious and provided them with the right mix of structure and constraints, as well as supporting creative freedom. The participants were able to effectively use the TTP toolkit for creatively and collaboratively generating conceptual designs of tangible tools for privacy management in a limited amount of time.

6.1 Generating Tangible Tools for Effective Privacy Management

To enhance the experience of end-users in managing their privacy in dynamic UbiComp environments, the task of disclosure regulation needs to be seamlessly embedded into and integrated across their different daily life contexts [27]. Designers must design interactions that are quick and easy to access whenever needed, non-interrupting, available in different granularity (from coarse-to fine-grained), and highly intuitive. To achieve such characteristics, designers need to look beyond ordinary GUI-based *touch-and-text* style interactions and question its' suitability in the context they are designing for. For example, how can an end-user interact with a GUI-based privacy interface to manage their privacy while jogging, driving a car, holding shopping bags, or when in a meeting, without disrupting their primary activity?

There are examples in the literature where concepts of tangibility have been used to specifically help users regulate digital access to themselves in contexts such as online social communications with known persons [9, 10], setting mobile phone location [14], mobile data privacy warnings and controls [24], and securely unlocking a

personal device [38]. However, this previous work does not focus on the design process, and therefore does not provide any guidance on how to generate meaningful designs of tangible privacy management tools.

Our toolkit can help designers in this quest by supporting them to collectively empathize with end-users' context and collaboratively ideate to generate design concepts for effective privacy management tools. With storyboards setting up the context to design for, our assortment of cards provides the designers with a diverse set to choose from:

(1) everyday objects as things to augment technology with;
(2) feedback modality in the form of changes in physical properties or motion of the object to be perceived through haptic, aural, smell or visual cues;
(3) action modality in the form of haptic manipulation on the object, spatial movement of the object or full body movement of the user themselves; and
(4) blank cards to add own cards.

Key criteria are then used to help designers reflect and improve their design concepts.

We envision our toolkit being used primarily in the ideation phase of a design activity for generating tangible privacy management tools. Designers should customise the storyboards, time allocated for each step or even individual cards, as per their privacy design context.

6.2 Online Format

Most card-based collaborative ideation workshops have been carried out in a physical face-to-face setting, all the more-so when discussing interactions that are inherently tangible. While initially we had also planned to carry out face-to-face workshops, due to social distancing rules of the Covid-19 pandemic we had to adjust and plan for a virtual setting. This challenged us to rethink our assumptions, and consider the benefits and weaknesses of moving such sessions online. The Miro online tool proved to be an excellent platform for supporting the type of collaborative workshop we wanted. The platform provided sufficient interactions to support use of the toolkit, with remote facilitation proving to be sufficient to run the workshops. Remote participation immediately offers benefits in terms of the recruitment of participants, with our study involving a diverse set of participants (residing in different countries), in a short period of time and involving practically no travel or time cost.

There were challenges to running the workshop sessions. While we referred to several general guides on the Internet on how to effectively run a virtual workshop and customised those best practices for our context, such facilitation skills only improve with more practice [30, 35, 36]. Steps such as verbally checking in with participants more often, monitoring their engagement via cursor-track feature, helping to keep the toolkit elements in place, were necessary to ensure participants could engage with the workshops. That said, it is impossible to judge whether face-to-face participation would have led to a more open discussion.

Overall, our work demonstrates that virtual workshops can be effective for meaningful discussions that support ideation for tangible designs, with the advantage of opening up these opportunities to more diverse, geographically distributed participants. The absence of any specific disadvantages highlights this online workshops should be more widely used. We urge the design community, particularly those interested in designing tangible interactions, to continue exploring the suitability of the physical and virtual formats.

7 LIMITATIONS AND FUTURE WORK

Translating a theoretical framework into a practical tool has limitations. For example, the selection of storyboards for use in playing the game is of central importance. There is a clear need for presenting sufficient detail, without prescribing creativity. The scenarios used in the study did not explicitly describe the persona of its' central characters (e.g. age, interests, likes/dislikes). Nonetheless, participants could imagine a persona, consider their personal needs and design concepts accordingly. Further work needs to experiment with a range of different scenarios to demonstrate broader efficacy of the toolkit. While the study uncovered no biases towards generating certain kinds of design, exploring the toolkit with a wide range of other storyboards would further demonstrate this.

Similarly, while we have followed established practices in demonstrating the efficacy of card games in the TEI community (e.g. [6, 11, 28, 29]), more needs to be done to evaluate the efficacy of the toolkit in supporting design ideation. As the framework is not intended to assist in generating designs, but to describe a conceptual space, comparing the framework against the toolkit in their respective abilities to support the development of designs would not result in any meaningful data. It has been more informative to explore the utility of the toolkit, with an understanding that further work is needed to construct a broader evidence base for the benefits the toolkit brings.

Furthermore, in focusing on the efficacy of the toolkit in supporting idea generation, we have not analysed the design concepts generated in terms of viability. Future work is needed to assess generated designs from a large number of scenarios to establish whether the toolkit goes beyond assisting with design thinking and ideation, but directly produces designs for development and field-testing.

8 CONCLUSIONS

We presented a card-based ideation toolkit that translates the theoretical knowledge of the Privacy Care tangible interactions framework for privacy management into practical insights [27]. We also presented results from 10 online participatory workshops that we conducted with 22 interaction designers. Data based on observations, feedback sessions and post study questionnaires suggest that our toolkit can effectively support teams of expert and non-expert designers to creatively and collaboratively generate meaningful conceptual designs of tangible privacy management tools. The designers do not necessarily require any prior design experience in privacy or tangible computing. The visual elements and a guiding playbook makes the toolkit fun and easy to engage with.

Our results also highlight that ideation workshops involving tangible tools can be run online, expanding the scale and demographics of potential participants for tangible-focussed design work. Further work should continue to explore how to best scaffold online design sessions to develop meaningful tangible design concepts.

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