Int. J. Human–Computer Studies 192 (2024) 103360

Contents lists available at ScienceDirect

International Journal of Human - Computer Studies

journal homepage: www.elsevier.com/locate/ijhcs

Reflections on using the story completion method in designing tangible user interfaces

Daniel Gooch [a,*], Arosha K. Bandara [a], Amel Bennaceur [a], Emilie Giles [a,b], Lydia Harkin [c], Dmitri Katz [a], Mark Levine [d], Vikram Mehta [a], Bashar Nuseibeh [a], Clifford Stevenson [c], Avelie Stuart [e], Catherine Talbot [f], Blaine A. Price [a]

[a] The Open University, Milton Keynes, UK
[b] Arts University Bournemouth, Bournemouth, UK
[c] Nottingham Trent University, 50 Shakespeare Street, Nottingham, NG1 4FQ, UK
[d] Lancaster University, Lancaster, LA1 4YF, UK
[e] University of Exeter, Exeter, UK
[f] Bournemouth University, Talbot Campus, Poole, BH12 5BB, UK

ARTICLE INFO

Keywords:
Story completion method
SCM
TUI
Design methods
Emotion logging
Privacy management

ABSTRACT

There are many design techniques to support the co-design of tangible technologies. However, few of these design methods allow the involvement of users at scale and across diverse geographic locations. While popular in psychology, the story completion method (SCM) has only recently started to be adopted within the HCI community. We explore whether SCM can generate meaningful design insights from large, diverse study populations for the design of Tangible User Interfaces (TUIs). Based on the results of two questionnaire studies using SCM, we conclude that the method can be used to generate meaningful design insights. Drawing on a systematic review of 870 TUI papers, we then contextualise the strengths and weaknesses of SCM against commonly used design methods, before reflecting on our experience of using the method across two distinct domains. We discuss the advantages of the method (particularly in terms of the scale and diversity of participation) and the challenges (particularly around constructing meaningful story stems, and developing the correct level of scaffolding to support creativity). We conclude that SCM is particularly suitable to be used in the early stages of the design process to understand the socio-cultural context of deployment.

1. Introduction

Designing interactive tangible devices and user experiences is hard. A diverse range of design methods have been developed to support and scaffold the design process (Shaer and Hornecker, 2010). As a research team, we are strong proponents of the principles of co-design, given the practical and moral benefits (Carroll and Rosson, 2007; Gooch et al., 2018). However, during the Covid-19 pandemic, face-to-face workshops and co-design sessions were not practical. While subsequent work has detailed experiences of developing mechanisms for supporting remote co-design, particularly DTE (designerly tele-experiences) (Bertran et al., 2022), the onset of the pandemic dramatically shifted design practices. Such a shift has other benefits, particularly in terms of sustainable design, designing for global populations, and the sustained shift to online and hybrid interactions.

During the pandemic, the authors were working on a Covid-19 project (called '*SERVICE*') focused on developing socio-technical systems to mitigate the rise in loneliness amongst older adults as a result of Covid-19 restrictions (Price et al., 2020). This motivated an interest in logging emotion and wellbeing, as well as an interest in preserving privacy in smart home environments. Given the limitations imposed by the pandemic, we had to consider alternative design approaches, particularly approaches used during the 'fuzzy front-end' of design, which Smit et al. (2022) describe as the stage where "designers aim to move from ambiguity and uncertainty to more concrete and focused design goals (Kaasinen et al., 2014) by means of collecting and sharing inspiration, knowledge and opportunities (Kwiatkowska et al., 2015), defining goals (Varsaluoma et al., 2015), generating ideas and developing initial concepts (Herstatt and Verworn, 2004)". Given the global nature of the pandemic, we also had an interest in exploring design methods that support engagement with a large number of diverse participants at a distance, to gather input and experiences from across the world.

* Corresponding author.
E-mail address: Daniel.Gooch@open.ac.uk (D. Gooch).

https://doi.org/10.1016/j.ijhcs.2024.103360
Received 21 August 2023; Received in revised form 14 August 2024; Accepted 16 August 2024
Available online 22 August 2024

Our primary research question is whether the story completion method (SCM) is a suitable design technique for developing tangible technologies. Little used amongst the HCI community, SCM, which strongly overlaps with Design Fiction, involves participants completing stories based on the start of an open-ended scenario proposed by the research team. The stories can then be analysed to identify key concerns expressed across the stories. As a method, it is "less demanding of time and resources than established face-to-face interactive methods" (Clarke et al., 2017) and supports input from a reasonably large number of participants (Wood et al., 2017).

In pursuing this question, our first contribution is two distinct questionnaire studies making use of SCM. The first study was designed to explore whether SCM has any value in the design of Tangible User Interfaces (TUIs) for logging emotions. Building on the methodological lessons learnt from this study, the second study examined the value of SCM in designing privacy management TUIs. These studies demonstrate the value SCM has in the design process.

Our second contribution is a systematic literature review of 870 papers involving tangible technology. To contextualise the method in the broad array of available design techniques, we present an analysis of 256 instantiations of design techniques identified from these papers, and alongside our reflections, consider how SCM may add to designers' toolkits of design approaches.

Our final contribution is in our reflections on the challenges and benefits SCM provides, and is meant to help other designers to contextualise and learn from our experiences. We discuss the advantages of the method (particularly in terms of the scale and diversity of participation) and the challenges (particularly around constructing meaningful story stems, and developing the correct level of scaffolding to support creativity).

The paper is structured as follows. In Section 2 we present background literature related to design fiction, and the use of SCM in HCI. Sections 3 and 4 present the two exemplar SCM studies, with Section 5 presenting a combined discussion of the findings from these studies. Section 6 outlines our systematic literature review of 870 papers, which is then used to contextualise our reflections on using SCM as a design method. We conclude that SCM is a design method the community should be using more, and that it is particularly suitable for use in the early stages of the design process to understand the socio-cultural context of deployment.

2. Background

The HCI community has used fiction as a tool for design in many different ways. Fiction can be useful in helping inspire and inform design (Blythe, 2014; Tanenbaum, 2014), as well as exploring the effects that systems may have on society (Lindley et al., 2017), without having to be constrained by the practicalities involved in developing realistic prototypes, or engineering specific contexts of use.

The most iconic fiction approach in the HCI community is design fiction (Bleecker, 2009; Dunne and Raby, 2013). While it has become a ubiquitous method, both within and beyond HCI, the heterogeneous approaches to design fiction make it challenging to provide a definition or scope the diverse contributions that can be made (Baumer et al., 2020).

Relying only on "a prototype that exists within a story world" (Lindley and Coulton, 2015), Design Fiction provides flexibility, whilst encouraging rich reflection on potential design directions. Various forms of Design Fiction include the imaginary abstracts of fiction papers about prototypes that do not exist (Blythe, 2014), as well as diverse media – including text, video, objects and graphics – being used to package design fictions (Markussen and Knutz, 2013). These fictions can be used in workshop settings to elicit feedback from users (e.g. Buskermolen and Terken (2012) and Dindler and Iversen (2007)). Nabil and Kirk use the format of a fictional IKEA-like product catalogue to present a series of design fictions to examine the embedding of interactive elements into home décor. Through their design fiction research, they both inspire other designers, and raise questions regarding the social implications of such products (Nabil and Kirk, 2021).

Luria and Candy present a case-study of using Ethnographic Experiential Futures (Luria and Candy, 2022). Using interviews with experts they develop three "letters from the future" — a form of design fiction. Shared with 15 Human–Robot Interaction or Human–Agent Interaction researchers across the USA, an anonymised questionnaire was used to capture reflections on the provocative ethical aspects embedded within the fictions. Their analysis of the responses led Luira and Candy to conclude that the technique offers a simple and engaging technique for supporting experts to explore potential ethical dilemmas early on. This focus on ethical issues and social justice is also present in Wong's investigation on using design fiction to explore how UX professionals at large companies engage with values and ethical issues in their work (Wong, 2021).

Moving beyond expert practitioners, Rüller discusses the development of fictional narratives as a starting point of developing activities that "explore participatory speculative design and touch-sensitive technology to bypass illiteracy" in Morocco (Rüller, 2022). As part of a long-term engagement with remote populations in the High Atlas region of Morocco, the authors argue that their experiences of using the design fictions to scaffold discussions with remote communities proved to be a successful approach in scaffolding the co-design process (Rüller et al., 2022).

Traditionally, design researchers have authored design fictions. Ambe et al. move beyond this, to structure group workshops where users 'co-designed' fictional stories "about the trend towards tracking and monitoring older people" (Ambe et al., 2019). The authors all belonged to a creative writing group, which may have supported their narrative skills, but the results demonstrated the value in involving users in the story writing process.

Harrington and Dillahunt take a similar approach, using co-design workshops to co-write design fictions with six young adults from the South Side of Chicago, 5 of whom were young Black or African American women (Harrington and Dillahunt, 2021). The main methodological question focussed on how design fictions might "elicit new ideas that speak to Chicago youth's concepts of a post- pandemic utopian reality". Integrated into six 2-hour workshops, the generated fictions elicited "radical visions and social, political, and cultural dimensions that are valuable to equitable design and innovation". While the method has a clear contribution, the effort involved is suited to deep engagement, rather than a shallow but broad considerations for design.

2.1. Story completion method in HCI

One method of utilising fiction which draws on a more participatory approach and which can work at scale, at a distance, is the Story Completion Method (SCM). An established method in psychology (Clarke et al., 2017; Kitzinger and Powell, 1995), widely used as a useful tool for exploratory work, SCM is a method that is slowly growing in popularity within the HCI community. It is primarily being used in areas where social discomfort encourages indirect measure (Clarke et al., 2017; Kitzinger and Powell, 1995), including virtual reality pornography (Wood et al., 2017), sex robots (Troiano et al., 2020), and post-Covid uses of technology (Troiano et al., 2021). It has also been used for speculative and fictional design (e.g. voice assistants Cambre et al., 2020, and smart device privacy controls Prange et al., 2021).

The Story Completion Method involves participants "writing stories about hypothetical scenarios created by the researcher, through responding to a stimulus" (Clarke et al., 2019). This stimulus is commonly called the 'stem', a short start to an open ended narrative, to which the participant provides the detail and finishes the story.

As a worked example from Wood et al. (2017), the story stem reads: *"Jack starts up his new virtual reality headset and positions it carefully over*

his head. He isn't quite sure what to expect. He's about to have his very first virtual reality porn experience…". With an example participant response reading: *"He realises this is a dark path to social exclusion so takes it off and goes back to his life"*.

As the fiction is not developed by the designer as a provocation (as in Design Fiction Cambre et al., 2020), but by end-users, the method is predominately used as a means of data gathering by designers to understand lived experiences, and to generate ideas that act as design inspiration.

There are different aspects of the design process that the resulting stories can support; these approaches closely mirror those that have been identified with the use of fictions in the design process (Tanenbaum, 2014; Blythe, 2014). The first approach is in interpreting the stories in terms of "envisioning not just the technical aspects of an invention, but also the possible social, political, and personal consequences and outcomes of a world with that technology" (Tanenbaum, 2014). This is the approach that has been predominantly used by Troiano across much of their use of SCM in HCI areas (Wood et al., 2017; Troiano et al., 2020, 2021); arguing that the method produces results that can identify insights and stimulate discussion "about the social, cultural and ethical implications of existing and emerging technologies" (Wood et al., 2017).

The second approach argues that interpreting the stories can produce "inspiration and motivation for design by exploring possible design requirements within a fictional scenario" (Tanenbaum, 2014). Prange et al. take this approach when considering the design characteristics for useable authentication in smart homes, arguing that by encouraging users to imagine scenarios that are not limited by current technology, their participants identified design concerns (such as using multiple profiles to support shared use, or mechanisms for access control) that are important design requirements (Prange et al., 2021). In reflecting on their experience of using SCM, Prange et al. argue that the method was useful in supporting the identification of early design considerations.

Similar results are reported by Cambre et al. in their focus on voice assistants (Cambre et al., 2020). In addition to revealing concerns around the current design of voice assistants, the thematic analysis applied to the stories helped identify characteristics of the technology, and raise questions for what that means for the design of voice assistants.

These examples demonstrate the potential value that SCM might have in designing TUIs, and we draw on the methodological contributions of this body of work when detailing the methods used in both of the studies presented. However, there are limitations of the current literature that are worth noting. Much of the work has heavily recruited participants who have creative writing skills (e.g. Wood et al. (2017), Troiano et al. (2020) and Troiano et al. (2021)) and there is a lack of evidence about the effectiveness of SCM with participants who do not identify as creative writers. Furthermore, while the literature is extremely useful in being transparent over the development of study materials, there is a need to understand how much scaffolding support needs to be provided to make SCM effective with participants who have no specific interest in creative writing, particularly when developing TUIs which may be an unknown technology to a general audience. These are both methodological challenges that we address across the two studies.

3. Study 1: Understanding affective tangible devices using SCM

Our first use of SCM was to explore whether the method could help the design of a future technology that allows the user to monitor their feelings. Loneliness, wellbeing, and emotions can be stigmatised and difficult for some people to discuss (Harkin et al., 2023; Barreto et al., 2022), making SCM appear to be an ideal choice for exploring ideas and design futures related to TUIs for logging emotion, given its suitability in areas of social discomfort (Clarke et al., 2017; Kitzinger and Powell, 1995). The literature has also demonstrated that tangible devices can be effective in recording emotions (Gooch et al., 2020, 2022; Sarzotti, 2018).

3.1. Method

Through a questionnaire study, we asked participants to complete two SCM stems related to the logging of emotion. We then analysed the stories for key design considerations, and in doing so examined the value of SCM as a design method for developing TUIs. In the following sections we outline the design of the story stems, the study procedure, the recruited participants, and the analysis technique used to review the resulting stories.

3.1.1. Crafting the story stems

The success of using SCM is based on having well-designed stems. The stem has to orient the participant to the topic under consideration (mood logging) and engage them, without being overly prescriptive, while leaving details open to imagination (Clarke et al., 2019; Cambre et al., 2020).

As we were keen to stimulate thinking beyond a screen-based scenario, we decided to use two different years — 2030 and 2050. This provides participants with an opportunity to imagine nearer-term devices (2030) and more blue-sky creative devices in the far-future (2050). This temporal distance has been used successfully in SCM studies in HCI, in terms of stimulating the creativity of participants and avoiding constraining thoughts regarding existing technology (Cambre et al., 2020).

Following best practice, our stems had to fulfil a number of criteria including:

- Using common English language names not associated with particular class or race (Clarke et al., 2019; Cambre et al., 2020). We chose to use Sam and Jamie.
- Keeping the stems similar lengths, starting and ending with the same sentence (Cambre et al., 2020).
- Maximising ambiguity to encourage creativity (Troiano et al., 2020).

With these criteria in mind, we crafted the following two story stems:

- *It is the year 2030. Sam get home from work and finds that the new tangible mood logging system she had ordered has arrived. Before setting it up, she reads the manual to understand what the system can do. The system is designed to…* [stem 1]
- *It is the year 2050. Jamie is a technology genius, and is about to launch her new mood logging system to the public. At the press announcement, she describes how the system works. This new mood logging system works by…* [stem 2]

3.1.2. Procedure

We created a questionnaire based on the Google Forms service, consisting of six main sections:

1. The gathering of informed consent.
2. Familiarising participants with tangible user interfaces. We provided participants with a short description of TUIs, before asking them to watch five selected videos from YouTube.[1,2,3,4,5]. These videos were selected to demonstrate a range of different forms of TUIs, ranging from wearables to physical logging tools, from shape changing displays to tool kits demonstrating social interaction and interactive manipulations. The first four are 30-s clips from the ACM SIGCHI channel; the fifth is from the MIT

[1] https://www.youtube.com/watch?v=sZ0HHn-NBuc.
[2] https://www.youtube.com/watch?v=TK-8-_obj4Y.
[3] https://www.youtube.com/watch?v=NujCd3QTDOY
[4] https://www.youtube.com/watch?v=jyuM8k3UPzk.
[5] https://www.youtube.com/watch?v=ouP9xNujkNo.

Tangible Media Group and lasts three minutes 40. These videos were selected due to a lack of short publicly available videos demonstrating commercial systems to a general audience.
3. Participants were asked to describe one of the TUIs, in order to ensure they had watched at least one of the videos.
4. Participants were asked to complete story stem 1.
5. To show participants an example tangible device in the area of emotion logging, an image of the Emotion Clock from Gooch et al. (2020) was shown, along with a description: *The Emotion Clock (shown below) is an example of a simple tangible mood logging system. The wooden clock has eight emotive words positioned around the clock face. A user selects an emotion by rotating the clock hand to the word describing the emotion they want to convey. They then push a button to record the emotion they have selected*.
6. Participants were asked to complete story stem 2.
7. Wrap up questions asked what other prompts would have been helpful, what prompts would have provided a clearer description of TUIs, and how familiar participants were with TUIs.

When completing the story stems, participants were provided with the instructions: *'Spend 10 min completing the story below. There are no right or wrong answers; and the more creative your story, the better — feel free to let your imagination run wild. We encourage you to describe how the mood logging technology works, and to introduce additional characters or context to make the story work'*. These instructions were adapted from prior work on story completion (Cambre et al., 2020; Braun et al., 2017).

After completing their story, participants were asked *"Consider the story you just wrote. Would you like to live in this future?"* on a five-point Likert item question from 'Definitely' to 'Definitely Not'. Once they had answered, they were asked to explain their choice through an open text field. Participants were also asked *'What inspired your story?'*.

3.1.3. Participants

While previous SCM work in HCI has focussed on recruiting participants from creative writing communities (Wood et al., 2017; Troiano et al., 2020), we wanted to explore whether the method could be used outside of this specialist demographic. Participants were recruited through the Prolific.[6] questionnaire service. Participants were paid 4.50 GBP (6.00 USD) for completing the study, which took around 30 min. All demographic data was recorded by participants in their Prolific profile. While we did not screen out experts in design or tangible technologies, we neither solicited their recruitment, nor recruited any across either of the two studies. Two pilot participants completed the questionnaire to ensure that the questions would generate meaningful stories. Their responses were meaningful, so no changes were made to the questionnaire prior to running the study.

The study was approved by our University's ethics review board, who reviewed all of the study materials. The first page of the questionnaire collected consent from participants. Participants agreed that their participation was voluntary and that they could leave the questionnaire at any time, without giving any reason. As that data was collected anonymously, participants had to agree that they understood that any data they had submitted was anonymous, and therefore could not be removed. They also provided consent that any submitted data may be used for academic publication but only in a form which cannot identify the individual.

52 participants were recruited, between the ages of 18 and 71. When recruiting the participants, we filtered on three criteria: (1) that participants were in the correct age-range, (2) that participants had fluent English and (3) that participants had not completed any previous studies related to emotion logging run by the research team through Prolific.

We structured our recruitment such that each version of the questionnaire would be completed from people across the age spectrum, with 10 participants each in the age ranges of 18–30, 31–40, 41–50, 51–60 and 60+. Due to an administrative error, 12 participants were recruited in the 18–30 range.

24 of our participants were male, 27 were female, and 1 did not specify a gender. 13 participants were born and lived in Portugal, with 12 born and living in South Africa. The remaining participants were born in, or lived in, 16 different countries across the six populated continents. This was a convenience sample, based on who responded through the Prolific platform. Based on their questionnaire responses, 39 participants were not familiar with TUIs, eight were somewhat familiar (including seeing them in films), and five were moderately to very familiar with the technology.

We argue that this participant pool represents a somewhat diverse set of participants, across age, gender, geographical location, and experience with technology. Information on the demographic profile of all of the members of Prolific are available (Prolific, 2023).

3.1.4. Analysis

There are a variety of approaches to analyse the collected stories, as outlined in Clarke et al. (2019). We have chosen to explore the data using a thematic analysis approach, in line with previous work in HCI (Kitzinger and Powell, 1995; Wood et al., 2017).

Our analytical approach follows previous work in taking a social constructionist approach (Clarke et al., 2019; Wood et al., 2017). As participants are providing endings to hypothetical scenarios, they are offering fictional accounts of third parties; we argue that such accounts are informed by experiences and socio-cultural values. Therefore, like Cambre et al. we "read the narratives as works of fiction, and consider the themes within them as speculations that can inform and inspire future design in this space" (Cambre et al., 2020).

The analysis was led by the first author, in discussion with the other authors. Given that our interest was in whether any design insights could be extracted from the stories, there was little concern in developing a consensus view, and more focus on understanding whether a given designer could extract value.

The stories went through three rounds of iterative coding by the first author. After a familiarisation read-through, during the second reading the coder identified 32 distinct codes, clustered into four high-level themes. The analysis was guided by an interest in identifying design insights related to the development of TUIs for logging emotions.

In a third reading, looking for convergence, these themes were reduced to two key themes, the nature of the technology, and design properties. In reporting the results, we include extracts from the completed stories to illustrate our findings, indicating the story stem the extract was in response to, and the participant ID of the author.

Given the number of respondents, a systematic analysis of the impact of age, geographic location, familiarity with TUIs or story length is not feasible due to the number of confounding factors. A final pass over the data did not identify any clear relationships between these demographic criteria and any element of the analysis.

3.2. Results

Of the 104 completed stories, the average story length was 70 words, with the stories ranging between 3 and 304 words. In analysing the stories, we are first going to discuss the nature of the technologies described by participants, before moving on to outline the key design properties we identified from the stories.

[6] www.prolific.co.

3.2.1. Nature of the technology

20 of the stories were off-topic, such as *"The system is designed to... Cook food, body massage, put orders and play any type of music"* [stem 1, P41]. 14 of these off-topic stories were from the first stem, six from the second stem. Four participants had written off-topic stories for both stems.

Of the remaining stories, 31 discussed the technology in a generic fashion, where it was challenging to determine the nature of the technology being described: *"The system is designed to... register the mood that the person is in. After analysing it will come up with activities to improve your mood and will even call some of your preferred contacts to see if they are available to do such activity with you"* [stem 1, P47]. A chi-square test of independence showed that there was no significant association between familiarity with tangible technology and a story being off-topic, generic or including tangible technology (stem 1 $\tilde{\chi}^2$ p = .35; stem 2 $\tilde{\chi}^2$ p = .48).

This left 51 stories which discuss some form of tangible technology. Wearable devices were strongly represented (20), alongside brain/computer interfaces (13) and smart home systems (6).

3.2.2. Design properties

The first design property was the nature by which logging occurred. In 13 of the stories – all of them using a tangible technology – the recording was completed automatically through recording some physical phenomenon inherent to the human body, be that pulse, gaze, heart-rate or brain waves: *"detecting the mood of the user by measuring their temperature and pulse rate through the touch of their hand when it is placed on a small platform that is part of the system."* [stem 2, P25]

This contrasts against the five stories which included an element of manual self-logging, where users actively made a decision to record an element of their affective state: *"The system is designed to... measure fluctuations in people's mood and improve their well-being by creating suggestions and reports based on the logged responses. The system includes a soft, sponge-like response handle and based on each mood indicated by different colors, the responders should squeeze the handle based on the intensity of the respective mood state/emotion."* [stem 1, P6]. This dichotomy between automatic or manual logging is prevalent in the literature, and thus interesting that it would be so clear in the narratives our participants constructed.

A similar debate runs through the literature in terms of whether logging systems should support self-reflection, or promote some form of behaviour change. 32 of the narratives included some form of behaviour change, whether that was through a set of suggestions, changing physical properties, or providing a behavioural analysis. None of the stories contained any identifiable reference to self-reflection.

The literature of emotion tracking highlights the need to understand the dynamics of how people would be prepared to share their emotion data (Gooch et al., 2020, 2022), particularly with whom, under what conditions and to what benefit. This was one of the most diverse design properties, with seven options across nine stories, including sharing with no-one for privacy reasons: *"This new mood logging system works by... a neural chip that we can connect to our head by a special adapter. It runs only local in our head and can not be access by anyone or anything from the internet but can be read by special adapter connected to our computer."* [stem 2, P10]

While other sharing options included sharing with medical staff, anyone the user chooses moment-by-moment, selected individuals, or with family: *"... Sam notices that the mood enhancer has a family mode, this allows for a personalized mood logging system plan for each member of the family as the mood logger is able to identify individuals..."* [stem 1, P33]

With the most open sharing option being sharing through a public display: *"This new mood logging system works by... Picking up on the wearers heart rate temperature and brain waves to tell their moods. Much like the old fashioned mood rings, the wearer mood flashes up on the badge for all to see."* [stem 2, P28]. This diversity of narratives certainly provides designers with various routes for inspiration.

The penultimate design property is the feedback mechanism, the means of showing users the emotions and moods they had logged. Colour was heavily used, with eight of the stories building on the cultural associations between colour and emotion, to integrate elements of colour either into the collection or display of the story participants' moods: *"... these will be transferred to computer software which will convert the information into visual kaleidoscope type patterns each having it's own colour scheme and conveying a certain mood or feeling..."* [stem 2, P44]

Five stories discussed broader feedback approaches, using a variety of tangible approaches. An innovative approach tightly coupled tangible input and output together, an approach which we had not previously considered: *"This new mood logging system works by... giving hugs or stroking. There is a teddy bear and you can hug or stroke it either briefly or long, gently or strongly. The system responds to the power and length of your hugs."* [stem 2, P31]

The final design insight came from two stories, which discussed divorcing the technology completely from objects in the world, allowing users to choose how to integrate the technology into their daily lives: *"This new mood logging system works by... Wearing any piece of clothing with the recently developed sensing technology. It can be your shoes, a shirt, even underwear..."* [stem 2, P37]

3.2.3. SCM feedback

In the wrap-up section of the questionnaire, we asked our participants how the study materials could have better supported them in writing imaginative stories about tangible devices. Participants were keen to have the stems provide greater scaffolding. Participants argued that providing character background and motivation, the purpose of the technology, more structure and some guidance on the story audience, would have helped the development of their stories. 15 participants would have liked to have seen more videos. 38 of our participants had suggestions for providing a clearer introduction to TUIs. Nine requested clearer textual prompts, and 16 participants requested videos of emotion logging TUIs.

Given the propensity of TUI design methods to utilise prompts (see Table 2 in Section 6), we were anticipating our participants to feedback that completing the stories would have been easier had they had greater exposure to actual TUI devices. Surprisingly, only five participants asked for a demo or "actual direct interaction with such devices" [P18], suggesting both that the prompting material was sufficient to scaffold the stories, and that it was possible for our participants to write meaningful stories without hands-on interaction with TUIs.

4. Study 2: Understanding privacy management tangible devices using SCM

The stories from the first study were informative, but we wanted to see if providing more scaffolding to users would result in higher-quality stories. A large percentage of the respondents from study 1 had requested some form of improvement to the scaffolding provided.

We decided to select a second topic area such that our findings demonstrate the applicability of SCM to a wide range of tangible interaction areas. Given our context within the SERVICE project (Price et al., 2020), we had an interest in exploring privacy management systems in smart home environments.

The research team has long argued that existing GUI-based privacy management tools can often feel physically interruptive, socially disruptive, time consuming and cumbersome. We argue that tangible technologies provide a suitable alternative for smart environments given their responsiveness, and ability to integrate into daily life (Mehta et al., 2021b, 2023, 2021a). However, to date, there are few reports of successful field deployments of tangible privacy management tools, presenting a gap in understanding of the most suitable design for such tools, and how they might integrate into daily life. Exploring the design of privacy tools using SCM would assist in addressing this gap.

4.1. Method

The overall method for study 2 was based on the method from study 1, with adjustments made to increase the level of scaffolding provided to participants. The study was approved by our University's ethics review board.

4.1.1. Story stems

Following the same guidelines in study 1, we generated two story stems based on location tracking and financial management; areas of current concern within privacy management (Mehta et al., 2021b; Maaß, 2011). We also minimised the use of personal pronouns in the story stems, ensuring that the characters had no clear gender (Clarke et al., 2019; Cambre et al., 2020).

- *It's the year 2030. Sam is careful with their money, and has many different accounts to maximise the benefits they receive from different banks. Sam is concerned about financial fraud, and having money stolen. An online announcement catches Sam's eye, as a revolutionary privacy management tool – PrivacyManager – is announced. This new privacy management system works by...* [stem 3]
- *It's the year 2050. As a busy estate agent, Robin is frequently on the move. Enjoying the flexibility of their job, they often complete personal tasks in-between seeing clients. Having just dropped a parcel off at the post office, Robin's PrivacyManager system highlights a potential privacy breach, with their location being tracked by an unknown person. The PrivacyManager system...* [stem 4]

4.1.2. Procedure

We again created a questionnaire based on the Google Forms service, consisting of seven main sections:

1. The gathering of informed consent.
2. Familiarising participants with tangible user interfaces. We used the same description and three of the same videos as in study 1. We replaced two of the videos[7,8] with examples that we believed would better introduce TUI devices to our participants.[9,10].
3. Participants were asked to describe one of the TUIs, in order to ensure they had watched at least one of the videos. We used this to filter out responses which had not engaged with the study.
4. We provided material to describe privacy, and how tangible devices have been developed to assist with privacy management. This drew on the Privacy Itch and Scratch tool (Mehta et al., 2016). Having read the description, participants were asked to outline the itch and scratch tool. The description was:
   With the massive expansion of computing devices, especially in public spaces, it had been difficult for people to keep track of their privacy. Think about the different devices that hold personal information about you — smartphones, tablets, laptops, smart home technology, voice assistants, CCTV cameras. Managing who has access to that information is extremely difficult. Privacy management tools try to make that process easier.
   Given the immediacy of potential privacy breaches, tangible devices have been used a lot. For example, the privacy itch and scratch device is a wearable band (see below). When a privacy breach is detected – for example an unexpected credit charge is made – the heating elements near the wrist warm up. Different privacy breaches result in different actions, with the band also containing a range of vibration motors. Depending on what the user wants to do about the breach – stop it, allow it, or pause it for further consideration – they "scratch" a different area of the band.
5. Participants were asked to complete story stem 3, with the same instructions as in study 1.
6. Metaphor is an important element of many tangible privacy management tools (e.g. Mehta et al. (2021a)). To provide users with more scaffolding, before completing the second story, we provided a short description of the importance of metaphor in digital systems, before listing three examples:
   - Virtual walls which can be made transparent, translucent, and opaque to provide different access to different people (Kapadia et al., 2007)
   - Radiation badges, which darken as more privacy is lost (Gisch et al., 2007)
   - Eyes which grow in size based on how many people have access to your location (Schlegel et al., 2011)
7. Participants were asked to complete story stem 4. Wanting to provide more specific guidance, we decided to add an additional constraint:
   In this story, we would like you to make sure the technology is embedded in EYEWEAR and it uses SMELL to provide information to the characters.
   Where the set of objects and interaction modalities were selected from a framework for developing tangible privacy management tools (Mehta et al., 2021b). We recruited 10 participants for each of the following five pairs:
   - Jewellery/Temperature
   - Eyewear/Smell
   - Jacket/Roughness
   - Shoe/Weight
   - Umbrella/Vibration.
8. We used the same wrap up questions as in study 1.

4.1.3. Participants

Participants were recruited through the Prolific.[11] questionnaire service. Participants were paid 7.00 GBP (9.00 USD) for completing the study, which took around 40 min. All demographic data was recorded by participants in their Prolific profile.

We recruited 50 participants, between the ages of 18 and 45. A further 12 submissions were rejected, as they did not correctly describe one of the tangible systems presented in the introductory video or the itch and scratch tool. When recruiting the participants, we filtered on two criteria: (1) that participants had fluent English and (2) that participants had not completed any previous study run by the research team on Prolific.

Twenty-five of our participants were male, and 25 were female. 14 participants were born and lived in South Africa, with 13 born and living in Portugal. The remaining participants were born in, or lived in, 15 different countries across Europe, Africa, Asia and South America. This was a convenience sample, based on who responded through the Prolific platform (Prolific, 2023). Based on their questionnaire responses, 34 participants were not familiar with TUIs, nine were somewhat familiar, and seven were moderately to very familiar with the technology. We argue that this participant pool represents a somewhat diverse set of participants, across age, gender, geographical location, and experience with technology.

[7] https://www.youtube.com/watch?v=TK-8-_obj4Y.
[8] https://www.youtube.com/watch?v=jyuM8k3UPzk.
[9] https://www.youtube.com/watch?v=dD5BQlVNrYE.
[10] https://www.youtube.com/watch?v=6ImauNvPTSY.
[11] www.prolific.co.

4.1.4. Analysis

We followed the same broad analysis approach as in the first study. The stories went through three rounds of iterative coding by the first author. After a familiarisation read-through, the coder identified 42 distinct codes, clustered into four high-level themes. In reporting the results, we include extracts from the completed stories to illustrate our findings, indicating the story stem the extract was in response to, and the participant ID of the author.

Given the number of respondents, a systematic analysis of the impact of age, geographic location, familiarity with TUIs or story length is not feasible due to the number of confounding factors. However, specific stories – where the impact of cultural diversity is clear – are highlighted.

4.2. Results

Of the 100 completed stories, the average story length was 91 words, with the stories ranging between 14 and 340 words. There was no observable difference in the story lengths between the non-prompted stem (stem 3) and the prompted stem (stem 4).

In analysing the stories, we are first going to consider the designs developed, discussing the inclusion of tangible technology in the participant-generated stories from stem 3, before moving on to outline the key design properties we identified from stem 3. We then move on to consider results related to the method itself, particularly the impact of prompts on the stories from stem 4, and the design properties embedded within these stories. We end the results section by outlining our participant feedback on how to provide a clearer understanding of tangible devices, and what prompts would have supported the story writing process.

4.2.1. Inclusion of tangible technology

One participant provided nonsense stories which were uninterpretable. Across the two stems, 27 stories did not include tangible technology, focusing instead on software systems. Five participants provided stories with no tangible aspect across both stems.

Sixteen stories from the first stem did not include a tangible aspect, with the focus being on software systems. These stories included seven current software solutions (including cold wallets, VPNs and some AI), with one story discussing the block chain, and another covering an AI solution.

Eleven stories from the second stem did not include a tangible aspect, with the focus being on software systems. These stories also covered location tracking (3 stories), facial recognition (1), and 1 account of the consequences of having the PrivacyManager system hacked. These were evenly distributed across the different prompts participants received (jewellery/heat(3), eyewear/smell(2), jacket/roughness (1), shoe/weight(1), umbrella/vibrate(3)).

A chi-square test of independence showed that there was no significant association between familiarity with tangible technology and a story discussing tangible technology (stem 3 $\tilde{\chi}^2$ p = .60; stem 4 $\tilde{\chi}^2$ p = .21). However, 8 of these non-tangible stories did highlight sociocultural factors relating to how such technology would integrate into daily life. Given the factors discussed, these stories may be indicative of cultural diversity. For example, seven of the stories – written by individuals in Portugal, Hungary and South Africa – indicate an acceptance of the benefits of close surveillance: *"... makes use of analysing your phones data. The privacy Manger system can detect who is viewing your cell phones data such as cell phone history, location and messages. The system can highlight people who potentially tracing your movements by the use of your cellphone. The system detects which IP address is interacting with your private data the most."* [stem 3, P8]

This acceptance of close surveillance was not identified as a story element in any other contribution. The final story was contributed by a participant from Zimbabwe, a country which has – alongside many others across the globe – faced economic concerns in recent history. This may explain why their story focused on concerns relating to bank fraud: *"... detecting any fraud in the banks. It is an electronic software where Sam can enter info on his banks..."* [stem 3, P46]

4.2.2. Design properties

Of the remaining 33 stories for the first stem, a wide variety of systems were proposed. While seven of the stories were heavily based on the itch and scratch device participants had been introduced to, there was also a great deal of creativity. Almost all involved an augmented object, with the range covering some form of jewellery (smartwatch/watch, bracelet, necklace, ring), clothing (shoes, wristband, armband, glasses/sunglasses/contact lenses, belt), day-to-day objects (bank cards, headphones) and implants (neural interface, thumb chip). The interaction modalities were more constrained, although covering vibration, colour, sound, HUD, pressure, holograms, shape-changing objects, heat, electric shocks and the neural interface. Only 20 of the stories included an input method, with this predominantly focussing on touching the device (11), using eye gaze (2) or manipulating the device (1). Six stories discussed using a smartphone as a companion for the device, recognising that while the TUI would be well-placed for notification, a GUI would be more suited for complex information input/output actions: *"a vibrating insole, that warns the user about movements in their bank account. This is customisable: the user can choose the pattern of vibration, the intensity of vibration and the amount of times they want the insole to vibrate. Then, the device sends all the information to a smartphone app, where the user can have access to what is happening and choose the course of action..."* [stem 4, P2]

Hybrid Privacy Management: three of the participants identified an alternative to focussing on a single augmented object, proposing a hybrid system. In such systems, the software is separated from the interaction, allowing a range of devices – glasses, rings, clothing – to be used as privacy management tools, while sharing the same underlying privacy rules. This is an area of current research with TUIs (e.g. Mehta et al. (2021a)): *"[a] small chip which can be placed in almost everything. It can be in a signet ring, smartphone case, under a smartwatch, and even under the skin. When privacy is breached chip starts to generate small impulses that are easy to sense and recognise..."* [stem 4, P39]

Design innovations: Four of the stories contained innovative design considerations which extended the thinking of the research team:

1. User needs, and the accessibility of the tangible system: *"it's an inclusive way because it can be used by people who can't see... by people who can't hear... and by people who have low sensibility and can't feel..."* [stem 3, P11]
2. The social aspects of who else the PrivacyManager contacted when breaches are detected, taking privacy management beyond an individual system and opening up the rich design space of multi-user privacy management.
3. The role of preventative measures in securing privacy, and how a positive reinforcement mechanism could encourage users to be more proactive and less reactive: *"always on top of his problems, and even managed to do some preventative measures, which the device also rewards"* [stem 3, P44]
4. Raising the question as to why users should trust the privacy management system. While the proposed solution is for a government-sponsored solution, this is unlikely to satisfy those people concerned about the insight that governments may then have of the individual: *"an application made by the government of the country, developed by the best developers in the country and the best cyber security company in the world"* [stem 3, P26]

4.2.3. Story prompts

The inclusion of prompts for the second story stems provides a different focus for the analysis, given that 28 of the 38 TUI-related stories used both prompts (object/modality). We use these prompts to organise similar results across the resulting stories.

For the six jewellery/heat stories, these generally followed the format of *"Is a necklace that instantly gets cold or decreases temperature whenever it detects a privacy breach"* [stem 4, P6]. Three of the stories discussed using a laptop/phone to delve into finer-grain information,

and an additional story mentioned a speech interface as the input technique.

The eight eyewear/smell stories followed a similar structure of a breach being detected and then reflected in the smell. The more interesting elements are related to the selection of the smell, with a relative degree of consensus that breaches related to 'bad' smells (fire, burning, citrus, manure, fish and faeces) while returning to pleasant smells (fresh, ocean, citrus, lavender) when no breach is detected. Allowing the user to customise the smell by their own preference was also identified as a meaningful design element, be that focussing on an individual (*"emits an unusual smell combining manure and aftershave, which immediately brings a certain well-dressed farmer to Robin's mind... block [Robin's] location from his shady arch nemesis"* [stem 4, P17]) or the nature of the breach (*"Robin has elected to use the smell of pine to denote location"* [stem 4, P20]).

Five of the eight stories prompted by the jacket/roughness pair do not use 'rough' as the output modality (potentially highlighting it as a poor tactile medium), with cold, weight, colour & vibration, electric shock and heat being used instead. Those that do use the phrase do not expand or elaborate on what 'roughness' means in the context of their story, or how it is used by the characters.

Of the nine stories based on the shoe/weight prompt, three did not use shoes, but smartwatches (with colour and vibration), while an additional two did not use weight, instead discussing colour/vibration or height. The remaining stories focussed heavily on the physical implementation of the shoes, ranging from spraying the shoes with a special liquid which could increase weight, to interacting with the shoes through combinations of touches, or through a smartphone.

Finally, the umbrella/vibrate stories, where six of the seven stories used a similar template. The remaining story did not discuss a specific object, but used sound and colour as the output modalities. Interestingly, this was the only story prompt which led to discussions of hybrid privacy management, with the umbrella used as an example object, with others – such as bracelets – also discussed in the same story.

Outside of the specific prompted stories, the only characteristic that was identified was a focus on law enforcement, discussed in seven of the 38 stories: *"the smell will grow in potency and after 5 min the authorities will be alerted and your location will be sent to them"* [stem 4, P16]. This lack of unprompted characteristics indicates that too many prompts were provided for the second stem, limiting creativity.

4.2.4. SCM feedback

The wrap-up section of the questionnaire was the same as study 1. The answers were extremely similar; participants were keen to have had the stems provide greater scaffolding. Eighteen participants commented that providing character background and motivation, more details of the technology, and greater context of the privacy breach, would have helped the development of their stories. Similarly, 12 participants requested clearer instructions and explanations of tangible devices (including of the example videos) to support a better understanding of tangible technology.

As with study 1, we had deliberately avoided providing too many details of existing privacy management TUIs, as we did not want to influence the nature of the stories our participants would write. Examples were requested for both understanding TUIs (3) and for writing stories (4), with participants also requesting real-world examples of TUIs beyond research prototypes (6). We will return to this in the discussion where we reflect on the construction of our story stems.

5. Combined study discussion

Prior to running the studies, we had no preconceived ideas as to the value SCM may have in the design of TUIs. We argue that our findings demonstrate that the method does have something to offer, enabling diverse and large-scale engagement with participants which is particularly helpful in the early stages of design in terms of understanding the socio-cultural context of deployment.

Table 1
Summary of identified design characteristics from the two studies.

Study 1 Design characteristics	Study 2 Design characteristics
Manual/automatic logging	Accessibility concerns
Data sharing preferences	Data sharing preferences
Diverse input/output mechanisms	Diverse input/output mechanisms
Tightly coupled input/output	Questions of trust in the technology
Divorcing the technology from objects in the world	Hybrid technology
	Preventative measures to ensure privacy

Many of the stories collected considered socio-cultural factors relating to how such technology would integrate into daily life. One of the benefits that SCM brings is the ability to recruit participants across a wide demographic — particularly geographic diversity. While our data is not substantial enough to make conclusive claims, some of the stories written in the second study provided some evidence of cultural diversity. Similarly, the discussion of trust in the privacy management system in study 2 provided a range of socio-cultural perspectives that somewhat reflected cultural norms. Given the potential for technologies to be deployed globally, utilising design methods which allow designers to engage with diverse cultural settings easily is a clear benefit. This broadly integrates with the arguments made in the few previous HCI uses of the method (Cambre et al., 2020).

Our analysis of the stories also demonstrate the usefulness of the method in identifying possible design requirements, with diverse design characteristics identified across both studies (see Table 1). Some of these design characteristics are unsurprising, and would likely have been generated by any team of designers thinking about the context of use. However, as active researchers in these two domains, it is notable that some of these characteristics extended our thinking. For example, the concept of tightly coupling the tangible input and output for the emotion logging tool was an approach which we had not previously considered. Nor had we considered the use case of multi-user privacy management tools, and how such systems would need to determine the appropriate action when a breach had occurred.

Other design characteristics referred to concepts which are currently under exploration. For example, hybrid privacy management tools were suggested, where the software is separated from the interaction, allowing a range of devices – glasses, rings, clothing – to be used as privacy management tools, while sharing the same underlying privacy rules. This is an area of current research within the domain of privacy management TUIs (e.g. Mehta et al. (2021a)).

We argue that both the socio-cultural insights and the design characteristics have value in the design process. While SCM produces complete designs (presented as stories), this is not where its true value lies. Rather, SCM's value is in enabling designers to engage with a diverse population, in a manner that scales easily, to identify interesting design characteristics not limited by existing technology. These characteristics can then be taken forward by the designer into a realistic construction of technology, or assessment of how technology should integrate into our social and political lives.

Such a translation step is not unusual in co-design methods, given the need to provide technical expertise on what is viable; the difference with SCM over more traditional co-design workshops is in how the different methods utilise the designer at different stages. The wide range of design characteristics identified – several of which had not occurred to the authors, who are active TUI researchers in both domains – highlights the value of the method in identifying interesting design characteristics. As such, we believe that our studies have demonstrated the value SCM has in the design process of developing TUIs, as an early scoping activity, engaging widely with diverse populations.

Table 2
Summary analysis of the identified design methods. Not all data is easily processed for this summary and is therefore excluded. This includes cases such as the numbers of participants described in terms of the number of classes involved, or where the geographic spread is undeterminable.

Design method	Number of papers	Number of participants	Geographic diversity by number of papers	F2F/ online	Prototypes used by number of papers
Workshop	103	Mean = 17.4 Median = 12	65 single location 7 single country 9 diverse	78 F2F 16 online 5 both	43 prototypes
Interview	70	Mean = 12.8 Median = 12	30 single location 13 single country 10 diverse	17 F2F 27 online 8 both	7 prototypes
Observation	18	Mean = 36.8 Median = 15	17 single location 1 single country	14 F2F 4 online	4 prototypes
Survey	17	Mean = 36.8 Median = 15	2 single location 6 single country 3 diverse	2 F2F 13 online	1 prototype
Ethnography	14	Mean = 10.3 Median = 10	11 single location 1 single country 1 diverse	9 F2F 3 online 1 both	4 prototypes
Elicitation studies	12	Mean = 35.0 Median = 19	7 single location 1 single country	10 F2F 2 online	7 prototypes
Wizard of Oz	4	Mean = 16.5 Median = 11.5	3 single location	4 F2F	4 prototypes
Probe	4	Mean = 7 Median = 5	1 single location 1 single country	1 F2F 2 online	1 prototype
Diary Study	3	Mean = 12 Median = 12	1 single location 1 single country	1 F2F 1 both	1 prototype
Bodystorming	2	Mean = 8 Median = 8	2 single location	2 F2F	
Gameplay	2	Mean = 7.5 Median = 7.5	1 single location	1 F2F	2 prototypes
Brainstorming	1	12	1 location	F2F	
Artist engagement	1	3	1 location	F2F	
Bulletin board analysis	1	13		Online	
Card Sort	1	22	Diverse	Online	
Delphi questioning	1	6	Diverse	Online	
Design session	1	7	1 location	F2F	
Design fiction feedback	1	6	1 location	Online	
Total	256	Mean = 32.8 Median = 12	144 single location 31 single country 25 diverse	142 F2F 71 online 15 both	73 prototypes
Our SCM studies	2	Mean = 51	Diverse	Online	

6. Systematic literature review discussion

Design is a broad practice that utilises many different techniques. To illustrate how the Story Completion Method compares against 'typical' design methods used in the development of tangible technology, the first author conducted a systematic literature review. Our area of interest was scoped to design methods used during the 'fuzzy front-end' of design, which Smit et al. (2022) describe as the stage where "designers aim to move from ambiguity and uncertainty to more concrete and focused design goals (Kaasinen et al., 2014) by means of collecting and sharing inspiration, knowledge and opportunities (Kwiatkowska et al., 2015), defining goals (Varsaluoma et al., 2015), generating ideas and developing initial concepts (Herstatt and Verworn, 2004)". We draw on this analysis in Section 7 when focussing on our reflections on the challenges and benefits SCM provides. Guided by relevant systematic reviews (Li et al., 2022; Beneteau, 2020; Kim et al., 2023; Stefanidi et al., 2023), our process was three-stage; an identification phase, a screening phase, and an analysis stage.

6.0.1. Identification phase

We first identified the date range we were interested in. Given we were motivated to explore SCM by the disruption to our standard design practices by Covid-19, we selected the data range of 2020–2023, to capture research conducted pre- and post-pandemic. For the conferences, this provides four proceedings. The search for the journals was completed over May and June 2023. In order to keep the number of papers reviewed viable, we decided to only consider full papers.

We selected four main venues to examine: TEI, CHI, IJHCS and TOCHI. Given the remit of TEI, we examined all of the full papers

published in our date range. We searched the other three venues using the search string "tangible" on the ACM Digital Library (filtering by venue), and the IJHCS section of Science Direct. This resulted in 870 papers being identified as needing to be screened. While this is unlikely to have identified all relevant papers, it provides a sufficient large set to be indicative of the design methods commonly used.

6.0.2. Screening phase

All 870 papers identified were written in English. Given the search term used, we were not surprised to have to filter a significant number of papers which used the phrase 'tangible' without discussing tangible technology. The first author reviewed the title and abstract of all 870 papers. If the paper appeared to not involve a tangible technology, the methods section was also reviewed. 260 papers were excluded for not including any tangible technology.

Our criteria for inclusion was that the paper clearly articulated at least one design method with users outside of the research team. For the purposes of this review, field trials and other evaluations – while important to the design process – were excluded, given their focus on improving a developed artefact, rather than embedding user voices into the early development of the artefact.

Educational studies – with students receiving course credit – alongside studies focussing on teaching interaction design students about tangible systems were deemed out of scope. Art installations engaging with an audience were also scoped out given the specific nature of the techniques used. We also excluded pilots within papers, as these rarely contained sufficient detail on the design method being utilised.

Papers that we excluded varied immensely, with common exclusions covering theory/opinion pieces, auto-ethnography, body sensing, design tools, experiments, expert design, meta-reviews, retrospectives and technology development. In total, 681 papers were excluded, with 189 papers identified as containing at least one design technique involving users and a tangible technology.

6.0.3. Analysis phase

For each design method within a paper, we recorded:

- DOI
- Design Method
- Number of participants
- Geographic spread of participants
- Whether the method was used face-to-face or online
- The use of prototypes or physical materials
- Any identified strengths or weaknesses in the methods, limitations or conclusion sections of the paper

As 50 papers utilised more than 1 design technique, this results in an identified 256 different instantiations of a design technique. Our completed data set is made available as supplementary material to this paper.

Table 2 provides a summary analysis of these 256 instantiations of design techniques. In doing so, we also situate our use of SCM with regards to existing design techniques, highlighting the distinctions between the different methods. We found no use of SCM amongst the papers we analysed.

Before moving on to the reported strengths and weaknesses of these methods, Table 2 highlights a number of important considerations. The first is clear; despite a wide-range of design techniques, the work we analysed coalesced around two main design methods; workshops and interviews. While these techniques support a deep engagement with participants, they mitigate against recruiting a large and diverse number of participants due to the effort involved. We would argue that there is a place for wide and shallow engagement, and SCM provides an additional method, alongside observational, survey and elicitation studies.

Table 3
Summary analysis of the identified strengths and weaknesses of the design techniques, excluding surveys.

Strength/ Weakness	Number of papers
Issues with bias in sample selection	21 interview papers 13 workshop papers 5 observation papers 4 elicitation papers 1 ethnography paper 1 diary study
Engage diverse stakeholders	3 interview papers
Inclusivity	9 workshop papers 1 ethnography paper 2 observation papers
Deep insight	3 workshop papers 1 ethnography paper
Strengths Weaknesses	18 papers 45 papers

Across all of the studies, there are clearly identifiable trends, with a focus on recruiting relatively modest numbers of participants, typically in a single location or country. Around $\frac{2}{3}$ of the reported studies engaged participants face-to-face, and a significant proportion – 29% – made use of a prototype device. These figures stand in stark contrast with our use of SCM, which engaged more people, across a diverse geographic area in an online manner without prototypes.

There is nothing wrong with these facets of the commonly use design techniques, and much of our own design practice follows these norms. However, we need to continue to question whether this is best serving our purposes, and whether we should be more aware of alternative methods in our toolbox of design techniques.

Table 3 provides a summary analysis of the strengths and weaknesses noted across the 256 instantiations of design techniques.

The first notable insight is how few papers report on methodological strengths and weaknesses. This may be related to the field expecting tacit knowledge regarding the strengths and weaknesses of certain methods; and the majority of papers offering design artefacts rather than methods as the typical contribution. However, this does not capture the strengths and weaknesses experienced within specific studies. For example, while there is an issue with bias in sample selection for interviews due to the size of study populations, there was no discussion in any of the papers reviewed regarding participants who went off-topic or were not forthcoming. One of the contributions we make regarding SCM is to make this tacit knowledge explicit, by highlighting the challenges and benefits of our experience in using the method.

With interviews and workshops being the preeminent methods, unsurprisingly the only weakness identified was sample selection, including limited cultural diversity, the generalisability of the population, the demographic profile of participants, and the sample size. Given how we deployed SCM as an online questionnaire, unsurprisingly the strengths and weaknesses of surveys align with our experiences. We argue that it is a good method for soliciting interesting initial evidence and providing breadth over depth (zum Hoff et al., 2022), but is a light-weight method unlikely to capture the full richness of peoples' perspectives, experiences or reflections (Scott et al., 2023; Luria and Candy, 2022).

7. Reflections on using SCM

Our reflections on using the Story Completion Method draw on our two empirical studies and the systematic literature review. They coalesce around 4 key themes; scale and diversity; the construction of story stems; the effort involved in using the method; and the practicalities of online distribution.

7.0.1. Scale and diversity

The story completion method supports engagement at a larger scale and with a more diverse population than typically recruited by the majority of other design techniques. By integrating SCM into an easy to distribute questionnaire, we recruited participants from around the globe, covering a wide age-range, with variations in careers and expertise in TUIs. Given the strong relationship between diversity and creativity, having design processes that easily support diversity is of clear benefit to the community.

The method was also successful at taking us as researchers beyond our lived experiences, to consider both the utopian and dystopian aspects of envisaged technology (Mancini et al., 2010). Despite having working in privacy for many years, because of the WEIRD (Western, Educated, Industrialised, Rich, and Democratic) nature of the design team, we had simply had not considered the risks involved in some envisaged privacy technology — whether that is elements of safety, the perceived acceptability of surveillance, or concerns over trust. While not necessarily relevant to the direct design artefact, this data provides a broader perspective with regards to the implications of the technology, and the potential impact on communities not directly engaged in the design process.

7.0.2. Construction of story stems

Construction of the story stems is challenging. Despite following the advice of previous researchers, and piloting the questionnaires with participants, the stems differed in how successful the resulting stories were in generating meaningful design input. In the first study, the first stem was not as good as the second stem in gathering design ideas, while the stories in study 2 were more influenced by the prompts in the study materials. Of course it is difficult to distinguish the impact of the study topic on the quality of the design ideas generated, but it is reasonable to assume that the level of scaffolding provided had a significant influence.

Providing the object/modality prompt for stem 2 limited creativity and design ideas, rather than acting as inspiration. Participants focussed on developing a narrative involving the prompts at the expense of exploring other design ideas. While suitable if exploring a mid-stage design, this proves less useful for early blue-sky thinking.

Overall our results indicate that providing the appropriate level of scaffolding supports creativity; while too little (as per study 1) and too much (prompts for stem 4) can be limiting. We would strongly encourage researchers interested in using SCM to extensively pilot their story stems, to ensure that the authored stories will generate useful data. We believe that as further work continues to utilise the method in the design of TUIs, further guidelines and best practice will be established by the community.

7.0.3. Study effort

The authors have used a range of design methods across diverse projects including workshops (Mehta et al., 2021a), ethnography (Gooch et al., 2018), elicitation (Gooch et al., 2020), surveys (Kelly and Gooch, 2012), diary studies (Gooch and Watts, 2014) and interviews (Gooch et al., 2016). This experience allows us to reflect on how our use of SCM compares against other techniques we have previous utilised.

Compared to these other techniques, we found the time the research team invested in deploying SCM was lower, particularly as compared to workshops and interviews. This is perhaps unsurprising, given the recognition that workshops are extremely time consuming and effortful for research teams (Superti Pantoja et al., 2020). While developing the prompts and story stems was effortful, it was broadly comparable to developing the prompts or interview protocols for workshops, interviews, or diary studies. Similarly, we found the overall analysis time for 50 SCM stories to be somewhat similar to what we would typically experience when analysing 10 hour-long interviews. Where the research team saved significant time is in recruiting participants, and conducting the workshop or interview.

There is a broader question regarding the overall time and effort invested; 10 min for 50 participants is over 8 h. A comparable investment of time in interviewing participants, or conducting observations, would reveal much deeper insights into practice. However, this does come at the cost of scale and diversity, and therefore designers need to consider which design techniques they are using for which purposes.

7.0.4. Practicalities of online distribution

We deployed SCM through a paid-for online questionnaire service, and our experiences reflect this. Our results – and arguments regarding scale and diversity – would be very different, had we tried to deploy it as a face-to-face survey. Unsurprisingly then, many of the challenges in terms of receiving meaningful stories are consistent with experiences with other crowd-sourcing sites. Around half of the stories in study 1 did not involve TUIs; and through the use of questions to validate responses in study 2 we increased the number of relevant stories to 75%. This is consistent with return rates on using crowdsourcing platforms (Downs et al., 2010).

There are methods for improving the quality of responses through crowdsourcing platforms, if designers require a guaranteed length of story, or for stories to cover a particular set of criteria. One of the most successful techniques is simply to filter out inappropriate responses, and do not process payment for them (Downs et al., 2010).

We would argue that designers need to be cautious in making such a decision, as the value of the story may not be apparent until the analysis has been conducted. For example, in the second study, the stems were better at prompting reflection into social context, even if those stories did not include elements of tangible technology. Such data can stimulate design thinking, even if – strictly speaking – it did not meet our specified criteria. As such, we would also argue that story length or story relevance are not necessarily good indicators as to the quality of the data in terms of providing insights into facets relevant to design practices.

Specific to working with tangibles is the issue of how to inform an non-expert audience about their capabilities without being able to physically demonstrate some examples. We achieved this by selecting a series of videos, which we acknowledge were designed for an expert rather than general audience.

Our findings suggest that our participants could interpret the general properties of TUIs from the videos and apply them in interesting ways to other domains, given that none of the stories were direct copies of design properties from the video prompts. While it would impact the cost/benefit/effort ratio of using the method, other design teams could consider developing their own custom videos to introduce participants to the capabilities of TUIs within the domain of interest.

8. Further work

While our use of the method is tightly interlinked with the domains we were working in, our account provides a rich account of our experiences. However, we are clear that further investigations are needed to better understand the relationship between the use of the method (such as story stem construction) and the domain under investigation.

As a method that is beginning to be used by the HCI and TUI communities, there are a host of directions for further work, particularly exploring the boundaries of how to generate meaningful data from the method, and establishing best practices for these communities. Avenues for exploration include developing an understanding of which domains or aspects of TUI development SCM would best support, through to different formulations of using the method. As identified by one of our participants, there is great value in group writing and adapting the method such that users ‘co-designed’ fictional stories (as in Ambe et al. (2019)) could lead to interesting results.

One direction which we would be particularly interested in, is exploring releasing completed stories as a resource for others to use to inspire design, similar to how studies commonly provide access to their data sets. We cannot do so with our stories, as we did not seek permission from our participants for this form of data sharing. However, this is something we would encourage others to do in the future, to allow the community to explore whether there is value in sharing such data.

Other clear directions include working with users with different kinds of expertise (design experts; creative writing experts; non experts) to understand the vagaries of the method and how to best utilise to inform design practice. Similarly, exploring the elements of the design process it is most suited for – device development, social context, ethical implications – is necessary. We would also argue that the implications for inclusion are not yet well understood, and the scale and diversity of being able to involve non-WEIRD (Western, Educated, Industrialised, Rich, and Democratic) participants easily could dramatically change design practice.

9. Conclusion

Our focus has been on exploring whether the story completion method has any value as a design method in the development of TUIs. Contextualised by our interest in emotion logging and privacy management, we present two distinct questionnaire studies, and analyse the resulting stories.

Paraphrasing Bertran et al. SCM "is not necessarily better or worse than existing methods, nor it seeks to displace or substitute them. Instead, it combines many of their strengths to tackle the emergent challenge of supporting early [design] in remote settings" (Bertran et al., 2022). It allows designers to draw on important aspects from existing methods to provide a focus on large-scale engagement on the "fuzzy front-end" of design with a diverse population in topic areas which may give rise to social discomfort.

It is clear from our analysis that SCM does have a role in the design of TUIs, particularly in the early stages of the design process. There are clear benefits in harnessing the creativity of diverse populations: SCM is ideally placed to explore a diverse range of domains. We argue that our findings demonstrate that the method does have something to offer, enabling diverse and large-scale engagement with participants which is particularly helpful in the early stages of design in terms of understanding the socio-cultural context of deployment.

CRediT authorship contribution statement

Daniel Gooch: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization. **Arosha K. Bandara:** Writing – review & editing, Supervision. **Amel Bennaceur:** Writing – review & editing, Funding acquisition. **Emilie Giles:** Writing – review & editing, Methodology, Investigation. **Lydia Harkin:** Writing – review & editing, Funding acquisition. **Dmitri Katz:** Writing – review & editing, Methodology, Investigation. **Mark Levine:** Writing – review & editing. **Vikram Mehta:** Writing – review & editing, Methodology, Investigation. **Bashar Nuseibeh:** Writing – review & editing, Supervision. **Clifford Stevenson:** Writing – review & editing, Funding acquisition. **Avelie Stuart:** Writing – review & editing, Funding acquisition. **Catherine Talbot:** Writing – review & editing, Funding acquisition. **Blaine A. Price:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Acknowledgements

We thank our participants for the creative brilliance of their stories; they were a true pleasure and inspiration to read.

This work was completed under support from the UK Engineering and Physical Sciences Research Council (EPSRC) grant EP/V027263/1 and EP/R013144/1. EPSRC had no role in the study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

Word count

The word count of the article is approximately 11,800 words, based on placing the .tex file in MS Word.

Appendix A. Supplementary data

For our analysis of the literature in the systematic literature review, please view our supplementary material, available online at: https://doi.org/10.1016/j.ijhcs.2024.103360.

References

Ambe, A.H., Brereton, M., Soro, A., Buys, L., Roe, P., 2019. The adventures of older authors: Exploring futures through co-design fictions. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. CHI '19, Association for Computing Machinery, New York, NY, USA, pp. 1–16, URL https://doi.org/10.1145/3290605.3300588.

Barreto, M., van Breen, J., Victor, C., Hammond, C., Eccles, A., Richins, M.T., Qualter, P., 2022. Exploring the nature and variation of the stigma associated with loneliness. J. Soc. Pers. Relatsh. 39 (9), 2658–2679, URL https://doi.org/10.1177/02654075221087190.

Baumer, E.P.S., Blythe, M., Tanenbaum, T.J., 2020. Evaluating design fiction: The right tool for the job. In: Proceedings of the 2020 ACM Designing Interactive Systems Conference. Association for Computing Machinery, New York, NY, USA, pp. 1901–1913.

Beneteau, E., 2020. Who are you asking?: Qualitative methods for involving AAC users as primary research participants. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. CHI '20, Association for Computing Machinery, New York, NY, USA, pp. 1–13, URL https://doi.org/10.1145/3313831.3376883.

Bertran, F.A., Pometko, A., Gupta, M., Wilcox, L., Banerjee, R., Isbister, K., 2022. Designerly tele-experiences: A new approach to remote yet still situated co-design. ACM Trans. Comput.-Hum. Interact. 29 (5), URL https://doi.org/10.1145/3506698.

Bleecker, J., 2009. Design Fiction: A Short Essay on Design, Science, Fact and Fiction. Vol. 29, Near future laboratory.

Blythe, M., 2014. Research through design fiction: Narrative in real and imaginary abstracts. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '14, Association for Computing Machinery, New York, NY, USA, pp. 703–712, URL https://doi.org/10.1145/2556288.2557098.

Braun, V., Clarke, V., Gray, D., 2017. Collecting Qualitative Data: A Practical Guide to Textual, Media and Virtual Techniques. Cambridge University Press, Cambridge, UK.

Buskermolen, D.O., Terken, J., 2012. Co-constructing stories: A participatory design technique to elicit in-depth user feedback and suggestions about design concepts. In: Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases - Volume 2. PDC '12, Association for Computing Machinery, New York, NY, USA, pp. 33–36, URL https://doi.org/10.1145/2348144.2348156.

Cambre, J., Reig, S., Kravitz, Q., Kulkarni, C., 2020. "All rise for the AI director": Eliciting possible futures of voice technology through story completion. In: Proceedings of the 2020 ACM Designing Interactive Systems Conference. DIS '20, Association for Computing Machinery, New York, NY, USA, pp. 2051–2064, URL https://doi.org/10.1145/3357236.3395479.

Carroll, J.M., Rosson, M.B., 2007. Participatory design in community informatics. Des. Stud. 28 (3), 243–261, Participatory Design. URL https://doi.org/10.1016/j.destud.2007.02.007.

Clarke, V., Braun, V., Frith, H., Moller, N., 2019. Editorial introduction to the special issue: Using story completion methods in qualitative research. Qual. Res. Psychol. 16 (1), 1–20, URL https://doi.org/10.1080/14780887.2018.1536378.

Clarke, V., Hayfield, N., Moller, N., Tischner, I., 2017. Once upon a time?: Story completion methods. In: Braun, V., Clarke, V., Gray, D. (Eds.), Collecting Qualitative Data: A Practical Guide to Textual, Media and Virtual Techniques. Cambridge University Press, Cambridge, pp. 45–70.

Dindler, C., Iversen, O.S., 2007. Fictional Inquiry—design collaboration in a shared narrative space. CoDesign 3 (4), 213–234, URL https://doi.org/10.1080/15710880701500187.

Downs, J.S., Holbrook, M.B., Sheng, S., Cranor, L.F., 2010. Are your participants gaming the system? Screening mechanical turk workers. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '10, Association for Computing Machinery, New York, NY, USA, pp. 2399–2402, URL https://doi.org/10.1145/1753326.1753688.

Dunne, A., Raby, F., 2013. Speculative Everything: Design, Fiction, and Social Dreaming. The MIT Press, Cambridge, MA, USA.

Gisch, M., De Luca, A., Blanchebarbe, M., 2007. The privacy badge: A privacy-awareness user interface for small devices. In: Proceedings of the 4th International Conference on Mobile Technology, Applications, and Systems and the 1st International Symposium on Computer Human Interaction in Mobile Technology. Mobility '07, Association for Computing Machinery, New York, NY, USA, pp. 583–586, URL https://doi.org/10.1145/1378063.1378159.

Gooch, D., Barker, M., Hudson, L., Kelly, R., Kortuem, G., Linden, J.V.D., Petre, M., Brown, R., Klis-Davies, A., Forbes, H., Mackinnon, J., Macpherson, R., Walton, C., 2018. Amplifying quiet voices: Challenges and opportunities for participatory design at an urban scale. ACM Trans. Comput.-Hum. Interact. 25 (1), URL https://doi.org/10.1145/3139398.

Gooch, D., Mehta, V., Price, B., McCormick, C., Bandara, A., Bennaceur, A., Bennasar, M., Stuart, A., Clare, L., Levine, M., Cohen, J., Nuseibeh, B., 2020. How are you feeling? Using tangibles to log the emotions of older adults. In: Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '20, Association for Computing Machinery, New York, NY, USA, pp. 31–43, URL https://doi.org/10.1145/3374920.3374922.

Gooch, D., Mehta, V., Stuart, A., Katz, D., Bennasar, M., Levine, M., Bandara, A., Nuseibeh, B., Bennaceur, A., Price, B., 2022. Designing tangibles to support emotion logging for older adults: Development and usability study. JMIR Hum. Factors 9 (2), e34606, URL https://doi.org/10.2196/34606.

Gooch, D., Vasalou, A., Benton, L., Khaled, R., 2016. Using gamification to motivate students with dyslexia. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. CHI '16, Association for Computing Machinery, New York, NY, USA, pp. 969–980, URL https://doi.org/10.1145/2858036.2858231.

Gooch, D., Watts, L., 2014. The impact of social presence on feelings of closeness in personal relationships. Interact. Comput. 27 (6), 661–674, arXiv:https://academic.oup.com/iwc/article-pdf/27/6/661/2619732/iwu020.pdf. URL https://doi.org/10.1093/iwc/iwu020.

Harkin, L., Stuart, A., Stevenson, C., Talbot, C., Daly, R., Park, M.S.-A., Katz, D., Gooch, D., Price, B., 2023. Being cut off from social identity resources has shaped loneliness during the coronavirus pandemic: A longitudinal interview study with medically vulnerable older adults from the United Kingdom. J. Community Appl. Soc. Psychol. URL https://doi.org/10.1002/casp.2724.

Harrington, C., Dillahunt, T.R., 2021. Eliciting tech futures among black young adults: A case study of remote speculative co-design. In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. CHI '21, Association for Computing Machinery, New York, NY, USA, pp. 1–15, URL https://doi.org/10.1145/3411764.3445723.

Herstatt, C., Verworn, B., 2004. The 'fuzzy front end' of innovation. In: Bringing Technology and Innovation Into the Boardroom: Strategy, Innovation and Competences for Business Value. Palgrave Macmillan UK, London, pp. 347–372, Ch. 16. URL https://doi.org/10.1057/9780230512771_16.

Kaasinen, E., Väätäjä, H., Karvonen, H., Lu, Y., 2014. The fuzzy front end of experience design. In: Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational. NordiCHI '14, Association for Computing Machinery, New York, NY, USA, pp. 797–800, URL https://doi.org/10.1145/2639189.2654829.

Kapadia, A., Henderson, T., Fielding, J.J., Kotz, D., 2007. Virtual walls: Protecting digital privacy in pervasive environments. In: LaMarca, A., Langheinrich, M., Truong, K.N. (Eds.), Pervasive Computing. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 162–179.

Kelly, R., Gooch, D., 2012. Understanding participation and opportunities for design from an online postcard sending community. In: Proceedings of the Designing Interactive Systems Conference. DIS '12, Association for Computing Machinery, New York, NY, USA, pp. 568–571, URL https://doi.org/10.1145/2317956.2318041.

Kim, R., Risseeuw, C., Groutars, E.G., Karana, E., 2023. Surfacing livingness in microbial displays: A design taxonomy for HCI. In: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. CHI '23, Association for Computing Machinery, New York, NY, USA, pp. 1–21, URL https://doi.org/10.1145/3544548.3581417.

Kitzinger, C., Powell, D., 1995. Engendering infidelity: Essentialist and social constructionist readings of a story completion task. Fem. Psychol. 5 (3), 345–372, URL https://doi.org/10.1177/0959353595053004.

Kwiatkowska, J., Bartkowski, W., Górnicka, O., Lamas, D., 2015. Applying generative techniques to avoid technology push effect in ideas and prototypes created by technology-oriented people. In: Proceedings of the Mulitimedia, Interaction, Design and Innnovation. MIDI '15, Association for Computing Machinery, New York, NY, USA, pp. 1–9, URL https://doi.org/10.1145/2814464.2814480.

Li, Y., Liang, M., Preissing, J., Bachl, N., Dutoit, M.M., Weber, T., Mayer, S., Hussmann, H., 2022. A meta-analysis of tangible learning studies from the TEI conference. In: Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '22, Association for Computing Machinery, New York, NY, USA, pp. 1–17, URL https://doi.org/10.1145/3490149.3501313.

Lindley, J., Coulton, P., 2015. Back to the future: 10 years of design fiction. In: Proceedings of the 2015 British HCI Conference. In: British HCI '15, Association for Computing Machinery, New York, NY, USA, pp. 210–211, URL https://doi.org/10.1145/2783446.2783592.

Lindley, J., Coulton, P., Sturdee, M., 2017. Implications for adoption. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. CHI '17, Association for Computing Machinery, New York, NY, USA, pp. 265–277, URL https://doi.org/10.1145/3025453.3025742.

Luria, M., Candy, S., 2022. Letters from the future: Exploring ethical dilemmas in the design of social agents. In: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. CHI '22, Association for Computing Machinery, New York, NY, USA, pp. 1–13, URL https://doi.org/10.1145/3491102.3517536.

Maaß, W., 2011. The elderly and the internet: How senior citizens deal with online privacy. In: Privacy Online: Perspectives on Privacy and Self-Disclosure in the Social Web. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 235–249, Ch. 17. URL https://doi.org/10.1007/978-3-642-21521-6_17.

Mancini, C., Rogers, Y., Bandara, A.K., Coe, T., Jedrzejczyk, L., Joinson, A.N., Price, B.A., Thomas, K., Nuseibeh, B., 2010. Contravision: Exploring users' reactions to futuristic technology. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '10, Association for Computing Machinery, New York, NY, USA, pp. 153–162, URL https://doi.org/10.1145/1753326.1753350.

Markussen, T., Knutz, E., 2013. The poetics of design fiction. In: Proceedings of the 6th International Conference on Designing Pleasurable Products and Interfaces. DPPI '13, Association for Computing Machinery, New York, NY, USA, pp. 231–240, URL https://doi.org/10.1145/2513506.2513531.

Mehta, V., Bandara, A.K., Price, B.A., Nuseibeh, B., 2016. Privacy itch and scratch: On body privacy warnings and controls. In: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. In: CHI EA '16, Association for Computing Machinery, New York, NY, USA, pp. 2417–2424, URL https://doi.org/10.1145/2851581.2892475.

Mehta, V., Bandara, A.K., Price, B.A., Nuseibeh, B., Gooch, D., 2021a. Up close & personal: Exploring user-preferred image schemas for intuitive privacy awareness and control. In: Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '21, Association for Computing Machinery, New York, NY, USA, pp. 1–13, URL https://doi.org/10.1145/3430524.3440626.

Mehta, V., Gooch, D., Bandara, A., Price, B., Nuseibeh, B., 2021b. Privacy care: A tangible interaction framework for privacy management. ACM Trans. Internet Technol. 21 (1), URL https://doi.org/10.1145/3430506.

Mehta, V., Gooch, D., Bandara, A., Price, B.A., Nuseibeh, B., 2023. A card-based ideation toolkit to generate designs for tangible privacy management tools. In: Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '23, Association for Computing Machinery, New York, NY, USA, pp. 1–13, URL https://doi.org/10.1145/3569009.3572903.

Nabil, S., Kirk, D., 2021. Decoraction: A catalogue for interactive home decor of the nearest-future. In: Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '21, Association for Computing Machinery, New York, NY, USA, pp. 1–13, URL https://doi.org/10.1145/3430524.3446074.

Prange, S., George, C., Alt, F., 2021. Design considerations for usable authentication in smart homes. In: Proceedings of Mensch Und Computer 2021. MuC '21, Association for Computing Machinery, New York, NY, USA, pp. 311–324, URL https://doi.org/10.1145/3473856.3473878.

Price, B., Gooch, D., Stevenson, C., Levine, M., Bennaceur, A., Katz, D., Stuart, A., 2020. SERVICE: Social and emotional resilience for the vulnerable impacted by the COVID-19 emergency. https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/V027263/1. (Accessed 10 July 2023).

Prolific, 2023. Who are the participants on Prolific? https://researcher-help.prolific.co/hc/en-gb/articles/360009220833, (Accessed 11 July 2023).

Rüller, S., 2022. Moving beyond illiteracy: Is wearable and touch-sensitive technology the way to go forward? Reflections on 'speculation' and 'fiction' in participatory design with imazighen in remote Morocco. In: Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '22, Association for Computing Machinery, New York, NY, USA, pp. 1–5, URL https://doi.org/10.1145/3490149.3503582.

Rüller, S., Aal, K., Tolmie, P., Hartmann, A., Rohde, M., Wulf, V., 2022. Speculative design as a collaborative practice: Ameliorating the consequences of illiteracy through digital touch. ACM Trans. Comput.-Hum. Interact. 29 (3), URL https://doi.org/10.1145/3487917.

Sarzotti, F., 2018. Self-monitoring of emotions and mood using a tangible approach. Computers 7 (1), URL https://doi.org/10.3390/computers7010007.

Schlegel, R., Kapadia, A., Lee, A.J., 2011. Eyeing your exposure: Quantifying and controlling information sharing for improved privacy. In: Proceedings of the Seventh Symposium on Usable Privacy and Security. SOUPS '11, Association for Computing Machinery, New York, NY, USA, pp. 1–14, URL https://doi.org/10.1145/2078827.2078846.

Scott, A.E., Neumann, D., Niess, J., Woźniak, P.W., 2023. Do you mind? User perceptions of machine consciousness. In: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. CHI '23, Association for Computing Machinery, New York, NY, USA, pp. 1–19, URL https://doi.org/10.1145/3544548.3581296.

Shaer, O., Hornecker, E., 2010. Tangible user interfaces: Past, present, and future directions. In: Foundations and Trends in Human-Computer Interaction Series, NOW, Delft, Holland, URL http://dx.doi.org/10.1561/1100000026.

Smit, D., Hengeveld, B., Murer, M., Tscheligi, M., 2022. Hybrid design tools for participatory, embodied sensemaking: An applied framework. In: Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '22, Association for Computing Machinery, New York, NY, USA, pp. 1–10, URL https://doi.org/10.1145/3490149.3501332.

Stefanidi, E., Bentvelzen, M., Woźniak, P.W., Kosch, T., Woźniak, M.P., Mildner, T., Schneegass, S., Müller, H., Niess, J., 2023. Literature reviews in HCI: A review of reviews. In: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. CHI '23, Association for Computing Machinery, New York, NY, USA, pp. 1–24, URL https://doi.org/10.1145/3544548.3581332.

Superti Pantoja, L., Diederich, K., Crawford, L., Corbett, M., Klemm, S., Peterman, K., Currin, F., Hourcade, J.P., 2020. Play-based design: Giving 3- to 4-year-old children a voice in the design process. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. CHI '20, Association for Computing Machinery, New York, NY, USA, pp. 1–14, URL https://doi.org/10.1145/3313831.3376407.

Tanenbaum, J., 2014. Design fictional interactions: Why HCI should care about stories. Interactions 21 (5), 22–23, URL https://doi.org/10.1145/2648414.

Troiano, G.M., Wood, M., Harteveld, C., 2020. "And this, kids, is how I met your mother": Consumerist, mundane, and uncanny futures with sex robots. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. CHI '20, Association for Computing Machinery, New York, NY, USA, pp. 1–17, URL https://doi.org/10.1145/3313831.3376598.

Troiano, G.M., Wood, M., Sonbudak, M.F., Padte, R.C., Harteveld, C., 2021. "Are we now post-COVID?": Exploring post-COVID futures through a gamified story completion method. In: Designing Interactive Systems Conference 2021. DIS '21, Association for Computing Machinery, New York, NY, USA, pp. 48–63, URL https://doi.org/10.1145/3461778.3462069.

Varsaluoma, J., Väätäjä, H., Kaasinen, E., Karvonen, H., Lu, Y., 2015. The fuzzy front end of experience design: Eliciting and communicating experience goals. In: Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction. OzCHI '15, Association for Computing Machinery, New York, NY, USA, pp. 324–332, URL https://doi.org/10.1145/2838739.2838761.

Wong, R.Y., 2021. Using design fiction memos to analyze UX professionals' values work practices: A case study bridging ethnographic and design futuring methods. In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. CHI '21, Association for Computing Machinery, New York, NY, USA, pp. 1–18, URL https://doi.org/10.1145/3411764.3445709.

Wood, M., Wood, G., Balaam, M., 2017. "They're just tixel pits, man": Disputing the 'reality' of virtual reality pornography through the story completion method. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. CHI '17, Association for Computing Machinery, New York, NY, USA, pp. 5439–5451, URL https://doi.org/10.1145/3025453.3025762.

zum Hoff, T., Großkopp, S., Neuhaus, R., Hassenzahl, M., Mirjam Lilith Vincent, M., 2022. Interactive tables for social experiences at home. In: Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction. TEI '22, Association for Computing Machinery, New York, NY, USA, pp. 1–12, URL https://doi.org/10.1145/3490149.3501325.