The TAC Toolkit: Supporting Design for User Acceptance of Health Technologies from a Macro-Temporal Perspective

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ABSTRACT

User acceptance is key for the successful uptake and use of health technologies, but also impacted by numerous factors not always easily accessible nor operationalised by designers in practice. This work seeks to facilitate the application of acceptance theory in design practice through the Technology Acceptance (TAC) toolkit: a novel theory-based design tool and method comprising 16 cards, 3 personas, 3 scenarios, a virtual think-space, and a website, which we evaluated through workshops conducted with 21 designers of health technologies. Findings showed that the toolkit revised and extended designers' knowledge of technology acceptance, fostered their appreciation, empathy and ethical values while designing for acceptance, and contributed towards shaping their future design practice. We discuss implications for considering user acceptance a dynamic, multi-stage process in design practice, and better supporting designers in imagining distant acceptance challenges. Finally, we examine the generative value of the TAC toolkit and its possible future evolution.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**.

KEYWORDS

technology acceptance, user-centered design, design cards, technology acceptance lifecycle, macro-temporal perspective

ACM Reference Format:
Camille Nadal, Shane McCully, Kevin Doherty, Corina Sas, and Gavin Doherty. 2022. The TAC Toolkit: Supporting Design for User Acceptance of Health Technologies from a Macro-Temporal Perspective. In *CHI Conference on Human Factors in Computing Systems (CHI '22), April 29-May 5, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 18 pages. https://doi.org/10.1145/3491102.3502039

CHI '22, April 29-May 5, 2022, New Orleans, LA, USA

ACM ISBN 978-1-4503-9157-3/22/04.
https://doi.org/10.1145/3491102.3502039

1 INTRODUCTION

Users' acceptance of health and mental health technologies is key to their successful design, uptake and use. As new technologies, from smartwatches to virtual reality headsets, are increasingly employed for diagnosis, treatment, and monitoring [72], evidence of clinical effectiveness is critical to their success in practice, yet not alone sufficient for individuals' willingness to take on and engage with the technology. User acceptance — an individual's perception of a technology leading to its use or non-use — is impacted by numerous factors, which have been articulated by multiple models over the past three decades [21, 95, 96, 98–100]. Despite such models however, it has been argued that our understanding of user acceptance in research practice is limited by the existence of precisely such numerous and diverse interpretations of the concept, at times incongruent with theory, as well as the inconsistent use of theory to support exploration and measurement [63]. Our perception of any one technology evolves over time: we may, for example, take up a new device, and only a week later discontinue its use. In the design of healthcare technologies, it is critical to understand and address the reasons for such abandonment, in particular given the longitudinal nature of care and trajectories of many chronic conditions. Despite the concept's importance, user acceptance is often overlooked during the process of design [63]; existing methods for attending to acceptance requiring the review of a large set of acceptance factors [22], or focusing arbitrarily on a few [29, 91, 104].

This paper strives to address this gap between theory and practice, by introducing the Technology Acceptance (TAC) toolkit — a novel design tool to support designers' reflection around user acceptance and its evolution across the user journey. We report on the evaluation of this toolkit by means of 7 workshops, conducted with 21 designers of health and mental health technologies with interdisciplinary expertise. These workshops were designed to support analysis and understanding of the following research question: *What is the value of the TAC toolkit for supporting reflection on technology acceptance and designing for acceptance from a macro-temporal perspective?*

Our contributions are three-fold, including (i) the TAC toolkit as a novel design tool and method to help designers leverage acceptance theory and apply it to the design of health technologies, (ii) the macro-temporal perspective as a means to support design for acceptance featuring *temporal multi-choice scenarios*, and (iii) implications for considering user acceptance a dynamic, multi-stage

process in design practice, better supporting designers in imagining distant user acceptance challenges, and examining the generative value of the TAC toolkit and its possible evolution over time.

2 RELATED WORK

Design for user acceptance of health technologies requires first understanding existing theories and the temporal dimension of the process, and secondly leveraging this knowledge in design practice.

2.1 Modeling User Acceptance

Research has extensively explored the reasons behind users' acceptance or rejection of technology [71]. Technology acceptance research initially focused on the workplace context, leading to models including the Technology Acceptance Model (TAM) [20], its extensions [95, 96, 98], and the Unified Theory of Acceptance and Use of Technology [99], before exploring broader contexts [15, 100]. As digital innovation gained traction in the healthcare context, user acceptance theories evolved accordingly, producing many new models [12, 23, 27, 41, 46, 79]. The expansion of acceptance theories to the health domain, while welcome, has therefore also resulted in a wide range of additional models, presenting diverse and numerous influencing factors. This complexity has rendered the field of knowledge difficult to navigate for designers of health and wellbeing technologies. Although Marangunić et al. reported "continuous progress in revealing new factors with significant influence on the core variables of the [TAM] model" [50, p. 81], Nadal et al.'s review [63] showed that interpretation of user acceptance varied significantly among digital health researchers, *perceived usefulness* being the factor most investigated, and that few studies engaged with acceptance models. Additionally, a strand of the literature has argued for considering user acceptance as a multi-stage process, evolving over time [24, 32, 52, 63, 70, 80, 85, 89]. Recently, the Technology Acceptance Lifecycle (TAL) [63], for example, articulated the stages of user acceptance according to the continuum *pre-use acceptability—initial use acceptance—sustained use acceptance.*

The rich body of work on technology acceptance has thus to date proved predominantly theoretical, focusing on models and factors, with limited accounting for the temporal aspect of acceptance.

2.2 Designing for User Acceptance

Despite the rich theoretical framework of acceptance, attempts to attend to this concept at design stage often consider only a small subset of acceptance factors present in validated models. Among these, *perceived usefulness* and *perceived ease of use* are the most addressed in design practice [29, 91, 104], although researchers have stressed the difficulty of addressing these factors in design [91], and the need for novel standardized design approaches [104]. Other design approaches include Detjen et al.'s method — employed in relation to acceptance of automated vehicles — of first reviewing existing acceptance models and comparing their different sets of factors, then reviewing existing approaches for addressing these factors, and finally formulating guidelines to design for user acceptance of these particular technologies [22].

While we therefore recognize researchers' efforts to rely on validated acceptance theories, current practices seem to focus on a subset of acceptance factors. This means that other potentially relevant factors (such as *self-image*, *technology anxiety*, etc.) are overlooked, reducing opportunities to improve the resulting designs. The lack of standardized approaches to design for acceptance furthermore leaves designers uncertain as to how to address acceptance in practice. This might result in a greater focus on acceptance at the deployment stage, instead of throughout the entire design process when challenges may more feasibly be addressed [54, 98]. Finally, while studies have occasionally attempted to account for a wider range of acceptance factors in design, doing so has required extensive reviews of the literature — an approach unsustainable for many design projects.

2.3 Temporality in HCI

The evolving nature of user acceptance furthermore suggests the need to consider how *temporality* is addressed in HCI research. Temporality has recently received attention beyond the traditional clock-time perspective, encompassing also socio-cultural and existential aspects of time [69]. These latter aspects have primarily been explored through the lens of user experience (UX), frameworks emphasizing the episodic quality of discrete experiences [31], or highlighting its felt-life quality [26, 55]. This early work has focused on discrete events, failing to capture the temporal richness and complexity of users' patterns of interaction with technology [26].

Other related work has focused on the adoption of domestication theory [83], describing the three stages of technology *adoption*: *commodification* raising expectations of technology's function and value before its use, *appropriation* during which users integrate technology into their lives, and *conversion* whereupon users accept the technology as reflecting their self-identity and signaling status. Karapanos et al.'s framework of user experience over time [44], additionally argues for the importance of moving from the micro-temporal perspective of how user experiences are formed, modified and stored, to how they change over time [44]; positing 4 key UX phases: *anticipation*, *orientation*, *incorporation*, and *identification.*

Temporal richness can also be surfaced by examining interactions over time intervals, rather than at discrete time points [30, 42]. Yet, limited work has explored the trajectory approach to user experience, with a small number of exceptions including Benford and Giannachi's framework for capturing the chronology of events in mobile games [6]. The concept of *interactional trajectory* also extends the traditional user journey "through a user experience" [93] to richer trajectories "over space and time [involving] multiple roles and interfaces" [7]. Most recently, temporality in HCI has been considered in speculative and futuring design [47].

The growing body of HCI research on temporality has thus mostly focused on interaction at the micro level or adopted the lens of situated and discrete user experiences — with much less work exploring the macro level perspective as to how user experiences change over time.

2.4 Design Tools to Bridge Theory & Practice and Represent User Trajectories

HCI researchers and designers have previously devised a variety of methods for bridging theory and practice [17, 94] during the early stages of technology design [76], including cards [35], personas, scenarios, cultural probes [33, 34], and toolkits [45, 48, 66, 75, 90].

Design cards in particular are often employed in early design, to support practices of reflection, ideation, and communication [8, 66].

The potential of these methods to succinctly communicate theoretically abstract concepts has led to the development of cards articulating concepts and models as diverse as the Tangible Interaction framework [40], Exertion framework [60], Playful Experiences framework [49], and child developmental concepts [5]. Designers of these card decks have drawn on a variety of means of communication, from sensitizing questions and illustrative images [40], to thematic thought-provoking questions [60], quotes, and both textual and graphical descriptions of activities [5].

The use of design cards in practice can also be supported by the parallel adoption of other design tools, including personas and scenarios, as means of depicting and anchoring users' interactions in relation to hypothetical future systems [16, 25]. Usually depicted in text form, scenarios can also be augmented visually [25], or rendered interactive, as in the case of hands-only [11], role-play [102], and design Thing'ing scenarios [82]. More recently, scenarios have also been used as means to educate designers in relation to theory (e.g. social science theories [102], psychology theories [68]), or to sensitize designers to users' feelings and lived experiences [74]. Personas and scenarios have finally been widely employed for the design of health technologies [36, 92, 101, 103].

Design cards' long history of the effective communication of theory suggests their potential as means of operationalizing the rich theoretical space of user acceptance, if made, and considered accessible, engaging and meaningful to practising designers. Employed alongside personas and scenarios, cards may furthermore prove means of usefully representing the temporal unfolding of the user acceptance journey with digital health interventions.

3 INTRODUCING THE TAC TOOLKIT

To address the challenge of designing for health technology acceptance — surfacing what matters most to designers and users in regard to health technology acceptance, and in turn supporting improved alignment of their needs and values — we developed the Technology Acceptance (TAC) toolkit. The toolkit aims to (i) render user acceptance theory more accessible to designers, (ii) produce a true-to-life context in which to weigh questions pertaining to user acceptance of technology, and 3) create a space in which to reflect upon and begin designing for health technologies. While diverse stakeholders might be involved in the use of health and wellbeing technologies, the TAC toolkit has as its primary target audience designers developing health and wellbeing technologies for users receiving support directly through these technologies. Materials in support of these aims were developed by the authors through an 8-month iterative design process.

Sensitively designed and informed by existing models of user acceptance, the TAC materials in their final form consist of five primary components: a set of 16 cards, 3 personas, 3 scenarios, a virtual think-space, and a website.

3.1 Designing the TAC Cards

Designing the cards involved the careful selection of relevant technology acceptance models, identification of key antecedent factors, and the design of the cards' textual and visual content.

3.1.1 Selecting the Models of Technology Acceptance. Drawing on the acceptance literature, we selected validated models as the theoretical basis for the TAC toolkit. We first considered those models and extensions constituting the current theoretical foundations of technology acceptance: the TAM [20], TAM2 [98], TAM2' [95], TAM3 [96], and UTAUT [99]. Next, we included models pertaining to pervasive technologies: the UTAUT2 [100], and PTAM [15]. Finally, we incorporated acceptance models devised specifically for the healthcare context: the HITAM [46], Hsu et al.'s model [41], Dou et al.'s model [27], Cheung et al.'s model [12], Schomakers et al.'s model [79], and Dhagarra et al.'s model [23].

3.1.2 Identifying the Key Concepts across the Selected Models. In order to ground discussion among designers in pragmatic terms pertinent to real-world design choices, we chose to focus the TAC cards on antecedent factors, representing explanatory variables impacting user acceptance. Table 1 provides a complete overview of the 16 antecedent factors included within the final TAC card deck, along with their definitions, and models of origin. To maintain a clear focus on the health context, we additionally excluded those constructs highly particular to the use of technology for work (e.g. *job relevance* [98, 99]). Where models overlapped, similar constructs were regrouped as a single unique factor to facilitate their inclusion (e.g. *reference group influence* [12] and *voluntariness to use* [96, 98, 99] were regrouped under *social pressure*).

3.1.3 Developing the Cards' Textual and Visual Content. Each card in the TAC deck[1] represents a single antecedent factor of technology acceptance, depicted on the front side in the form of a title and icon combination, intended to support memorability and the ability to easily distinguish cards from one another (see Fig. 1). Following both the common acceptance literature practice of categorizing acceptance factors [27, 46], and Alkhuzai and Denisova's design card heuristics recommending the grouping of cards and differentiation of groups using color [2], we created three color-coded categories pertaining to **H**ealth (red), **I**ndividuality & Social context (orange), and **T**echnology (blue), linking each of the 16 TAC factors to the category most closely related to their definition. This categorization was devised to both facilitate users' familiarization with the cards and increase the learnability of the 16 acceptance factors.

Inspired by previous work concerning the value of sensitizing concepts [76] and interaction design tools intended to make frameworks (including for tangible interaction [81]) more accessible, we furthermore developed a series of thought-provoking, sensitizing questions pertaining to each factor (displayed on the back of each card). The first of these questions served to communicate the factor's definition in an accessible and engaging fashion, while the remaining questions encouraged deeper reflection in relation to different and specific aspects of the concept's definition. The cards were finally designed to resemble playing cards in support of user engagement.

[1]The complete set of TAC cards is available for download from the supplementary materials.

Table 1: The acceptance antecedents covered by the TAC cards, by category, alongside their definition and models of origin.

Factors	Definitions	Models
Health		
Health status	Whether one "has any diseases or comorbidity" [46, p. 3].	[46]
Health beliefs and concerns	Perceived susceptibility and issue severity [37].	[12, 46]
Healthcare professional relationship	Trust in clinician to deliver accurate health information, and help seeking behavior [27].	[27]
Individuality & Social context		
Demographics	Gender, age, socio-economic status [15, 99, 100].	[15, 99, 100]
Resistance to change	"People's attempt to maintain their previous behaviors and habits in the face of change required" [27, p. 3].	[27]
Self-image	"The degree to which use of an innovation is perceived to enhance one's image or status in one's social system" [59, p. 195].	[96, 98]
Social pressure	"The perceived social pressure to perform or not to perform the behavior" [1, p. 454].	[12, 15, 46, 99, 100]
Perceived social support	Facilitating conditions, or "the availability of resources needed to engage in a behavior" [88, p. 139].	[12, 95, 96]
Technology		
Technology anxiety	"The fear or apprehension felt by individuals… when they considered the possibility of computer utilization" [84, p. 238].	[46, 95, 96]
Perceived reliability	Output quality ("how well the system performs [required] tasks" [98, p. 191]) and result demonstrability ("tangibility of the results of using the innovation" [59, p. 203]).	[46, 96, 98]
Technology playfulness	"The degree of cognitive spontaneity in microcomputer interactions" [105, p. 204].	[46, 95, 96]
Technology enjoyment	"The extent to which the activity of using a specific system is perceived to be enjoyable in its own right" [95, p. 351].	[46, 95, 96]
Privacy protection	"Concern for loss of privacy and need for protection against uncalled-for communication and misuse of personal information" [23, p. 4].	[23, 41, 79]
Trust	Belief that "the healthcare provider [will] fulfill [the patient's] needs" [23, p. 4].	[23]
Objective usability	Construct allowing to "compare different systems using objective measures of usability/system characteristics" [97, p. 457].	[27, 46, 95, 96]
Integration	"How well the technology is integrated into our lives" [15, p. 4].	[15]

3.2 Crafting the TAC Context

Primarily envisioned as an exploratory design method for use early in the design process, the TAC toolkit furthermore comprised personas, scenarios, a think-space, and a website.

3.2.1 The TAC Personas. We adopted the use of personas and scenarios as means of crafting a realistic context for reflection on technology acceptance on behalf of persons receiving health or mental health care, both as a means of providing examples of an implementation of the acceptance journey, and for enabling us to explore one possible use of the TAC cards in the design process. Through iterative collaborative design, we developed 3 personas[2], each associated with a respective scenario. While designing these personas, we aimed to ensure diversity of age, gender, and health concerns, creating three fictional characters living with common yet diverse health issues, for which technological solutions are often offered. These include Ella, a young woman and trainee solicitor diagnosed with type 2 Diabetes; Ali, an elderly bereaved spouse and retired florist, prescribed and struggling to manage antidepressant medications; and Alex, a middle-aged bus driver and father of three, worried about the possibility of catching COVID-19 and passing it on to his family. Each persona was defined in terms of information including demographic details (i.e. age, occupation, health status, social context), experience with technology, challenges faced, and personal traits that may influence acceptance of technology.

3.2.2 The TAC Scenarios. In parallel with these personas, we developed 3 scenarios[3] designed to inspire engagement with the unfolding of each persona's *interaction trajectory* with a pertinent technology, namely a glucose monitoring sensor and app (Ella, Diabetes), medication reminder app (Ali, depression), or governmental contact tracing app (Alex, COVID-19). To account for the evolving nature of user acceptance over time, we emphasized the macro-temporal perspective of technology acceptance by employing the Technology Acceptance Lifecycle (TAL) timeline to structure each scenario in terms of the 3 consecutive stages of *pre-use acceptability*, *initial use acceptance*, and *sustained use acceptance* [63]. The *pre-use acceptability* stage encompasses the period before any interaction with a technology occurs, but when both awareness and contemplation of its use surface. Thus, drawing also from previous

[2]The 3 TAC personas are available at [62].

[3]The 3 TAC scenarios are available at [62].

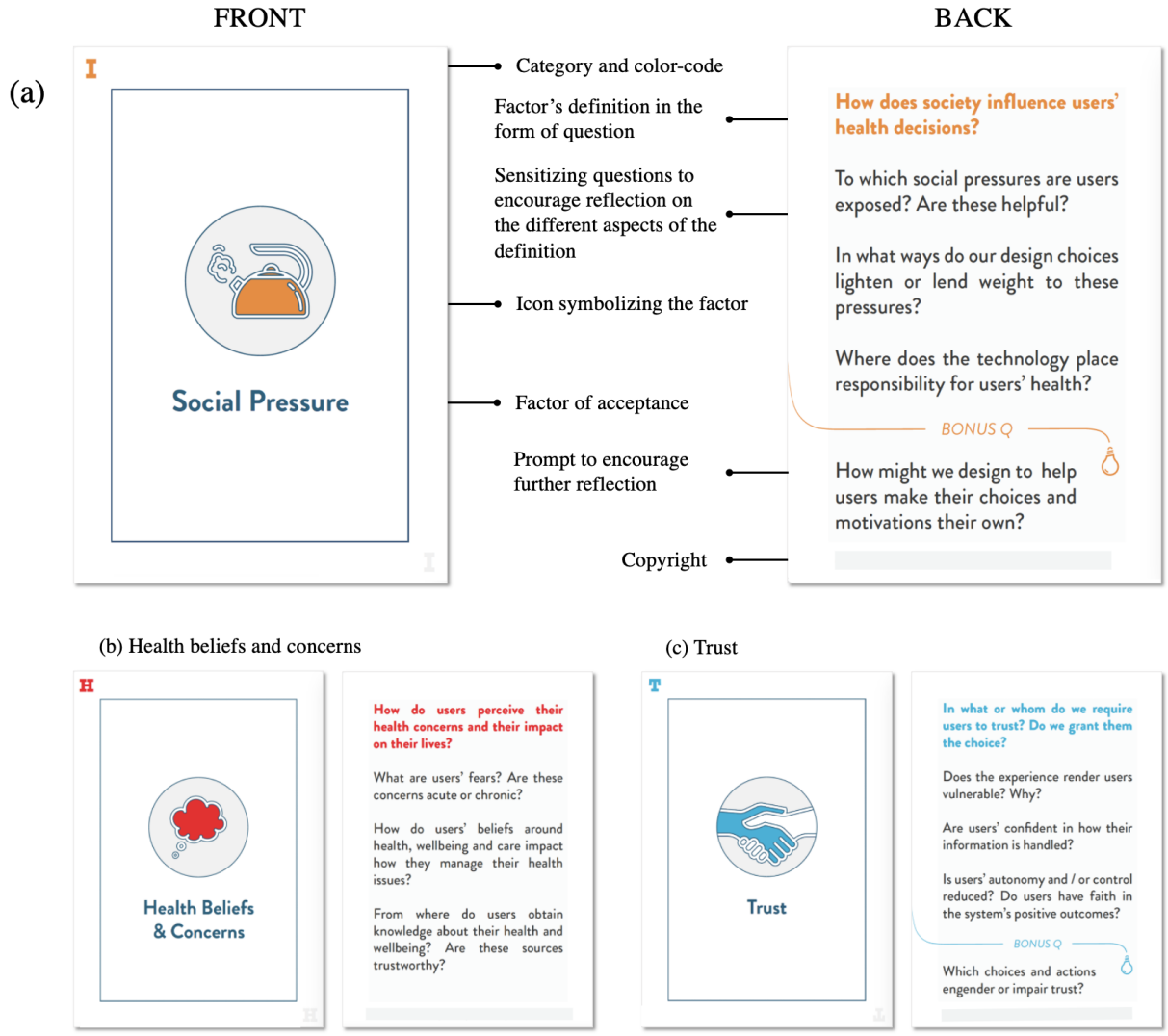

Figure 1: Examples of TAC cards showing on the front antecedents of technology acceptance: (a)*Social pressure,* (b) *Health beliefs and concerns,* and (c) *Trust,* and on the back sensitizing questions.

work, 2 specific and critical temporal milestones in this stage were identified as *seeking advice* (a critical step in an individual's health trajectory [67]), and *choosing technology* (the decision to start using a health technology [86]). The very first interaction with a technology marks the end of *pre-use*, and the beginning of the *initial use acceptance* stage. Here, to facilitate exploration of a more granular time scale, we considered the following 3 temporal milestones: *first interaction*, *next day*, and *a week later*. Finally, in the last stage of *sustained use acceptance*, we considered the following temporal milestones: *after 1 month*, *after 3 months*, and *after 1 year* — the first 2 of which have been suggested as milestones for long-term acceptance in previous work [98], while the last was added to reflect the lengthy or lifelong nature of many health conditions.

To support rich engagement on behalf of designers, we furthermore identified and described for each specific milestone 3 paths; each recounting acceptance issues of either high, medium or low degrees of challenge. For this, we drew inspiration from interactive narratives [3], where multi-choice scenarios have been employed in place of linear sequence stories or traditional linear scenarios. Thus, at each temporal milestone, designers can choose among 3 different paths that which they would prefer to explore (see Appendix A).

Design tools fostering empathy have long acknowledged the value of scenarios, in the mental health context in particular, from video stories [38] to vignettes, as means of describing the lived experience of ill health [74], or supporting therapeutic role-play [53]. To further elicit empathy in this case, both personas and scenarios were written in the first person, and employing believable, colloquial language. We aimed to furthermore increase empathetic engagement through the use of role-play, as previously employed to support the design of health technologies [53].

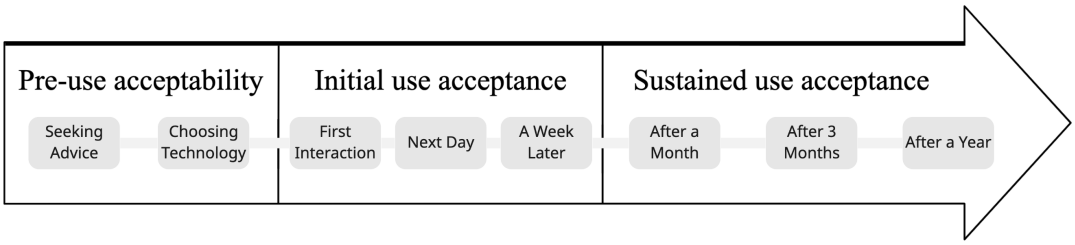

Figure 2: Scenarios' temporal milestones, alongside the 3 stages of the Technology Acceptance Lifecycle [63]: *pre-use acceptability, initial use acceptance,* and *sustained use acceptance.*

3.3 Devising the TAC Process

The final step in completing the design of the TAC toolkit was to provide designers a space in which to collaborate and interact with the TAC cards, personas, and scenarios.

3.3.1 The TAC Think-Space. To enable designers to work collaboratively with the TAC cards in relation to specific design problems, we created a virtual board using the online platform Miro [58]. This think-space enabled participants to interact with the TAC cards in virtual-analogue form, displaying their front side only, in a collaborative digital space, at the same time as interacting with the physical deck. This space allowed designers to place selected cards against each temporal milestone of the user journey, while making notes reflecting their decision-making process to the side (Fig. 3).

3.3.2 The TAC Website. Finally, as multi-choice scenarios can be more effectively implemented digitally, we also developed the TAC interactive website [62] to host the digital personas and scenarios (see Fig. 4).

4 EVALUATING THE TAC TOOLKIT

We designed a study to support evaluation of the TAC toolkit as a novel exploratory design tool with the aim of gathering insight into designers' experiences of using the toolkit, and perceptions of its value for designing for user acceptance of health technologies.

4.1 Participants

We recruited designers of health and mental health technologies through our personal and professional networks as well as Twitter postings. Participants were deemed eligible if over 18, proficient in

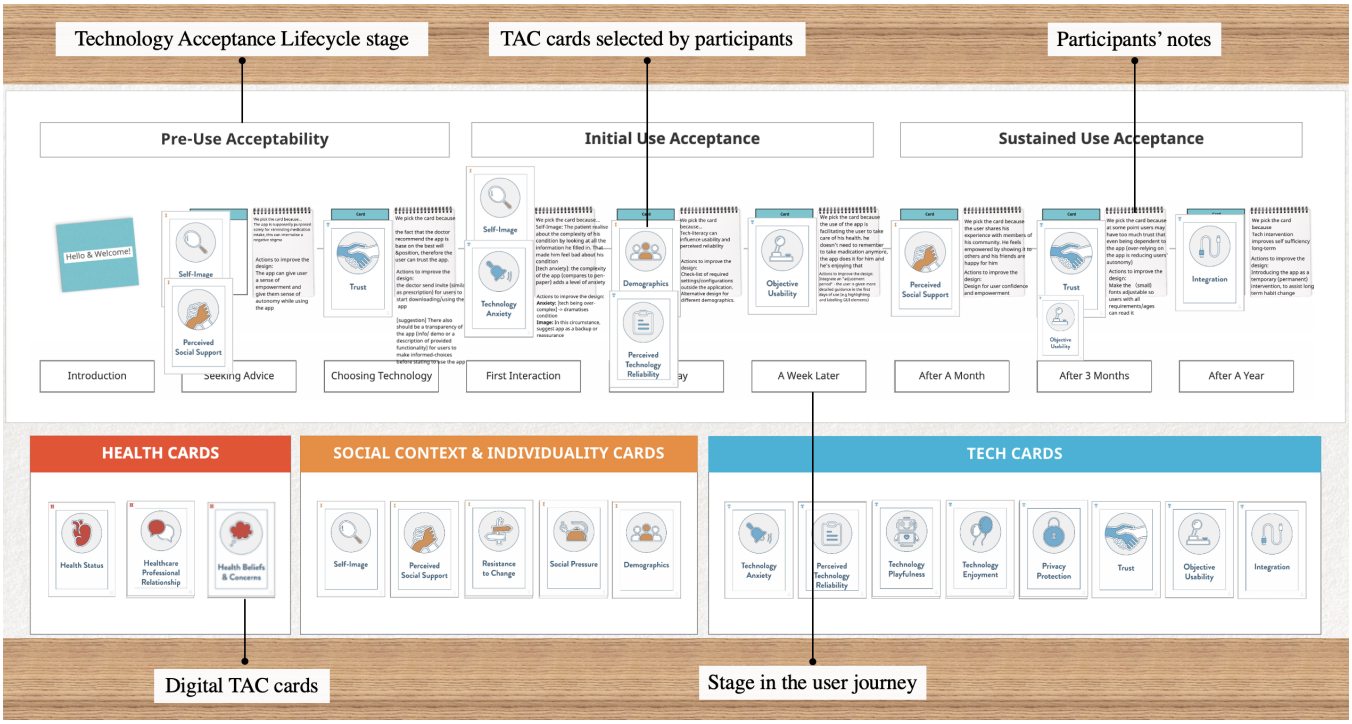

Figure 3: Post-workshop think-space (Group 5) showing the 3 stages of technology acceptance (top), the cards selected by participants for the 8 temporal milestones (middle), and the 16 TAC cards color-coded by category (bottom).

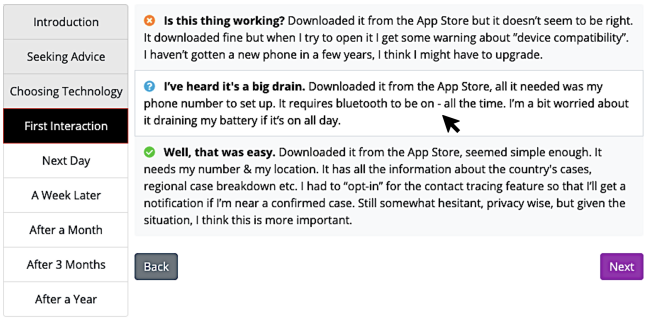

Figure 4: Website view of persona Alex's (COVID-19) scenario. The current milestone is 'First interaction', with 3 possible paths forward in the event of first launching a contact tracing app: "Is this thing working?" (high degree of challenge), "I've heard it's a big drain" (medium degree of challenge) and "Well, that was easy" (low degree of challenge).

English, and currently actively designing digital health or wellbeing interventions. The study was approved by the SCSS Research Ethics Committee at Trinity College Dublin, and designers received a £20 Amazon voucher for their participation in the workshop (≈1h30) and follow-up interview (≈30min). Participants' ages ranged from 25 to 34 (17), and 35 to 44 (4). Ten identified as female, 10 as male and 1 preferred not to disclose their gender. Most originated from within the EU (15), and all were working in Europe: 14 in academia (4 with prior industry experience) and 7 in industry; 16 in the design of mental health technologies, 5 in health, and 3 in both. This participant sample spanned multiple degrees of expertise: 11 PhD students, 3 post-doctoral researchers, 3 senior researchers (1 lecturer, 1 assistant professor, 1 digital health scientist), 1 clinical trials associate, 1 digital health project manager, and 2 UX designers. We also sought to recruit individuals with diverse backgrounds to reflect the interdisciplinary work of designing health technologies, resulting in a diverse range of participants specializing in HCI (8), clinical psychology (4), design (4), HCI and psychology (2), biomedical engineering (2) and software engineering (1). Two participants (P16 & P20) had previously encountered particular acceptance theories in their work; the remaining 19 participants disclosed no previous experience with acceptance-related theoretical frameworks.

4.2 Method

The 21 participants were divided into groups of 3 prior to the workshops: each group including at least one person with a background other than HCI, in order to simulate the diversity of expertise typically encountered in design teams. The 7 workshops took place in the form of Zoom sessions, supported by a single facilitator (either authors 1, 2 or 3). At the start of each session, each participant read the study information sheet, provided digital consent, and answered an online demographic survey. The facilitator then described the purpose of the workshop (i.e. an opportunity for researchers to understand, and participants to gain insight into technology acceptance and new design tools, and confirmed that all participants had access to both the physical and digital materials. The facilitator then explained that one person in the group would play a fictional user experiencing health or mental health difficulties, in the form of a persona to-be-selected, while both others would play the the role of designers. Each group decided among themselves who would take on that role — a choice made to strengthen users' ownership of the scenario and overall process. Once roles were claimed, the workshop then proceeded following the 9 steps described in Figure 5; the 2 designers and single user attempting to expose technology acceptance issues while traversing and actively shaping the persona's narrative throughout the user journey, and discussing possible design actions in response to issues as they arose. Following the workshop, each participant took part in a 30-minute semi-structured interview, during which they were asked about their experience and perceptions of the different elements of the toolkit and method employed[4].

4.3 Data Analysis

Each workshop and interview was audio recorded, totaling over 20h of audio, including 9h42m (an average of 1h23m per group) from the workshops, and 10h50m (an average of 30min per participant) from the interviews. These recordings were anonymized and fully transcribed. Firstly, an inductive thematic analysis of workshops and interview transcripts was conducted by authors 1 & 2, following Braun and Clarke's approach [10]. This process entailed successive readings of the transcripts and familiarization with the data, complete coding of the data, pattern identification and analysis, definition of themes, and reporting of findings. Then, a deductive thematic analysis of the same data set was conducted by the first author, focusing specifically on the temporal dimension of participants' experiences with the TAC toolkit, and grounded in the TAL timeline [63]. Finally, each group's completed think-space board was captured, and examples extracted to illustrate and further support results of the thematic analyses.

5 FINDINGS | INDUCTIVE THEMATIC ANALYSIS

Inductive thematic analysis of these 7 workshops and 21 interviews provided insight into participants' actual and possible future use of the TAC toolkit, including in particular its value for bridging theory and design practice, and for fostering richer conversations and reflection on users' acceptance of health technologies.

5.1 Bridging Acceptance Theory and Design Practice

One of our primary aims in designing the TAC toolkit was to help bridge theory and practice for the design of health technologies that account for users' acceptance. Findings from both workshops and interviews highlighted the threefold value of the TAC toolkit in facilitating such bridging through challenging designers' preconceptions about technology acceptance and extending their understanding, motivating the application of technology acceptance theory through role-play, and shaping designers' actions to better account for user acceptance.

[4]The Interview Guide is available in supplementary materials.

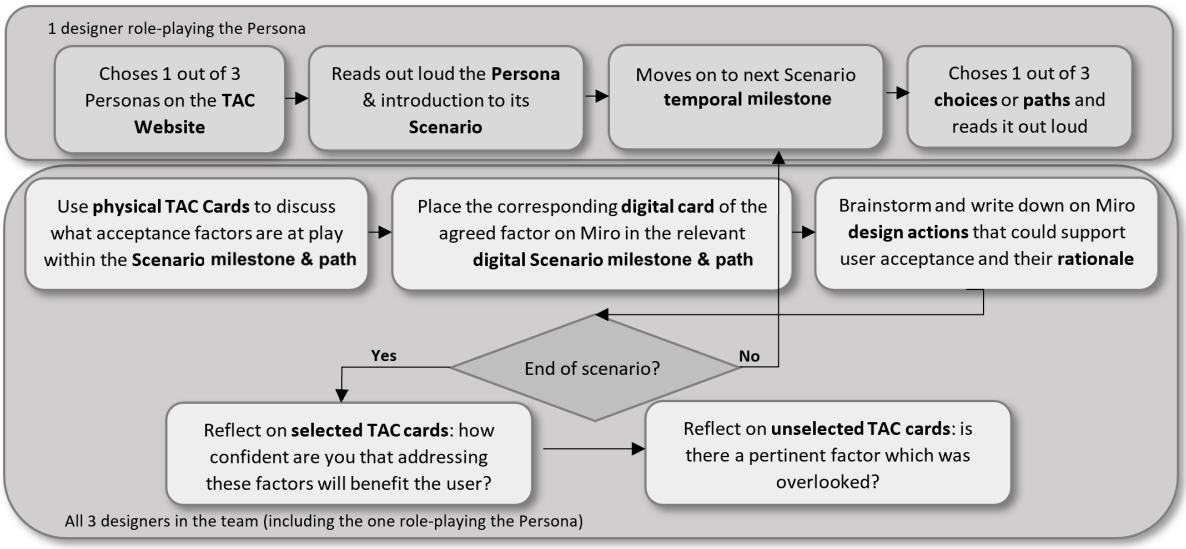

Figure 5: Workshop procedure showing the 4 activities performed by the designer role-playing the persona (top) and the 5 performed by the two other designers (bottom).

5.1.1 Challenging Designers' Preconceptions about User Acceptance. It was through challenging participants' preconceptions of acceptance that the impact of the TAC toolkit was rendered most visible. In particular, designers commented often on the role of the toolkit in challenging a commonly-held assumption that the question of acceptance ceases to prove relevant once the user begins using the technology: "*You made me realize that you have to consider acceptability at different points and that this acceptability may change because the needs of the user may change over time*" (P14). Participants spoke then of coming to conceive of **acceptance as a dynamic process**, in line with the underlying theory [24, 32, 52, 63, 70, 80, 85, 89]. A participant with some prior familiarity with existing models of acceptance, explained: "*It definitely makes you think about the technology [as] less static… something that needs to kind of grow and continue with this person and their needs*" (P20). This comment suggests renewed awareness of the value of exploring acceptance across the entire user journey. This can in turn foster greater sensitivity towards the design of complex technologies, as required to accommodate users' evolving needs.

Responses additionally indicate that the toolkit's timeline and cards' three categories provided designers a means of visualizing this transformation of users' needs. For example, on reviewing their final think-space board, P17 noted that "*it is quite interesting how the 'social context' is at the beginning, and then the 'health' cards are at the beginning and end… and the 'technology' cards are all over [the user journey]*". This reflects an understanding of acceptance as extending beyond the *pre-use* stage and indicates an emerging practice among designers of **linking the process of acceptance to the user journey**: "*It really helps to re-focus the design in a user-centered perspective all along, and going from the short [term]… to the use and adoption of the device in [the] long-term*" (P9). This key finding suggests heightened awareness of evolving use and user acceptance over time, as further reflected in P14's comment concerning the importance of **accounting for the possible evolution of user needs**: "*when people are using it [the system], maybe we forget that we still need to make some adjustments*".

Some designers also reported that **acceptance issues began to feel even more concrete** in the later stages of the user journey, where issues become "*tangibles, whereas in the beginning there's still a lot of too many [sic] intangibles*" (P18). This was an impression described as further accentuated by the role-play component of the scenario: "*It becomes more personal because I've now invested a year in this thing [technology]*" (P5, playing the persona). These moments of insight pertained not only to the concept of user acceptance in a broad sense but also to the nature of health technologies in particular. This was highlighted by P1, a designer with a mixed HCI and psychology background, who pointed out that designing healthcare technologies was a complex process "*with lots of different stages, and different stakeholders*" and that therefore, the path to acceptance was likely to be longer than for other technologies.

Finally, engaging with the TAC cards during these sessions appeared often to **nurture designers' appreciation for, and challenge their understanding of acceptance factors** in particular, leading them to develop a richer understanding of their definition and interaction, through reflection on the cards and conversation with other participants. P11, for example, speaking of the factor of 'trust', explained coming to understand that "*it is not only about 'trust' as in 'the data is safe', but there's also other aspects that we should consider*".

5.1.2 Extending Designers' Understanding of Technology Acceptance. The TAC toolkit also expanded designers' perspectives on user acceptance, exposing factors that some wouldn't have otherwise considered: "*I hadn't thought about all those forms of acceptance*

before, I think particularly the social ones" (P5). The **number of factors influencing acceptance** was also spoken of as a surprise by many designers: "*I would never have thought of that many factors at play*" (P6) and "*I was not familiar with all these factors… My spectrum and my way of speaking changed around that topic*" (P21).

Selecting **positive user stories** during the multi-choice scenarios made some designers realize that, even when 'all is going well', there may still be room for improvement in terms of user acceptance. As P14 commented, even if "*everything went well, still there was a bone that you could try to address*" — a point also reflected in Group 2's notes made using the think-space "*The user seemed to be enjoying/accepting the app enough to be prompting friends to install it. [Design action:] Include easy sharing mechanic to allow viral spread*". One participant furthermore reflected as to how "*designers are trained to look at barriers"* while there is also value to be found in amplifying positive elements: "*I like the idea of choosing some of the positive stories… we can think about how could this 'social support' or 'enjoyment' of the technology be amplified?*" (P1).

The multi-choice scenarios also helped designers **picture the range of possible user experiences**. P17, for instance, who was playing the persona and therefore had to pick a path at each scenario step, described how "*it's quite interesting to see the different sorts of people that you may find*". Although real-world acceptance issues often **involve a mix of factors**, we initially asked participants to pick only one card per scenario step, to encourage negotiation and deeper conversation within groups, through trade-off-driven design [60]. While discussing cards for the first step however, all groups asked if they could select several cards, as they felt one wasn't sufficient to cover the factors at play. The facilitator then informed participants that they could pick multiple cards if they felt several factors were involved. We provided designers this autonomy during sessions in order to avoid creating an overly artificial study context. P20 commented: "*if we'd only picked one, then maybe some important things wouldn't have been considered… we'd never have 'privacy protection' in there*". Group discussions furthermore revealed close relationships among factors, and their negotiation. Group 2, for example, discussed the interplay between 'social support' and 'social pressure' — "*This support through pressure… It's like the strategy to provide the 'social support' is 'pressure'. It's why it feels so entwined*" (P5). Participants also spoke of and leveraged the **positive vs. negative impact** of acceptance factors — "*before it was a lack of 'trust' and now it's too much*" (P13) — and suggested making this positive/negative outlook more visually explicit in using the TAC cards by, for example, flipping the card upside down on the board (Groups 1 & 2).

Participants additionally came to recognize developing an accurate understanding of users' needs as a less than straightforward process. They did comment however that the TAC cards **helped identify users' needs**: "*I feel like users are very complex and it [the cards] were helping me maybe see the nuances*" (P17), by "*facilitating a faster understanding of what are the main targets, the main things to design for*" (P11). One developer commented that "*it's hard to design for a person as opposed to for a person's needs*" (P4), elaborating that the cards allowed them to "*turn this user into a set of experiences and actions"* in order to find "*the set of steps to solve this [acceptance] problem*".

5.1.3 Motivating the Application of Acceptance Theory through Playfulness. During interviews, the physicality of the cards was continually raised as a positive aspect of participants' experience. In particular, most participants enjoyed the playfulness of the TAC toolkit and compared it to a game: "*It felt like playing a board game, because the physical cards, the notion of placing things, the notion of choosing… gave a tactile nature to it that I really liked*" (P4). We observed that this **playfulness encouraged designers to translate acceptance theory into practice**. P4 explains how the physicality of the materials made it feel as if they were 'solving a mystery': "*Holding the cards, but in a way that the cards are telling a story… The mystery is how do we improve the user's journey with an app?*". The challenge of determining the influencing factors at each of a scenario's temporal milestones made the task meaningful and engaging: "*It felt almost like we were trying to find the right answer. Even though there is no right answer, that's not the point*" (P3), and additionally highlighted **designers' understanding that there is no exact truth** — in that the factors selected depended upon designers' interpretation of the scenario. Finally, participants felt **satisfaction at being able to leverage the complex issue** of acceptance, "*touch[ing] on kind of the core components of a really complex problem and tech solution*" (P7).

5.1.4 Supporting the Negotiation of Acceptance Factors. The physical externalisation of the selection process was furthermore described as **helping participants determine which acceptance factors were, or were not, relevant** to a given scenario: "*I like physical stuff to touch, move around… To say 'this card does not apply', I'm literally physically gonna put it over here behind my monitor and not look at it*" (P3). Participants typically began this decision-making process by considering all of the cards, usually face up, before making an initial selection of 3 to 6 cards deemed relevant for the factor at hand. They would then turn the selected cards over, read the sensitizing questions on the back, and discard the less relevant factors. This practice aligns with descriptions found within the broader literature of **a simplified comparison process** entailing twin stages of orientation or familiarization with the cards [5, 40, 60], and (re)framing of the problem space by selecting and discarding cards [5]. Some participants described arranging the cards spatially on their desk to prioritize the factors they judged most relevant to the scenario step in question: "*I had them [the cards] on the keyboard… I could put them forward and backwards… to physically prioritize them*" (P4).

Finally, the tangibility of the cards was commonly reported as both helpful and refreshing in the context of the hybrid setting. In particular, **working with the physical cards appeared to encourage individual reflection**, allowing participants to examine the factors and form their opinion at their own pace, while also selecting those they felt relevant without being overly influenced by the other designer's choices: "*It frees your thinking when you have something tangible, and you're not just staring at a screen and other people, what they're picking out. I had my cards here in my hand. I felt quite free to pick as I wanted*" (P6). Instances of physical interaction, from displaying cards to the camera to shuffling cards in hand, were often observed during the workshops — the combination of physical and digital appearing to render the experience more tangible and meaningful. The sensitizing questions on the back of the cards

helped designers (in)validate their intuition about the acceptance factors at play, as reflected in a comment made during Group 5's workshop: "*I definitely think there's elements in the 'self-image' that is related to this situation, as in 'Might the technology itself carry a medicalizing or even stigmatizing effect?' [sensitizing question]*" (P15). Finally, the 3 categories of cards furthermore shaped designers' reflections in relation to acceptance at different points of the user journey. For instance, P17 (who played the persona) explained to their group: "*In this stage, my main worries are about the 'social context and individuality' because I don't think I'm thinking about [the] technology per se*".

5.1.5 Shaping Designers' Practice to better Account for Acceptance. During the interviews, designers mentioned a number of ways in which the TAC toolkit could shape their future design practice. Several participants explained that they would use the kit to **stimulate their own reflection on acceptance** "*not only design for a specific goal, but also really think about how this [technology] can be integrated in someone's life*" (P17). For P1 (with a background in psychology), the cards would be useful for "*think[ing] a bit more broadly about the technology side of things… when I'm brainstorming*". Other designers mentioned that **the cards helped them to reflect on their own design practice**: "*I'm more aware of acceptance as a thing that I need to consider in design… maybe use the cards to make sure I was really thinking of it*" (P20). Similarly, P6 (a clinical psychologist) commented that they would use the cards to **guide design conversations** in an interdisciplinary environment, by having "*these to hand in that kind of design phase to ensure that we're having the right conversations*". This comment implies the need for tangible support to orientate discussion of user acceptance within interdisciplinary settings.

Finally, although the cards were initially framed for use by designers, several participants commented on the potential of the toolkit to **facilitate conversations with users** in two ways. It was described as potentially supporting the elicitation of user needs "*maybe if you bring cards with examples, they'll start to think deeper about these factors, they'll realize 'Oh, this might actually be important for me, now that you've brought it up'*" (P10). It was suggested that the TAC cards might require several adjustments however (e.g. 'with examples') to fulfill this aim of eliciting users' needs and to be successfully employed with users, such as "*mak[ing] a simplified version, perhaps for users, that has different questions*" (P1). An alternative approach suggested by P3 was to employ the cards as a means of '*priming the conversation*' with users. Group 1's workshop provided an example of what leading a conversation with the TAC cards could look like: Designer P2 asking User P1 "*Between 'health beliefs and concerns' and 'self-image' what do you think, Ali [persona], is more critical here for you?*".

5.1.6 Adopting a more Ethical Approach to Design for Acceptance. Researchers have more recently also begun to acknowledge the association between technology acceptance and ethical design (e.g. in value sensitive design [4]), including *ethicality* as a factor in user acceptance — motivated in part by the acceleration towards digital healthcare driven by the COVID-19 pandemic, and the enforcement of governmental contact tracing apps [64, 65, 87]. Paska, for example, argues that "*technology acceptance models should also take into account the ethical aspects of technology in terms of how technology shapes the image of today's world*" [64]. Although the TAC cards didn't include this ethicality factor, the workshop activities led designers to consider ethical principles while envisaging solutions to user acceptance issues.

At each scenario step, participants were asked to think of 'design actions' which might be taken to address the user's acceptance challenges. A large number of the **design choices suggested by the groups coincided with the transdisciplinary ethical principles** developed by Bowie-DaBreo and colleagues [9]; *Transparency*, as evoked by 4 groups (e.g. "*an indication of how reliable the [glucose sensor's] results are*", Group 4); *Autonomy*, mentioned by 3 groups (e.g. "*allowing user[s] to stay in control proactively (not reactively)*", Group 3); *Accessibility*, recommended by 2 groups (e.g. "*make the (small) fonts adjustable so users with all requirements/ages can read it*", Group 5); And *Privacy*, discussed by a single group ("*notifications are [kept] general to protect privacy*", Group 7). Finally, in line with the move towards more personalized health and mental health technologies, recommendations for more *tailoring* of the technology were made across 4 groups (Groups 3, 4, 5 & 7).

5.2 Fostering Richer Reflection on Acceptance Concepts and Process

Participants discussed how using the toolkit changed their approach to reflecting upon user acceptance, through helping designers unfamiliar with the concept overcome obstacles to richer reflection, and encouraging new perspectives on user acceptance through interdisciplinary collaboration.

5.2.1 Facilitating Reflection around Acceptance. As our participants noted, multiple obstacles stand in the way of designers' capacity to reflect upon and engage in discussion of user acceptance. Firstly, technology acceptance is an 'immense research field' (P11), and the multitude of theories can prove overwhelming. By translating these theories into a relatively concise framework, the TAC cards **created a defined space for designers to approach theoretical constructs**:

> « *I've come across 15 theories myself… slightly different perspectives depending on the context… A set of generalizable or standardized questions that could be asked for general constructs that are suggested in those different theories, it's a really useful tool to have.* » P16

Workshops furthermore revealed that designers lacking familiarity with user acceptance often refrain from taking part in design conversations if they feel they have 'nothing to bring to the table'. The TAC cards, in this regard, created a safe environment, **helping designers feel more confident in discussing acceptance**: "*I could be an important part of the discussion, on equal terms with the others*" (P11). Another challenge for designers new to the concept of user acceptance is understanding the numerous individual aspects of the concept: "*You have to remember that there could be all these different things at play*" (P1). The issue here is two-fold: on the one hand, designers might not remember all acceptance factors and fail to address key elements in technology design; on the other hand, they might overly focus on a subset of acceptance factors, and overlook others relevant. Trying to remember these theories furthermore adds to designers' cognitive load. While the TAC toolkit

helps tackle these issues, we also observed the presence of a learning curve during participants' first use of the cards, as reflected in P20's comment that "*initially, it was a little overwhelming… as time went on, you became more familiar with them*".

The toolkit was also described as **lending a concrete dimension** to the concept of user acceptance, often perceived as too abstract, by operationalizing the acceptance factors in a form easier to grasp and apply in design: *without the moderation of the cards, when I think about user acceptance, well I think about it at a very abstract level… it kind of helped navigate our thinking to one certain area in depth* (P15). When participants were unsure about the meaning of a factor, **the sensitizing questions at the back of the cards provided clarification** (P2). Similarly, when a factor's title appeared too vague or ambiguous, designers checked their interpretation against the questions provided: "*my computer science brain obviously assumed 'integration' meant compatibility across technologies, but really it was 'life integration'*" (P3).

5.2.2 Opening New Perspectives through Interdisciplinary Collaboration. The interdisciplinary setup of the groups also appeared to benefit designers' reflection, some participants reporting that the collaboration exposed factors they hadn't considered: "*I could see some aspects from a scenario that I wasn't considering, that came with the collaboration*" (P19). During interview, P6 further explained how working in an interdisciplinary group **broadened their own perspective**: "*[P5] saw things a different way. So, it definitely widened my perspective on how people can feel about a technology*". The value of involving psychologists in acceptance conversations was also underlined by P20 (clinical psychologist), particularly in order to discern nuances in users' behaviors and thought processes, and identify manifestations of mental health difficulties.

5.3 Supporting Conversations through a Common Vocabulary of Acceptance

Most participants discussed the role the TAC cards specifically played in both facilitating and enriching their communication throughout the workshops. By granting designers the necessary language to discuss acceptance up front — and via a medium tangible, accessible, and playful — rewarding discussions about a complex topic were made easier. Multiple participants reported that **the cards were a conversation starter**. As each group comprised participants of varied backgrounds, there was often a gap in pre-existing knowledge around acceptance factors. The TAC cards quickly gave participants a shared context through which to engage with one another: "*The cards are like your invitation to join the party*" (P7). The cards lowered the entry point to traditionally complex topics, quickly equipping designers with enough knowledge about a given acceptance factor such that they could meaningfully engage in discussion: "*It's easier to navigate [than models]… they serve their purpose so speedily it allowed that conversation to emerge.*" (P7). Given the complexity of acceptance and the often ambiguous terminology found within existing theory, **the TAC cards serve, conversationally, as a ground truth** from which participants could refine their understanding; P14 explaining that they were able to agree on the importance of each factor "*because all of us shared an understanding of the factors*".

6 FINDINGS | DEDUCTIVE THEMATIC ANALYSIS ALONG THE TEMPORAL DIMENSION OF ACCEPTANCE

While the inductive thematic analysis (Section 5) focused on designers' experience using the TAC toolkit during the workshops, we further explored how the toolkit supported leverage of the temporal dimension of user acceptance by designers. This deductive thematic analysis, anchored in the TAL timeline, investigates how the use of the TAC toolkit supported designers in considering acceptance throughout the user journey, negotiated the interplay between factors, and accounted for the variety of user trajectories as well as the difficulties they faced in envisaging future acceptance issues.

6.1 Considering the Question of Acceptance throughout the User Journey

Designers reported that using the toolkit they could **see the unfolding of a user acceptance journey over time**: "*It kind of felt [like] I'm going on with the user progress… It made me curious at this step to know what is the next step*" (P19). Considering their richness, it can be taxing to grasp and understand the range of elements influencing user acceptance and how they evolve in time. By creating 8 temporal milestones inside the user journey, and putting the set of acceptance factors in designers' hands, the TAC toolkit helped participants **understand the reasons behind a user's trajectory**, and enabled them to **get a richer appreciation of the complexity of user experience**. For instance, P6 described how the temporal dimension of the scenario helped them to understand the persona trajectory of abandonment of the technology (P6).

6.1.1 Leveraging the Temporal Continuum: Pre-Use Acceptability — Initial Use Acceptance — Sustained Use Acceptance. Nadal et al.'s prior review showed that user acceptance was rarely examined at the *pre-use* stage [63]. In addition, user journeys tend to focus on users' *interactions* with the technology (e.g. patient journey mapping looking at patients' 'touchpoints' with healthcare technologies [56]), thus failing to consider users' *perceptions* of the technology. The TAC toolkit aimed to tackle this possible oversight by showing that the user acceptance journey consists of **a sequence of experiences, each susceptible to changing the user's perception of the technology**. Participants observed this connection when Persona Ella took on the glucose monitoring app:

> Ella (P8): « *Setting it all up was easier than I expected. The sensor is attached to my stomach, just above my hip. It's a bit weird but it's discreet. I'll get used to it…*
> P9: *The 'technology anxiety' she [Ella] has has been suddenly reduced.*
> P7: *Yeah, there's a sense of 'enjoyment' in terms of [the app] being initially usable, easier than expected.* »

Furthermore, most studies measuring acceptance have focused on the *sustained use* stage [63], evaluating the extent to which users have accepted the technology after long-term use. This approach reduces acceptance to a point measure, which does not capture the evolution of user experience. Measuring *sustained use acceptance* also requires deploying the health technology, potentially with a clinical population. This is a more taxing process for gaining insight into acceptance problems that could have been identified

earlier in the course of design. The TAC toolkit as an exploratory design tool, thus used at an early design stage, enabled designers to **look into prospective user acceptance issues** with a system, and **understand how design choices could lead to a particular user acceptance trajectory**. P20 explained that, in the *sustained use stage* of the workshop, they noticed that "*[the persona] is still in the same [problematic] place: what does that mean?*". They then reflected on the acceptance factors the group had flagged as relevant in the previous steps of the user journey: "*we had picked that before and now he [the persona] is here. So, you know, what do we need to think of for the technology?*".

6.2 Negotiating the Interplay among Factors Influencing Acceptance

The weight of each acceptance factor varies throughout the user acceptance journey [63], some proving more pertinent at the *pre-use* stage, and others having greater impact at the point of *long-term* use. The multi-choice scenario gave designers the opportunity to explore different trajectories for the same persona, depicting various issues of acceptance. Each group's final think-space provided **a visualization of the trade-off between acceptance factors** — as reflected in Fig. 6 which shows how the user's 'anxiety' is first reduced by their 'enjoyment', but later exacerbated by the system 'usability' and the person's lack of 'trust'. Complementarity between acceptance factors was also rendered visible, **making explicit the complex nature of some acceptance issues**. The notes taken by Group 6 reflect the interdependency between the cards 'healthcare professional relationship', 'trust' and 'self-image' selected: "*We pick the cards because the app is sharing Ali's [the persona] little secrets with the doctor and she feels upset, as she thought it was going to be a useful tool"*. Finally, creating new meaning through the think-space's virtual elements, some participants represented the interplay between factors by overlaying cards on the board:

> « *P1: It's like both [factors] overlayed on top of each other… it's maybe more 'health beliefs and concerns' because... Oh I don't know yeah, it's kind of both...*
> *P2: We can maybe put one [card] on top of another, like showing that they overlap?* »

6.3 Accounting for the Variety of User Trajectories when Considering Acceptance

The user journey with technology is rarely linear — intermittent or discontinued use proving common issues, particularly in the healthcare context [61, 80]. It is essential therefore that design accounts for the variety of experiences across the full user journey. However, User Experience models tend to provide punctual representations of the user journey [93], or tend to adopt an optimistic view of the user's experience, failing to capture how a technology can be abandoned at any stage in the user journey — even before the first use [43]. Being able to explore the user journey through temporal windows, and also **from both more and less optimistic perspectives**, helped designers envisage various possible user trajectories. P17 (who played the persona) reflected on the activity of selecting a storyline among the three available at each scenario step: "*I found it quite useful to have these scenarios, to see how things could go*".

6.4 The Difficulty of Envisaging Future Acceptance Issues

Velt et al.'s review found that "taking into account trajectories helped with the design of future experiences" as "trajectories raised novel design requirements for a class of experiences" [93, p. 2095]. During the workshop, participants worked with prospective user trajectories, in a near or distant future, which enabled them to **design for possible future issues regarding acceptance**. Although most designers are familiar with reflecting on users' *past* experiences, envisaging *future* experiences — especially distant ones — was for many both novel and challenging. Two aspects of the design task threw off some participants.

Firstly, the length of the time scale negatively impacted designers' ability to envision users' trajectories, particularly those distant in time: "*It's very hard for me to take that whole year-long view… the ask was getting too fine-grained on something [a user trajectory] that's more sketchy*" (P18). To address the difficulty of working with a detailed view of the long-term user journey, P18 suggested an iterative approach where designers would first "*try and get the basics down and move on to the next one [scenario step]*" before "*zoning in on each one [step] to go more in depth*".

Secondly, some participants commented on **an impression of a too rapid passing of time**, which was materialized by the time intervals between each scenario step: "*Even though you actually had '1 week', '3 months', '1 year'… it was a bit fast in some sense*" (P11). The granularity of the time intervals was mentioned as a possible explanation: "*the temporal side wasn't quite the right granularity* (P5). Thinking back on the group's design ideas for addressing future acceptance issues, P11 spoke of recognizing greater substance in latter parts of the journey: "*There was a lot more to discuss somehow… because now the user has been using it [the system]… it will be interesting to have even more snippets of stories in that area*".

7 DISCUSSION

Findings indicate designers' overall enjoyable experience of engaging with the TAC toolkit and its playfulness as facilitated in particular by the cards. We now reflect on the value of the TAC toolkit, for supporting reflection on and design for acceptance from a macro-temporal perspective, and discuss its impact on designers' knowledge, values, and behaviors, with a focus on intentions to change future design practice.

7.1 Revising & Extending Knowledge of the Technology Acceptance Process: Dynamic, Multi-stage, Complex

Findings indicate that the TAC toolkit prompted designers to change the way they think about acceptance. The toolkit and its method supported participants in gaining richer design knowledge of acceptance in three main directions.

Firstly, it helped them uncover and challenge inaccurate assumptions that acceptance is a static process with limited temporal qualities rather than a dynamic one to be best understood from a macro-temporal perspective. Thus, our findings extend those on user experience frameworks focusing on discrete experiences [31, 55] and

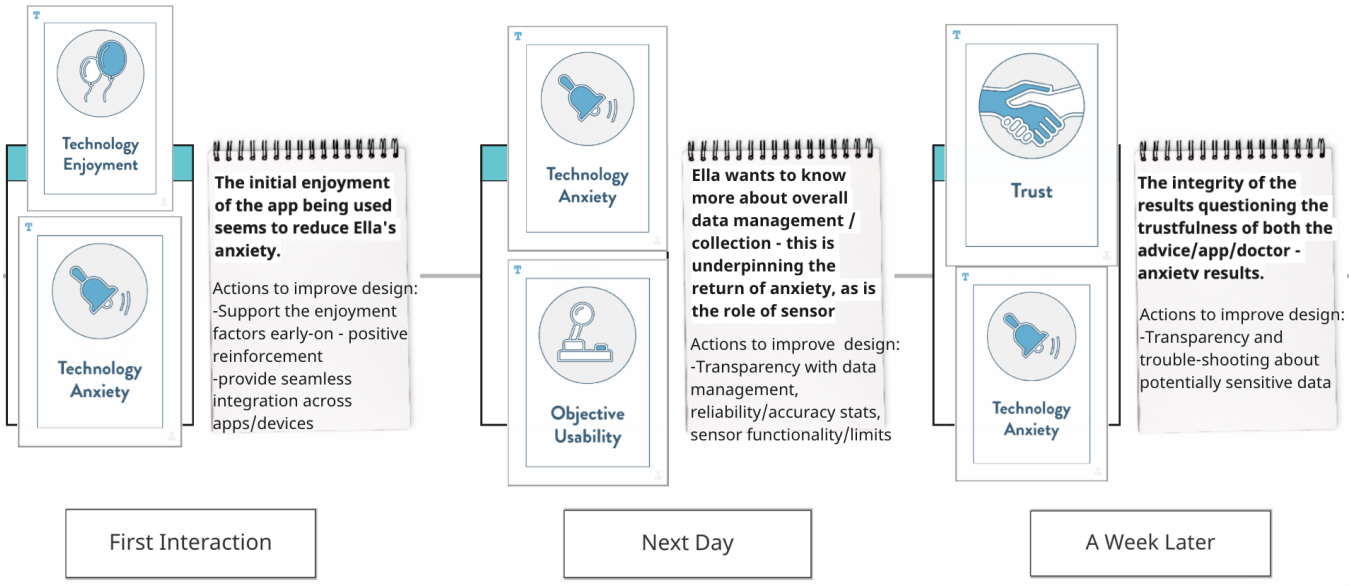

Figure 6: The think-space generated by Group 3, showing their notes on the negotiation of 4 factors: *technology anxiety, enjoyment, objective usability, & trust*, across the 3 temporal milestones of the *initial use acceptance* stage. Elements of interest are in bold.

those that change in time [44] by integrating a theoretically informed macro-level temporal perspective of technology acceptance [26]. We have introduced a novel type of scenario — which we call *temporal multi-choice scenarios* — that we designed to embody such a macro-temporal perspective through the eight temporal milestones across the three stages of the TAL acceptance process [63]. Unlike the traditional scenario depicting situated use of technology at a single and usually indeterminate moment in time, our approach marked a significant shift accounting for the temporal dynamic of user acceptance process, thus going beyond individual experiences to experiences changing in time. We define *temporal multi-choice scenarios* as a sequence of scenarios capturing the evolution of users' interaction at a macro-temporal level, from *acceptability* and *initial acceptance* to *sustained acceptance*, while also providing the choice of exploring low, medium or high degrees of challenge in relation to different acceptance factors relevant at each temporal milestone. To visually represent these scenarios we employed the concept of interactional trajectories [7] via the TAC website (Fig. 4) which we further tailor as *interactional acceptance trajectories*. We define these as visual representations of richer trajectories extending over space and time, and in particular across the 8 temporal milestones of the TAC toolkit, involving specific user groups engaging with a target technology.

Secondly, findings showed how such toolkits could challenge the assumption that acceptance is a simple one-stage process, no longer relevant once the technology starts being used. In other words, it helped revise designers' mental model of acceptance as a multi-stage process, as argued by a wealth of theoretical models [24, 32, 52, 70, 80, 85, 89], whose relevance for design practice has been less explored. In particular, findings indicated participants' richer understanding of the importance of considering in design the other stages of acceptance, stretching both before and after the *initial use* stage within the TAL model [63].

Third, the method explored provided an engaging and accessible operationalization of the rather complex acceptance process and its rich set of factors from self-image [98], computer anxiety [95] or demographic traits [99], to health beliefs and concerns [46], and trust [23]. This is a key outcome towards bridging the theory of acceptance and design practice, given that most of the work on acceptance has overlooked many of the validated acceptance factors [63]. The cards ensured more than mere communication of information regarding these factors, but also deep engagement and constructivist learning of factors' meanings, and more importantly their complementary or compromising aspects when applied to the situated richness of the selected persona and scenario.

7.2 Sensitizing towards Designing for Acceptance: Appreciation, Empathy & Ethics

Findings have also shown how the TAC toolkit and its method impacted on designers' values, sensitizing them towards the appreciation of the dynamic, multi-stage and complex acceptance process, eliciting empathy for the long-term users of health technologies, and helping them unpack additional ethical issues when designing for acceptance. Our rich qualitative findings revealed that designers' appreciation of the acceptance process was underpinned by cognitive emotions of curiosity, surprise, insight, and realization [77, 78]. Apart from the cards and their sensitizing questions, the method requiring the review and selection of relevant cards per temporal milestone of the scenario was key to developing such appreciation.

Empathy was supported by the first-person narrative form of the scenarios, and in particular by our choice of role-play. Participants also unpacked important ethical concerns, and were prompted to reflect on the design actions which might address the identified difficulties in acceptance of these technologies. Their rich answers reflected ethical principles of *transparency*, *autonomy*, *accessibility*, or *privacy*, which are key for health technology design [9, 72]. While traditional exploratory design methods in general, and those employed for sensitive contexts like health [36, 74, 92, 101, 103], have long acknowledged the significance of fostering empathy and ethical values, they have focused mostly on *discrete* user experiences rather than *continuous* experiences as entailed in long-term acceptance and its macro-temporal perspective.

7.3 Impacting Future Design Practice

In addition to helping designers change how they think and feel about designing for long-term acceptance of health technologies, our findings suggest the value of the TAC toolkit as a means of changing designers' future practice. Participants' expressed desire to use the toolkit in their future practice is a significant outcome, given that intended behavior change is an indicator of transformative learning as highlighted within several models of reflection [57]. Interestingly, the perceived ease of use of the TAC toolkit made it an attractive design tool envisaged also for use with other stakeholders, and importantly, with future users in early stages of the design process. Traditional exploratory design methods intended to bridge the design gap [76] such as personas [51], scenarios [106], design cards [8], or toolkits [48] have focused predominantly on the design of technologies for the *initial use* stage, with limited focus on the *pre-use*, and *sustained use* stages. Our findings, however, increased participants' awareness of change at two levels: change in users' needs over time, and change to their personal constellation of relevant determinants of technology acceptance. Together, these changes support a broader and more flexible set of requirements for technology design.

7.4 Implications for Design Research

We now reflect on the implications for design research entailed in our findings. We discuss the value of integrating design tools to better support the bridging of acceptance theory and design practice, of considering the evolution of acceptance factors and how the TAC toolkit may also evolve over time, and for more tailored support for designers to imagine future experiences in the sustained use stage.

7.4.1 Integrating Design Tools for Bridging Acceptance Theory and Design Practice. Findings indicate the value of the TAC toolkit for articulating and leveraging theoretical HCI work on technology acceptance in order to better inform the design for acceptance of health technologies. The significant need within HCI for bridging the gap between theory and design practice has been long acknowledged, and efforts to address it have led to conceptual contributions, such as translational resources [13, 14], intermediate design knowledge, strong concepts [39], bridging concepts [17], boundary objects, [94], or implications for design [76]. However, despite the progress made at a conceptual level and the wealth of traditional design tools, those for better bridging the gap are still much needed. We argue that the value of the TAC toolkit resides in the integration of exploratory design methods, such as personas and scenarios, with the TAC cards, and within the think-space and website. While personas and scenarios have been traditionally coupled in design research [16, 25], our findings suggest the added value of integrating these with acceptance theory, operationalized through the TAC cards and their sensitizing questions.

7.4.2 Considering the Evolution of Acceptance Factors in Designing Tools for Acceptance. Another implication for design tools supporting long-term acceptance of health technologies is accounting for how the factors of acceptance may change over time. This has been reflected in the evolution of acceptance models, moving from a focus on technologies for the workplace [20, 21, 88, 95, 96, 98, 99], through pervasive technologies [15, 100], to healthcare technologies [23, 27, 41, 46, 79]. Our findings also provide empirical support for ethicality as an emerging antecedent of user acceptance [64, 65, 87]. This is a clear indication that, while the TAC cards comprise an effective capturing of today's most relevant antecedent factors, they will benefit from future revisions in order to align with evolving technologies and their users' needs. The TAC toolkit is itself finally a key contribution of this work, which we make available to designers and researchers for adoption and adaptation to the unique context of their own health technology designs.

7.4.3 Supporting Design for Long-Term Acceptance. Unlike the exploration of user acceptance challenges before and at the early stages of use of the technology, considering distant user acceptance issues (in the *sustained use* stage) proved challenging. This related to the less familiar task of envisioning the long-term evolution of user experiences. Despite these challenges, designers appreciated the importance of such future experiences, and highlighted the value of a longer design activity to address those. Previous findings in cognition research showing that future events can be better imagined and pre-experienced when they are positive, and rich in sensorial details [28], we can imagine temporal multi-choice scenarios that are likewise richer in sensorial details to support designers in this task.

7.5 Future Work

This study investigated one specific context and procedure of use of the TAC toolkit. Future work will explore other possible directions, such as (a) adopting the same scenario-based method as a pedagogical exercise for elevating designers' knowledge, (b) using the toolkit in the process of designing specific real-world technologies, shaping and orienting designers' reflections, and (c) as a resource to be used in user-centered research methods (e.g. interviews with real users). The diversity of the TAC personas and scenarios additionally facilitate their tailoring to other digital health contexts worth exploring, from mindfulness [18, 19] to dementia [73] or chronic physical conditions. As suggested by P12, there might furthermore lie value in developing a new tool to support creation and elaboration of temporal user acceptance scenarios. Finally, future research might consider adapting the TAC toolkit for use outside the healthcare context, to better support design for technology adoption from a macro-temporal perspective.

8 CONCLUSIONS

We report the design and evaluation of the TAC toolkit, a novel theory-based design tool and method, with the aim of exploring how user acceptance theory can be leveraged in the design of health technologies. Findings showed that, through playful engagement, the toolkit revised and extended designers' knowledge of technology acceptance, fostered their appreciation, empathy and ethical values while designing for acceptance, and motivated its future use in their design practice. Finally, we discussed implications for considering user acceptance a dynamic, multi-stage process in design practice and better supporting designers in imagining distant user acceptance challenges, and we considered the generative value of the TAC toolkit and its possible future evolution.

ACKNOWLEDGMENTS

This work has been jointly supported by AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 People Programme under Marie Skłodowska-Curie (grant 722022), the Science Foundation Ireland Centre for Research Training in Digitally-Enhanced Reality (d-real, grant 18/CRT/6224), and the Novo Nordisk Foundation (grant NNF16OC0022038). This work also received the financial support of Science Foundation Ireland (ADAPT, grant 13/RC/2106_P2, and LERO, grant 13/RC/2094_P2).

REFERENCES

[1] Icek Ajzen and Thomas J Madden. 1986. Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of experimental social psychology* 22, 5 (1986), 453–474.

[2] Khadeeja Alkhuzai and Alena Denisova. 2021. Evaluating the Use of Persuasive Design Cards for Novice Designers. *Journal of Usability Studies* 16, 2 (2021).

[3] Daniel Andrews and Chris Baber. 2014. Visualizing Interactive Narratives: Employing a Branching Comic to Tell a Story and Show Its Readings. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI '14)*. Association for Computing Machinery, New York, NY, USA, 1895–1904. https://doi.org/10.1145/2556288.2557296

[4] Balbir S Barn and Ravinder Barn. 2018. Human and value sensitive aspects of mobile app design: a Foucauldian perspective. In *International Conference on Advanced Information Systems Engineering*. Springer, 103–118.

[5] Tilde Bekker and Alissa N Antle. 2011. Developmentally situated design (DSD) making theoretical knowledge accessible to designers of children's technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2531–2540.

[6] Steve Benford and Gabriella Giannachi. 2008. Temporal trajectories in shared interactive narratives. In *Proceedings of the sigchi conference on human factors in computing systems*. 73–82.

[7] Steve Benford, Gabriella Giannachi, Boriana Koleva, and Tom Rodden. 2009. *From Interaction to Trajectories: Designing Coherent Journeys through User Experiences.* Association for Computing Machinery, New York, NY, USA, 709–718. https://doi.org/10.1145/1518701.1518812

[8] Nis Bornoe, Anders Bruun, and Jan Stage. 2016. Facilitating redesign with design cards: experiences with novice designers. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction*. 452–461.

[9] Dionne Bowie-DaBreo, Heather Iles-Smith, Sandra-Ilona Sunram-Lea, and Corina Sas. 2020. Transdisciplinary ethical principles and standards for mobile mental health. *Mental Wellbeing: Future Agenda Drawing from Design, HCI, and Big Data* (2020).

[10] Virginia Braun and Victoria Clarke. 2012. Thematic analysis. (2012).

[11] Jacob Buur, Mads Vedel Jensen, and Tom Djajadiningrat. 2004. Hands-only scenarios and video action walls: novel methods for tangible user interaction design. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques*. 185–192.

[12] Man Lai Cheung, Ka Yin Chau, Michael Huen Sum Lam, Gary Tse, Ka Yan Ho, Stuart W Flint, David R Broom, Ejoe Kar Ho Tso, and Ka Yiu Lee. 2019. Examining consumers' adoption of wearable healthcare technology: The role of health attributes. *International journal of environmental research and public health* 16, 13 (2019), 2257.

[13] Lucas Colusso, Cynthia L Bennett, Gary Hsieh, and Sean A Munson. 2017. Translational resources: Reducing the gap between academic research and HCI practice. In *Proceedings of the 2017 Conference on Designing Interactive Systems*. 957–968.

[14] Lucas Colusso, Ridley Jones, Sean A Munson, and Gary Hsieh. 2019. A translational science model for HCI. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[15] Kay Connelly. 2007. On developing a technology acceptance model for pervasive computing. In *9th International Conference on Ubiquitous Computing (UBICOMP)-Workshop of Ubiquitous System Evaluation (USE), Springer, Innsbruck, Austria*. Citeseer, 520.

[16] Alan Cooper, Robert Reimann, and David Cronin. 2012. *About Face 3: The Essentials of Interaction Design.* John Wiley & Sons.

[17] Peter Dalsgaard and Christian Dindler. 2014. Between Theory and Practice: Bridging Concepts in HCI Research *(CHI '14)*. Association for Computing Machinery, New York, NY, USA, 1635–1644. https://doi.org/10.1145/2556288.2557342

[18] Claudia Daudén Roquet and Corina Sas. 2020. Body Matters: Exploration of the Human Body as a Resource for the Design of Technologies for Meditation. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 533–546. https://doi.org/10.1145/3357236.3395499

[19] Claudia Daudén Roquet and Corina Sas. 2021. *Interoceptive Interaction: An Embodied Metaphor Inspired Approach to Designing for Meditation.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445137

[20] Fred D Davis. 1985. *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* Ph. D. Dissertation. Massachusetts Institute of Technology.

[21] Fred D Davis, Richard P Bagozzi, and Paul R Warshaw. 1989. User acceptance of computer technology: a comparison of two theoretical models. *Management science* 35, 8 (1989), 982–1003.

[22] Henrik Detjen, Sarah Faltaous, Bastian Pfleging, Stefan Geisler, and Stefan Schneegass. 2021. How to Increase Automated Vehicles' Acceptance through In-Vehicle Interaction Design: A Review. *International Journal of Human–Computer Interaction* 37, 4 (2021), 308–330.

[23] Devendra Dhagarra, Mohit Goswami, and Gopal Kumar. 2020. Impact of trust and privacy concerns on technology acceptance in healthcare: an Indian perspective. *International journal of medical informatics* 141 (2020), 104164.

[24] Verena Distler, Carine Lallemand, and Thierry Bellet. 2018. Acceptability and acceptance of autonomous mobility on demand: The impact of an immersive experience. In *Proceedings of the 2018 CHI conference on human factors in computing systems*. 1–10.

[25] Alan Dix, Alan John Dix, Janet Finlay, Gregory D Abowd, and Russell Beale. 2003. *Human-computer interaction.* Pearson Education.

[26] Kevin Doherty and Gavin Doherty. 2018. The construal of experience in HCI: Understanding self-reports. *International Journal of Human-Computer Studies* 110 (2018), 63–74.

[27] Kaili Dou, Ping Yu, Ning Deng, Fang Liu, YingPing Guan, Zhenye Li, Yumeng Ji, Ningkai Du, Xudong Lu, and Huilong Duan. 2017. Patients' acceptance of smartphone health technology for chronic disease management: a theoretical model and empirical test. *JMIR mHealth and uHealth* 5, 12 (2017), e177.

[28] Arnaud D'Argembeau and Martial Van der Linden. 2004. Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and cognition* 13, 4 (2004), 844–858.

[29] Emmanuel Eilu. 2021. Design Strategies for Improving Anticipated User Experience in a Developing Country Setting: Case of Uganda. In *Digital Literacy and Socio-Cultural Acceptance of ICT in Developing Countries*. Springer, 65–77.

[30] Giorgio P Faconti and Mieke Massink. 2000. Continuity in human computer interaction. In *CHI'00 extended abstracts on Human factors in computing systems*. 364–364.

[31] Jodi Forlizzi and Katja Battarbee. 2004. Understanding Experience in Interactive Systems. In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (Cambridge, MA, USA) *(DIS '04)*. Association for Computing Machinery, New York, NY, USA, 261–268. https://doi.org/10.1145/1013115.1013152

[32] Giovanny Arbelaez Garces, Auguste Rakotondranaivo, and Eric Bonjour. 2016. An acceptability estimation and analysis methodology based on Bayesian networks. *International Journal of Industrial Ergonomics* 53 (2016), 245–256.

[33] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: cultural probes. *interactions* 6, 1 (1999), 21–29.

[34] Tom Gayler, Corina Sas, and Vaiva Kalnikaitundefined. 2021. *Sensory Probes: An Exploratory Design Research Method for Human-Food Interaction.* Association for Computing Machinery, New York, NY, USA, 666–682. https://doi.org/10.1145/3461778.3462013

[35] Kim Halskov and Peter Dalsgård. 2006. Inspiration card workshops. In *Proceedings of the 6th conference on Designing Interactive systems*. 2–11.

[36] Susanne Hensely-Schinkinger, Aparecido Fabiano Pinatti de Carvalho, Michael Glanznig, and Hilda Tellioğlu. 2015. The definition and use of personas in the

design of technologies for informal caregivers. In *International Conference on Human-Computer Interaction*. Springer, 202–213.
[37] Godfrey Hochbaum, Irwin Rosenstock, and Stephen Kegels. 1952. Health belief model. *United states public health service* 1 (1952).
[38] Mahsa Honary, Roisin McNaney, and Fiona Lobban. 2018. Designing Video Stories around the Lived Experience of Severe Mental Illness. In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction* (Oslo, Norway) *(NordiCHI '18)*. Association for Computing Machinery, New York, NY, USA, 25–38. https://doi.org/10.1145/3240167.3240188
[39] Kristina Höök and Jonas Löwgren. 2012. Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Transactions on Computer-Human Interaction (TOCHI)* 19, 3 (2012), 1–18.
[40] Eva Hornecker. 2010. Creative idea exploration within the structure of a guiding framework: the card brainstorming game. In *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction*. 101–108.
[41] Chien-Lung Hsu, Ming-Ren Lee, and Chien-Hui Su. 2013. The role of privacy protection in healthcare information systems adoption. *Journal of medical systems* 37, 5 (2013), 1–12.
[42] Chung-Ching Huang and Erik Stolterman. 2011. Temporality in Interaction Design. In *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces* (Milano, Italy) *(DPPI '11)*. Association for Computing Machinery, New York, NY, USA, Article 62, 8 pages. https://doi.org/10.1145/2347504.2347572
[43] Armağan Karahanoğlu and Yekta Bakırlıoğlu. 2020. Evaluation of the usefulness of path of long-term user experience model in design process. *Behaviour & Information Technology* (2020), 1–19.
[44] Evangelos Karapanos, John Zimmerman, Jodi Forlizzi, and Jean-Bernard Martens. 2009. *User Experience over Time: An Initial Framework*. Association for Computing Machinery, New York, NY, USA, 729–738. https://doi.org/10.1145/1518701.1518814
[45] Irni Eliana Khairuddin, Corina Sas, and Chris Speed. 2019. BlocKit: A Physical Kit for Materializing and Designing for Blockchain Infrastructure. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. Association for Computing Machinery, New York, NY, USA, 1449–1462. https://doi.org/10.1145/3322276.3322370
[46] Jeongeun Kim and Hyeoun-Ae Park. 2012. Development of a health information technology acceptance model using consumers' health behavior intention. *Journal of medical Internet research* 14, 5 (2012), e133.
[47] Sandjar Kozubaev, Chris Elsden, Noura Howell, Marie Louise Juul Søndergaard, Nick Merrill, Britta Schulte, and Richmond Y. Wong. 2020. *Expanding Modes of Reflection in Design Futuring*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3313831.3376526
[48] David Ledo, Steven Houben, Jo Vermeulen, Nicolai Marquardt, Lora Oehlberg, and Saul Greenberg. 2018. Evaluation strategies for HCI toolkit research. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–17.
[49] Andrés Lucero and Juha Arrasvuori. 2010. PLEX Cards: A Source of Inspiration When Designing for Playfulness. In *Proceedings of the 3rd International Conference on Fun and Games* (Leuven, Belgium) *(Fun and Games '10)*. Association for Computing Machinery, New York, NY, USA, 28–37. https://doi.org/10.1145/1823818.1823821
[50] Nikola Marangunić and Andrina Granić. 2015. Technology acceptance model: a literature review from 1986 to 2013. *Universal access in the information society* 14, 1 (2015), 81–95.
[51] Nicola Marsden and Maren Haag. 2016. Stereotypes and politics: reflections on personas. In *Proceedings of the 2016 CHI conference on human factors in computing systems*. 4017–4031.
[52] Nicolas Martin, Séverine Erhel, Éric Jamet, and Géraldine Rouxel. 2015. What links between user experience and acceptability?. In *Proceedings of the 27th Conference on l'Interaction Homme-Machine*. 1–6.
[53] Mark Matthews, Geri Gay, and Gavin Doherty. 2014. Taking part: role-play in the design of therapeutic systems. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 643–652.
[54] Mark Matthews, Stephen Voida, Saeed Abdullah, Gavin Doherty, Tanzeem Choudhury, Sangha Im, and Geri Gay. 2015. In situ design for mental illness: Considering the pathology of bipolar disorder in mhealth design. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*. 86–97.
[55] John McCarthy and Peter Wright. 2004. Technology as experience. *interactions* 11, 5 (2004), 42–43.
[56] S McCarthy, P O'Raghallaigh, S Woodworth, YY Lim, LC Kenny, and F Adam. 2020. The "Integrated Patient Journey Map": A Design Tool for Embedding the Pillars of Quality in Health Information Technology Solutions. *JMIR Hum Factors* (2020).
[57] Jack Mezirow et al. 1990. How critical reflection triggers transformative learning. *Fostering critical reflection in adulthood* 1, 20 (1990), 1–6.
[58] Miro. 2021. Online Whiteboard for Visual Collaboration. https://miro.com/
[59] Gary C Moore and Izak Benbasat. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information systems research* 2, 3 (1991), 192–222.
[60] Florian Mueller, Martin R Gibbs, Frank Vetere, and Darren Edge. 2014. Supporting the creative game design process with exertion cards. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2211–2220.
[61] Camille Nadal, Gavin Doherty, and Corina Sas. 2019. Technology acceptability, acceptance and adoption-definitions and measurement. In *2019 CHI Conference on Human Factors in Computing Systems*.
[62] Camille Nadal, Shane McCully, Kevin Doherty, Corina Sas, and Gavin Doherty. 2021. TAC Toolkit. http://ehealthacceptancedesign.com/
[63] Camille Nadal, Corina Sas, and Gavin Doherty. 2020. Technology acceptance in mobile health: scoping review of definitions, models, and measurement. *Journal of Medical Internet Research* 22, 7 (2020), e17256.
[64] Marcin Paska. 2021. The Aspect of Ethics Determined by Technological Impact. (2021).
[65] Olga Perski and Camille E Short. 2021. Acceptability of digital health interventions: embracing the complexity. *Translational Behavioral Medicine* (2021).
[66] Dorian Peters, Lian Loke, and Naseem Ahmadpour. 2020. Toolkits, cards and games–a review of analogue tools for collaborative ideation. *CoDesign* (2020), 1–25.
[67] Claudette Pretorius, Darragh McCashin, Naoise Kavanagh, and David Coyle. 2020. Searching for mental health: a mixed-methods study of young people's online help-seeking. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.
[68] Chengcheng Qu, Corina Sas, and Gavin Doherty. 2020. Reviewing and evaluating mobile apps for memory impairments in depression. In *25th annual international CyberPsychology, CyberTherapy & Social Networking Conference*.
[69] Amon Rapp, William Odom, Larissa Pschetz, and Daniela Petrelli. 2021. Introduction to the special issue on time and HCI. *Human–Computer Interaction* (2021), 1–14.
[70] Everett M Rogers. 1983. *Diffusion of innovations*. Simon and Schuster.
[71] Antti Salovaara, Kristina Höök, Keith Cheverst, Michael Twidale, Matthew Chalmers, and Corina Sas. 2011. Appropriation and Creative Use: Linking User Studies and Design. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI EA '11)*. Association for Computing Machinery, New York, NY, USA, 37–40. https://doi.org/10.1145/1979742.1979585
[72] Pedro Sanches, Axel Janson, Pavel Karpashevich, Camille Nadal, Chengcheng Qu, Claudia Daudén Roquet, Muhammad Umair, Charles Windlin, Gavin Doherty, Kristina Höök, et al. 2019. HCI and Affective Health: Taking stock of a decade of studies and charting future research directions. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–17.
[73] Corina Sas, Nigel Davies, Sarah Clinch, Peter Shaw, Mateusz Mikusz, Madeleine Steeds, and Lukas Nohrer. 2020. Supporting Stimulation Needs in Dementia Care through Wall-Sized Displays. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–16. https://doi.org/10.1145/3313831.3376361
[74] Corina Sas, Kobi Hartley, and Muhammad Umair. 2020. ManneqKit cards: A kinesthetic empathic design tool communicating depression experiences. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*. 1479–1493.
[75] Corina Sas and Carman Neustaedter. 2017. Exploring DIY practices of complex home technologies. *ACM Transactions on Computer-Human Interaction (TOCHI)* 24, 2 (2017), 1–29.
[76] Corina Sas, Steve Whittaker, Steven Dow, Jodi Forlizzi, and John Zimmerman. 2014. Generating implications for design through design research. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1971–1980.
[77] Corina Sas and Chenyan Zhang. 2010. Do Emotions Matter in Creative Design?. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (Aarhus, Denmark) *(DIS '10)*. Association for Computing Machinery, New York, NY, USA, 372–375. https://doi.org/10.1145/1858171.1858241
[78] Israel Scheffler. 1981. In praise of the cognitive emotions. *Thinking: the Journal of Philosophy for Children* 3, 2 (1981), 16–23.
[79] Eva-Maria Schomakers, Chantal Lidynia, and Martina Ziefle. 2019. Listen to my heart? How privacy concerns shape users' acceptance of e-health technologies. In *2019 International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)*. IEEE, 306–311.
[80] Mandeep Sekhon, Martin Cartwright, and Jill J Francis. 2017. Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC health services research* 17, 1 (2017), 88.
[81] Orit Shaer and Eva Hornecker. 2010. *Tangible user interfaces: past, present, and future directions*. Now Publishers Inc.
[82] Vimal Sharma, Suvodeep Das, and Susheel Kewaley. 2015. Design Thing'ing: methodology for understanding and discovering Use cases in IoT scenarios. In *Proceedings of the 7th International Conference on HCI, IndiaHCI 2015*. 113–115.
[83] Roger Silverstone and Eric Hirsch. 1992. *Consuming technologies: Media and information in domestic spaces*. Routledge.

[84] Michael R Simonson, Matthew Maurer, Mary Montag-Torardi, and Mary Whitaker. 1987. Development of a standardized test of computer literacy and a computer anxiety index. *Journal of educational computing research* 3, 2 (1987), 231–247.

[85] A Somat, E Jamet, G Menguy, JF Forzy, and M El-Jaafari. 2012. Acceptabilité individuelle, sociale & acceptation. *Livrable L5* 3 (2012).

[86] Dorothy Szinay, Olga Perski, Andy Jones, Tim Chadborn, Jamie Brown, and Felix Naughton. 2021. Influences on the Uptake of Health and Well-being Apps and Curated App Portals: Think-Aloud and Interview Study. *JMIR mHealth and uHealth* 9, 4 (2021), e27173.

[87] Guillaume Tabourdeau and Camille Grange. 2020. From User Acceptance to Social Acceptance. (2020).

[88] Shirley Taylor and Peter A Todd. 1995. Understanding information technology usage: A test of competing models. *Information systems research* 6, 2 (1995), 144–176.

[89] Florence Terrade, Hélène Pasquier, Juliette Reerinck-Boulanger, Gérard Guingouain, and Alain Somat. 2009. L'acceptabilité sociale: la prise en compte des déterminants sociaux dans l'analyse de l'acceptabilité des systèmes technologiques. *Le travail humain* 72, 4 (2009), 383–395.

[90] Muhammad Umair, Corina Sas, and Miquel Alfaras. 2020. *ThermoPixels: Toolkit for Personalizing Arousal-Based Interfaces through Hybrid Crafting.* Association for Computing Machinery, New York, NY, USA, 1017–1032. https://doi.org/10.1145/3357236.3395512

[91] Thea M Van Der Geest and Hendrik P Buimer. 2015. User-centered priority setting for accessible devices and applications. In *Mensch und Computer 2015–Workshopband*. De Gruyter, 383–390.

[92] Lex Van Velsen, Lisette van Gemert-Pijnen, Nicol Nijland, Desirée Beaujean, and Jim Van Steenbergen. 2012. Personas: The linking pin in holistic design for eHealth. In *The Fourth International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED 2012), IARIA*. 128–133.

[93] Raphael Velt, Steve Benford, and Stuart Reeves. 2017. A survey of the trajectories conceptual framework: Investigating theory use in HCI. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. 2091–2105.

[94] Raphael Velt, Steve Benford, and Stuart Reeves. 2020. Translations and Boundaries in the Gap Between HCI Theory and Design Practice. *ACM Transactions on Computer-Human Interaction (TOCHI)* 27, 4 (2020), 1–28.

[95] Viswanath Venkatesh. 2000. Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information systems research* 11, 4 (2000), 342–365.

[96] Viswanath Venkatesh and Hillol Bala. 2008. Technology acceptance model 3 and a research agenda on interventions. *Decision sciences* 39, 2 (2008), 273–315.

[97] Viswanath Venkatesh and Fred D Davis. 1996. A model of the antecedents of perceived ease of use: Development and test. *Decision sciences* 27, 3 (1996), 451–481.

[98] Viswanath Venkatesh and Fred D Davis. 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science* 46, 2 (2000), 186–204.

[99] Viswanath Venkatesh, Michael G Morris, Gordon B Davis, and Fred D Davis. 2003. User acceptance of information technology: Toward a unified view. *MIS quarterly* (2003), 425–478.

[100] Viswanath Venkatesh, James YL Thong, and Xin Xu. 2012. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly* (2012), 157–178.

[101] Sandra Vosbergen, JMR Mulder-Wiggers, JP Lacroix, HMC Kemps, Roderik A Kraaijenhagen, Monique WM Jaspers, and Niels Peek. 2015. Using personas to tailor educational messages to the preferences of coronary heart disease patients. *Journal of biomedical informatics* 53 (2015), 100–112.

[102] Annika Waern, Paulina Rajkowska, Karin B Johansson, Jon Bac, Jocelyn Spence, and Anders Sundnes Løvlie. 2020. Sensitizing Scenarios: Sensitizing Designer Teams to Theory. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.

[103] Pontus Wärnestål, Petra Svedberg, Susanne Lindberg, and Jens M Nygren. 2017. Effects of using child personas in the development of a digital peer support service for childhood cancer survivors. *Journal of medical Internet research* 19, 5 (2017), e161.

[104] Bard O Wartena and Hylke W van Dijk. 2013. Bias Blaster–aiding cognitive bias modification-interpretation through a bubble shooter induced gameflow. In *Games for health*. Springer, 47–60.

[105] Jane Webster and Joseph J Martocchio. 1992. Microcomputer playfulness: Development of a measure with workplace implications. *MIS quarterly* (1992), 201–226.

[106] Richard M Young and Phil Barnard. 1986. The use of scenarios in human-computer interaction research: Turbocharging the tortoise of cumulative science. In *Proceedings of the SIGCHI/GI conference on Human factors in computing systems and graphics interface*. 291–296.

A APPENDIX

Nodes	Neutral path #1	Neutral path #2	Neutral path #3
SEEKING ADVICE	**We were watching the news when.** The Minister for Health was on the news explaining how important "contact tracing" app is in terms of dealing with this whole COVID thing. They were talking about how important this is for us to download it, how it's fully GDPR compliant, we can opt out whenever etc etc. Seems important.	**I talked to the family.** We were having dinner, chatting & once again COVID was the topic of conversation. They're worried about me coming into contact with it working the bus route, and to be honest, so am I - especially with my heart. My son asks if I have downloaded the contact tracing app. I mention I have some hesitations, privacy and all that, but he walks me through it.	**I was on the internet.** I've seen a lot people talking about this "contact tracing" app on Twitter in the past few days, not all positive. There's been a bit of chat in my WhatsApp groups about it - which is far from peer-reviewed I know - but still, I've got some apprehensions about it. The health minister tweeted a series of videos explaining how important contact tracing was to the public effort.
CHOOSING TECHNOLOGY	**There it was, in the AppStore.** When I logged on to Twitter this morning the first Ad in my feed was from the government, for this contact tracing app. I was going to download it anyway, but decided to click in straight away and get it downloaded before I forgot.	**It was on the boss's orders.** We all got an email in work from the head office. They have insisted we download the COVID tracker app if we want to stay on the job. I would have probably done it anyway but still, the role is public facing & public sector so I can see why. Went onto the App Store and downloaded it.	**We were chatting over dinner.** COVID has been the main topic of conversation at our dinner table lately. I ask my son about this contact tracing app, tell him some of my hesitations - what I've been seeing in my WhatsApp chat. He's a bit more turned into this tech stuff. Says it's WhatsApp I should be worried about, not the contact tracing app - especially with my condition. He walks me through it a bit more, even downloads it for me.
	High severity path	Medium severity path	Low severity path
FIRST INTERACTION	**Is this thing working?** Downloaded it from the App Store but it doesn't seem to be right. It downloaded fine but when I try to open it I get some warning about "device compatibility". I haven't gotten a new phone in a few years, I think I might have to upgrade.	**I've heard it's a big drain.** Downloaded it from the App Store, all it needed was my phone number to set up. It requires bluetooth to be on - all the time. I'm a bit worried about it draining my battery if it's on all day.	**Well, that was easy.** Downloaded it from the App Store, seemed simple enough. It needs my number & my location. It has all the information about the country's cases, regional case breakdown etc. I had to "opt-in" for the contact tracing feature so that I'll get a notification if I'm near a confirmed case. Still somewhat hesitant, privacy wise, but given the situation, I think this is more important.
NEXT DAY	**I'm lost in the settings.** I thought I had it set up correctly but after talking to a friend at work about it, I realised I didn't "opt-in" for the contact tracing. I'm a bit lost in the settings to be honest, but I think I have it turned on now.	**My battery seems low.** I "checked in" this morning before work. No symptoms obviously. I charge my phone overnight and it generally lasts me all the next day, but my battery was at 20% by lunch today. It must be the tracker app, I've heard it's a big drain.	**It only takes me seconds.** Checked in this morning and that was it really. Over and done with in a few taps. It has information about the country's cases & stuff but other than that, there's not much to it.
A WEEK LATER	**I was really worried when I saw the notification.** I got an "exposure notification" yesterday. Apparently I had been in close contact with someone who tested positive - the only thing is, I've been off work the last two days, I haven't left the house I was thinking maybe it was a family member but none of them have gotten the same notification. I have no symptoms but I called my doctor regardless. Not too confident in the app at the moment.	**I think I need a new phone.** I bought a new phone. My old one wasn't compatible and now is as good a time as any to upgrade I suppose. The app is set up on my new phone & seems to be working fine. I check in once a day & haven't gotten any notifications.	**I use it once a day and then forget about it.** I check in once a day & haven't gotten any notifications. It doesn't bother me & I've been encouraging those around me to download it.
AFTER A MONTH	**I got tested.** Initially I thought I was overreacting, slight cough, bit of a headache etc. But as soon as my taste & smell started to go I knew something was wrong. Thankfully I had been off work. Got tested 3 days ago & have been quarantined ever since. The doctor asked me if I had the app & then asked if they could put in a code to notify close contacts. I said yes, it was the least of my concerns. Quarantined in the spare room, slightly worried.	**I picked up a power bank.** I had to buy a power bank for my phone. Having my bluetooth on all day was draining my battery too much. It's quite annoying & clunky.	**I barely notice it.** It's routine now, I check in over breakfast each morning, close the app & forget about it. Haven't gotten a single notification.
AFTER 3 MONTHS	**It keeps crashing for me.** I don't know if it's my phone or the app but it crashes everytime I try to check in. I've kept the app because it has up-to-date information about the number of cases in the country but I'm not sure how much good I'm doing by having it if it doesn't work as intended.	**I haven't thought of it much.** I've forgotten about it to be honest. It's useful for the case data but that's on the news most evenings & I don't know how much I need to hear daily cases if we just have to live with this COVID situation. It's overwhelming. I don't usually check in but I keep the app just in case I get a close contact notification.	**I got a worrying notification.** I got a notification last week that I had been in close contact with someone who tested positive. Given my work on public transport, it's not surprising. It was quite worrying to be honest. I thought "if I have it, then the rest of the family do as well, not to mention everyone at work". I would hate to be the one to have given it to family & friends. Everyone at home felt fine but we got tested regardless. Negative thankfully, but those were a stressful few days regardless!
AFTER A YEAR	**I don't think I need it.** We haven't had a community transmission in 6 months. The threat is still there but life has returned to normal - more or less. I got a new phone a few months ago & didn't bother to download the contact tracing app.	**It's no hassle to keep it.** I kept the app on my phone & checked in every day for a while, gradually less & less, and now I don't use it at all to be honest but things are a lot more under control at the moment. We haven't had a community transmission in 6 months, the threat is still there but life goes on. Still hesitant with regards to sharing my location constantly but it's a small price to pay considering the national risk.	**I'm glad I used it.** I'm glad I downloaded it to be honest! The family had a couple of scares where we got close contact notifications and had to get tested. Having the case numbers was handy but probably a bit too much information at times. Thankfully we've all managed to stay healthy.

Figure 7: Temporal multi-choice scenario for the persona Alex (COVID-19). Each of the 8 temporal milestones presents 3 paths, each exploring acceptance issues of high, medium or low degrees of challenge. The milestones of *seeking advice* and *choosing technology* (situated before technology use) present 3 neutral paths, as acceptance issues are yet to arise.