



Digital, Analog, or Hybrid: Comparing Strategies to Support Self-Reflection

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ABSTRACT

Recently, various digital solutions have emerged to enhance the process of self-reflection, which can be crucial for personal growth and resilience. However, whether technology can meaningfully match or augment a traditional approach like pen or paper remains to be ascertained. Our objective was to build an better understanding of design paradigms' role in introspection. Through formative iterations, informed by Self-Determination Theory (SDT), we designed and developed different tool formulations (*Analogue*, *Digital*, and *Hybrid*) for comparison. Participants ($N = 48$) received one variant, completing a pre- and post-six-week assessment with the Self Reflection and Insight Scale (SRIS) and intermediary self-reports for qualitative feedback. We found scores for *Hybrid* and *Digital* conditions change significantly, suggesting format decisions have meaningful impacts on the efficacy of designs to alter intrinsic motivation toward introspective behaviour. We also identify determinants and design considerations to help others conceive solutions to support or stimulate a component of broader well-being.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI*; **Interaction paradigms**; • **Applied computing** → *Health informatics*.

KEYWORDS

psychological therapy, reflection, self-reflection, technology use

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1 INTRODUCTION

Technology is an inextricable part of daily life, affecting how we reflect on our experiences and ourselves - the pace and scale of which challenges our cognitive faculties. A growing concern is that our constant engagement with electronic devices may erode our capacity for thought that is more profound and self-facing [57, 64].

The World Health Organization's definition of well-being, which this study follows, describes it as multi-dimensional - "*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.*" [71]. Well-being is not merely an *absence* (or mitigation) of health-related issues but also requires positive attributes, competency and self-awareness in one's ability to manage daily life effectively through good health practices or maintaining productive social relationships. Against this understanding, introspection (or *self-reflection*) is integral to well-being as it helps us to parse experiences from multiple perspectives [65], evaluate performance across dimensions [89, 91], and prepare our mindsets or intentions for actions in the future [40, 53, 70].

However, concerns about the interference of technologies in these processes are not limited to academia; they extend into the popular discourse. Headlines spotlight the implications of excessive screen time on mental health [43], or polarising effects of social media on political and social issues [33, 59]. Despite this unease, technology is becoming more embedded in healthcare especially. For areas like mental health, this is in response to unprecedented demand and an attempt to address a shortfall in resources [67]. While some believe digital solutions can potentially promote well-being [14, 77], others are concerned about their addictive qualities or passive consumption [74]. They might question the 'need' or 'benefit' of a digital paradigm over *analogue* approaches that have helped sense-making for centuries. This dichotomy underpins the current state of the world: a world increasingly mediated by technology while grappling with its implications for foundational parts of the human psyche and activity. However, during inevitable life changes (positive or negative) [18, 44], to direct ourselves in introspective ways is a core competency for well-being [23, 80, 99], decision-making [26] and problem-solving [13, 41]. Appreciating effective ways to encourage this has consequences for us and the world.

HCI researchers and technology companies recognise the importance of introspection [105], but effectively harnessing these tools to facilitate psychological processes without harm is challenging. *Conceptualising* and *instantiating* the technology is one aspect - we must ascertain if design approaches ensure a net positive for users, especially in contrast to existing approaches. Technology enables many new kinds of *engagement* with self-reflection, but knowledge about whether they are superficial, fleeting, or truly enhancing is inconsistent. For instance, although popular apps like Day One [1] or stoic [94] suggest a public *willingness* to engage with digital tools for well-being, we must appreciate how feasible it is to expect them to match or surpass analogue alternatives. While it is true that many products mention they are 'backed by research', studies



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often predate significant evolutions in devices, do not involve technology at all, or rely on platforms that are no longer mainstream (e.g., pagers, SMS).

Newer research is emerging, but studies frequently focus on use cases (e.g., healthcare, education), sub-groups within them (e.g., nurses, teachers), or reflection on contextual issues (e.g., patient empathy, addressing social issues in the classroom) [6]. While insightful, generalisations may only be appropriate (or possible) sometimes. Also, despite many constructs [22, 68], HCI commonly refers to a narrow definition of 'self-reflection' or 'introspection' [39]. The restrictive focus and definition in HCI are problematic because technological use rarely fits into neat, predictable boxes - it often fluctuates with circumstances [18, 100]. As creators of experiences that become embedded in life, HCI should better understand this mechanism of well-being. Understanding whether digital solutions undermine or augment reflection has far-reaching consequences - from individual wellness to issues at the societal level. We should contrast them with the alternatives *already* in use. Although HCI often elevates the 'digital' aspect and positions it centrally, a more *neutral* approach may be more *optimal* or *effective*. Our study is not about the efficacy of digital supports but examines how to situate technology most *appropriately*, ideally in a way that captures the 'best of all worlds'.

Although HCI is no stranger to introspection, we must appreciate how likely our interventions will effectively motivate users when many alternatives exist—understanding if single paradigms are better than others for this activity and *why* can calibrate our expectations. As such, our study sought to develop a system in different variants to encourage self-reflective behaviour in response to the lack of comparative data on general-purpose supports or how different paradigms affect outcomes for most people. Our process involved a mixed-method approach over six weeks, with participants (N = 48) in one of three conditions (or a *Control* group) and given a design permutation; either a smartphone application (*Digital*), paper cards (*Analogue*) or both (*Hybrid*) - the *Control* group was given no tool but obtained the same introduction as others. We took measurements of self-reflection using the *Self-Reflection and Insight Scale* (SRIS) [44], and did a thematic analysis on open-ended responses to surveys or intermediate reports to help us glean contextual insight on how tools were used or perceived. We aimed to quantify the variant effectiveness and understand the nuances of how each paradigm influences the reflective process. Broadly, our effort aligns with three research questions:

RQ1. Can tools designed to encourage self-reflection have a *measurable* effect? (i.e. SRIS)

RQ2. Which *design paradigms* for these tools are the most (or least) *effective*?

RQ3. Which *design factors* or *features* for these tools have the most (or least) *influence*?

The first question (RQ1) establishes if designs improve participants' self-reflective ability or inclination. The second (RQ2) resolves if *particular* approaches were more effective than others before, and finally, (RQ3) the design factors which could explain the observable results.

Our study revealed that participants using our *Hybrid* and *Digital* versions showed significant improvements in their self-reflection scores, as indicated by SRIS measurements. Notably, the most substantial improvements were associated with the *Hybrid* variant, outperforming the exclusively *Digital* or *Analogue* conditions. These findings suggest that while digital tools *can* positively affect self-reflection, a *blended approach* that incorporates digital and analogue elements might be most effective at *consistently* stimulating introspective activity.

In summary, we believe this work makes the following contributions:

1. Key Determinants of Efficacy in Reflective Tools: We identify critical factors (*Access, Relevance, Adaptation, and Modularity*) that influence the effectiveness of *Digital, Analogue, and Hybrid* introspection tools - offering insights for future tool design that is relevant to others addressing the broad influence of reflection

2. Design-Neutral Reflective Support: Our comparative study introduces an example of a design-neutral tool to assist introspection, aiming for broad applicability in HCI research and beyond. Study materials are available in our Open Science Foundation (OSF) repository for replication and further study.¹

In the following section, we examine the research on introspection so far (outside or within HCI) before progressing to our work and the implications for collective understanding.

2 RELATED WORK

Centrally, self-reflection helps us to process, integrate and instigate change [65]. Learning theorist Donald Schön identified at least two varieties, *in-action* and *on-action* - reflection which occurs *during* activity or *after* [89, 91]. He argues that self-reflective capacity improves performance when assessing one's actions and thinking before reattempting them. Later work also introduces reflection *for-action* - focusing on *anticipated* futures or plans [40, 53, 70]. To John Dewey, more literally, we can understand the act itself as "*active, persistent and careful consideration*", which can lead to new insights or conclusions [25]. Such framings are essential, but they are not comprehensive. We can understand introspection from many perspectives [10, 12, 37, 50, 56], appreciate the influences of social context, race, class, or gender [5, 35, 86]. Moreover, it is not passive or benign; it includes the potential to be *maladaptive* and *ruminative* [96, 98].

Nonetheless, research on self-reflection adjoins many domains and examinations in different contexts with good reason. Argyris felt reflection was also crucial for organisations, introducing *single* and *double* loop learning as mechanisms for responsive problem-solving [2]. Neuroscientists and clinical psychologists have also explored *functional* aspects using functional magnetic resonance imaging (fMRI) or electroencephalography (EEG). Their current understanding is that contemplative activity is associated with activity

¹Study materials on the Open Science Foundation repository <https://osf.io/7vbxa/>, Last Accessed February 2023

in parts of the brain associated with rest and links outward well-being [24, 62]. However, reflection is often in isolation, a desirable by-product or requirement for something larger [6].

In parallel, with machine intelligence developing at unprecedented speed, there are concerns that AI may supplant critical thinking altogether [101]. Accessibility to virtual environments such as AR or VR has led to a discussion on whether these can evoke contemplative experiences in new ways [36, 90], and some wonder if technology has yet to reach its potential when supporting well-being [14]. Amidst these opposites, some have open minds and believe that ‘traditional’ or ‘analogue’ practices still have much to teach us [3]. To better understand our situation, as reflection plays a central role in mediating actions that matter to us, it stands to reason that HCI researchers can benefit from a broader understanding of how their endeavours cultivate (or harm) such a process.

2.1 Self-Reflection Outside of HCI

Prior literature on introspection, outside of HCI, broadly focuses on how it influences *well-being*, *education* or *performance*. Often, it is applied in a *therapeutic* manner to facilitate the evaluation of thoughts, feelings, or behaviours - especially for the development of intentional behavioural change [39]. How individuals *interpret* their experiences has an impact on subsequent assessments of life satisfaction and interpersonal relationships [81, 85]. Interpretations vary [16], and reflective activity can help develop *psychological resilience* [23]. Although it is usually private, it can be instigated collaboratively [9] - helpful to clinicians and patients alike [7]. Schraw and Moshman outlined that meta-cognitive knowledge and meta-cognitive regulation play a role as we determine what we know about the thinking or influence of others (or ourselves), with poor assessments contributing toward psychological issues like anxiety [106] or undermine our quality of life [50, 95]. Within education, self-reflection may help students to develop critical thinking skills [102] or evaluate progress [20, 52, 66], with pedagogical researchers examining impacts from many perspectives: student’s learning [15, 49, 60] or the social environment around them [21, 54], educator approaches [107], and collaborative learning [76]. During COVID-19, attention turned to students’ self-regulatory abilities [34, 45] and stimulating participation in remote teaching [61]. Finally, for *athletic* performance, research has looked at *coaching* techniques and *personal development*, suggesting reflection may also encourage recovery [38, 51].

2.2 Self-Reflection Within HCI

Thanks to researchers, the HCI community has had warnings about the broadness and ambiguity of introspective activity. Baumer et al. found that most works do not provide a precise definitions for reflection itself [6], and the minority of papers drew predominantly from Schön’s work. This point is alarming, considering HCI’s investment in well-being and how much work is available to appreciate the role of introspection. Extensively, Calvo and Peters (known for their work on *Positive Computing*) believe that technology may have the potential to *augment* well-being beyond our traditional capacity [14, 77] and work within *personal informatics* is foundational for many consumer products for well-being that are now commonplace [27, 28]. Elsdén, who examined smart-journaling

practices, suggests that the popularity of devices for fitness and other use cases stems from universal desires to *account for one’s life* or to construct *unique perspectives* [27]. Reminiscent of this is the work of Rapp, who explored the creation of ‘design fictions’ to promote reflection that actualises critical thinking for learning [82] and how self-tracking devices stimulate introspection to support behavioural change [83].

HCI often ostracises individuals who do not participate in these technological ‘revolutions’ as *non-users*, but this can be short-sighted, failing to distinguish those who are inactive through *circumstances* and consciously *abstaining* [18]. For self-reflection, it may be essential to consider those ‘left behind’ - value in this process can come from the material, time or effort we invest, and non-technological approaches can reveal why there may be preferences for *tangible* experiences [69]. Ayobi examined the customisation strategies of ‘*Bullet Journalers*’ [4] and translated principle aspects to an application for those with *multiple sclerosis* [3], scrutinising paradigm differences. Work on interaction paradigms often focuses on issues of *interfaces* - such as their reliability [73], effectiveness [93] or influence in comparison to ‘physical’ controls [42, 88]. It is also frequent that studies lean *forward* into derivative paradigms or anticipated developments, like comparing immersive experiences in virtual reality (VR) to a non-immersive desktop counterpart [72].

However, HCI researchers have explored self-reflection as a conducive activity for *sense-making*. Paul and Morris created a system to support sense-making during web searching through collaborative reflection enabled by different interactive views [75]. Given the ways a user can generate and capture data *autonomously* with modern devices, it can be invaluable within a feedback loop to surface insights that may promote healthier perspectives or behaviour [78, 79, 84]. With *behavioural change* itself, it is not uncommon for HCI researchers to use different constructs to understand underlying mechanisms. One such system with extensive use is the *Self-Determination Theory* of Ryan and Deci - also known as *SDT* [87]. Their work describes that three *basic psychological needs* influence human motivation; the more an activity satisfies them, the more likely motivation toward this activity becomes intrinsically *self-sustaining*. Self-reflection is essential in how we react or behave, helping to assess our situation, and SDT suggests this self-assessment of needs is occurring continually. The use of SDT to gauge, critique and appreciate user interactions with interactive systems is well established [77, 103], and we believe it is also appropriate for examining technologically-assisted self-reflection. While it is unsurprising that modern interventions would desire digital aspects, the HCI community should know more about how to do this *optimally*. Interactive systems offer advantages, but benefits can be mute if designs oppose our natural tendencies.

3 DESIGN

Previous research, including a large-scale UK survey [100], highlights that proficient self-reflectors utilise technology strategically, often as a supplementary tool rather than their sole approach. These individuals frequently use heuristics and spontaneity to overcome obstacles that less experienced reflectors struggle to surmount. Our goal was to develop a system that would emulate or encourage these efficacious strategies and see whether it could be helpful

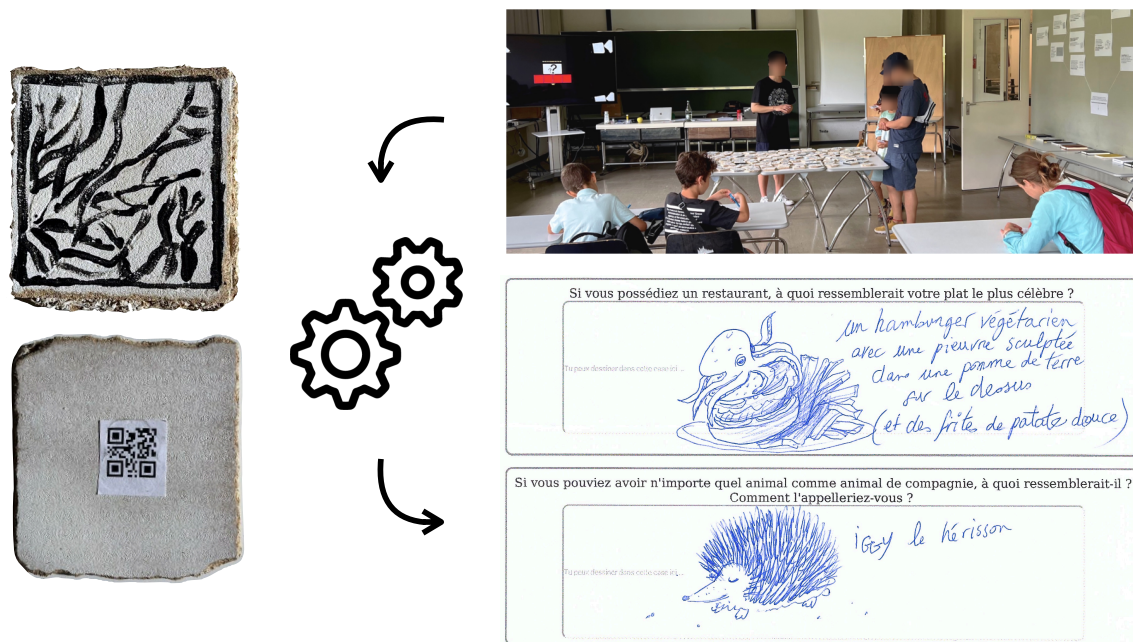


Figure 1: An early Hybrid design prototype. Event visitors (*Top-Right*) received worksheets with *personalised prompts* (*Bottom-Right*) using objects (*Left*) from a table of options (100+). Translations: ‘If you owned a restaurant, what would your most famous dish be?’: ‘a veggie burger with an octopus carved into a potato on top (and sweet potato fries)’ (*Bottom-Right, Upper*), ‘If you could have any animal as a pet, what would it look like? What would you call it?’ : ‘Iggly the Hedgehog’ (*Bottom-Right, Lower*)

to those who have found introspection historically tricky. For a complete picture, we would compare digital and analogue versions alongside a third ‘hybrid’ group to assess the advantages of using one paradigm exclusively or integrating both.

3.1 Early Prototyping

Over several months, we iterated on concepts incorporating proficient self-reflectors’ strategies. This process involved discussion and prototyping, from descriptive texts to sophisticated mock-ups. This development period contained an opportunity to participate in a university outreach event attended by thousands to gather large-scale feedback. In a prototype for the event, visitors selected objects from a table of options, each with a QR code. Visitors could scan them with a bar-code reader attached to a single-board computer. Their selections were processed using a Python script, and a printer delivered a *personalised* worksheet of reflective prompts.

We designed the prototypes with crude pictographs derived from a random list of nouns to maintain ambiguity and avoid bias (see Figure 1). Each worksheet prompted participants to draw or write responses, fostering ‘active, persistent, and careful consideration’ as per Dewey [25], in line with the motivational constructs of Self-Determination Theory (SDT) [87]. This approach aimed to address the psychological needs of Competency, Autonomy, and Relatedness by allowing spontaneous interactions that also felt personalised. During a four-day event, 348 participants engaged with our prototype. The initial two days involved school groups (ages 8 to 12), and due to child safety regulations, more extensive

data collection occurred in the latter half with a general audience, enabling richer one-on-one interactions.

Observational data revealed distinct patterns in how different groups interacted with the system. While most participants chose objects deliberately, some supervisors (teachers or parents) hastened the selection process, negatively impacting engagement. This interference contrasted with participants who selected without interruption, displaying a higher motivation and immediate interaction with the system. Feedback highlighted the system’s perceived complexity and approachability, though the design was straightforward, with randomly generated prompts for each object.

3.2 Final Design

The feedback from the event guided key design decisions for our experimental setup. Recognising that creating multiple sets of objects would be impractical, we opted for simplicity, which was well-received by users of the event prototype. This simplicity and the intentional ambiguity or ‘white space’ in the design promoted spontaneity, aligning with findings from earlier work. Researchers proceeded with further design iteration and discussion, leading to a system of *cards* with similar prompts. We believed cards would feel familiar to users, and it is a common metaphor in apps people use. It would also be easier to make our *Digital* version as close as possible to the *Analogue* counterpart, and /in a *Hybrid* group (with access to both), the choice to use one version over another would be attributable to *preference* or *convenience* instead of one version being ‘better’ (i.e. having *more* features). Finally, a card-based format is

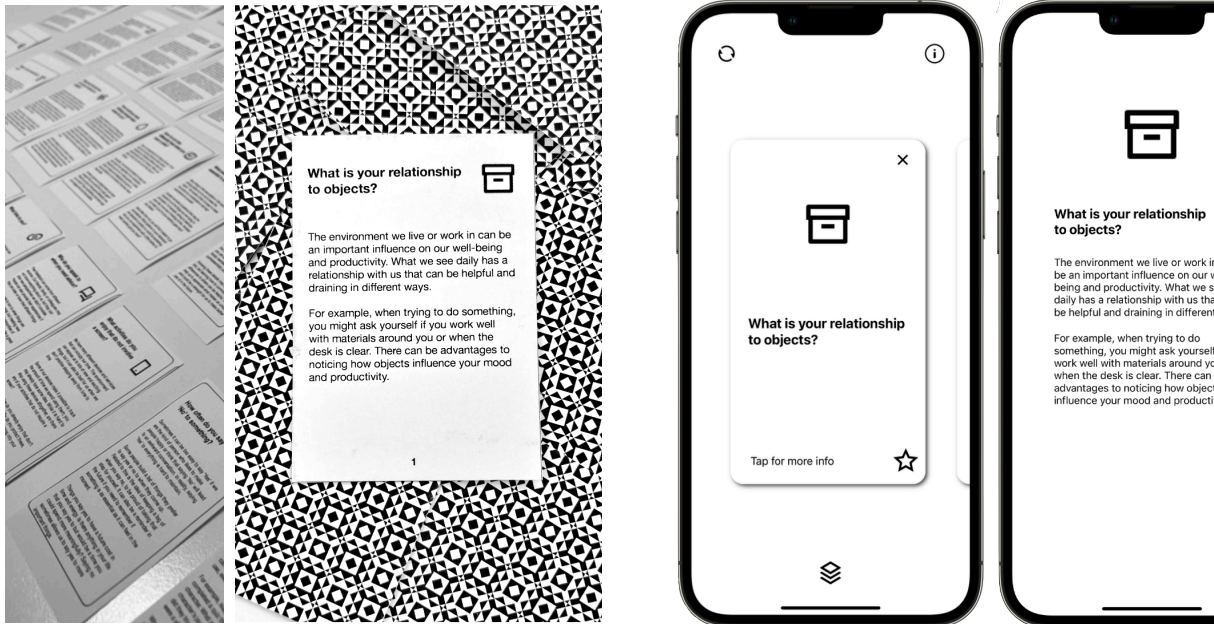


Figure 2: The Analogue variant using card stock (Left) and Digital iOS application (Right). The Hybrid formulation consisted of both.

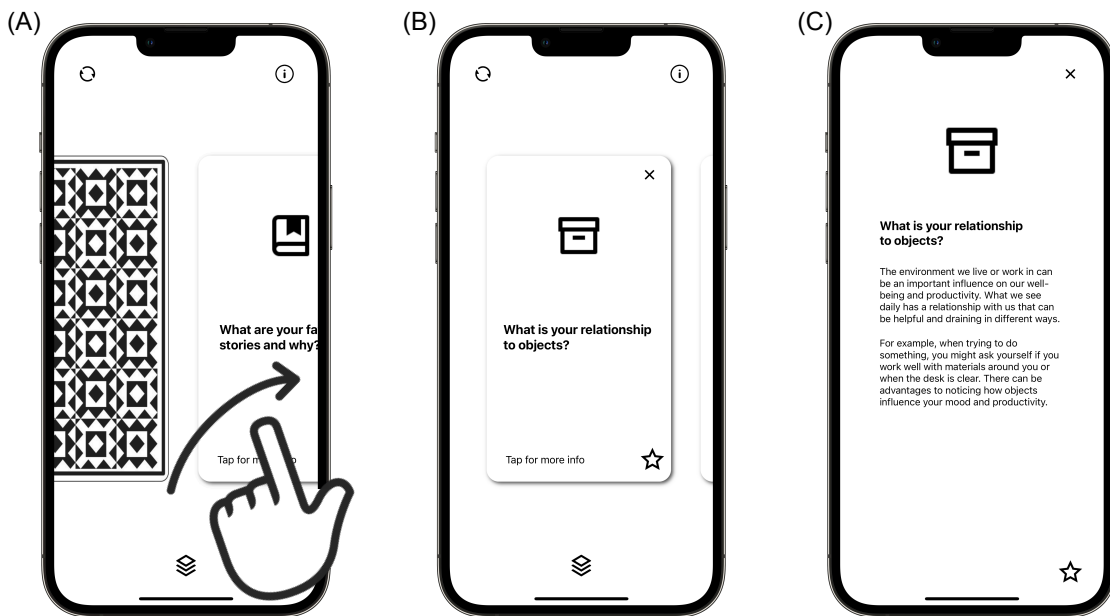


Figure 3: (A) 'Swiping' in the Default View, (B) the Default View whilst stationary, (C) detailed text in the Card View.

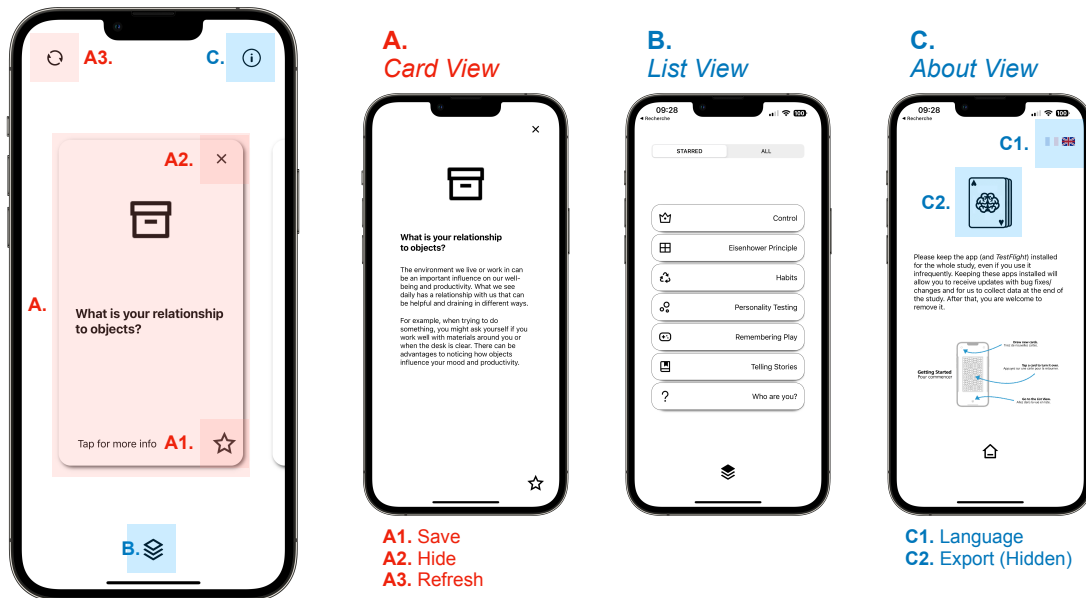


Figure 4: Interface elements/interactions zones of the application given to *Digital* and *Hybrid* participants.

inherently flexible, allowing participants to experiment close to the heuristic use we mentioned earlier and promoting their *Autonomy*.

The development of the digital and analogue versions was a collaborative effort between the first two authors, who maintained a unified design language and utilised common assets to ensure consistency across platforms. The application, built with Xcode [48] using Swift [47], featured interactive 'cards' that mimicked the physical experience of the analogue version. Users could interact with these cards by swiping or tapping, enhancing usability across devices of various sizes (see Figures 3 and 4). Key to the interface was the 'Card View,' designed for optimal readability, and an 'About View' that included tools for language selection and a 'hidden button' to export experimental data. Hiding this feature preserved the interface's appearance and addressed potential concerns about data privacy by allowing users to control if or when to share data.

The analogue version mirrored the digital design, using the same typeface, colours, and open-source icons [19], printed on standard playing card stock (300 g/m²) to avoid unfamiliarity and distraction. Texts for both the analogue and digital versions were produced in English and French, enhancing accessibility and ensuring uniformity across versions.

For the content, we selected 52 prompts randomly from a more extensive database developed for the earlier prototype, with each card featuring a unique icon and extended texts to stimulate deeper reflection 'on-action' or 'in-action' [89], or 'for-action' [40, 53, 70]. The design of these prompts was to promote 'active, persistent, and careful consideration' [25] without being overly time-consuming or stressful.

The first author primarily drafted and refined the final texts collaboratively for clarity. Native speakers of both languages then

reviewed the cards to ensure they were understandable to a general audience. Additional materials, including self-report and diary sheets and entrance and exit surveys, complemented the cards to enrich participant engagement. All components of the final design and the application source code are available on the Open Science Repository (OSF).²

4 METHODOLOGY

Our study used a mixed-method approach. The final design from the previous section became the basis of three experimental conditions, which we deployed along with a control group in a comparative six-week between-subjects experiment. Each participant got a design variant: either the physical version (*Analogue*), iOS TestFlight application (*Digital*) or both (*Hybrid*).³ The *Control* group received the same introduction as others but no tool/s. At the beginning and end of the experiment, we took measurements using the Self-Reflection and Insight Scale (SRIS) alongside additional open and closed survey questions deriving from an earlier study on the use of technology for self-reflection [100]. These questions were about what *activities*, *objects*, or *routines* were already associated with their reflective practices. We chose the SRIS because it is a consistent measurement in related work with validation across multiple languages. The SRIS has three sub-scales (*Engagement in Self-Reflection*, *Need for Self-Reflection*, and *Insight*), and these help distinguish individuals' reflective *activity* from their *inclination* toward it. We considered using the Technology-Supported Reflection Inventory (TSRI) as an

²Components of the final design in the Open Science Foundation repository <https://osf.io/7vbxax/>

³The source code for the application will be made available on the OSF repository <https://osf.io/7vbxax/>

alternative to the SRIS. However, because our comparison involves *Analogue* and *Digital* aspects, we believe the SRIS is a more agnostic assessment of self-reflection outcomes themselves (rather than the instrument supporting it). As the name implies, the TSRI felt a more appropriate measure for assessing an exclusively *Digital* design, and our comparison includes *Analogue* as well as a *Control* [8]. Lastly, intermediate 'self-reports' were sent out to provide insight into participants' experiences over the study.

4.1 Participants

Although there was no physical risk to participants, we were conscious of introspection's psychological influence. Individuals with psychological training ensured they were not harmful or ruminative when developing the card texts. As an additional precaution, we gave participants information about local psychological services if they needed support, and the introductory information clarified that they were not obligated to continue if they felt distress. As mentioned, the iOS application did not transmit data automatically, and participants could complete surveys independently. We also told them that sharing their private introspection (i.e. what they thought about or wrote about) was not a requirement to participate. We gave our University IRB a report detailing these measures, and after their approval, we recruited 63 participants (see Figure 5). Our recruitment used flyers around our campus and a participant pool maintained by the University. There were 31 women and 32 men participants; 53 were between 18 to 25 years old at the time of enrollment, a further 10 were 26 to 33 years old, and one was between 34 to 40. As expected in longitudinal studies, we observed a drop-out rate of 23.8% (n=15) by the end of the six weeks, leaving a final count of 48 active participants.

Participants who left the study listed reasons such as other time commitments they prioritised (e.g., exam preparation, supporting family members), unrelated illness or travel where it would be difficult or impossible to participate. Four participants were excluded from the analysis because they did not complete the necessary *Exit Survey* after several invitations. As the University of Lausanne offers courses in both English and French, we also collected information on the number of languages spoken by each participant ($M = 2.56$, $SD = 1.00$) as well as their preference between English ($N = 28$) and French ($N = 35$). Participants always spoke one or both of these, and the materials reflected the languages taught at the University. Participants could receive up to 82 CHF (eq. 93 USD) depending on how many self-reports they completed. The minimum they could receive for *only* the mandatory *Entrance* and *Exit* surveys was 30 CHF (eq. 34 USD). We ensured the conditions had no underlying biases related to age or gender to maintain the integrity of our subsequent analysis.

4.2 Apparatus

In addition to tool variants, each participant received further materials depending on their condition, and we gave them packs in identical envelopes after a random assignment. This pack included an *introductory sheet* welcoming them with an overview of what to expect over six weeks and contact details; they also received an *information sheet* describing the concept of self-reflection with examples of introspective or reflective activity. Unlike the *Control*,

the *Analogue*, *Digital* and *Hybrid* conditions received formulations of our tool in addition. The *Analogue* condition received identical decks of the 52 *physical* cards with instructions on using them, and *Digital* got instructions for downloading our app (which includes the same cards). Finally, the *Hybrid* condition received *both* (the app and physical cards) with their relevant instructions.

The cards' contents were a culmination of *Design* work described earlier, question-based prompts with expanding text on the topic or thought. We wrote these to encourage reflection on topics from different perspectives or how they could take different approaches in certain situations. Topics included their relationship to others (e.g., "What things are you connected to in life?", "Who was the last person you thanked, and why?"), distinguishing aspects about themselves (e.g., "What is your favourite sense?", "Do you play differently now than as a child?") or how they behave in life (e.g., "Who do you speak to when you need advice?", "How do you visualise important things?"). Prompts emerged from several iterations of random nouns and articulating reflection in the ways we had read about within the literature - e.g., 'on-action', 'in-action' (described by Schön) [89], and 'for-action' [40, 53, 70]. We gave the cards to colleagues in our laboratory and other professionals with a background in psychology at a partner hospital of the University to check. This step was to ensure the cards were accessible to readers of any level and that questions about specific topics were elaborated upon appropriately or sensitively (e.g., "What would you like to do before you die?", "What does it mean to you to be spiritual?").

We could not predict/know which cards or topics participants would prefer, and this was likely to differ from person to person. As such, we tried to ensure enough coverage and variety in topics that meant an individual would always be able to find *something* with the potential to spark "*active, persistent and careful consideration*" as Dewey describes [25]. Concerning well-being, the effort put into the variety was to broaden the chances of instigating reflection itself in the first place, and the tone or accessibility was to make it more likely that it was a helpful or positive experience. Any changes in the SRIS scores would help us to understand if their reflective activity (e.g., *need* for or *engagement* with) responds to our intervention. While it was likely that movements in well-being could also emerge from qualitative observations, we felt this would be more appropriate to examine in detail through a more extended study, *after* establishing the intervention encouraged meaningful differences at all. Our rationale, however, is that the emphasis placed on encouraging participants to understand situations or themselves from different perspectives (combined with the principles of SDT in our design) would be more likely to strengthen their abilities to act in everyday situations than not.

4.3 Procedure

We asked participants to complete an *Entrance Survey* (20 minutes) before receiving envelopes. During the six weeks, we sent three different self-reports via an online Google Form, short self-assessments (5 minutes) on their activities, tools and experiences in the preceding time. Participants also had diary sheets to record thoughts and return at the end. Participants returned to collect payments after completing an *Exit Survey* (20 minutes) when the

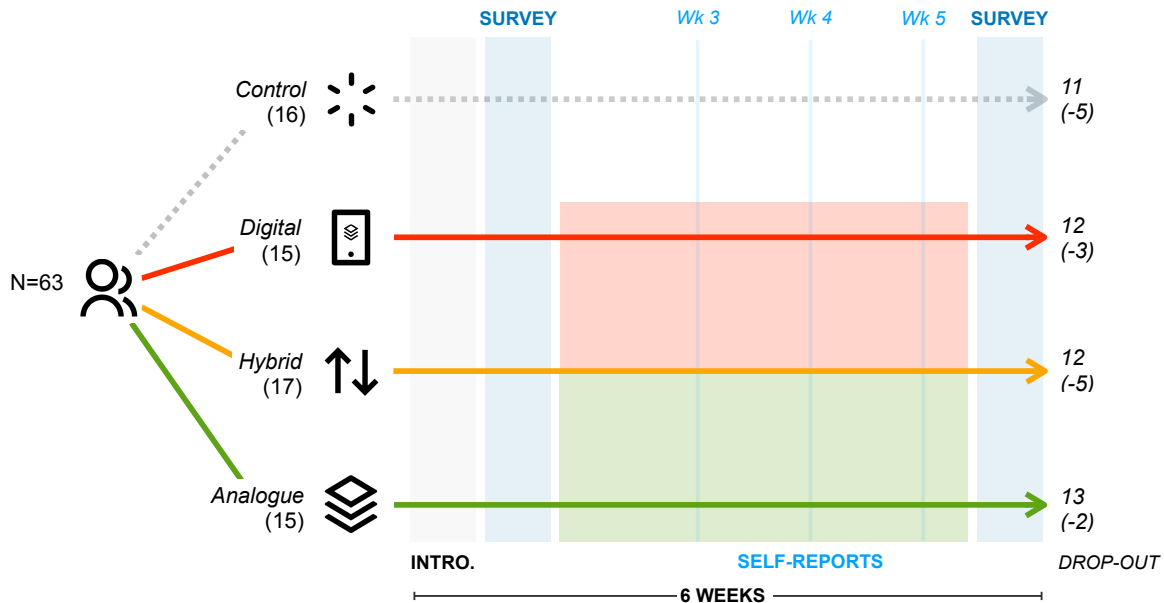


Figure 5: Overview of the six-week experiment, including participant numbers and group drop-out rates.

six weeks ended. Both surveys were mandatory (as they included the SRIS), and the diary sheets and self-reports were optional.

As we mentioned earlier, the questions for the *Entrance Survey* came from a study on a larger population of self-reflective practices and technology usage [100]. The *Entrance Survey* begins with the SRIS before questions on the *activities, objects, and routines* they are aware of (or use) for self-reflection. The survey concludes with another scale to assess life stressors in the past year. Known as the *Social Readjustment Rating Scale* (or SRRS), it has been validated many times in different fields for indication of contextual duress an individual may be experiencing [44]. The *Exit Survey* included the SRIS scale again for pre-post analysis and space for concluding remarks. The design intent for surveys was to contextualise participants' temperaments, engagement with self-reflection, and resources (analogue or digital). All materials are in our repository.⁴

4.4 Analysis

To analyse the qualitative data from surveys, self-reports, and diary sheets, we adapted Braun and Clarke's Thematic Analysis (TA) [11]; the first and second authors familiarised themselves separately with the open-ended responses before coding the significant features. Researchers undertook steps to generate, review, and define themes encircling different clusters when new codes became infrequent. Other researchers in our laboratory collaborated in discussions for additional clarity on interpreting themes.

For quantitative data, specific questions from the surveys (and not part of the SRIS) were closed-ended. We made summaries of

⁴Examples of surveys and self-reports on the Open Science Foundation repository <https://osf.io/7vbxal>

these and demographic information using descriptive statistics. In-depth analyses of the SRIS were with Python - specifically, the modules `statsmodel` [92] and `scipy` [104]. While we were able to conduct some time-series analysis of interactions with the application, we did not explore this extensively as it would not be possible to compare these with *Analogue* variant.

Our analysis focuses on the differences between groups in the SRIS measurements and how attitudes or experiences evolved. Our design aimed to increase the likelihood that participants would intuitively replicate the efficacious techniques seen in competent reflectors in earlier work. While our design *could* be the only tool our participants used, we did not wish (or expect) to constrain them. We were ultimately looking to see if *access* to the tool was associated with a difference in their ability by the end of the study. Forcing one approach would oppose SDT satisfaction of *Autonomy*, is likely to influence measurements, and is not reflective of real-world conditions. Because it would not have been as easy to collect quantitative measures in some of the paradigms (i.e. we could not track physical card use in the same ways as the app), our experimental design focuses on observations that could be made consistently across the conditions to scaffold our broader understanding.

5 RESULTS

The results from analysing data of 48 participants after six weeks suggest that design modality can have pronounced influences. The *Hybrid* and *Digital* formulations were associated with a statistically significant increase in the self-reflection (SRIS) scores, but each group saw changes. We will explore these variations and their implications, supporting researchers designing interactive systems

for introspection. Study materials can be found online in our repository.⁵

5.1 Statistical Analysis of SRIS Scores

5.1.1 Initial Group Comparison. We ensured no statistical differences existed between groups at the outset using a one-way ANOVA and a Kruskal-Wallis test on the *Entrance Survey* SRIS scores. This step confirmed that all groups began with similar distributions of insight, engagement and need for self-reflection. Additionally, we looked into the drop-out rates across the groups (See Figure 5); the drop-out rate was highest in the control group (31%) compared to the digital (20%), hybrid (29%), and analogue (13%) groups. This variation might reflect different levels of engagement with the design variants, potentially influencing the outcomes we report. Upon examination, most participants left the study due to unrelated illnesses or travel, which made it difficult or impossible to participate further. While some participants did not complete the necessary *Exit Survey* after several invitations or reported a need to re-prioritise their time into studies, these were mainly in the control group or evenly distributed across others. We believe that these drop-outs were, on a case-by-case basis, not related to the experiment, and participants in the control group (who did not receive a version of the tool) may have been less motivated to complete the *Exit Survey* compared to others after six weeks. We also could not find any other demographic similarities in the drop-outs that might point to issues in our design(s).

5.1.2 Pre-Post Intervention Analysis. A paired t-test and a Wilcoxon signed-rank test revealed significant improvements in the *Hybrid* group's *Need for Self-Reflection* scores ($p=.05$, *Wilcoxon*: $p<.05$), and in the *Digital* group's *Insight* scores ($p<.05$, *Wilcoxon*: $p<.05$). This suggests the interventions positively impacted participants' self-reflective capabilities (see Table 2 and Table 1).

5.1.3 Inter-Group Comparisons. Finally, we conducted pairwise comparisons between groups using one-way ANOVA and Kruskal-Wallis tests, complemented by Tukey HSD and Dunn post hoc tests. While the *Hybrid* group showed mean improvements overall, the differences to the other groups did not reach statistical significance. Note that our *Pre-Post Intervention Analysis* focuses on changes *within* each group compared to themselves. The *Inter-Group Comparison* was to ascertain differences *between* the groups. *Digital* and *Hybrid* did make significant improvements in six weeks compared to where they started; the differences may have been more pronounced over a longer time frame.

In summary, we used parametric and non-parametric methods to ensure that understanding was robust and comprehensive. They reveal advancements for the *Hybrid* and *Digital* groups that are worth noting. It would be a valid point that our tools' novelty effect may influence improvements; however, the same development was not a feature in the *Analogue* group, which also received a variant of our design. While it is true that participants in the *Hybrid* group saw statistical benefits, attributing this solely to 'more choice' is an oversimplification. Similarly, the *Digital* group also demonstrated noteworthy improvements. We believe a future study, in addition to

a longer time frame, could benefit from capturing user observations beyond the experimental period.

5.2 Qualitative Analysis and Emergent Themes

Moving into qualitative insights, we see a more precise picture of the complex interaction between participants and tools against the differences in the statistical backdrop. Our analysis resulted in four distinct themes concerning the design aspects that facilitated (or hindered) the introspective practices of participants: *Engagement Accessibility*, *Personal Resonance*, *User-Driven Customisation*, and *Design Flexibility*. We will elaborate and detail the experiences of the experimental conditions for each of these aspects.

Engagement Accessibility (henceforth Access): Codes relating to *Access* were when participants referred to their engagement (or non-engagement) with reflective practice with attribution to the *accessibility* of our design. In this context, *Access* refers to the direct ability to use the tool. Participants' quotes could include reference to the *portability* of the tool, whether it was *convenient* or *intuitive* in moments they were motivated.

The *Digital* group appreciated the user-friendly 'card-based' design and the app's convenience, especially in mobile contexts. While finding the card-based approach intuitive, the *Analogue* group also derived significant additional value from the tactile nature of physical cards. They appreciated the physical interaction, feeling it facilitated a deeper engagement with the material. The tangible aspect of handling and arranging the cards was seen as meditative and reflective - aiding their cognitive process and emotional connection to content. Meanwhile, participants in the *Hybrid* group commented similarly about each version with a utility of free choice to select an approach that matched their specific situation.

[P58 (Male, 18–25, Hybrid) in 1st Self-Report, Week 3]:
"I took time in public transport to ask myself questions with the application."

Although we built our design modalities to be functionally and aesthetically identical, the *tangible* cards could also be problematic. For P11, in our *Analogue* group (without *Access* to a *Digital* version), losing their cards was consequential and highlighted the difference they were making to them.

[P11 (Female, 18–25, Analogue) in 2nd Self-Report, Week 4]: "For a few days, I could not find my pack of self-reflection cards. During this time, I noticed that I was more stressed and anxious. I think it proves that sitting down each day with some calm music to do a bit of self-reflection really does have a positive impact on my well-being."

Hybrid participants, with *both* variants of our tool, seemed less likely to disengage or postpone reflection than other conditions. Our design was helpful for both *Analogue* and *Digital* groups, but participants could practice most *consistently* with access to both.

Personal Resonance (henceforth Relevancy): The theme of *Relevancy* encapsulates codes where participants described aspects of our design as appropriate to preferences or needs. This theme is distinct from *accessibility*, which often outlined an 'appropriateness' afforded by the *form* of the design from the *impact* and function of it. *Relevancy* in our terms is when the design of our tool appeared

⁵All study materials are accessible on Open Science Foundation (<https://osf.io/7vbxax/>)

Score	Digital-(EN-EX)	Digital-PR(>S)	Control-(EN-EX)	Control-PR(>S)	Analogue-(EN-EX)	Analogue-PR(>S)	Hybrid-(EN-EX)	Hybrid-PR(>S)
E	-0.25	0.74	-1.28	0.21	-0.47	0.63	-1.25	0.31
N	0.58	0.44	0.00	1.00	-1.24	0.11	-2.59	0.05*
I	2.83	0.02*	-0.10	0.94	-0.24	0.81	-2.01	0.33

Table 1: Multiple paired t-test Entrance (EN) versus Exit (EX) across subscales E = Engagement in Self-Reflection, I = Insight, N = Need for Self-Reflection

Score	Digital-(EN-EX)	Digital-PR(>S)	Control-(EN-EX)	Control-PR(>S)	Analogue-(EN-EX)	Analogue-PR(>S)	Hybrid-(EN-EX)	Hybrid-PR(>S)
E	-0.25	0.73	-1.28	0.27	-0.47	0.75	-1.25	0.47
N	0.58	0.67	0.00	0.71	-1.24	0.11	-2.59	0.04*
I	2.83	0.02*	-0.10	0.79	-0.24	0.89	-2.01	0.38

Table 2: Multiple Wilcoxon test Entrance (EN) versus Exit (EX) across subscales E = Engagement in Self-Reflection, I = Insight, N = Need for Self-Reflection

to be facilitating (or blocking) the reflective process. For example, when a participant referred to the tool as *helpful, though-provoking, or meaningful*.

[P19 (Male, 18–25, Analogue) in Exit Survey]: *"I tried to vary a bit what I was doing, to think differently, to examine my thoughts from another angle, I experimented with activities that I had never done before. I think the activities mostly changed at the beginning, when I tried new things."*

There was often a link to how relevant participants found the tool to sensitivities that include aspects of gender, culture and other preferences. Cultural trends toward using electronic devices less were one reason to express a disposition toward paper and pen methods. There was often an entanglement of technological perceptions and whether a modality was more or less 'suited' to their needs. The disposition toward technological support in a 'personal' activity appears to correspond with broader identity issues and relationships with technology. In a practical example, some chose paper and pen because they *knew* devices were too distracting - that it was easy to switch to other apps. Participants also needed time to find rhythms or habits that work for them. With any tool, we can expect it will take time to integrate into the user's lifestyle or routines - this may not occur if the user is dissatisfied enough. *Hybrid* participants seem to have found it easier to find compatibility with their temperament and, in some cases, choose one over the other outright.

[P61 (Male, 18–25, Hybrid) in Exit Survey]: *"I really liked the cards more than the mobile app. They are nice and easy to follow...I think the mobile app is completely unnecessary. The cards were more helpful for me."*

In all conditions, participants commented positively on the *variety* of prompts in the cards. Many codes beneath this theme relate to the explicit mentioning that these altered their perspective or gave scaffolding to develop aspects of themselves.

[P63 (Male, 18–25, Digital) in Exit Survey]: *"The cards were really nice with interesting points and questions. And the tips helped a lot to elaborate on my thoughts."*

However, to retain a fair comparison to the physical version, the content of these prompt cards was identical in the app, and there was no machine learning or recommendation. This necessity often meant that users were required to sift through cards to find ones that stood out. In a rarer case, a participant might describe 'boredom' or 'tiredness' with the same cards in either variant.

[P11 (Female, 18–25, Analogue) in Exit Survey]: *"At some point, doing self-reflection with the same cards again and again became a bit long and therefore less motivating."*

User-Driven Customisation (or Adaptation): In *Relevancy*, we described the appropriateness of our tool for individuals and that it could lead to frustration when cards became repetitive or seemed less suited to their needs. The theme of *Adaptation* corresponded to coded statements where our participants address such issues through *extending* or *adapting* the design themselves.

Participants across all conditions were found to have creatively reshaped aspects of our tool materially or conceptually. These changes included modifying the cards (e.g., marking cards they read, highlighting passages) or finding new approaches to using them. We noted that these kinds of changes often corresponded with another theme in parallel - for example, creating a routine to use the cards when the activities would be most approachable (*Access*) and picking the card that seemed to resonate with them the most from a certain number (*Relevancy*). In practice, this could be picking four cards after breakfast and focusing on the most compelling. We saw variations in the number of cards chosen (e.g., picking the first from the top, picking six or more at a time) and where or when participants chose to engage (e.g., public transport, leaving or arriving home).

The cards contained short texts with questions to evoke user thinking, some encouraging them to write responses. As such, a common strategy involved another tool, such as a new page in a journal or note-taking app, to capture their thoughts. This behaviour was not unexpected, given the nature of the prompts, but some saw content elsewhere and 'extended' the collection of prompts we provided. These could be concepts they came across in life, social media, or studies that felt important, and creating *new* cards that mimicked

the style or structure of the originals was relatively easy. In one example, a *Analogue* participant had seen a post on Instagram that was a series of images with similar prompts; she wrote these on small flash cards and added them to the others. Similarly, whilst it was less common, some employed cards as ice-breakers for discussions with others. One participant explained that parsing their introspective thoughts with someone close was more helpful than drawing or writing about them.

[P02 (Female, 18–25, Digital) in 2nd Self-Report, Week 4]: "I've started to talk with my best friend about my self-reflections, and this helped me more than drawing or writing."

In another example, the discussions highlighted differences between participants and their partners. They could then appreciate that their partner approached introspective thoughts wholly differently, which fostered a better understanding of them and themselves.

[P39 (Female, 18–25, Analogue) in Exit Survey]: "I have used the "self-reflection" cards to get to know my significant other better...Previous to this, I thought everyone took the time to go over their emotions and self-reflect with their own method. However, it turned out that when a situation occurs (that I believe self-reflection will be beneficial), he blocks out such thoughts and emotions. When I went over the cards, I could instantly form answers to the questions. However, for him, he could not answer as he had never thought about such aspects of his life and told me to think of such questions were 'too draining'."

For the design of our tool, participants made it clear that the card-based approach was easy to grasp, and this may help them to shape the exercises or content to their circumstances. Uniquely, however, the *Hybrid* group experienced a complementary benefit of the design. Because of consistency *between* versions, participants in that condition mentioned using the cards, even if they were travelling or forgot the physical version, with identical strategies. The experience acquired using one variant was applied across both, allowing the practice minimal disruption if circumstances meant they had to use the version they preferred least.

Design Flexibility (henceforth **Modularity**): Similar to the proximity shared by *Access* and *Relevancy*, our last theme shares resembles *Adaptation* but is fundamentally distinct. In *Modularity*, codes corresponded to comments that referred to the design's flexible nature. While *Adaptation* covers how participants built upon or modified our design, *Modularity* refers to the design features enabling this customisation.

In practical terms, participants could digest and map the elements of our design to their needs. While adaptations are distinguishable in their own right, *Modularity* often manifested in codes that mentioned discrete ways the participants *broke down* or *divided* the design of our tool to facilitate experimentation.

For some, the modular aspect of cards allowed them to develop adaptations more *intuitively*. Some compared the design to 'flashcards', appreciating how they could manipulate and prioritise them. Flashcards typically serve a different purpose - for retrieval or practice, and our cards have no 'correct' answers. They may evoke

entirely different responses each time. Often, participants established routines or practices as the basis of their adherence strategy. In this sense, the comparison to flashcards is justifiable, as the repetitive exposure to specific prompts made it easier for them to attain feelings of 'Competence' or 'Mastery'.

[P11 (Female, 18–25, Analogue) in Exit Survey]: "Having a structure with (picking and reading) the 4 cards a day made it easier and more motivating to do some self-reflection."

As described in *Adaptation*, participants often felt comfortable going 'beyond' the cards, whose content they describe as short and 'approachable'. Participants sometimes employed similar strategies with the cards to *other* introspective practices, which felt encouraging or complimentary. They often referred to habits or routines they built in ways that were consistent with the content.

[P32 (Male, 18-25, Digital) in 1st Self-Report, Week 3]: "It pushed me to take 10 minutes in the morning and evening to meditate."

In the case of the *Analogue* and *Hybrid* conditions, creating cards was relatively straightforward if they chose to. As this was not an anticipated behaviour, it was difficult for our *Digital* condition to replicate with no facility to *add* new cards in the application. Adjacently, participants creating new (paper) cards in the *Hybrid* condition would then encounter disparity between the *Digital* and *Analogue* variants. In the example of a participant creating cards from similar prompts she had seen on Instagram, she did not encounter this issue because she was in an *Analogue* group.

5.3 Summary

Finally, we end this section with a quote from an *Analogue* participant who felt their sense of 'mastery' develop over the experiment. For them, our tool seemed an excellent match for their temperament and context. In ideal conditions, a reflective tool can be what someone needs at the right time and place.

[P39 (Female, 18–25, Analogue) in Exit Survey]: "As the routine of self-reflection became more frequent during the experiment, I felt it took a shorter period of time to analyse how and why I felt a certain way/acted a certain way in a situation."

However, our results encapsulate complex ways individuals engage with self-reflective tools in reality. Although consistent introspection has been linked to improvements in well-being, it may also be harmful in excess and our analysis underscores factors that influence a self-reflective tool altering SRIS measures firstly - the quality of introspection occurring is an intuitive next step to optimise. We found that the ease of access to the tool and its relevance to individual preferences and needs was significant to engagement. The capacity for participants to adapt and personalise the tool, whether it was the physical interaction with the *Analogue* version or the digital convenience of the *Digital* format, enhanced their introspective experience enough to adopt it's sustained use on some level. However, in the *Hybrid* condition, participants seem to have been able to capitalise and multiply the benefits in a pronounced way. We surmise that for our tool to become embedded, to the extent that SRIS scores *did* change, users have found advantages in using

them in the six weeks. As we will expand upon in the next part, this is an important beachhead where other improvements might be explored and further study can help us understand more the ways that this can be sustained or optimised even further.

6 DISCUSSION

Our study delved into the differences between a tool to support introspective activity in digital, analogue, and hybrid modalities. Concerning our original research questions, we first saw improvements in all conditions *and* the *Control* (RQ1). This result suggests that even an orientation (and periodic self-assessment reminders) were enough to elicit change in post-experimental measures. Though we did not give them a version of our design, our *Control* was not passive. Many explored the topic for themselves, keeping reflections in the Notes app of their phone, buying a notebook and trying different apps. The intention of this group was not a representation of non-engagement with the concept or practice of self-reflection. Instead, they were not *supported* beyond the introduction. Their improvements were impressive but modest, and we believe the difference in conditions is far more revealing. In contrast, these participants saw *amplified* changes.

This finding leads to our second research question that there *was* different degrees of change in the SRIS scores of conditions (RQ2). More specifically, the *Hybrid* and *Digital* participants experienced statistically significant improvement - in the *Hybrid* condition most of all. In line with Schön's description of reflection as an activity that comes in different forms [89, 91], when encouraged (regardless of modality), it has value to us. However, design affordances of certain paradigms seem to have a stronger or weaker influence. Participants change with access to any variant, but *which* impacted the degree, and we believe the quantitative difference becomes more accessible when appreciated alongside qualitative themes. These determinants develop *distinctions* between the ways paradigms facilitate - particularly concerning the extent and consistency (RQ3).

Participants noted the card-based design was 'easy to understand' in all conditions, but *Hybrid* participants enjoyed a *multiplication* of that strength. Their condition could switch between the tactile and electronic versions without 're-learning' conventions. Their practice was less exposed to interruption than participants with access to one modality (*Analogue* or *Digital*). If they were in situations that blocked their use of one variant, the other was still accessible, and also when *enthusiasm* for a format developed over time. While self-reflection and card-based approaches to encourage it have appeared in the literature before [31, 32, 97], this study targeted introspection as an activity in its own right - not in a specific use case. Prior work often focuses on *specific* aspects or outcomes, such as psychological resilience [30], decision making [26], and professionalism [55]. However, introspection for well-being often encapsulates many life aspects and moves between them. Though some worry about the *implications* of technological use on psychological well-being in recent years [58, 63], our work articulates an optimistic development. Our position agrees that we should be cautious of solutions that rely on technology exclusively, but we reason that it may be less *optimal* and *efficacious* overall. We postulate that in the future, a similarly hybrid design, in *combination* with

adaptive components, could potentially augment the improvements we have seen and expand our rationale in the following sections.

6.1 Hybrid Solutions Avoid Cognitive Fixation

Interactive systems to encourage user introspection will often attempt to *digitise* (all or part of) analogue approaches that are known to be effective. This strategy can work on some level because users exploit their existing understanding to learn the 'new' interface, and our design also exploits this effect through cards. The problem is that self-reflection involves a dialogue with oneself that can occur in many contexts, and human factors like energy or enthusiasm can fluctuate daily. Our results indicate that systems purposely designed for deployment as a pair, *Digital and Analogue*, may be more effective than one or the other alone. When the variants are consistent in appearance and functionality, the likelihood of meaningful use increases because transferable experience may reduce hesitance. Another reason may be that access to both versions allows engagement in more situations, user states of mind, and across *types* of reflection as Schön describes (e.g., reflection-in-action, on-action, or for-action) [89]. This inherent flexibility also accommodates Baumer's observation on the *many* definitions of what constitutes introspection in literature [6] and the equivalent variety in the general population [100]. At a more superficial level, it seems a hybrid solution can be most effective at facilitating *persistence* - a key component in Dewey's outline of self-reflection (i.e. "*active, persistent, and careful consideration*") [25].

Like other interactive systems, extended or obsessive engagement with digital tools may become counterproductive or ruminative [17, 29, 46] and hybrid designs afford a natural opportunity for self-regulation. Users can disengage more easily from the technological approach without losing the ability to sustain their reflective process, potentially mitigating *maladaptive* practice [96, 98] by engaging cognitive processes in different ways. The choice of options can also be a way to regulate distractions—for example, using a *Analogue* tool to avoid seeing notifications or switching to other apps like Instagram and Twitter, or using the *Digital* version because they are self-conscious about writing in a journal or reading a 'self-help' book on public transport. We must consider sub-processes of meta-cognition as well [24, 62] and how visceral aspects like *tactility* or *latency* in tools may alter the user experience—the *functional* differences in brain activity between the modalities we present here are also a place to explore.

Contrary to one or the other approach, our findings suggest that *Digital* or *Analogue* aspects do not need to be hierarchical. Hybrid designs may be most effective when they embody each version as equals - rather than one being 'lesser' or 'complementary'. We believe that by Dewey's definition of reflection as *active* or *persistent* [25], the *Hybrid* formulation was less obstructive and flexible when needed. From that perspective, it may be that the opportunities (or surface area) for participants to encounter the desirable outcomes of new *insights* and *conclusions* were more reliably consistent. It can be tempting to envision the opportunities of digital systems and lose sight of users' needs or how they change. Digital tools come with challenges that we see in the sensitivities of our participants. For example, for many, self-reflection is viewed as a solitary or private activity and although a small number of participants asked

about the possibility of our application having a way to record thoughts in the future, most preferred to keep their *actual* reflection in private spaces like a journal or note. Their predominant use of any tool (paper or digital) was to often to *start* the process. Designers may also wish to consider the social features cautiously for similar reasons. While Self-Determination Theory (SDT) emphasises the importance of relatedness and social connections, our study found that participants engaged in this aspect subtly. While a small number used cards to others, most use discrete insights to prompt meaningful discussions with others, fulfilling their need for relatedness more indirectly. This kind of ‘sharing’ could be a better kind of *Relatedness* satisfaction to encourage through design choices than including social features to share verbatim content.

6.2 Modularity Supports User’ Intrinsic Motivation

Our findings advocate for greater recognition of the malleability of introspective practices or the design of interactive systems to encourage them. By focusing on Modularity and Adaptability, we can empower users with greater control over their introspective experiences. This perspective is crucial for HCI researchers and practitioners, emphasising the need to shift from traditional, rigid designs to more flexible and user-centric ones. By ‘user-centric’, we mean designs that allow users to personalise their interaction more directly. For instance, an introspection app could offer customisable question paths based on individual user preferences, or a digital journal might adapt prompts in response to previous entries.

Additionally, a hybrid tool could combine digital convenience with the tangible feel of physical elements, like combining an app with a physical journal, offering users the choice of medium based on their mood or situation. This need for inherent flexibility aligns with what we have seen in prior research - that self-reflection is relevant to many circumstances or states of mind. While research often pursues outcomes in areas such as *therapeutic* [7, 9, 81, 85], *educational* [20, 52, 66, 102] and *athletic performance* [38, 51], it is evident that the process is far more fluid across contexts. Our participants describe their practices moving between perspectives or topics, and this was also a feature of the representative sample of a population in previous work [100]. We believe that creating tools that evolve and adapt based on ongoing user feedback is crucial. Ensuring they can remain relevant for various practices or temperaments, including permutations that seem atypical or *deprioritise* the digital aspect. Our study’s success with flexibility and user control points to a valid conviction that we must continue to learn about user engagement and motivation across paradigms [3, 4], particularly with processes involving the self.

We highlight how crucial it is to fulfil the psychological needs of autonomy (the need for self-direction) and competence (the need to feel skilled and capable) to make the activity of introspection itself an engaging prospect for a user. According to SDT, satisfying these needs is vital for developing a behaviour into something natural and *intrinsic* [87]. In the Hybrid condition – where participants used a combination of digital and analogue tools – a participant could choose to use a digital app when on the go for convenience but switch to physical journaling at home for a more tactile, reflective experience. This flexibility in the hybrid approach, treating

both digital and analogue methods equally valuable, appears to satisfy these psychological needs more effectively - much as the choice between a physical map or GPS can be more appropriate to certain kinds of journeys. In HCI, especially in well-being, it must understand and accommodate user fluctuations for a design to be genuinely *user-centric*. To offer users *multiple* paradigms may meet their needs more holistically. Our approach was fundamentally *decentralised* as well, with those paradigms being as identical as possible for comparison. Many existing Hybrid products have both elements, but one paradigm will often be ‘primary’ and the other a ‘companion’ - our design made variants equal, with no functionally ‘better’ version.

6.3 Adaptation Can Be Proactive and Reactive

In this study, our design was intentionally *non-adaptive*, so our comparisons between conditions were as fair as possible. As we have shown, because it was intuitive, many users still found ways to adapt the design themselves. We refer to this as *proactive adaptation* - where users took the initiative. The other possibility for these interfaces is *reactive adaptation*, where tailoring of interface or content is in response to user interaction. In our study, which did not have such a system (in the prototype or the final design), some participants asked if the app presented cards because of others they interacted with earlier. While we could not comment until the experiment was complete, this was *surprising* to participants when they told them later. These individuals could build *narratives* and connections around disparate elements. We see this as an opportunity to explore as it suggests that any *reactive adaptation* may not need to be as sophisticated if users were still able to *find* relevance in a design without processes of anticipation.

In prior work, we identified that many focus on individual use cases and populations [6]. While it is understandable that researchers would wish to focus on their respective fields, we believe our work addresses gaps at an *underlying* level that will help those targeting *particular* forms of introspection as well. We envision there is potential for hybrid designs which can serve *multiple* purposes through aforementioned *Modularity* as well. What we mean by this is that a system could be *extended*. Such expandability could be especially appropriate in the health care setting, where conditions can evolve or encompass different co-morbidities. In one scenario, a therapist beginning work with a new client could introduce prompts and activities *gradually* as they work through in-person therapy or coping strategies across multiple diagnoses. Other professionals (e.g., physical therapists and guidance counsellors) could contribute to the same database, giving the end user access through a single holistic interface.

The critical point is that adaptation in both forms (proactive and reactive) may provide a way to continuously balance the facilitation of basic psychological needs from an SDT perspective [87]. The modularity and accessibility of our design seem to have been helpful for participants’ needs for *Autonomy* or *Competency*. We believe it would be possible to add reactive adaptations to improve *Relevancy* satisfaction and retain the neutrality of a *Hybrid* solution. A digital tool could include functionality to export PDFs for printing, and completed materials could be re-imported to use as feedback for *reactive adaptation* in a digital component. Although inappropriate

for our comparative design, the ‘personalisation’ of prompts in our prototype would be a promising development strategy. It is not unprecedented to imagine that technologies already available for rapid document scanning or test grading (subtle design features or markers that aid computer vision) could be incorporated into printed sheets to reduce user friction. For interoperability, longevity, and life cycle, we imagine this system using an existing approach to language-independent data formatting (i.e. JSON) or a markup language (i.e. Markdown) that is easy for humans or machines to read - also simplifying the expandability we suggested earlier.

6.4 Limitations

In assessing our methodological approach, it is important to recognise several limits. Our design was to encourage the *persistence* of introspective practice in any form [25], and we did not restrict participants to using our tool/s alone. We believe enforcing exclusive use could negatively impact observations - by compromising the psychological need for autonomy [87]. This choice does mean an absolute picture of participant engagement is complex. Scale also constrained our ability to deeply examine certain aspects, such as the novelty effect of the tools or a comparison of improvements against the participants’ existing introspective practices. In addition to a larger sample or duration, we suggest that future research include post-hoc free will engagement, user satisfaction, and a more diverse population. Diversity of the population is especially worth noting as our experiment relied on a pool of individuals from the University community, which may be a common practice of many studies but comes with inherent limits. The limited diversity and number of participants in this study may affect how our findings generalise. Future research should aim to include a broader demographic to better understand the universal applicability, allowing a more thorough understanding of whether the effects are likely to *persist in consistent* ways across different dimensions. Finally, our work predominantly follows the definitions of self-reflection given by Schön and Dewey - as active and persistent consideration in various orientations [25, 89, 91]. We echo the call of Baumer by following his recommendation to be *explicit* about the definitions we refer to and acknowledge the many other interpretations (amongst researchers *and* users alike) [6]. We would also add that although our work made efforts to ensure that participants would experience positive outcomes for their well-being through reflection (e.g., through the tone and content of the cards), our experimental design and research questions focus on capturing if these design variant made meaningful differences in SRIS scores. Research suggests that consistent introspection can be linked to positive well-being changes but it can also be problematic in *excess*. Our qualitative observations do suggest participants found well-being improvements, but this is more difficult to measure and would be appropriate to a detailed analysis on a longer time frame. What we can say with more confidence is that, for a *system* with these goals, certain design paradigms alter or encourage introspective behaviours more than others. Beyond the platform of delivery, researchers must also optimise the *content* in a considered manner to ensure the most desirable outcomes from user reflection.

6.5 Future Work

We saw that applications (e.g., Day One, stoic) that partially or predominantly encourage self-reflective activity were already popular amongst our participants. That digital support is something that many are open to and actively pursuing is promising and not unexpected. It makes sense that users want ways to engage in introspection with the devices already integrated into their lives. There is still a way to go before we consider these solutions mature from a design perspective. We share the position of Calvo and Peters that technology can promote our well-being - perhaps in ways that augment it beyond what has been possible before [14]. However, we cannot assume that prior work on self-reflection, pre-dating personal devices like the smartphone, is directly translatable to the modern situation. Even relatively recent work is grounded in technologies from a ‘distant’ past (e.g., SMS, pagers) and digitising analogue methods like-for-like misses opportunities. Ways for designers to discover unexpected approaches to accommodate introspective experiences and build beyond the horizon.

As large companies like Apple begin to include more health and ‘wellness’ features in their operating systems [105], it is essential to scrutinise their efforts. With a recent release of its mobile operating system (iOS 17.2), Apple brought a new ‘Journal’ application to all iPhone users by default. While the design is reminiscent of existing applications like ‘stoic’ [94] and ‘Day One’ [1], as a *first-party* application, it can benefit from a far deeper integration. Apple’s ‘Journal’ app can suggest topics and media facilitate writing from information gathered directly from device sensors or usage patterns. A ‘Suggestions’ API was made available in parallel, allowing existing applications also to bring similar inferences to their designs, and this may be an interesting opportunity for researchers to observe the impacts or machine learning elements across different styles of interface - either across apps that choose to adopt the API or by leveraging it in designs for their studies. However, an aspect worth stressing is that the exact processes Apple uses to create these suggestions are *opaque*. As we have discussed, while it is exciting to see corporate validation and expansion into this kind of ‘wellness’ - the characteristics of private or *proprietary* interests differ from research in the *public domain*. As a consumer electronics and services vendor, it is also likely that designs will be more technologically centric than *agnostic*, which may not be as advantageous for users as it is for the company. Companies can disproportionately influence which paradigms become the ‘standard’ for years, perhaps to discover that ‘older’ interaction models were more functional or natural for most people to use (e.g., voice assistants vs. LLMs).

Technologies like LLMs will also become highly relevant to this space. Public adoption of technologies based on transformer models (e.g., ChatGPT, Midjourney) has grown significantly. It enables new kinds of user-created content, and while some may argue on the *authenticity* of this kind of ‘expression’, it is not improbable to imagine an interface to support introspection by assisting users with less experience or confidence. We can imagine an interface that asks fundamental questions before articulating summaries of responses, perhaps accepting different kinds of media to write short journal entries on the user’s behalf. We expect these features to emerge but would doubt their ability to improve the generation of ‘new insights and conclusions’ [25] unless these interfaces encourage some form

of engagement or feedback with the content they generate. It would be interesting to evaluate different forms of adaptation against one another to understand whether one approach is better, as we have sought to do with different design paradigms. We could imagine these generative forms of AI as a way to create new user activities, tailoring to their previous interactions. In this case, aligning with our observations, the user would still complete the reflective component, and the generation could adapt across different inferences. These optimisations could include increasing or decreasing the difficulty of subject matter, writing complexity, or the form the prompts take (e.g., open-ended, yes or no, multiple choice). It also seems that participant preferences could be under the influence of factors such as age, cultural background, and socioeconomic status, suggesting a need to consider these dimensions in tool design as well.

7 CONCLUSION

This study sheds light on the situation of technology within introspective activities. We sought to understand if different formulations of a reflective tool had a stronger or weaker influence on the ability to self-reflect and the characteristics that might be important for researchers to consider amidst the development of similar tools. Although our tool was limited to ensure that the comparison was fair and did not ‘respond’ or adapt to the user, there were significant differences between paradigms after six weeks. While all groups improved, the *Hybrid* and *Digital* conditions saw statistically significant changes.

Our findings are meaningful to the HCI community as a concrete example of an artefact subjected to comparative testing in an empirical setting, accessible through our OSF repository for others to build upon.⁶ We believe it is the first example of such a design in HCI that takes a neutral design approach as well. As technology becomes commonplace in many aspects of contemporary life, it is appropriate to consider the when, where or how it can make differences in a manner that is *effacious*. Our guidance emphasises the criticality of *Access* and *Relevancy* in interactive systems that support introspective activity, especially that *Adaptation* and *Modularity* may be meaningful ways to enhance the user experience within this context. Underlying this, we show that form or format is consequential and that *Hybrid* formulations that respect this guidance relatively quickly impacted our participants’ self-reflection scores.

The modular nature of our final design is flexible enough for application in other domains. We welcome researchers to contact us if they require further guidance or are interested in how to configure our design for their purposes. This study is the first attempt at hybrid technological support of self-reflection with an inherently neutral and flexible design. Our design delivered greater satisfaction of users’ psychological needs, as SDT describes, with intentional agnosticism.

Rather than focusing on *user engagement*, we argue that support can be as and more effective if digital elements are fluid. This approach is also essential to address the concerns of Baumer, who recommends that HCI avoids rigidity in its definitions of self-reflection

[6]. We would add an avoidance of rigidity in application and that there is still much more to learn from dynamic sensibility. Our research supports this by showing the efficacy of a hybrid, adaptable tool. Whilst technology was a component, because it was not assuming a *central* or *critical* role, our participants were able to use it in a more discretionary manner when it was the most *appropriate*.

We also see many *design challenges* which interactive supports for introspective behaviour still must address. We have learned from our participants that *Access* and *Relevancy* can substantially undermine if the design poorly addresses them. Designs with greater *Access* are more likely to be used in the first place but must also be relevant enough that a user wishes to *continue* using them. Neither aspect is discretionary. Our findings suggest that *Modularity* and *Adaptability* are similarly entwined and may address these factors substantially. Designs with these qualities make it easier for users to tailor their experiences to their needs, which is crucial to activities of this nature. However, we see how personal and varied the activity can be. Our study’s empirical aspects challenge the HCI community with a quantifiable baseline for the argument that researchers should consider the hybrid approach seriously and that *exclusively* digital solutions could be at a disadvantage for these purposes.

Investigations into causal relationships between tool formulation and tangible improvements in self-reflection remain relatively tertiary in other studies despite the importance of this mechanism for many issues. Understanding the improvements seen here and how psychological needs (such as those outlined by SDT) were satisfied may shed light on critical prerequisites for systems that interface with profound human nature or motivation. Directing a narrower focus on this issue may be pivotal to a deeper understanding, allowing us to *anticipate* the impact of a design paradigm on introspective action before beginning to design a solution to facilitate it. Beyond HCI, our findings have broad cross-disciplinary implications, particularly for well-being in an epoch where analogue approaches are no longer predominant or prioritised, and technology is central in daily life. Our findings do not invalidate the research invested in digital approaches; they make the case that the image is still developing. Designs which are *intentionally* hybrid from the start may promote engagement and growth that could augment introspection more efficaciously than before. When designs for introspective tools are too exclusive to one modality, they can, at best, apply to a subset of users and only as long as temperaments or circumstances are constant or predictable.

Traditional care is likely to remain foundational for areas like mental health, and our findings validate the possibility of new pathways that may *complement* established practices without requiring radical upheaval. They may help empower individuals exposed within the ‘gaps’ of healthcare systems toward the greater satisfaction of *Competency* and *Autonomy* amidst challenging moments where they must manage their well-being without support. Although some of our findings may seem counter-intuitive in a field built around the technological perspective, the implications warrant optimism for an informed future for these applications - the ‘best of all worlds’.

⁶Study materials on the Open Science Foundation repository <https://osf.io/7vbxal/>, Last Accessed February 2023

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