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**Article**

# Happy Click!: Investigating the Use of a Tangible Interface to Facilitate the Three Good Things Positive Psychology Intervention

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The 'Three Good Things' (TGT), a structured journaling exercise, has shown great effect in helping improve mental well-being. However, the exercise could be quite tedious and difficult to carry out daily. To improve the user experience of the exercise, we developed 'Happy Click', a mobile application which makes use of a physically present smart button to enable users to record their daily TGT in a more engaging manner. Two preliminary exploratory studies were carried out to examine the feasibility of our approach where the effects of the TGT intervention designed around the mobile and tangible happy click concepts were examined. The findings suggested that participants had significantly less stress after carrying out the TGT using the tangible interface. Participants also reported better user experience and acceptance when carrying out the exercise using the tangible interface compared to the mobile and higher levels of attractiveness and stimulation with the mobile TGT compared to the traditional approach. While these promising results should be interpreted with caution due to the limited sample size, they also underscore the potential advantages of our 'Happy click' approach and highlight the need for further, larger-scale evaluations to be conducted to validate its efficacy and scalability.

**RESEARCH HIGHLIGHTS**

- We developed HappyClick, a mobile application which makes use of a Tangible user interface to facilitate the Three Good Things (TGT) positive psychology exercise
- The results from preliminary studies, albeit with small sample sizes, suggested that the tangible and mobile TGT was able to significantly reduce stress
- Users reported significantly higher levels of attractiveness, stimulation and intention to use with the mobile TGT compared to the traditional TGT
- Users reported highlighter levels of effectiveness, stimulation and intention to use with the physical button TGT compared to the mobile TGT

*Keywords*: *mobile devices; consumer health; ubiquitous computing*

## 1. INTRODUCTION

Following the rapid development of mobile technology, smartphones have evolved beyond being a mere tool to facilitate communication to become increasingly ubiquitous and essential in our daily lives. Recent studies have shown how these devices can be adapted and used to support activities in a variety of domains such as in sports and education (Crompton and Burke, 2018; Hosseinpour and Terlutter, 2019). Healthcare is one area which has especially benefited from this technology, with studies showing how mobile devices can be used to support healthcare practices in a number of ways, such as by facilitating self-monitoring activities (Alessa *et al.*, 2018) and supporting clinical diagnosis (Rowland *et al.*, 2020). In mental healthcare, researchers have found that digital interventions could be delivered through mobile devices in a more personalized, timely and cost effective manner (Bidargaddi *et al.*, 2020; Baños *et al.*, 2022) and as such, this technology has shown promising results in supporting the treatment of a variety of mental disorders such as depression and substance abuse (Blankers and Mujcic, 2017; Porras-Segovia *et al.*, 2020).

While traditional uses of mobile technology in mental health tend to focus on preventing users from developing serious mental illnesses or supporting their recovery from mental disorders which have a detrimental effect to their psychological well-being, a small number of studies have also begun to investigate how this technology could be developed to enhance the general well-being for healthy adults (e.g. moving from 'Mobile Mental Health'

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to 'Mobile Well-being' (Gaggioli and Riva, 2013)). This use of psychology not only as a means to 'cure' mental illnesses, but also to build positive traits and practices which lead to improvements in the quality and satisfaction with life has been termed as 'positive psychology' (Seligman and Csikszentmihalyi, 2014). A notable intervention in this domain is the 'Three good things' (TGT) journaling exercise, which posits that by writing down three good things that went well during the day each night, participants would improve their ability to recognize genuinely good things that occur around them which in turn would help cultivate positive cognition and emotions (Seligman *et al.*, 2005). Overall, the TGT intervention has been found to help reduce depression, emotional exhaustion and improve happiness (Sexton and Adair, 2019).

Despite the effectiveness of the TGT intervention, the exercise can be quite tedious and difficult to carry out daily (Frein and Ponsler, 2014) as this requires participants to remember and note down detailed events which occur in their daily life. To facilitate this process, researchers have proposed using various mobile systems such as messaging apps (messages are sent through the online chat application from the research assistants to remind users to submit details of their positive moments) (Guo *et al.*, 2020) and SMS messaging services (users are asked to submit their TGT entries through text-based SMS messages) (Lam and Kahler, 2018). While these features help remind users to carry out the activity, the intervention itself still require a considerable amount of effort.

In our study, we explored the possibility of using mobile and tangible interaction to facilitate the TGT exercise. We devised a happy click design, in which, by using either a virtual happy button on a smart phone interface or a physical button created by attaching a Bluetooth button to a wristband, we created a mechanism that allows users to effectively record moments of happiness in real time: on the moment they encounter them during the day. For the tangible interface, the presence of the button also serves to help remind users of their task. In addition, the physical sensation from 'pressing the button' together with the self-initiative taken to record the positive events was expected to result in a more engaging experience.

Overall, we aim to address the following three key research questions in our study.

RQ1) Would the TGT intervention, when designed around the happy click concept using a mobile interface, be effective in improving mental well-being and how would such an intervention compare to a traditional TGT intervention in terms of user experience and intention to use?

RQ2) Would the TGT intervention designed around a tangible user interface be effective in improving factors related to mental well-being such as stress, happiness and depression and how would such an intervention compare to a TGT intervention designed around a mobile user interface?

RQ3) Would the use of a tangible user interface to implement a TGT intervention based on the happy click design improve user experience and intention to use when compared to a mobile based interface?

To address these research questions, we carried out two exploratory experiment studies. The first was a preliminary study which investigated the effects of the TGT exercise when carried out through a mobile application designed based on the happy click concept in comparison to the traditional approach (RQ1). In the second experiment, we investigated how a tangible user interface could be used to further enhance the underlying experience of carrying out the TGT exercise by implementing a 'physical happy button' in comparison to the 'digital happy button' used in the mobile application (RQ2 and RQ3).

## 2. RELATED WORKS

In this section, we briefly discuss three key areas of research that are relevant to the work in this paper. First, we highlight previous studies that have shown how mobile technology has been used to support mental healthcare. Afterwards, we discuss positive psychology and their interventions, focusing especially on the Three Good Things exercise. Finally, we discuss previous studies that have examined how digital technology could be used to facilitate the aforementioned Three Good Things exercise.

### 2.1. M-health: The use of mobile technology to support mental healthcare

Accessibility in the mental healthcare is increasingly important, with almost one in four of people worldwide being at the risk of developing mental health issues (W. H. Organization, 2001). Mobile technology offers a relatively low-cost, highly accessible and potentially effective resource for mental healthcare and has been widely used in this context for a variety of purposes such as for self-management, cognition improvement, social support and symptoms tracking. Mobile applications such as Youper (Mehta *et al.*, 2021), Calm (Huberty *et al.*, 2019) Headspace (Mani *et al.*, 2015) and Happify (Parks *et al.*, 2018) are frequently recommended to users who have concerns related to Depression, Anxiety or Stress and have even been used as an adjunct to traditional psychotherapies (Lui *et al.*, 2017). While the interest in mobile mental healthcare applications have been increasing in both industry and academia (Wasil *et al.*, 2020), several important questions have remained unanswered regarding their efficacy, usability and engagement. For example, even though the demand of m-health technologies is driven by actual user needs (e.g. to fill in the treatment gap due to lack of mental health professionals), the efficacy of many of such technologies has not been tested and there have been calls for more concrete design guidelines and more reviews about their efficacy (Bevan Jones *et al.*, 2020; Lattie *et al.*, 2019). In addition, the mobile mental healthcare applications currently available today are highly concentrated on supporting the treatment of common mental disorders such as Depression and Anxiety, resulting in fewer attention on applications which aim to enhance an individual's overall psychological well-being (Gaggioli and Riva, 2013). It still remains relatively under explored whether m-health technologies, which can deliver promising results in treating mental disorders (Chan *et al.*, 2014) can be similarly effective when developed to enhance an individual's psychological well-being. To the best of our knowledge, literature regarding how such technologies could be designed and developed and whether they are effective is scarce. As such, it is worth exploring whether positive psychology interventions can also be adapted into effective m-health technologies, especially when the majority of mental healthcare services are offered to treating mental disorders, but fewer resources are available for individuals who seek positive psychology interventions.

### 2.2. The three good things exercise

While early psychological research focused mainly on diagnosing and treating individuals who develop mental disorders, more recently, a number of psychological researchers had introduced a new domain that aims to facilitate personal growth and improve mental well-being and the quality of life (Seligman and Csikszentmihalyi, 2014). Positive Psychology researchers propose that

certain intentional activities can result in a significant impact to our level of happiness and based on that proposition, have developed a variety of positive interventions, including The Three Good Things, which aims to nurture an individual's positive feelings, behaviors and cognition (Sin and Lyubomirsky, 2009). Various studies have shown how the TGT exercise can help decrease depression and improve happiness (Bolier *et al.*, 2013; Seligman *et al.*, 2005; Sin and Lyubomirsky, 2009). In addition, burgeoning literature has also shown that positive psychology interventions can also be applied to other domains such as reducing burnout for employees in an organization (Donaldson *et al.*, 2019; Meyers *et al.*, 2013) and improving academic performance for students (Waters, 2011). While positive psychology interventions are promising in cultivating an individual's well-being, similar to other journaling-based exercise activities, previous studies have found the TGT exercise to be quite tedious and not so engaging. In one study, 22 out of the 60 participants dropped out of the study before the first week (Frein and Ponsler, 2014). Overall, it was difficult to continuously engage participants throughout the exercise (Rippstein-Leuenberger *et al.*, 2017) which has stimulated calls to develop tools that make the TGT exercise more accessible and enjoyable (Sexton and Adair, 2019).

### 2.3. The use of digital technology to support the three good things exercise

Given the challenge to engage participants with the TGT exercise, recent studies have begun to examine how digital technology can be used to facilitate the intervention process or to motivate participants to persist longer in the exercise. For example, several studies have attempted to use gamification technologies to increase motivation and to improve adherence to the exercise, with preliminary results being promising (Kelders *et al.*, 2018; Wu, 2020). However, researchers have also cautioned against the long term use of gamification to enhance interventions aimed at improving mental well-being, as they question whether the idea of 'winning' or the concept of 'rewards' typically used in gamification are actually helpful for promoting the autonomous motivation that is required for those interventions to be effective in the long term (Pogrebtsova *et al.*, 2017). Other studies have implemented the TGT exercise through social media platforms such as Facebook. While the findings indicate that adding a social component to the exercise can be beneficial (e.g. sharing happy moments with others), users were generally cautious about who might have access to information about their recorded happy moments (e.g. public vs group friends) (Munson *et al.*, 2010). For a large number of the studies however, digital technology was used as a means to remind and prompt users to carry out the exercise, either by implementing the intervention through a chat based application and sending messages to remind users (Guo *et al.*, 2020), prompting participants to carry out the exercise through automated notifications sent from social media platforms (Munson *et al.*, 2010) or through daily email reminders (Rippstein-Leuenberger *et al.*, 2017). Previous studies have even suggested that recommender systems could be developed to highlight nearby locations that might provide opportunities of positive affect for individuals who might struggle to notice such events in their daily life (such as those with low self-esteem) (Suzuki, 1997).

In our study, we examined the use of tangible user interfaces as a means to facilitate the TGT exercise. The concept of tangible user interfaces was initially introduced by Ishii and Ullmer and referred to an approach which allows users to interact with digital content directly using their hand (Ishii and Ullmer, 1997). This method was thought to help improve the communication between humans and computer systems by providing users with a direct touch experience and immediate perceptible feedback. In such an interface, physical objects are generally used as both an interface and interaction device for users to engage with a digital system (Hornecker and Buur, 2006). In our case, we used a smart button as the tangible interface. Each user was provided with a smart button that can easily be carried around in their daily life, and whenever they encountered a good things moment, users could easily record that moment by 'pressing down' on the physical button. While research into the use of such interfaces is more common in the domain of education and entertainment (Zhou and Wang, 2015), healthcare researchers have only begun to examine their use, mostly in the context of self-monitoring. Examples include studies which have developed tangible user interfaces to help users self-report their pain (Adams *et al.*, n.d.) as well as their moods and emotions (Sarzotti, 2018). Some studies have even proposed the development of specially designed fidgeting tools as a relaxing and enjoyable way for users to self-report their emotions (Fuentes *et al.*, 2015) or monitor their mental wellbeing (Woodward and Kanjo, 2020). Smart buttons have also been identified as an effective way to facilitate self-reporting and one study has shown how they could be used to aid in the reporting of medication intake to promote adherence (Ellis *et al.*, 2019). Researchers have even proposed a term, 'Intentive computing', to describe how this approach of allowing individuals to consciously trigger a system through a simple interaction (e.g. pressing a button) while providing immediate feedback to prompt them to reflect on their actions could be beneficial in providing both real-time relief and also serving as a memory anchor, helping users recall specific events more vividly (Ferrario *et al.*, 2017). Overall, these studies showed that compared to a traditional computer screen interface, tangible user interfaces have the potential to provide a more accessible, appealing and engaging way to self-record information about ones' daily life. Given such potential benefits, we had speculated that a tangible user interface could also be used to enhance the user experience and effectiveness of the Three Good Thing positive psychology exercise, especially when compared to a traditional mobile interface. This has also been confirmed through a series of iterative design sessions which were carried out (see Section 3.1). The immediate physical feedback from a tangible interface such as a smart button could make users more mindful of their action while recording a positive moment, allowing users to recall them more vividly later on and as a result, help reinforce positive memories (Ferrario *et al.*, 2017). Furthermore, the physical presence of the device could also serve as a constant visible reminder to encourage users to self-record positive moments in daily life and the ease in which users are able to do so (pressing a button versus having to access an application within their mobile phone) could improve their user experience as they participate in the exercise (Ishii and Ullmer, 1997). Despite such benefits however, few studies have made use of such interfaces to support positive psychology interventions and inspired by this knowledge gap, our current study examined whether they could indeed be useful in supporting the self-reporting process used in the TGT exercise.

## 3. DESIGN AND DEVELOPMENT OF THE HAPPY CLICK SYSTEM

In our study, we developed 'Happy Click', a mobile application which makes use of a tangible user interface to enhance the underlying experience of users when carrying out the TGT exercise. In particular, the original TGT exercise was found to be quite

tedious as (i) it was difficult for participants to try to accurately remember the 'Good things' events which had happened during each day and (ii) participants often forgot to carry out the exercise and tend to need daily reminders (e.g. (Rippstein-Leuenberger *et al.*, 2017)). By making use a smart button, which both serves as a physical reminder for the exercise and allows users to record positive moments easily and effortlessly at any time during the day, we hope to make it easier and more engaging for users to recollect and reflect on the good events which happen during their daily life.

### 3.1. Initial conceptualization of the Happy Click system

The initial conceptualization and design of the system was based on our earlier work which sought to develop interactive technologies to improve resilience and well-being for people in stressful occupations (Jain, 2016).

Initially, nine concepts were generated based on several approaches used in positive psychology. Concepts included, for example, 'problem bank' a concept which people would try to post and solve each other's problems and 'plus button', an earlier iteration of the happy click concept, which encourages people to consciously watch out for positive moments by providing a tangible artifact that allows users to record such experiences. After an evaluation with 12 participants, the 'plus button' concept, which was based on the Three-Good-Things exercise, was found to have the most potential and was selected for further refinement.

After analyzing the original Three-Good-Things exercise and conducting a series of iterative user studies, we confirmed that (i) Having the task of identifying positive moments during the day made people more receptive toward such moments and could serve as a useful reminder, (ii) Attempting to provide an explanation and reflecting on the moment at the time of recording proved to be too cumbersome, (iii) The interaction within the exercise could be broken down to the moment of registering the positive moment and reflecting on the positive moment, (iv) Reflection should be done at night (as an indication that the day had ended) or at a time indicated by user and prompts such as the time and location of the recorded moment of happiness would serve as a useful reminder, (v) The interaction qualities of registering the moments should be instantaneous (be of minimum effort) and mindful (be aware of the moment) and the interaction qualities of reflecting on the moment should be savoring and inviting. Based on these insights, several concepts of a tangible interaction device which could be used register the positive moments were devised and evaluated with end users (e.g. a camera attached to a keyring, touchable wooden panel attached to smartphone, smart textile and an interactable fitness band which could be squeezed or pressed etc.). The interactable fitness band was selected as the final concept, and this concept was implemented in our study by using a Bluetooth smart button attached to a watch wristband. Users could press on the button on the band to register their positive moments.

### 3.2. The TGT mechanism in the Happy Click system

In the Happy Click system, we modified the original procedure in which participants had to recall the 'Good Things' events from scratch every night to a mechanism where participants use their mobile device to record whenever a 'Good Things' event happens to them during the day (without adding any details) and later during the night, would try to recall the details of each recorded event and reflect upon why the event made them happy. A smart button is used as a tangible user interface to allow users to record their 'good things' event more easily during the day. In a sense, the interaction of users with the tangible interface was designed to conceptually mimic their interactions with a camera, in which users 'press down' on the 'camera shutter button' to capture a picture of an important life event. The physical sensation from 'pressing the button' and the active initiative taken to record the positive events during the day (as opposed to passively recalling them during the night) was thought to create a more engaging experience in the exercise. A small user test carried out with eight participants during the conceptualization of our system had provided preliminary confirmation that this mechanism does indeed raise awareness toward positive moments and that participants generally enjoyed registering positive moments by pressing on the button and were able to reflect meaningfully on those moments at the end of the day (Jain, 2016). In addition, it should also be noted that as a consequence of allowing participants to record their 'Good things' event freely using the Happy Click button (both mobile based and physical buttons) during the day, they were able to record more than three good things each day. Previous studies have shown that this should not impact the effectiveness of the intervention, as one study found that the amount of recalled 'Good Things' did not have an effect on the mental well-being impact of the exercise (Bahník *et al.*, 2015).

Overall, two versions of this application were developed for use in the experiments that were carried out in this study. The first version, the mobile happy click application was developed and used in a preliminary study which aimed to investigate whether the TGT exercise would still be effective if it were implemented through a mobile application using our current design and whether implementing it in such a manner would improve user experience and acceptance in comparison to the traditional TGT exercise. The second version of the application, the 'Tangible happy click application' was developed and used in an experiment study which aimed to investigate whether the use of a tangible user interface (e.g. a 'physical happy button') enhances user experience and the effects on mental well-being in comparison to a traditional mobile interface (e.g. a 'digital happy button').

### 3.3. The Mobile Happy Click application

The Mobile Happy Click application used in the first study was developed as a progressive web application using Ionic React.[1] The mobile application consists of three pages: (**i) an authentication page** where users login to use the system for the first time, (**ii) a record happiness page** which contains a virtual button that users use to record the exact moments when 'a good thing happened' or when they 'felt happy' during the day and (**iii) a happiness log page** where users are shown a list of 'good thing moments' which they recorded during the day (with the date, time and location). At the end of each day, users can press on each of the recorded moment and are able to record details about what 'good thing' happened to them and to note down the reason why the event made them happy. Figure 1 shows screenshots of the application.

### 3.4. Tangible Happy Click application

The Tangible Happy Click application used in the second experiment had a similar interaction flow as the mobile application used in the first experiment. However, instead of using a virtual button interface, we used a tangible button interface. The tangible

[1] https://ionicframework.com/docs/react

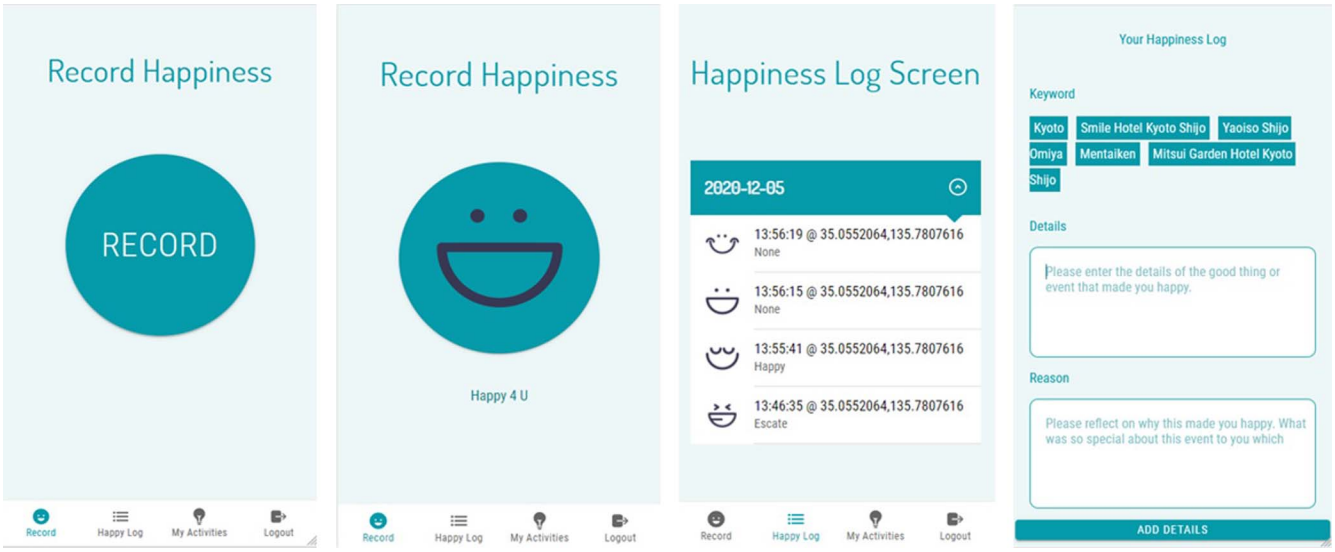



**FIGURE 1.** Screenshots of the virtual happy button application. (Left) the record happiness page, (middle left) the record happiness page after users press the button to record their 'good things moment', (middle right) the happiness log page listing the recorded moments and (Right) the happiness log page where users try to recall and record details of the 'good things' moments

button interface was developed using Flic2, a smart button that transmits a signal to a mobile device once it has been pressed. The button can provide haptic feedback through vibration.[2] The button was attached to a watch wristband which users wore during the experiment. They pressed the button whenever they encounter a 'good thing' during the day, and at the end of the day, they added details of each recorded moment through a mobile phone application (using a similar process as the one used with the Mobile Happy Click application). The Tangible Happy Click application itself was developed using React Native [3] and has three pages. The first page is the home screen of the application which lists all the moments of 'good things' which had been recorded using the Flic2 button. On the second page users can add details about the 'good things' moments which they recorded during the day. On the third page, users can check their connection status to the Flic2 button. It should be noted that we had developed two versions of the Tangible Happy Click application, one used by the control group (where users recorded their 'three good things' moment using a virtual button) and the other which was used by the tangible interface group (where users recorded their moments using the Flic2 button). In the control group version, there was a 'plus' button on the home screen that users could use to add their 'three good things moment'. Figure 2 shows screenshots of this application and the Tangible button interface.

## 4. PRELIMINARY STUDY: EVALUATING THE MOBILE TGT INTERVENTION IN COMPARISON TO THE TRADITIONAL TGT INTERVENTION

Overall, two exploratory experiments were carried out in this study. The first, a small-scale preliminary experiment, adopted a within-participants design to examine the effects on mental well-being, user experience and acceptance of a mobile TGT intervention in comparison to the traditional TGT intervention. The studies were approved by the Institutional Review Board at [Removed for blind review] (A public university in Japan).

### 4.1. Study procedure

In the preliminary study, participants who agreed to participate in the study were first provided with a detailed explanation of the study process and then divided into two groups. Group membership determined the order in which a participant carried out the TGT exercise. This was done to control for order effects. Half of the participants first carried out the TGT exercise using the traditional approach (through google forms) and then carried out the TGT exercise using the mobile application (The Mobile Happy Click Application described previously in Section 3.3). For the second group, this order was reversed.

Before carrying out the TGT exercise, a pre-evaluation session was carried out to evaluate participants on metrics related to their mental well-being (perceived happiness, stress and depression). Participants were also provided with a brief tutorial on how to carry out the TGT activity using the system assigned to them based on their condition. The TGT exercise itself was carried out through a period of one week for all conditions. Previous studies had shown that this duration was sufficient for the TGT exercise and other similar positive psychology exercises (e.g. Three Good Things for others) to have a positive effect on mental well-being (Laguna *et al.*, 2021; Mongrain and Anselmo-Matthews, 2012; Seligman *et al.*, 2005). In the google forms condition, participants were provided with a link to a google forms page each day where they were asked to 'write down three good things that happened today' and 'write down why these good things made you happy' before they went to bed. These instructions were similar to those used in previous studies (Mongrain and Anselmo-Matthews, 2012; Sekizawa and Yoshitake, 2015). After carrying out the TGT exercise, a post-evaluation session was carried out, where participants were asked to fill in questionnaires to evaluate their mental well-being after carrying out the TGT exercise as well as their experience of conducting the exercise using the system assigned to them in their condition. Before moving on to the next TGT exercise condition as part of the within-participant study protocol, participants

[2] https://flic.io/
[3] https://reactnative.dev/

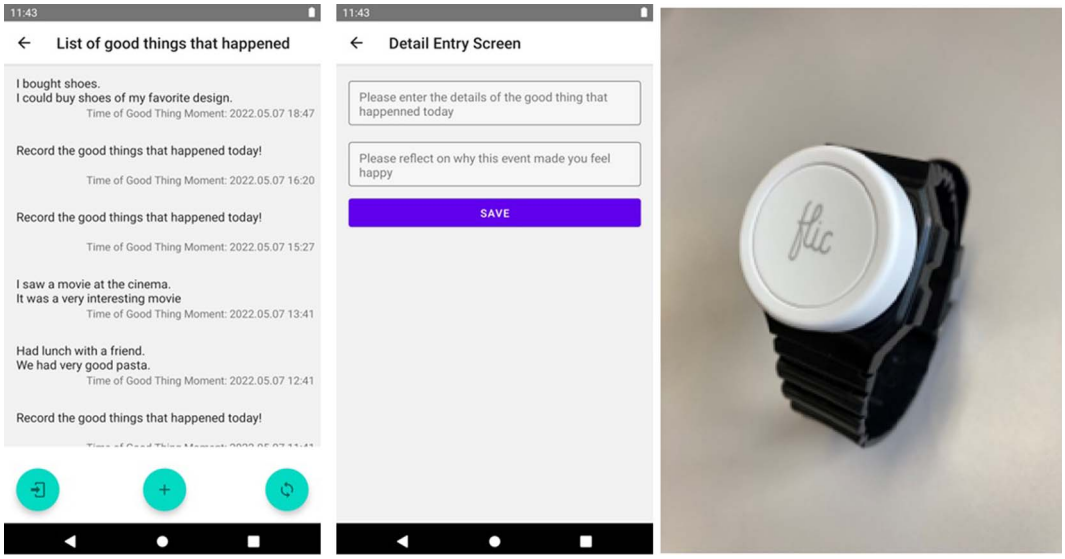



**FIGURE 2.** Screenshots of the Tangible Happy Click Application. (left) the home screen page (the plus button at the center of the screen is the digital button in the control group version that was used to add the 'good things') (middle) the add details page where users try to recall and record details of the 'good things' moments (right) the tangible button interface which consists of the Flic2 button attached to a watch wristband.

were also provided with a rest period which lasted 1 week to lessen the learning effects of the earlier TGT exercise.

## 4.2. Participants

Participants were recruited through convenience sampling from a university student population in Japan. Participants were Bachelor and Master students between the ages of 20 and 25. Eight participants completed the preliminary experiment (nine started, of which one dropped out during the study). Of the eight participants, seven were male and one was female. Participants had no prior experience with similar mood tracking or mental health tracking applications and were not compensated for the study. In addition, as far as we know, participants had no prior history with mental illness.

## 4.3. Evaluation measures

Two categories of measurement data were collected. The first are (i) measurements related to mental well-being (depression, stress and happiness) and (ii) measurements related to user experience and technology acceptance. Japanese versions of these questionnaires were used in this study.

### 4.3.1. *Mental well-being measurements*

To determine whether the intervention was effective, we examined three psychological metrics related to mental well-being. These metrics were areas of mental well-being which the TGT had been found to be particularly effective (Richardson and Sheffield, 2019; Seligman *et al.*, 2005; Sexton and Adair, 2019). The first was **perceived happiness** which was measured using **the Oxford Happiness Questionnaire (OHQ)**. This 29-item self-reported questionnaire was devised as broad unidimensional measurement of personal happiness and is one of scales commonly used to assess subjective well-being (Hills and Argyle, 2002). The questionnaire utilizes a six point Likert Scale response format and has been found to have good internal consistency and reliability (Cronbach's alpha of more than 0.9). Next, we measured **perceived stress** using the **Stress Response Scale-18 (SRS-18).** This scale consists of 18 items that measure perceived stress based on three dimensions (depression-anxiety, irritability-anger, and helplessness) using a four point Likert scale (Suzuki, 1997). The item scores in this scale are summed up to provide a total score which represents the participant's psychological stress. In addition, we measured **depression** using the **Center for Epidemiological Studies Depression Scale (CES-D)**. This 20-item measure was developed to screen for depression and contains questions which assess a wide range of depressive symptoms. Participants rate the frequency in which these symptoms occur on a four-point Likert scale. The sum score of the items represents the participant's level of depression (Orme *et al.*, 1986).

### 4.3.2. *User experience measurements*

The **User Experience Questionnaire (UEQ)** was used to measure the experience of users as they carried out the TGT exercise. The questionnaire contains scales which measure both the Usability and User Experience when users engage with an interactive system (Schrepp *et al.*, 2017). These scales include **Attractiveness** (the overall impression of users with the system), **Perspicuity** (Whether it was easy to learn how to carry out the activity), **Efficiency** (How efficiently were they able to carry out the activity), **Dependability** (Whether users feel in control of the process), **Stimulation** (How excited or motivating did users feel) and Novelty (Whether users felt interested in the system).

### 4.3.3. *Technology acceptance measurements*

**The Technology Acceptance Model (TAM)** was used to measure the degree to which participants were acceptive toward carrying out the TGT activity through the different mediums (pen-and-paper, mobile interface, tangible interface) (Yairi, 2016) (See Appendix A for the English Version of the questionnaire). While the TAM was initially developed to gauge an individual's acceptance toward new technology and determine what factors (e.g. **Perceived Usefulness** and **Perceived Ease of Use**) might influence their **intention to use** the technology (Lee *et al.*, 2003), in our study, we use the constructs from the TAM as standalone measures. This was based on the rationale that these measures could also serve as holistic indicators of their respective factors (e.g. **Behavioral Intention to Use** serving as an indicator of the participant's motivation and intention to carry out the TGT activity). As one of

the aims of our study was to examine if there was a significant difference in whether users are interested in carrying out the Three Good things using different mediums (and if there is a difference in perceived usefulness and ease of use between the various systems), we decided to leverage the measures as singular metrics to independently evaluate the factors they represent across the different mediums.

### 4.4. Data analysis

The data were analyzed with the IBM SPSS Software (Version 26). To determine whether the data showed a normal distribution, we examined the Skewness and Kurtosis values for each variable. Variables which had a Skewness and Kurtosis value between −1.5 and 1.5 were considered to be normally distributed (Trochim and Donnelly, 2006). In such cases, parametric tests were used to analyze the results. For variables which were not normally distributed, we used the equivalent non-parametric tests to conduct our statistical analysis instead. It should also be noted that due to the low sample size and the high correlative nature of the dependent variables which we would be examining (e.g. measures related to mental well-being which are similar in nature to each other such as happiness, depression and stress), we decided to analyze the effect of the different TGT interventions on each dependent variable separately (rather than altogether through a method such as MANOVA) to avoid issues related to multicollinearity. Furthermore, due to the preliminary nature of our study and the limited sample size, we had also opted for a more cautious approach with regards to applying statistical corrections for multiple comparisons. Applying such stringent correctional methods with a small sample size could lead to over-adjustment, as prior studies have shown that while such statistical corrections could be suitable for studies with a large sample size, they could impose severe penalties and substantially increase the type II error rate when applied to statistical tests with small sample sizes (Nakagawa, n.d.; VanderWeele and Mathur, 2019). This risks obscuring meaningful insights in the data or potential areas of interest which could warrant further investigation with larger confirmatory studies. As such, given the balance between minimizing false positives and preserving the ability to detect true positives, we opted to not implement corrections for multiple comparisons in this study.

## 5. PRELIMINARY STUDY RESULTS

When analyzing the results of the first preliminary study, we examined (i) pre-post changes in measurements related to mental well-being for both the traditional TGT intervention which was administered through google forms and the TGT intervention which was administered through our mobile application and (ii) differences in user experience, user acceptance and the effects on mental well-being between the two TGT interventions.

### 5.1. Pre–post effects on mental well-being

Paired *t*-tests were carried out to investigate the mental well-being impact of the TGT intervention when carried out through the traditional approach and with the mobile application. The results showed that there was a significant change in **Perceived Stress** ($t(7) = 2.63$, $P < 0.05$) and **Depression** ($t(7) = 4.98$, $P < 0.005$) 1 week after users had carried out the TGT intervention using the traditional approach. More specifically, participants had **reduced stress** (before: mean SRS score = 18.25, SD = 10.40, after: mean SRS score = 13.75, SD = 8.14) and **reduced depression** after (before: mean CES-D score = 21.5, SD = 6.82, after: mean CES-D score = 14.38, SD = 4.34) conducting the exercise. However, there was no significant change in **perceived happiness**.

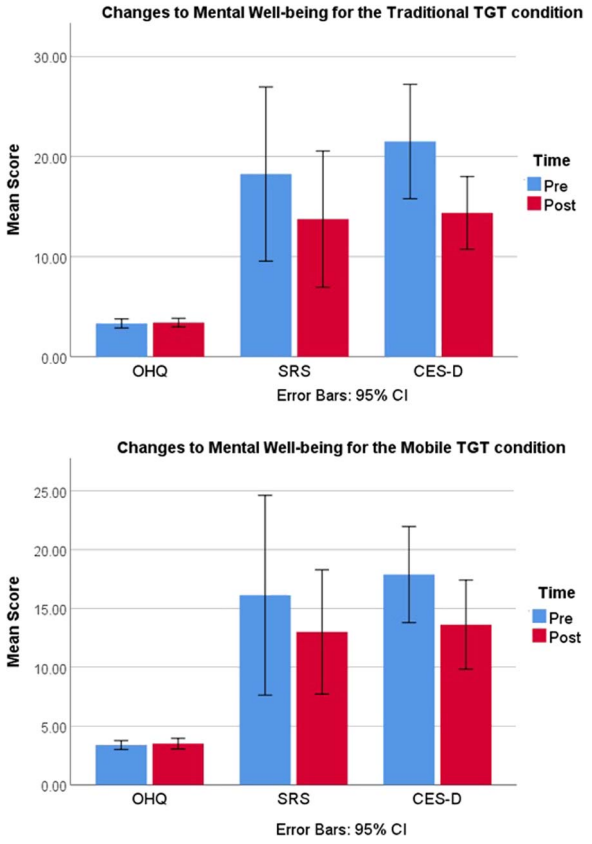



**FIGURE 3.** Changes to mental well-being for participants who (i) carried out the intervention using the traditional approach and (ii) the mobile application in the preliminary study

For participants carrying out the TGT intervention using the mobile application, we found that there was a significant change in **depression** ($t(7) = 3.325$, $P < 0.05$) and a borderline significant change in **happiness** ($P = 0.08$) but not in **stress**. Overall, participants reported less depression (before: mean CES-D score = 17.88, SD = 4.88, after: mean CES-D score = 13.63, SD = 4.53) after carrying out the TGT intervention with the mobile application. Figure 3 shows the changes in mental well-being after carrying out the intervention for participants in the first study.

### 5.2. Differences in user experience, intention to use and the effects on mental well-being between the TGT interventions

To examine whether there was a difference between the intervention type (mobile vs traditional) with regards to changes to mental well-being, we carried 2 × 2 Mixed ANOVAs. Time was used as the within-participant factor in the test and the between-participant factor was the intervention type. While the results showed that the main effect for Time was significant for **stress** ($F(1,14) = 6.275$, $P < 0.05$) and **depression** ($F(1,14) = 35.110$, $P < 0.001$), there was not a significant Time x Intervention-type interaction between the three mental well-being measures.

In regards to user experience, as the variables **Attractiveness, Perspicuity**, **Stimulation** and **Novelty** in the UEQ questionnaire was not normally distributed, Wilcoxon Signed Ranked tests were carried out to investigated whether there were significant differences in user experience between the TGT intervention with

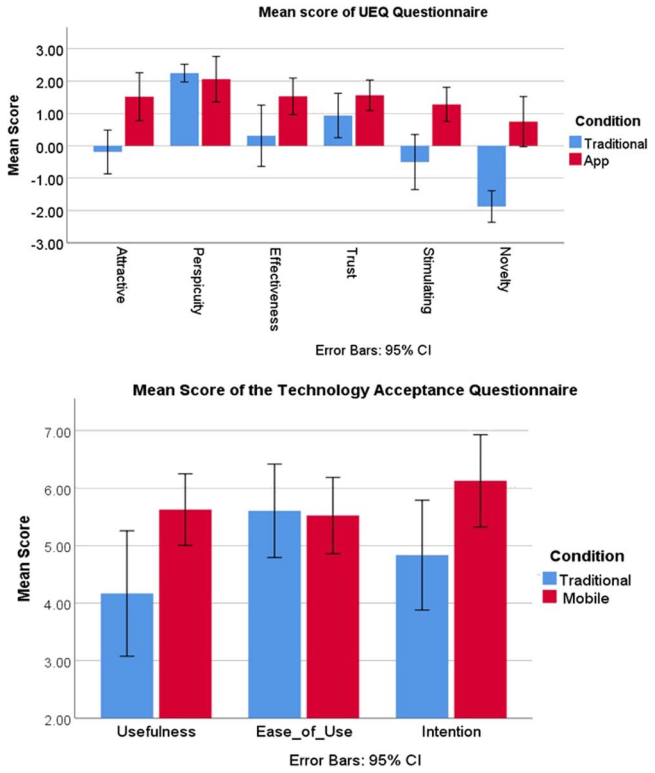



**FIGURE 4.** Mean score for the User Experience Questionnaire (top) and the Technology Acceptance Model (bottom) for participants in the preliminary study

the traditional approach versus the mobile application approach. Results showed that participants perceived the TGT intervention through the mobile application as significantly more **attractive** (mobile mean rank = 5 vs traditional mean rank = 1), $Z = -2.38$, $P < 0.05$, more **stimulating** (mobile mean rank = 4 vs traditional mean rank = 0), $Z = -2.384$, $P < 0.05$ and more **novel** (mobile mean rank = 4.5 vs traditional mean rank = 0), $Z = -2.52$, $P < 0.05$. For **Effectiveness** and **Trust**, paired *t*-tests showed that participants rated carrying out the TGT intervention through the mobile application as significantly more **effective** (mean = 1.53, sd = 0.67) than the traditional approach (mean = 0.31, sd = 1.13) ($t(7) = -2.698$, $P < 0.05$). However, there was not a significant difference in **Trust** between the two conditions. Figure 4 (top) shows the results of the user experience questionnaire for participants in the first study.

For intention to use, as the variable **Behavioral Intention to Use** was not normally distributed, Wilcoxon Signed Ranked tests were carried out to investigate whether there were significant differences with regards to how acceptive users were in carrying out the TGT exercise through the traditional approach in comparison to the mobile approach. The results showed that participants reported a **higher behavioral intention to carry out the exercise** through the mobile approach (mean rank = 3.5) in comparison to the traditional approach (mean rank = 0), $z = -2.20$, $P < 0.05$. For **Perceived usefulness** and **Perceived ease of use**, Paired *t*-tests showed that there was a borderline significance in **Perceived usefulness**, where participants felt that the mobile application (mean = 5.62, sd = 0.74) was **more useful** in carrying out the TGT exercise in comparison to the traditional approach (mean = 4.17, sd = 1.30) ($t(7) = -2.34$, $P = 0.052$). However, there was not a significant difference in perceived **ease of use** between the two conditions. Figure 4 (bottom) shows the results of the technology acceptance model questionnaire for participants in the first study.

# 6. MAIN STUDY: EVALUATING THE PHYSICAL BUTTON TGT INTERVENTION IN COMPARISON TO THE DIGITAL BUTTON TGT INTERVENTION

The main exploratory study used a within-participant design and was carried out to examine the effects on mental well-being, user experience and acceptance of a tangible user interface TGT intervention (physical happy button) in comparison to a digital user interface TGT intervention (digital happy button).

## 6.1. Study procedure

The main study was conducted using the same procedure as the preliminary study. A key difference was that instead of participants carrying out the TGT exercise using Google forms and the Mobile Happy Click Application, participants instead carried out the TGT exercise using the digital and physical button versions of the Happy Click Application (See Section 3.4). More specifically, participants were divided into two groups, after which participants in the first group first carried out the TGT exercise using the digital button version of the Tangible Happy Click Application and afterwards carried out the TGT exercise using the physical button version of the Tangible Happy Click Application. For the second group, this order was reversed. Similar to the preliminary study, each TGT exercise carried out using the Digital and Physical Happy Click Application lasted for one week and a one-week rest period was provided in between the two conditions to lessen the learning effects. Pre–post measurements of metrics related to the mental well-being of participants (perceived happiness, stress and depression) were taken during each TGT exercise and after each exercise, participants were also asked to evaluate their user experience and acceptance of the system.

## 6.2. Participants

Similar to the preliminary study, participants were recruited from a private university in Japan from a Bachelor and Master university student population. Fifteen participants completed the main experiment (16 started, of which 1 dropped out due to technical difficulties with the Flic2 smart button device). Fourteen of the participants were male and one was female. No prior participants from the preliminary study participated in the main study.

## 6.3. Evaluation measures

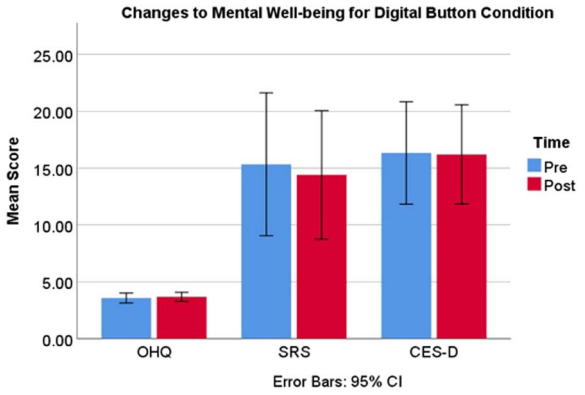
The same questionnaires used in the preliminary study were also used in the main study, namely the **Oxford Happiness Questionnaire** for perceived happiness, the **Stress response scale** for perceived stress, **the Center for Epidemiological Studies Depression Scale** for depression, the **User Experience Questionnaire** for user experience and the **Technology Acceptance Model Questionnaire** for perceived acceptance and motivation.

# 7. MAIN STUDY RESULTS

In the main study, we compared the differences in user experience, user acceptance and the effects on mental well-being between the TGT intervention that used the Tangible User Interface (Physical happy button) versus the TGT intervention that used the Digital User Interface (Digital happy button).

## 7.1. Pre–post effects on mental well-being

Paired *t* tests were carried out to investigate whether there were significant changes in mental well-being after participants had carried out the TGT intervention using the physical button and



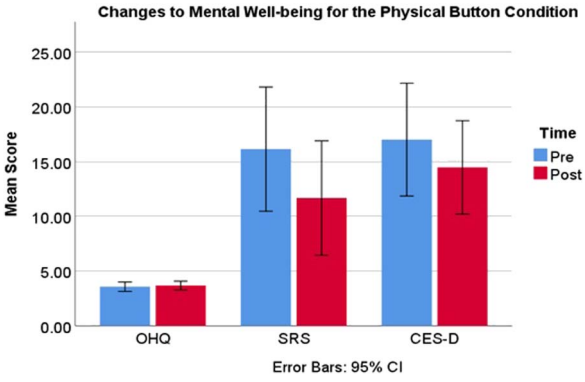
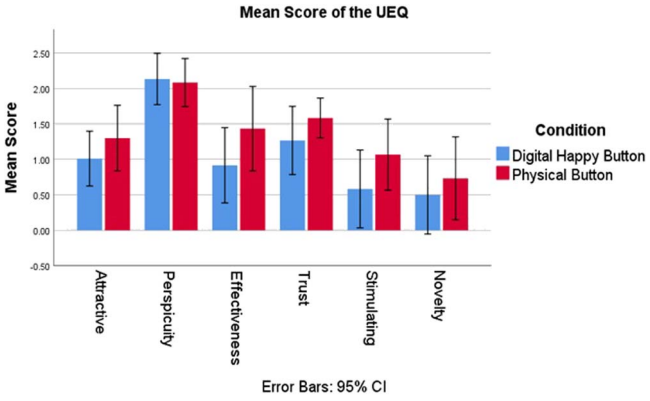




**FIGURE 5.** Changes to mental well-being for participants who (i) carried out the intervention using the digital button and (ii) the physical button in the main study



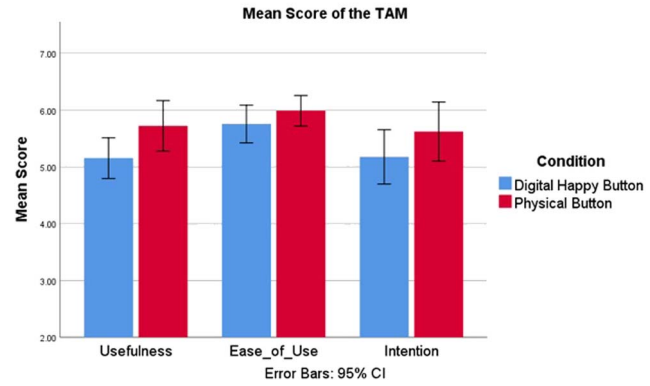




**FIGURE 6.** Mean score for the User Experience Questionnaire (top) and Technology Acceptance Model (bottom) for participants in the main study

the digital button. Results show that when carrying out the intervention using the physical button, there was a significant change in **Perceived Stress** ($t(14) = 3.175$, $P < 0.01$) and a borderline significant change in **Depression** ($P = 0.08$). More specifically, after the exercise, participants had significantly **reduced stress** (before: mean SRS score = 16.13, SD = 10.24, after: mean SRS score = 11.66, SD = 9.43) and **reduced depression** (before: mean CES-D score = 17.0, SD = 9.30, after: mean CES-D score = 14.46, SD = 7.69). However, there was no significant change in **perceived happiness**. When participants carried out the TGT intervention using the digital button, no significant change was found in either **happiness**, **stress** or **depression**. Figure 5 shows the changes in mental well-being after carrying out the intervention for participants in the main study.

### 7.2. Differences in user experience, intention to use and the effects on mental well-being between the physical and digital button TGT interventions.

To examine whether there was an effect of button type (physical vs digital) on changes in mental well-being, we carried 2 × 2 Mixed ANOVAs to evaluate pre–post differences in perceived happiness, stress and depression. Time was used as the within-participant factor in the test and the between-participant factor was the button type. While the results showed a significant main effect for Time **stress** ($F(1,28) = 8.05$, $P < 0.01$), there was not a significant Time × Button-type interaction between the three mental well-being measures.

To investigate whether there were significant differences in user experience between carrying out the TGT intervention using the digital button and physical button approach, paired $t$-test were conducted. The results showed that participants rated carrying out the TGT intervention using the physical button as significantly more **effective** (mean = 1.43, sd = 1.07) than the digital button (mean = 0.92, sd = 0.50) ($t(14) = 3.507$, $P < 0.01$). In addition, they also reported carrying out the intervention using the physical button as significantly more **stimulating** (mean = 1.06, sd = 0.90) than the digital button (mean = 0.58, sd = 0.99) ($t(14) = 2.41$, $P < 0.05$). However, there was not a significant difference in **Attractiveness**, **Perspicuity**, **Trust** and **Novelty** between the two conditions. Figure 6 (top) shows the results of the user experience questionnaire in the main study.

Paired $t$-tests were also carried out to investigate whether there were significant differences in regard to how acceptive users were to conducting the TGT exercise by using the physical button in comparison to the digital button. The results showed that participants reported a **higher behavioral intention to carry out the exercise** by using the physical button (mean = 5.62, sd = 0.94) than the digital button (mean = 5.17, sd = 0.86) ($t(14) = 2.81$, $P < 0.05$). Similarly, there was a significant difference in **Perceived usefulness** when participants carried out the TGT intervention using the physical button (mean = 5.72, sd = 0.80) versus the digital button (mean = 5.16, sd = 0.65) ($t(14) = 2.70$, $P < 0.05$). Finally, there was a borderline significant difference in **Ease of Use** for participants carrying out the TGT intervention using the physical button (mean = 5.99, sd = 0.48) in comparison to the digital button (mean = 5.76, sd = 0.60) ($P = 0.059$). Figure 6 (bottom) shows the results of the technology acceptance model questionnaire.

## 8. DISCUSSION

*RQ1) Would the TGT intervention, when designed around the happy click concept using a mobile interface, be effective in improving mental*

*well-being and how would such an intervention compare to a traditional TGT intervention in terms of user experience and intention to use?*

Similar to previous studies, the results from our study showed that the TGT exercise, in its traditional form was able to significantly reduce stress and depression (Bolier *et al.*, 2013; Proyer *et al.*, 2014; Seligman *et al.*, 2005; Sin and Lyubomirsky, 2009). However, we observed mixed results when the TGT exercise was implemented through a mobile-based interface, as there was a significant reduction of depression for the mobile TGT exercise used in the first study, but not in the second. We suspect that this could be due to how, in the first application, the digital Happy Click button was displayed more prominently and was programmed to show feedback in the form of a smiley face with a congratulatory message when pressed (as seen in Fig. 1), while in the second study, only a small 'plus' button was shown to participants at the bottom of the screen (as seen in Fig. 2) and did not include any prominent feedback. This can have made it easier for users to record their 'good things' event (participants reported higher effectiveness when using the mobile app for the TGT exercise in the first study (mean = 1.53) than the second (mean = 0.92)) and the feedback design might have resulted in a higher sense of satisfaction after recording the events (participants reported high levels of stimulation in the first application (mean = 1.28) than in the second (mean = 0.58)). Previous studies support this notion that individuals tend to have empathy to feel other people's emotions, hence the happy face feedback might have inadvertently contributed to users improving their mood (Caruso and Mayer, 1998; Ma *et al.*, 2016). Regarding happiness, our results also showed that the TGT exercise did not improve perceived happiness in both the traditional and mobile TGT conditions. We suspect that this was caused by the time-period of the exercise, which may have been too short to have a strong enough effect on perceived happiness. As Richardson and Sheffield found in their 5-day intervention study, a TGT intervention can result in no effect in improving mental well-being due to a short intervention period (Richardson and Sheffield, 2019).

In regard to user experience and intention to use, our preliminary study did show that when the TGT was carried out using the traditional approach, the underlying experience reported by users was quite low, with perceived stimulation, novelty and attractiveness falling below the 25 percentile compared to a standard benchmark (Schrepp *et al.*, 2017), thus replicating the results of earlier studies that showed how tedious the exercise activity could be (Frein and Ponsler, 2014). The experience of users was significantly improved with the happy click design, when a virtual button was used to facilitate the self-reporting process of the 'Good things event', with participants reporting significantly higher levels of Attractiveness, Novelty, Effectiveness, Stimulation and Behavioral intention to use in comparison to the traditional TGT exercise. These results helped confirmed some of the qualitative findings from the design sessions, highlighting how adding a simple mechanism that allows users to instantaneously self-report positive moments as they experience them during the day and then encouraging them to recall and reflect upon the recorded moments later at night did indeed help enhance both the effectiveness and user engagement of the process used in the TGT exercise.

*RQ2) Would the TGT intervention designed around a tangible user interface be effective in improving factors related to mental well-being and how would such an intervention compare to a TGT intervention designed around a mobile user interface?*

Our results showed that when a tangible user interface (e.g. a physical button) was used to implement our proposed happy click concept, there was a significant reduction in perceived stress and borderline significance reduction in depression, indicating that despite the introduction of an external modality to facilitate the self-reporting process, the positive psychology exercise had remained relatively effective. However, the use of a tangible artifact to facilitate the TGT exercise did not improve the mental health outcome to a significant degree beyond the virtual counterpart. One possible explanation could be that the mental well-being effects from the TGT exercise could be more dependent on the meaningful and in-depth reflection of positive moments in daily life rather than on the amount or comprehensiveness of the memories (Bahník *et al.*, 2015).

Therefore, while the use of the physical button might have enhanced the engagement of the self-reporting process and created more awareness toward different positive moments, as participants reported higher levels of stimulation, effectiveness and perceived usefulness, it might have also prompted users to record more happy moments which might have not been as salient or meaningful. The results from the design session gives several hints on how this could be addressed to further improve then mental health effect of our concept, for example, by adding mechanisms that allow users to report on the intensity of the positive moments encountered (so they become more aware/selective of which moments are meaningful to them) or adding mechanisms which improve the reflection process of those positive moments (e.g. during reflection, allowing users to categorize moments based on the different types of gratitude (intrapersonal, present happenings etc.) or group them based on who or what they felt thankful for in each instance) or providing an easy to understand visual summary for users, for instance, in the form of a bubble chart.

*RQ3) Would the use of a tangible user interface to implement a TGT intervention based on the happy click design improve user experience and intention to use when compared to a mobile based interface?*

Overall, the results from our main study show that the experiences of users were significantly improved when a physical button was used to facilitate the self-reporting process in comparison to a virtual button in a mobile based interface. Participants carrying out the TGT exercise using the physical button reported significantly higher levels of effectiveness, stimulation (which were above average in comparison to the standard benchmark (Schrepp *et al.*, 2017)) as well as behavioral intention to use and perceived usefulness in comparison to when a virtual button was used. From the design sessions, we could perhaps speculate that the physical satisfaction from pressing a button to record the happy moments could have led to the increased stimulation and the awareness from seeing the button attached to their wristband in daily life and the accessibility of being able to press it instantly could have led to the increased perception of effectiveness in the TGT exercise experience.

This notion has also been supported by previous studies examining the use of tangible user interfaces, which have argued how tactile experiences could often influence the emotional state of users (e.g. helping increase positive engagement and decreasing negative emotions). The act of pressing a physical button offers immediate tangible feedback which could amplify the sense of interaction and engagement with the task, thus providing a form of positive engagement and increasing stimulation (Ferrario *et al.*, 2017). In addition, the sense of security and comfort associated with the physicality of the button (which is less pronounced in a virtual button) could reinforce the user's perception of agency and control with their experience and serve as a stable and reassuring anchor to their interactions (Dourish, 2001; Ferrario *et al.*, 2017),

potentially leading to a more positive emotional experience. Several studies have also demonstrated a direct link between tactile experiences and emotional response (Suk et al., 2009), showing how tactile experiences can enrich the overall user experience by making interactions more enjoyable, memorable and emotionally satisfying and thus decreasing negative emotions (Bong et al., 2018; Ishii, 2008). Overall, this reduction of negative affect and the enhancement of positive experiences from the tactile experiences could perhaps explain why users reported being more inclined to use the system.

While more detailed studies are needed to confirm whether these particular elements in our design led to such improvements, as a whole the findings do provide preliminary evidence for the potential value of tangible interaction in enhancing mental health interventions, thus helping address the calls raised in earlier studies for more research of this nature to be carried out (Woodward et al., 2020). Similar to earlier studies, the results from our study highlighted how a tangible, portable and easy to use device could enhance the user experience and satisfaction for self-reporting tasks (Adams et al., 2018; Sarzotti, 2018); however, we also extend the results from these earlier studies by providing empirical evidence as to the benefits of a tangible interface over their virtual counterpart. A clinical review paper published by Torous et al. (2018) highlighted how critical treatment engagement was in psychotherapy and our results suggested that interactive technologies such as the tangible interfaces could be used to facilitate a more meaningful and responsive interaction with end-users, and thus such technology could have great potential in addressing this challenge.

As a whole, the findings from our study contribute to existing research by highlighting how mobile and tangible interaction technology can enhance the experience of users of positive psychology exercises such as the TGT. In line with previous research (Desmet and Sääksjärvi, 2016), we found that the design of an intervention has a significant impact on user experience and overall effectiveness. We indicated how such technology could potentially help address one of the key issues commonly encountered in previous research when such exercises are put into practice, namely, the lack of engagement toward the exercise activity (Piskioulis et al., 2021; Rippstein-Leuenberger et al., 2017; Sexton and Adair, 2019). In a wider context, our results also highlight an approach in which tangible user interfaces could be potentially useful when translating psychological interventions into self-administered m-health systems, given that such a process requires more than superficially replicating the 'activity' but designing a key mechanism to encourage patients/users to persist in that activity. While previous studies have focused mainly on the use of passive sensing technologies to alleviate the burden of users by automatically recording their emotions or psychological states (Lind et al., 2018; Piskioulis et al., 2021; Tzafilkou et al., 2022), our study proposes an alternative approach in which the process of self-monitoring could be made more enjoyable through the use of a tangible interface. If such a self-monitoring approach is later shown to be consistently valid, the implications of the system which we developed could move beyond the domain of positive psychology and could be useful for instance, as a means of collecting large scale data for human behavior research.

## 9. CONCLUSION

In this study, we designed, developed and tested Happy Click, a mobile application that aims to enhance the experience of users as they carry out the Three Good Things positive psychology exercise. The application made use of a tangible user interface in the form of a physically present smart button that enables users to more easily record 'good things' moments as they encounter them in their daily life. We conducted two experiment studies to examine the feasibility of carrying out the TGT exercise through such an approach. The first was a preliminary study that investigated whether the TGT exercise would still be effective if implemented through a mobile application based on our current design and whether this would lead to an improved user experience in comparison to the traditional approach. The second study investigated whether using the tangible user interface (a physical button to record 'Good Things' events) would further enhance the user experience when compared to a traditional mobile interface (an in-app button to record the events).

The results showed that the TGT exercise was effective in reducing stress when it was implemented through a tangible user interface. However, we did not find the effects on mental well-being to be superior when implementing the TGT exercise through a mobile application in comparison to a traditional approach or when implementing the exercise through a tangible interface in comparison to a digital one. In terms of user experience and user acceptance, participants reported carrying out the TGT exercise through the mobile system to be significantly more attractive, stimulating, novel and effective compared to the traditional approach as well as a higher intention to use the system. Using a physical button also resulted in higher levels of effectiveness, stimulation, perceived usefulness and intention to use in comparison to using a digital button.

Several limitations should be noted for this study. First, the experiments were carried out with participants recruited from a university student population, which implies that it is unclear to what degree the results can be generalized to other population groups. In addition, we should also note that there was an imbalance in terms of gender among our participants which was the result of the convenient sampling approach used to recruit participants in our studies. While previous studies which had sought to explore the mental health effects of the Three-good-things exercise did not explicitly examine gender differences (Seligman et al., 2005; Sekizawa and Yoshitake, 2015; Sexton and Adair, 2019), and so far there have yet been studies reporting the impact of gender on this particular exercise, previous studies have also argued that gender could influence the effectiveness of positive psychology interventions in general (e.g. females are suspected to have a higher person-activity fit toward exercises centered around expressing gratitude (Thompson et al., 2015)) and that gender could influence context sensitivity surrounding the perception and regulation of different emotional experiences (Goubet and Chrysikou, 2019) as well as the preference and acceptance for tangible user interfaces (Zuckerman and Gal-Oz, 2013). As such, the findings observed in this study could be influenced by gender dynamics not yet fully captured and warrant further investigation. It is also important to note that the decrease in depression score does not guarantee that our approach will be effective in treating individuals with serious mental disorders such as Major Depressive Disorders. In addition, as we only examined the immediate after-effects which the digitalized TGT interventions had on mental well-being, follow up measurements (1 month and 3 months follow up etc.) would be required for a more robust evaluation of the proposed systems. Finally, due to the costs of the modified smart buttons, our studies had a relatively small sample size. Despite

employing statistical tests that were appropriate for small and non-normally distributed groups in our analysis, the inherent constraints of a small sample size naturally limits the statistical power of the tests and prevents us from exploring in detail the nuanced relationships between the various variables. Additionally, the smaller sample size increases the likelihood of bias and could lead to less representative results, thus restricting our ability to generalize the findings to the broader population. Moreover, our decision to not correct for multiple comparisons, which was made after careful consideration of the need to balance between Type I and Type II errors in lieu of the limited sample size and the preliminary nature of our research, introduces additional limitations by increasing the risk of false positives. As such, the results presented in this study would need to be interpreted cautiously and further verified in larger and more definite studies. Despite such limitations, we believe that the results from our study serve as a preliminary investigation to provide useful insights into the feasibility of using mobile and tangible interaction technology to enhance positive psychology interventions.

In our future work, we plan to further validate the initial results from this study and improve the generalizability of our findings by conducting large-scale experiment studies with a more diverse population group and across different usage scenarios. More specifically, we plan to investigate whether the use of a tangible user interface based TGT exercise can improve mental well-being and resilience for people in the workplace and those suffering from chronic illnesses. In particular, we plan to adapt and implement the system to support (i) people in stressful occupations such as social workers or caregivers, (ii) general office staff (e.g. Human Resources and Accounting) at a public company and (iii) patients in long term treatment for conditions such as diabetes and cancer to investigate whether such mobile mediated interventions can be helpful in reducing stress and increasing baseline mental well-being. Design sessions would be carried out with the target audience in each group and the mobile application and tangible devices would be further refined to better suit their use context. For example, early sessions carried out with office workers and caregivers had indicated that the location-based keywords which are indicative of nearby places where the happy moment occurred (e.g. cafe or 'park') were of less interest to such users who were often stationary while working. Participants were more interested in predefined categories of happiness as keywords (e.g. 'interpersonal relationship' or 'food and drinks') and as such, we aim to redesign the application to incorporate visual representations (bubble charts etc.) which makes it easier for participants to reflect on moments of happiness through these categories. In addition, we would also experiment with different types of tangible interfaces that might be better suited to serve as a 'physical happy button' in a workplace context (e.g. wearable badge, a customized bobblehead etc.). Through the experiments, we hope to provide a more comprehensive large-scale evaluation of our approach and enhance the generalizability of our findings.

## FUNDING

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## STATEMENTS AND DECLARATIONS

On behalf of all authors, the corresponding author states that there is no conflict of interest or competing interests.

## DATA AVAILABILITY

The data that supports the findings of this study are available upon reasonable request from the corresponding author.

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# APPENDIX

## Appendix A: Technology Acceptance Model Questionnaire

Please rate to what extent do you agree with each of the following questions.

Note: The Three good things exercise will be referred to as the TGT exercise.

1. Using this system for the TGT exercise enables me to accomplish tasks faster than other methods.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
2. Using this system will improve the performance of TGT exercises.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
3. Using this system will the increase productivity for the TGT exercises.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
4. Using this system will enhance the effectiveness of the TGT exercise.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
5. Using this system makes it easier to do the TGT exercise.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
6. I found this system useful for carrying out the TGT exercise
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
7. Learning how to operate this system was easy for me.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
8. I found it easy to get the system to do what I want it to do
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
9. My interactions with this system has been clear and understandable
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
10. I found this system to be flexible to interact with.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
11. It was easy for me to become skillful at using this system.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
12. I found this system easy to use.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
13. I think it is a good idea to use this system.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
14. Using this system would be beneficial to me.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.
15. I have a positive impression of using this system.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree.