SnapAppy: A Positive Psychology Intervention using Smartphone Photography to Improve Emotional Well-Being

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Abstract

Momentary photography is enjoyed by many smartphone users, especially with the popularity of apps such as Snapchat and Instagram. Many traditional positive psychology interventions focus on lengthy writing tasks to express positive emotions experienced during past events, acts of kindness and gratuitous situations. In this work we developed SnapAppy, a smartphone application to integrate momentary photography with traditional intervention methodologies to conduct a month-long positive psychology intervention to improve emotional well-being. A study involving 74 participants aimed to assess whether photo-taking, photo viewing and image contents are correlated with improvements in certain aspects of the participant's emotional well-being including their mood, affect and satisfaction with life. The results indicated that features including the number of photos, the variety of categories, the effort applied to annotating photos, the number of photos revisited and photos taken of people were positively correlated with an improvement in the participant's mood and positive and negative affect (PANAS).

Keywords: smartphone photography, positive psychology intervention, mental well-being, mood, emotion, affect, gratitude, kindness

1. Introduction

Mental health problems are one of the main causes of disease burden worldwide [1], with depression, in particular, as the second leading cause of global disability [2]. Considering the impact that mental well-being can have in society and the relatively high cost of offering appropriate support, significant effort is being made by the research community to explore new techniques for diagnosis, progress tracking and intervention to improve mental well-being. In this work, we investigate the feasibility of using smartphone photography as an intervention that can help improve the emotional well-being of individuals, specifically their mood, affect and satisfaction with life.

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Traditional psychological interventions involve a range of techniques and practical tasks that can influence the general mood and overall well-being of a person. A common way of helping individuals improve their daily mood and satisfaction with life involves interventions where participants express their experiences and emotions through writing tasks [3]. Keeping a log of positive events and expressions of kindness and reflecting on happy memories are common techniques that have shown positive results in improving overall mood and feelings of happiness. Motivated by these techniques, we aimed to explore the effect of using smartphone photography as a method for capturing happy memories and positive events in the daily lives of participants, and enabling the review and reflection of such events through photos.

With the wide use of smartphone devices, photography has become a prominent activity for many users. The popularity of photo sharing applications like Instagram and Snapchat has created a wide community of primarily younger smartphone users where smartphone photography is a common daily hobby. In this work our motivation is to leverage the familiarity of these user groups with smartphone photography. Specifically, we developed a smartphone application called SnapAppy to motivate users to take photos of positive events in their daily lives. Through this smartphone app, users can annotate, review and reflect on the photos they take. We consider the task of taking and reviewing photos as a translation of the traditional writing exercises that are applied in typical psychological interventions. Considering that, with the proliferation of technology, daily writing tasks are becoming less common for typical users, our objective is to explore a more familiar method for such positive psychology interventions. Familiarity with the particular technology can lead to higher adoption and retention of participants.

Our primary aim in this study was to investigate potential relations between the use of smartphone photography as a positive psychology intervention and the psychological state of participants. Significant challenges in our approach involved our aim to shape the design of the SnapAppy application as a translation of traditional well-being interventions. An additional challenge was our goal to ensure the collection of unbiased datasets about user activity and their emotional state, whilst minimising the potential burden for the participants.

Working closely with cognitive psychologists, we deployed the application across a group of 74 participants who used the app for an average of 35.3 days. As part of the study, participants submitted daily mood reports and regular surveys of affect and satisfaction with life. Furthermore, the app was instrumented to allow us to collect detailed activity logs of how the users interacted with the app on a daily basis. Through the analysis of the collected datasets, we identified correlations between the activities that the participants performed within the app (e.g. taking and reviewing photos) and the captured change in their psychological state. Moreover, an analysis on the contents of the photos showed that particular combinations of photo content seem to have a more positive effect on the change of the participants' mood and affect.

The primary contributions of this work are:

- To the best of our knowledge this is the first longitudinal study that aims to discover how specific interaction patterns in the context of smartphone photography are related to changes in mood, affect and satisfaction with life.

- Through this study we have identified that specific interaction patterns such as photo-taking frequency, photo annotation length, photo reviewing frequency and photos containing people are positively correlated with improved mood and affective state.

We believe that our results contribute to the better understanding of the link between spon-

taneous smartphone photography and psychological well-being and demonstrate the potential of exploring momentary photography as a positive psychology intervention.

2. Related Work

Many traditional interventions for improving emotional well-being rely on the participants expressing their experiences and emotions through writing tasks. The therapeutic effects on mental health by writing about emotional experiences has been documented in Pennebaker's 1997 paper in which participants were instructed to write down their thoughts and feelings about an influential, emotional issue experienced during their lives [3]. The paper discusses the positive effects of disclosure, especially when done so in an anonymised fashion. Another such task involves focusing on and writing about intensely **positive** experiences, expressing as much detail about the feelings, thoughts and emotions that were experienced during that moment [4]. A different intervention type involved group **reminiscence** sessions in elderly nursing homes producing a significant increase in life satisfaction by recollecting positive experiences such as holidays, school, marriage and family. News articles, music and old photos were used to stimulate topics of conversation [5]. A study in Japan found correlations between kindness and subjective happiness with the happier participants showing a higher desire to be kind and a higher aptitude for recognising kindness. They additionally reported a significant increase in happiness after counting their own acts of **kindness** [6]. In another study, participants were required to log things that they were **grateful** for. The results displayed a significant increase in how the participants rated their lives, in addition to improved optimism and increased joy and happiness in response to being grateful about receiving aid [7]. Gratuity was the focus of another writing study where participants were instructed to think about a time when they were grateful for something that someone did for them and write a letter to that person about that experience and how it affected them [8]. A relatively less common but interesting positive intervention task involves the participant thinking about and discussing a positive thing or event in their life that might have never occurred had something in the past happened differently. In these interventions participants are invited to consider events that they may think were caused by "**destiny**" or "fate". A paper by Koo et al. asked participants to write about such surprising events and compared them with participants who wrote about unsurprising events and found that those in the surprising condition reported more positive feelings [9]. In our work we consider these findings as core influences that drive our exploration of smartphone photography and its link to emotional well-being. Indeed, photography is an alternative method of capturing memories and revisiting them at a later stage. In designing our study, we attempt to translate these traditional techniques into a smartphone photo-taking intervention and investigate its effects.

There has been limited research into using photos for therapeutic purposes. Common techniques involve using photography either as assessment tools [10, 11] or as part of counselling. Phototherapy (not to be confused with the physical treatment involving exposure to light) is used in counselling to enhance the therapy process by using photos by, or of, the patient as a way to evoke memories and feelings [12]. Reflecting upon photographs can also be a method to recognise and document development during an intervention [13]. In these approaches, photos are used as artefacts that can enhance the counselling process, performed by an expert. However, an interesting question is the extent to which photo-taking and photo viewing on their own are related to changes in affective state.

So far there has been very limited work exploring how the *act* of photography can affect well-being. A study by Isaacs et al. [14] focuses on "technology mediated reflection", where a

smartphone app is used to promote reflection on different events that are happening in the users' lives. In addition to writing thoughts, the app also allows the capture of photos. A small scale study with 10 participants and a "before-after" analysis, demonstrated an increase in subjective happiness, well-being, satisfaction with life and attentiveness due to the process of reflection. However, there was no attempt to analyse the effects of photography specifically. A study by Kurtz [15] focuses on smartphone photography more explicitly. It follows a tightly prescribed photo-taking methodology, where participants were asked to take a single photo on certain days, themed around "campus architecture", "your friends" or "your natural environment". An analysis of the "before-after" effects of the intervention showed links to better mood, appreciation and motivation measures. Similarly, studies by Chen et al [16, 17] follow a prescribed photo-taking methodology, asking participants to either take a smiling selfie, a photo that makes them happy, or a photo that would make others happy, once a day. Analysis of the "before-after" effects showed significant increase in valence for all conditions. Both of these lines of work suffer from two major limitations. Firstly, the highly prescribed methodology does not allow the investigation of a photo-taking behaviour that is more inline with the typical spontaneous photo-taking activity of smartphone users, where frequency of photos and photo themes can vary significantly across different days. In the context of emotional well-being, even the motivation to take one or more photos on a specific day can be related to the emotional state of the user, for example. Secondly, the analysis in these studies explored the overall effect of the intervention, focusing primarily on the "before-after" effects. However, such results do not allow us to understand the links between emotional well-being and spontaneous smartphone photography as it is used in a realistic setting, where the patterns of interaction can change significantly over a shorter period of time.

The use of photo sharing applications such as Snapchat, Instagram and Facebook and their effects on mental health have been the subject of many research papers. However, the focus is usually on negative social comparison and the use of the communication or social feedback features rather than the impact of the photo-taking itself. On Instagram, research has observed social feedback such as photo comments [10], social comparison with followed strangers [18, 19] and increased posting of false self-presentation photos [19] having associations with depression. Photo sharing is also a common instigator of negative social comparison and jealousy leading to negative mood [20, 21]. Snapchat, on the other hand, is more commonly associated with positive mood, tending to be described as a more humorous and playful platform [22, 23]. Studies have shown that interactions in Snapchat, usually performed via back-and-forth sharing of photos with captions, were considered to be associated with a more positive mood in comparison with texting, email and Facebook [24]. Unlike these studies, we will be focusing on using photo-taking on a private platform, thus eliminating some of the negative impacts that arise from social networks and photo sharing.

3. Motivation

Frequent, spontaneous smartphone photography is a popular activity for most smartphone users. Photography in general is a form of memory augmentation as well as a way of expressing a person's feelings and attitudes. Drawing similarities with the practice of personal diaries, we consider that smartphone photography can play a similar role when presented as a form of intervention to help improve a person's emotional well-being. In this work we aim to translate the techniques applied in positive psychology interventions, where the participants are required to use writing in order to record and recollect positive events in their lives. As one of the first attempts

to explore the practice of smartphone photography as a potential positive psychology intervention, our primary aim is to see if there is indeed an association between the practice of smartphone photography and changes in mood and affect. Our primary objective is twofold: firstly, to explore if smartphone photography is correlated with positive changes in mood, affect and satisfaction with life and, secondly, whether there are particular aspects of photographic activities (i.e. photo-taking frequency, contents of photos) that demonstrate a correlation with the effectiveness of the intervention.

Specifically, in the context of a smartphone photography positive psychology intervention, we attempt to address the following research questions:

- *RQ1: Do smartphone photography activities correlate with changes in mood, affect and satisfaction with life?*
- *RQ2: Which specific smartphone photography activities show statistically significant correlations with change in mood, affect and satisfaction with life?*

In attempting to answer these questions we conducted a study involving a smartphone application called SnapAppy that was developed to facilitate a photo-taking intervention associated with changes in daily mood and regular changes in affect and satisfaction with life. In designing our study, we aimed to avoid any strict prescriptions of behaviour for our participants (e.g. take a photo of each category) in order to capture behaviours that are closer to a realistic usage pattern. Following a study involving 74 participants for a period of a month, we explored detailed activity logs to identify possible correlations between reported psychological states and the participants' behaviour.

4. Methodology

A user study was conducted between summer 2017 and spring 2018 which was approved by the University of Kent ethics committee. A key component of this study was a smartphone application that was purposely designed to allow us to explore the effects of smartphone photography as a form of positive psychology intervention. The literature regarding traditional and digital psychological assessment, experience sampling, existing positive psychology interventions and intervention efficacy was closely followed when designing this study. This ensured that the best methodology and intervention practices were followed and the limitations were understood.

4.1. The Application

A smartphone application called SnapAppy was developed for Android and iOS smartphones using Apache Cordova [25]. The main functionality of the app was to support photo-taking and annotation and the reviewing of those photos. To allow the app to function as a form of positive psychology intervention, additional features were added allowing participants to categorise photos into different types of positive moments or actions that the photos may represent.

The implementation of the mobile app followed a typical software development cycle including multiple rounds of user testing before the app was deployed for the study. A focus group of nine users/testers was recruited to evaluate the app in terms of functionality, design and user experience, and to help identify potential bugs. The feedback from this user testing cycle was crucial in order to ensure the app was reliable and instructions were clear and easy to understand for the study participants.

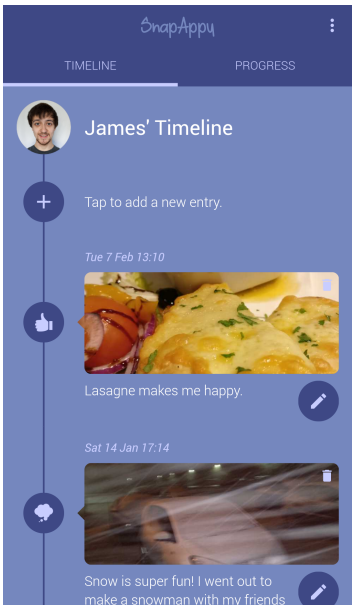

Figure 1: Entry photos, categories and descriptions can be viewed on the timeline screen.

Figure 2: When taking a photo for a new entry, it must be assigned to a category corresponding to its type of positivity.

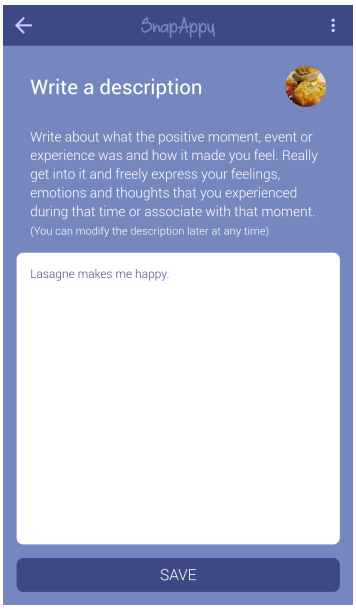

Figure 3: After assigning the photo to a category, one can write a description describing how the event made them feel.

In designing the app, we tried to limit the introduction of features that may potentially influence the results of the study. In particular, we made a conscious decision to avoid introducing advanced features that have the potential to enhance the experience of the users interacting with SnapAppy, such as showing motivational messaging or employing gamification and virtual rewards. This was to ensure that any effects we may have observed during the study were not influenced by these additional features.

In general, the app offers the following main functions:

4.1.1. Photo-Taking and Annotation

Participants could use the app to take photos using the smartphone camera or upload a photo from the device. For each photo the participant could assign a category that corresponded to the type of positive situation the photo represented (Figure 2). These categories helped to guide the participant, providing inspiration for adding a variety of photos into the app. The category definitions were displayed when selecting a category to ensure each participant had a consistent understanding, as shown in Figure 2. The possible categories that participants could assign to their photos were based on the types of activities used in traditional psychological interventions as discussed in Section 2. They are broadly split into two groups: categories that describe specific scenarios that are typically advised in note-taking/journal-based interventions as motivation scenarios to trigger positive thoughts. Categories that are broad in their definition that can be used by the participant if there are situations that don't fit any of the specific scenarios. Specifically, the categories provided were:

- Broad categories
  - Positivity: A positive moment, event or experience that is happening right now. [3, 4]

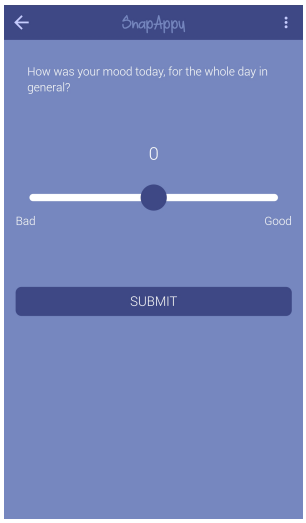

Figure 4: Mood is reported using a 7-point Likert slider ranging from -3 (bad) to +3 (good).

Figure 5: The survey screen showing one affective state and the various answers from the PANAS survey.

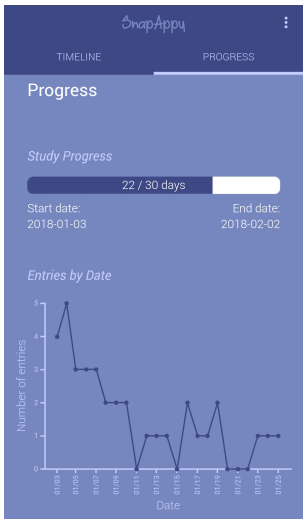

Figure 6: This screen shows the participant's progress through the study and the number of entries per day.

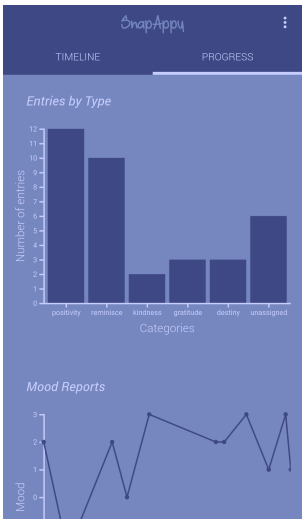

Figure 7: The progress screen also shows the number of entries per category and the participant's mood reports.

  - Reminisce: A positive moment, event or experience that happened in the past. [5]

- Specific scenarios
  - Kindness: An act of kindness, performed by yourself or someone else, or that you have received. [6]
  - Gratitude: An entity that you are grateful or thankful for (e.g. family, friend, pet, job). [7, 8]
  - Destiny: A positive moment, event or experience that might never have occurred if something in the past had happened differently (e.g. never meeting a particular friend if a particular job wasn't taken). [9]

For each photo, participants had the option to write a description about what the positive moment, event or experience was and how it made them feel. Participants were encouraged to freely express their feelings, emotions and thoughts that they experienced during that time or associated with that moment (Figure 3).

Participants were asked to take at least one photo per day. This encouragement was inline with the advice given in traditional, writing-based psychological interventions (see Section 2). Indeed, in traditional interventions, daily engagement is considered important to motivate participants to engage regularly with positive thoughts [3, 6, 8]. No other photos were captured outside those taken with, or uploaded to, the app.

Immediately after logging in, the participants were familiarised with the study through the use of multiple onboarding screens explaining what was required of them. These screens were also accessible at any time during the study via the "Help" button within the menu.

4.1.2. Photo Timeline and Review

The main entry screen of the app is a timeline containing the photos the participant has taken (Figure 1). The participant was free to scroll through their timeline at any time to revisit entries that they had previously logged. Tapping on an entry's photo would maximise it to be viewed fullscreen. Photo reviewing also allowed participants to change both the category assigned to that photo and the text description.

4.1.3. Psychological Surveys

In addition to logging daily entries, participants were notified to log their mood at the end of each day. Due to the difference in everyone's circadian rhythm, the time of the notification was not fixed. Instead, the default was set to 10pm and we offered the choice to change it between 8pm and midnight, which allowed the participants to choose an appropriate time according to their sleep schedule. This level of freedom will not be appropriate for all study designs and may, in some cases, introduce an extra variable into the analysis. However, in our case, it ensured that emotional events occurring late in the day were incorporated into the daily mood reports. Participants were asked "How was your mood today, for the whole day in general?" and could respond on a 7-point Likert scale with clearly marked extremes: -3 (Bad) to +3 (Good) [26] (Figure 4).

Furthermore, in order to capture more longer-term effects of the intervention, the app invited participants to submit formal surveys approximately every 10 days. We incorporated commonly used measures to assess the psychological state of participants before, during and after the intervention. Specifically, we chose the Positive and Negative Affect Schedule (PANAS) [27] and the Satisfaction with Life Scale (SWLS) [28] to be most appropriate for this study. Both metrics offer objective, normalised values about the psychological state of each participant and are favoured by traditional psychological studies instead of more subjective assessment methods such as self efficacy and the perceived effectiveness of an intervention. These two metrics are the most commonly used measures in both Sin and Lyubomirsky's meta-analysis of positive psychology interventions [29] (where 43% and 24% of the studies use PANAS and SWLS respectively) and our own literature review. The PANAS comprises two affect scales, one that measures positive affect and the other that measures negative affect. The positive and negative scales consist of ten emotionally descriptive words such as "excited", "scared" and "inspired". The extent to which the participant feels each word must be responded to using a 5-point Likert scale ranging from "extremely" to "very slightly/not at all" resulting in scores ranging between 10–50. For the positive scale a higher value indicates a more positive affect; for the negative scale a higher value indicates a more negative affect. The SWLS metric consists of five statements to which the participant must respond on a 7-point Likert scale ranging from "strongly agree" to "strongly disagree". The answers produce a single value between 5–35 where a higher value demonstrates a higher satisfaction with life. PANAS and SWLS were also chosen for their relatively quick completion times as the in-the-wild nature of this study would not have been conducive for longer surveys. Furthermore, using shorter surveys meant that we could conduct psychological assessments *during* the study, rather than merely pre-test and post-test as was common in past literature. Therefore every 10 days during the study, participants were notified to complete PANAS and SWLS surveys (Figure 5). From herein we will refer to these collectively as "surveys". On day 0 they also provided information about any other strategies or practices for influencing mental health in which they were participating. The participants were not screened for pre-existing mental health conditions and no major real-world events were recorded that may have caused an emotional effect on the whole population of participants.

PROTOCOL SUMMARY	
Duration	Participants were asked to participate for at least 30 days.
Daily	Participants were expected to take a photo, assign a category and optionally write a description for it, at least once per day.
Daily	Participants were notified to log their mood at the end of each day.
Every 10 days	Participants were notified to submit formal surveys every 10 days (PANAS & SWLS).
Allowances	Throughout the study participants could: • Take more than one photo per day. • Freely review their photo entries on their timeline. • Continue using SnapAppy beyond the 30 days.

Table 1: Summary of the study protocol highlighting the key tasks that participants were expected to perform.

A summary of the key tasks that participants were expected to perform during the study can be found in Table 1.

4.1.4. Retention and User Engagement

Although not strictly part of the main intervention, the app was instrumented with a few screens that allowed participants to observe their level of participation in the study. A "Progress" screen in the app allowed users to track their start and end dates for the study and view graphs showing information about entries, categories and mood reports (Figure 6). The inclusion of these screens was motivated by prior work on motivating learning through summative feedback (i.e. "knowledge of performance") which has been shown to improve the participants' engagement [30]. In particular, the bar graph comparing the number of entries belonging to each category was designed to encourage the participants to experiment with the different entry categories [31, 32] (Figure 7).

Finally, the app was instrumented with a detailed logging system that captured all interactions within the app. This included every "tap" and "scroll" gesture the participants performed, the time they spent performing specific actions, the amount of text they entered, all the photos they took and how many times they revisited them. All gesture datasets were timestamped and then linked to specific photos or screens. This allowed us to extract information such as the number of times they reviewed their timeline, which photo they tapped to view, when a photo description was changed, how long they spent viewing a particular screen (e.g. when editing a description), etc. These data logs ultimately formed the feature set described in Figure 2 and were examined during the analysis.

4.2. Recruitment & Exclusion Criteria

Recruitment was aimed at smartphone users who could read and write in English. The study was advertised publicly on social media platforms including mental health related Facebook groups and Subreddits and also within the University of Kent via forums and well-being events. The advertisement campaign invited participants to download the smartphone app from the App/Play

Store onto their personal smartphone. Enrolment in the study was performed through the smartphone app. Every participant was compensated with course credits if they were a student or entry into a prize draw of £50 which was funded by the University of Kent.

The recruitment campaign resulted in 201 people who downloaded the app and 87 people who started the study (by taking at least one photo, completing the first survey period and logging at least one mood report). Each participant was expected to engage with the study for a minimum of one month; however, they were encouraged to continue using the application if they so desired. Participants were asked to log at least one entry (photo) per day about a positive moment, event or experience. In addition to logging daily entries, participants were notified to log the two different types of psychological ground truth outlined in Section 4.1.3. Figure 8 shows the initial 87 participants who remained engaged across the duration of the study. We can observe the dropout rate for the study, where 86% of participants remained at day 20 and 51% remained at day 30 at the end of the study. This distribution may suggest a "sweet spot" around 20 days for this type of intervention study, perhaps due to participant burden or fatigue which can often be experienced with longitudinal studies. 33 participants continued using the application beyond the 30 days of the study and only 6 participants engaged for less than half of the required duration. Due to the "in-the-wild" distribution of the app, users will often install an app out of curiosity rather than having a genuine intention to participate in the study, which could explain some of the early drop-outs from the study. Despite this, it is clear that some participants continued to partake in this intervention past the duration that was initially required of them.

After the completion of the study, the cohort of participants were further assessed in terms of the quality of the submitted data. In order to be able to analyse the collected datasets it was necessary for each participant to have submitted sufficient ground truth data. A set of exclusion criteria were used to remove participants who did not submit enough data. Participants or survey periods were excluded from the analysis using the following criteria:

- Participants who only completed 1 or 2 surveys.
- Participants who reported <7 daily mood reports in total (approx. $\frac{1}{4}$ of the 30 day study duration).
- Participants who reported exactly the same mood every day (straightlining).
- Periods which were <5 or >20 days between surveys (this occurred when participants missed a survey or due to an error).
- Days where no mood was reported.

The resulting dataset included a total of 74 participants who were aged between 18-52 and 63 were female. The average age was 21 alluding to the fact that this form of intervention may be more popular for younger users who are more adept with the use of smartphones and spontaneous smartphone photography. The shape of the distribution of participants over time remains similar before and after the exclusion criteria (Figure 8).

5. Descriptive Statistics

The average duration of participation was 35.3 days. During that time a total of 2,178 photos were taken, with an average of 29.4 photos per participant across the study (per day: $min =$

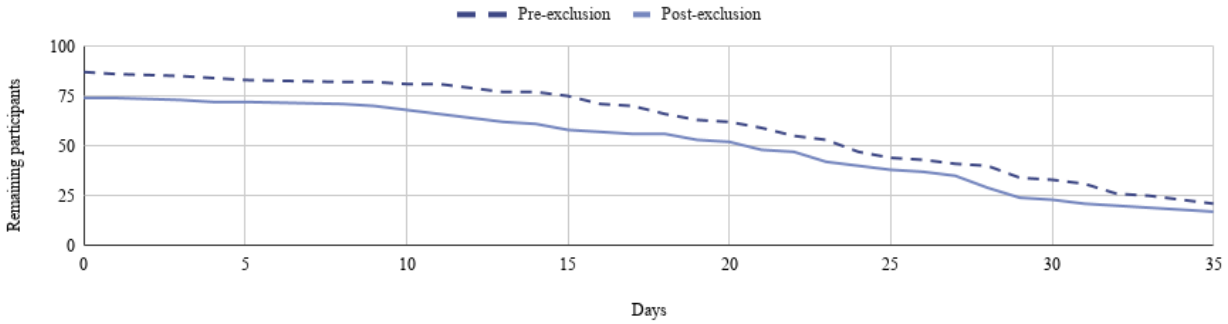

Figure 8: Distribution of participants over time, before and after the exclusion criteria.

0, $M = 0.83$, $max = 8$). 52% of the photos were assigned to the positivity category, 16% were reminisce, 13% gratitude, 7% kindness, 4% destiny and 8% remained unassigned. Descriptions had an average length of 93.3 characters ($min = 0$, $Mdn = 57$, $max = 973$) (approx. 18 words), participants spent a median of 32.7 seconds writing them and 190 photos had no descriptions. On average, participants revisited their old photos 1.1 times per day with a range of 0–32 times. Participants logged a total of 2,535 mood reports with an average of 34.3 per participant and 240 surveys with an average of 3.2 per participant. These results show significant variation in the levels of engagement across our participants. This variation enabled us to explore how different levels of engagement may demonstrate potentially different associations with mood or affect as reported by the participants.

The distribution of mood reported by all participants during the study is shown in Figure 9. The majority of moods reported were >0 ($M = 1.18$) indicating that participants reported to be feeling positive more often than negative. SWLS scores range from 5–35 and the distribution shows that the scores have an average of 22 which is within the average range (20–24) for this metric. PANAS scores are calculated separately for positive and negative affect and scores range from 10–50. The distribution of positive PANAS scores are relatively spread, with an average of 26 which is slightly lower than the mean score of 31.3 found by Crawford and Henry [33] who reported average scores for the general adult population. The negative PANAS scores have an average of 19 which is slightly higher than the mean score of 16. These scores demonstrate that the participants overall followed a similar distribution of affect that can be expected by the general population. The relatively lower than average scores for the positive PANAS could indicate a possible selection bias for our participants where people with lower positive affect might be more interested in joining a positive psychology intervention. However, as our objective is to discover the possible relation that a photo-taking intervention may have on their affective state, we need to explore whether their level of engagement with the intervention is related to their change of psychological state during the study.

6. Inferential Statistics

In our analysis, we attempt to address the main research questions by analysing the datasets collected during the study. Our main approach is to explore how the participants' activities using the smartphone application may be related with the observed changes in their daily mood and affective state throughout the study.

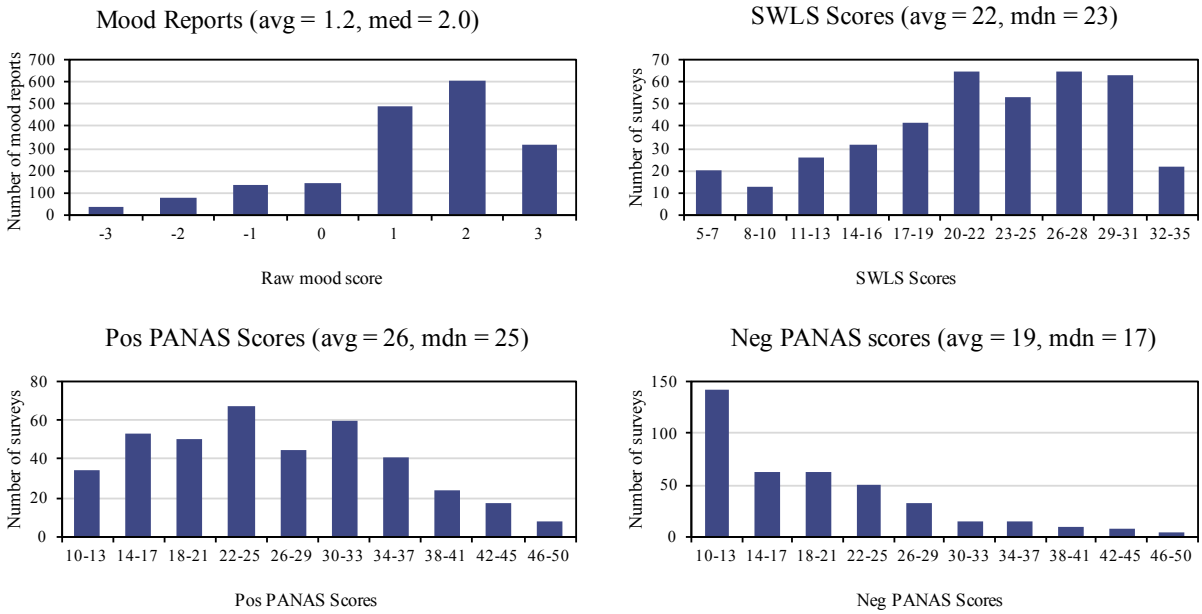

Figure 9: Distribution of mood reports, SWLS and PANAS scores.

6.1. Before–After Analysis

We began our analysis by looking at the overall effect of the intervention, attempting to see if there was a common pattern of change across the whole cohort. Ignoring any details about what the participants did during the study, we tried to see if the overall state of the participants changed after their participation by using the formal surveys that they completed at the beginning and end of the study. Specifically, this was the change between the very first and very last survey they completed. To explore if there was a statistically significant change, we performed a Wilcoxon signed-rank test on the survey scores. With respect to the PANAS results, the test showed that simply participating in the study did not lead to a significant difference in the positive PANAS scores (before $Mdn = 25$, after $Mdn = 24$, $r = .032$, $p = .609$, $Z = .512$, where Z is the z-score). Similarly, no significant change was found for the negative PANAS scores (before $Mdn = 19$, after $Mdn = 18$, $r = -.011$, $p = .855$, $Z = -.183$). When analysing the SWLS results, we did find a statistically significant change in the participants' satisfaction with life scores, with a 10% median increase out of the maximum range of scores (before $Mdn = 20$, after $Mdn = 23$, $r = .192$, $p = .002$, $Z = 3.078$). Additionally, the box plots in Figure 10 show the raw scores for positive PANAS, negative PANAS and SWLS across the duration of the study. Although the average survey results showed improvements over time, we may observe a slight plateau of the average PANAS scores between days 20 and 30. As previously mentioned in Section 4.2, this appears to approximately align with the data in Figure 8 and may suggest a "sweet spot" for this type of intervention, perhaps due to participant burden, fatigue or dropouts which can often be experienced with longitudinal studies. There were also a significant range of scores across the intervention. This demonstrates that simply joining the study would not necessarily lead to a clear improvement in the participants' positive and negative affect or satisfaction with life. However, these results gave us the opportunity to investigate differences in behaviours between our participants and identify particular patterns that could potentially lead to a better or worse psychological state.

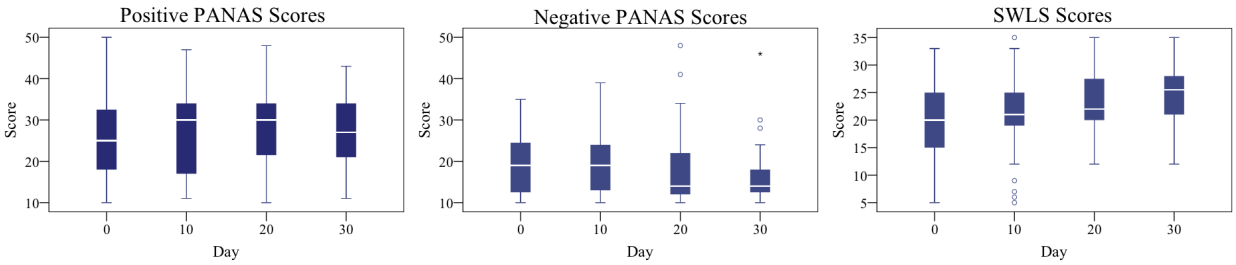

Figure 10: The raw positive PANAS, negative PANAS and SWLS scores across the duration of the study.

6.2. Analysis per Survey Period

In our study we had two different types of ground truth. Participants were required to complete surveys every 10 days during the study, which allowed us to see significant changes within such periods. Moreover, participants submitted short daily mood reports, which gave us an indication of how mood changed on a daily basis. The regular survey reports formed a natural split over our dataset into periods where we can study changes across a number of days. Although the app notified participants every 10 days to submit a survey, participants did not always submit their surveys when they were notified, thus participants who submitted too few surveys were ignored. Following the exclusion criteria discussed in Section 4.2, we were left with a total of 134 periods across 53 participants (out of the total 74 participants who completed the study). Each participant generated an average of ∼3 periods of data (encompassed by 4 submitted surveys) and the average period duration was 10.9 days (SD = 2.7).

In our analysis we tried to explore how the engagement of the participants with the smartphone application could be related to the changes of psychological state during each period. Using the logs generated by the application we extracted a number of features that represent how users engaged with the application. These included the number of photos taken per day, how often they scrolled on their timeline or viewed particular photos in full screen, and the sentiment score of the photo descriptions. Table 2 describes the full list of extracted features.

With respect to the ground truth, the psychological features were extracted by calculating the change in positive PANAS scores (ΔP_{pos}), negative PANAS scores (ΔP_{neg}) and SWLS scores (ΔS) between the survey responses encompassing the period. Mood reports were standardised within participants using z-score so that the value represents the deviation from the participant's average mood across the whole study:

$$z_{it} = \frac{x_{it} - \mu_i}{\sigma_i} \tag{1}$$

Where x_{it} is the mood reported by the participant i on date t, μ_i and σ_i are the average and standard deviation of mood for that participant over the duration of the study. The average standardised mood $\bar{M}_i$ of a participant i was then calculated for each period by summing the standardised mood for each day during that period and dividing by the number of days.

6.2.1. Results

We explored potential correlations using Pearson's correlation coefficient (r_p) between each feature and our ground truth for the 134 periods. The results are shown in Table 3. In the cases where we observed statistically significant correlation ($p < 0.05$), the result is highlighted in bold.

FEATURE	DESCRIPTION
Photos taken	Average number of photo entries per day.
Photo entry consistency	The spread (low standard deviation) of photo entry counts across the days during the period.
Category spread	The spread (low standard deviation) of photo entries across the five categories.
Avg. desc. length	Average character length of the photo descriptions.
Avg. desc. duration	Average number of seconds spent writing the descriptions.
Desc. edits	Average number of times the descriptions were edited per day.
Avg. desc. positivity	Average sentiment score of the entry descriptions calculated using LIWC [34]. *(No. of positive words - No. of negative words) / All affect words*
Photos viewed	Average number of times photos are tapped on to be viewed fullscreen per day.
Timeline explored	Average number of times the user scrolls up or down the timeline (where the scroll length is more than the height of three entries and with an interval of >10 seconds) per day.

Table 2: Description of features.

SURVEY →	ΔP_{pos}		ΔP_{neg}		ΔS		$\bar{M}$	
FEATURE ↓	r_p	p-value	r_p	p-value	r_p	p-value	r_p	p-value
Photos taken	0.0083	0.9240	-0.1128	0.1943	0.0070	0.9359	**0.2418**	**0.0049**
Photo entry consistency	0.0868	0.3184	**-0.1698**	**0.0499**	0.0292	0.7388	0.1619	0.0617
Category spread	-0.0699	0.4220	-0.0848	0.3300	0.0327	0.7090	**0.2353**	**0.0062**
Avg. desc. length	**0.2063**	**0.0168**	-0.0023	0.9786	0.0480	0.5832	0.1005	0.2481
Avg. desc. duration	0.0669	0.4424	-0.1305	0.1327	0.1165	0.1816	0.1199	0.1675
Desc. edits	0.1089	0.2105	-0.1462	0.0918	0.0352	0.6878	0.1481	0.0876
Avg. desc. positivity	-0.0638	0.4926	0.0006	0.9948	-0.0368	0.6937	0.0959	0.3016
Photos viewed	-0.0032	0.9704	**-0.1770**	**0.0408**	0.0723	0.4082	**0.2048**	**0.0176**
Timeline explored	-0.0570	0.5129	-0.1630	0.0598	0.0032	0.9712	0.1075	0.2162

Table 3: Correlation results of survey features. Where r_p is the Pearson correlation coefficient and $p < 0.05$ are marked in **bold**.

We observe that the *average description length* has a positive and significant correlation with ΔP_{pos} showing that there is a relationship between the length of the entry descriptions and an improvement in positive affect. These correlations fall in line with past literature which describes that the more effort the participant puts into the intervention, the more effect it has [8].

ΔP_{neg} shows a significant, negative correlation with *photo entry consistency*. Past literature has shown that a consistent, distributed use of an intervention is key to its success [35] which reflects this correlation. The number of *photos viewed* is also negatively correlated with ΔP_{neg} showing that revisiting old photos is related to a lower negative affect. The correlation with *timeline explored* is also close to $p < 0.05$ which is logical considering reviewing old photos requires scrolling through the timeline.

ΔS does not show any significant correlations with any of the features. This could be due to the fact that SWLS is a more long-term assessment of the participant's state, thus attempting to observe changes over shorter periods is not appropriate. This result also suggests that the

FEATURE	r_s	p-value
Photos taken	**0.0832**	**0.0004**
Category spread	**0.0903**	**0.0001**
Avg. desc. length	**0.0696**	**0.0031**
Avg. desc. duration	**0.0516**	**0.0282**
Avg. desc. positivity	**0.0780**	**0.0146**
Photos viewed	0.0460	0.0505
Timeline explored	-0.0111	0.6359

Table 4: Correlation results of daily mood features. Where r_s is the Spearman correlation coefficient and $p < 0.05$ are marked in **bold**.

significant improvements in SWLS found from the Wilcoxon signed-rank test (Section 6.1) may not be related to the way participants engaged with the intervention.

$\bar{M}$ shows significant, positive correlations with *photos taken*, *category spread* and *viewing photos* demonstrating that taking more positive photos, varying the categories in which they belong and viewing more old photos are associated with positive mood. Additionally, a more extended study could reveal a possible correlation with *photo entry consistency* as it is close to $p < 0.05$.

From these results we can conclude that the consistent usage of, and engagement with, this photo-taking and annotation intervention is closely related with a positive change of the participant's psychological state. We can also conclude that the act of revisiting photographic content that participants generated to document positive events is significantly related with positive mood and affective change.

6.3. Analysis per Day

The mood reports submitted by participants allowed us to explore potential correlations between the engagement of participants within the app and their daily mood. Participants were required to report their mood once at the end of each day and were cleaned using the mood-related exclusion criteria in Section 4.2. The reported mood values were standardised using z-score.

Following cleaning, the dataset consisted of 1812 individual days of mood reports across 70 participants (out of the 74 who completed the study). Our aim was to explore correlations between daily mood and the participant's activities. For each day we extracted features which represented the participant's activity within the application for that day. The features that were extracted are similar to those calculated for the survey period analysis, but in this case they were calculated per day.

6.3.1. Results

We used Spearman's correlation coefficient (r_s) to calculate the relationship between the mood reports and each feature. Spearman was chosen to minimise the effects of the outliers present in some of the data. The results are shown in Table 4.

The *photos taken* and *category spread* features display weak but significant correlations with mood, showing that logging more entries per day and spreading the categories in which they belong are correlated with a more positive mood. A participant who logs more entries is displaying a higher engagement with the intervention which has been shown to improve the effectiveness of such interventions [8]. *Category spread* is a feature we wanted to explore after the work by

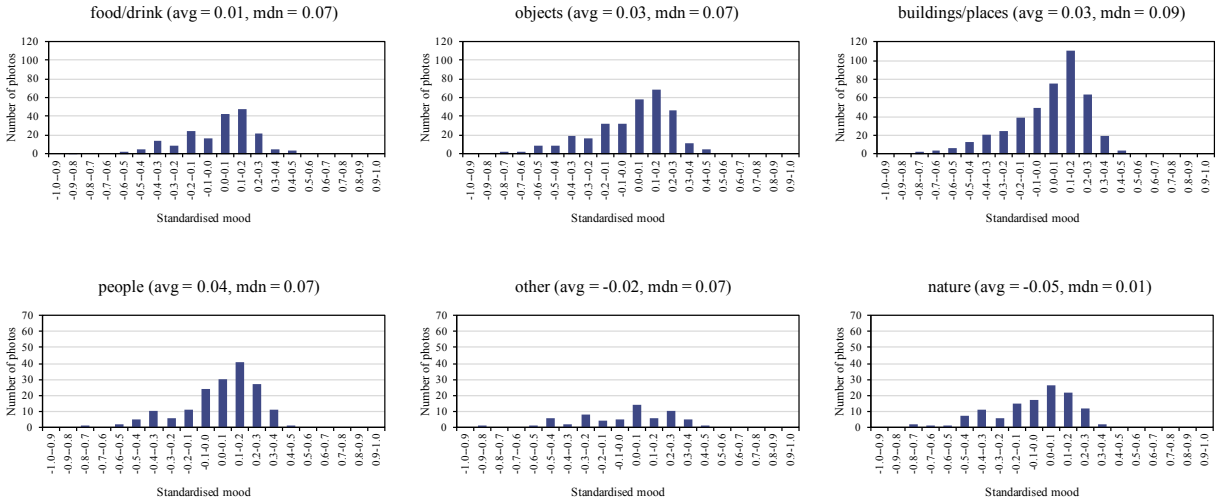

Figure 11: Distribution of photos by their associated standardised mood reports for each class group.

Parks et al. [31] discussed the positive impact of completing an assortment of tasks within a single intervention. *Description length*, *duration* and *positivity* show that the time and dedication one applies to the entry descriptions are also significantly correlated with mood. The *photos viewed* feature is also close to $p < 0.05$ and might show a significant correlation with more data considering that survey correlations with the same feature were found in Section 6.2. We can therefore conclude that taking more photos, engaging in a variety of different categories of positive experiences and writing longer and more positive descriptions are activities which are related to positive mood. Compared to the results from the survey periods, the correlation coefficients are relatively weaker. However, this is somewhat expected as the daily analysis considers short-term relationships within a single day. The sparsity of this type of daily engagement is also in line with the methodologies observed in traditional interventions [3, 4, 7] where participants are expected to engage with the intervention only once per day.

In our study we did not attempt to capture any external factors such as specific events that may influence the participant's emotional state. We acknowledge that certain important events can have an effect that can skew their emotional state in a specific direction irrespective of their engagement with this intervention. However, by analysing the participant's activities daily and within each period, we can also reduce the effects of external time or event influences such as holidays or exams for example. These external influences will factor into the participant's behaviours and emotional well-being each day and will be captured by their actions and surveys.

6.4. Image Analysis

During the study participants submitted 2178 photos with a range of content. As part of the analysis we wanted to explore if the type of content that participants generated is correlated with their change of psychological state. We utilised the IBM Watson's Visual Recognition deep learning service [36] to automatically extract information about the content of the photos. Watson extracted a range of descriptors about the content of each photo, including types of objects, number of faces and the dominant colour in each photo. Watson returned an array of classes, each with a score representing the service's confidence in the recognised class. Results could contain a class

hierarchy like "/drink/beverage/alcoholic beverage/liquor/whiskey" representing different levels of detail for the recognised content.

Following the retrieval of results from Watson, we further cleaned up the image recognition dataset. We extracted the class with the highest confidence score which generally resulted in the least specific class in the hierarchy being extracted ("drink" in the previous example). Classes with a confidence score below 70% were discarded.

Watson detected a total of 221 unique classes across our dataset, of which the top 10 most common included: food (11%), indoors (10%), person (7%), building (6%), machine (5%), electronic device (3%), animal (3%), nature (3%), people (2%) and plant (2%). 23% of the photos were not classified, either due to a score below the threshold or Watson being unable to determine the contents of the photo. After extracting the classes we were left with many which were too specific, therefore we manually re-categorised them into 6 distinct groups: buildings/places (26%), objects (19%), food/drink (12%), people (10%), nature (7%) and other (4%). The number of faces in each photo was also extracted, with 20% of photos containing a single face and 17% containing two or more faces.

Watson also extracted the dominant colour in each photo. 50 unique colour classes were extracted by choosing the colour with the highest confidence score in each photo. These were then grouped into standard colours: red (16%), green (15%), black (15%), grey (15%), brown (11%), blue (8%), yellow (4%), pink (3%), orange (3%), purple (3%), white (2%) and unclassified (5%).

Figures 12 through 15 display some examples of the variety of photos taken by participants (cropped to fit). The photo in Figure 12 was first classified by IBM Watson as a "building" (90% accuracy) of "gray color" (77% accuracy) which was then manually grouped into "buildings/places" and "grey". This entry was categorised by the participant as "gratitude" who wrote about "*feeling angry but that going to church and praying and crying brought them relief*". Figure 13 was first classified as "food" (96%) and "beige" (97%) which was then grouped into "food/drink" and "brown". This entry was also categorised as "gratitude" and described "*being grateful towards an acquaintance who bought them coffee and offered career advice*". Figure 14 was first classified as "nature" (87%) of "blue color" (99%) which was then grouped into "nature" and "blue". This participant was reminiscing about a prior holiday and aptly placed the entry into the "reminiscence" category. Lastly, Figure 15 was first classified as "keyboard" (79%) and "coal black" (97%) which was then grouped into "objects" and "black". The participant categorised this entry as "positivity" and wrote about "*finally playing their keyboard*".

First, we tried to see how the different classes and colours of content were related to the reported mood on the particular date they were captured. Each photo was annotated with the standardised mood ($range$ = -1–1) on that particular date. We then explored the distribution of mood reports for each class and colour of photo content (Figure 11). We can observe that for most classes and colours the distributions have averages close to 0 with negative skews. The distribution of photos classified as containing people shows a slightly more positive mood average of 0.04 ($Mdn = 0.07$) compared with the other classes, thus appearing to have a weak, positive relationship with mood.

Following these observations, we considered that the number of people present in a given photo could be a significant feature to explore. The correlations between the number of faces in the photos and the psychological changes over a survey period and the daily mood were calculated. Although the results from the survey period analysis did not show any significant correlations (Table 5), we did observe a weak but significant correlation between the number of faces appearing in photos and the daily mood reports. (Table 6).

Figure 12: A photo classified by IBM Watson as "buildings/places" and "grey".

Figure 13: A photo classified by IBM Watson as "food/drink" and "brown".

Figure 14: A photo classified by IBM Watson as "nature" and "blue".

Figure 15: A photo classified by IBM Watson as "object" and "black".

SURVEY →	ΔP_{pos}		ΔP_{neg}		ΔS		$\bar{M}$	
FEATURE ↓	r_p	p-value	r_p	p-value	r_p	p-value	r_p	p-value
Avg. no. of faces	-0.0075	0.9312	-0.0119	0.8919	0.0572	0.5133	0.0418	0.6317

Table 5: Correlation of # of faces over a survey period. Where r_p is the Pearson correlation coefficient.

FEATURE	r_s	p-value
Avg. no. of faces	**0.0684**	**0.0034**

Table 6: Correlation of # of faces with daily mood. Where r_s is the Spearman correlation coefficient.

7. Key Findings

Following the analysis of the intervention's datasets, we are in a position to answer the research questions outlined in Section 3.

RQ1: Do smartphone photography activities correlate with changes in mood, affect and satisfaction with life?

Based on the analysis of results we can see significant correlations between the level of engagement of participants with smartphone photography as a form of intervention and their positive change of affective state over ∼10 day periods and mood changes on a daily basis. Satisfaction with life is shown to have a general improvement across the study.

RQ2: Which specific smartphone photography activities show statistically significant correlations with change in mood, affect and satisfaction with life?

In our analysis we have identified a number of photo-taking activity patterns that are related to positive change in mood and affect. The length of photo annotations is associated with a positive change in PANAS scores. Frequent and consistent photo-taking over the duration of the study spread across multiple categories is significantly correlated with negative affect and positive mood. Reviewing past photos is related to a reduction in negative PANAS scores and positively correlated with reported mood. Finally, with respect to the photo content, the number of faces in the photos shows a weak, positive correlation with mood reports.

It is important to emphasise the significance and limitations of the "intervention bias" and "selection bias" that are commonly observed in such studies. These refer to the fact that the participants are aware that they are involved in a positive psychology intervention, and that those

who chose to participate may have done so because they experience negative emotional well-being and want to improve it. The intervention bias is a key aspect of most psychological interventions and in many cases it is a desirable effect that is part of the intervention mechanism itself. In most interventions, the desired effects can be achieved only when the participants are fully aware of the purpose of the intervention. We did not specifically study this phenomenon in this paper but it was incorporated into the study and app design. Regarding selection bias, our data showed that there was such effect in our study as well. The average PANAS scores when participants joined the study were slightly lower than the average scores for the general population. Our results show that for such individuals, engaging with smartphone photography as a form of positive psychological intervention can be associated with positive changes in their mood and affective state.

8. Discussion

Photo-taking and viewing has always played an emotional role in people's lives. Traditional photos and tangible photo albums were always objects with significant emotional effect, either as ways of capturing happy (or unhappy) memories or by invoking positive feelings when we revisit them. The proliferation of smartphone photography has offered new opportunities for people to easily capture a range of moments in their lives that would have been significantly more difficult in the past. However, the relative ease of smartphone photography has also enabled a more "relaxed" attitude towards photo-taking and reviewing. Users may take photos at a significantly higher rate than before with less consideration about the meaning or importance of the subject of the photos. This random nature of spontaneous smartphone photography can lead to a more disorganised photo-taking practice and possibly a lower rate of revisiting older photos mainly due to the significantly increased quantity.

Based on the findings of this study, we believe that there is an opportunity for amateur smartphone photography to play a more active role in people's affective state if applied in an appropriate manner. For smartphone photography to act as a positive intervention there is a need for a more disciplined and structured engagement with photo-taking. In this study, participants were expected to take photos that had a particular meaning which was directly related to their psychological state. Regular taking of such photos and reviewing is shown to be related to positive changes in mood and affect. Considering existing photo-taking systems, either stand-alone photo galleries, or social network integrated applications (e.g. Instagram or Facebook), the explicit indication of purpose related to mood or emotion would be key. The possible integration of "emotional purpose" annotation on photos (possibly related to the categories used in this study) can play that role. This technique would enable users to consider the emotional content of their photos and the role they play in helping them re-experience particular emotions. Furthermore, such explicit annotation can instil a more focused and engaged attitude towards emotionally meaningful photo-taking.

Regarding the reviewing of photos with potential emotional impact, there have already been examples developed by online services, such as Facebook's "Memories" feature (previously called "On This Day"), which prompts users to view their activity and posts from previous years. Such features can take the form of a more explicit intervention if they can be activated when the target user is in need of an emotional boost. As shown in the observations, lower PANAS scores were more prevalent suggesting a potential selection bias of participants who were more willing to engage with an intervention that could potentially improve their psychological state. Existing work has demonstrated techniques to passively detect changes in mood by analysing the user's online activity [26], which could then trigger appropriate photo viewing opportunities when mood

is low. It is worth noting that, although our results demonstrate significant correlations between certain smartphone photography activities and changes in daily mood, the sparsity of the relevant activities make it infeasible to use photo-taking and viewing as a way to passively detect daily mood changes.

Lastly, it is important to consider how the findings of this work could be applied in the context of a long-term intervention to help improve emotional well-being. In the design of the SnapAppy application we followed a minimalist approach, avoiding features that could potentially enhance the user experience in order to ensure the collection of unbiased data. Such features could include encouraging users to take more photos, showing motivational messaging, gamification and virtual rewards, and avoiding the participation in formal surveys like PANAS on a regular basis. Incorporating such features would improve user retention, and could lead to a system that can be used over long periods of time. Nevertheless, it is important to note that any psychological intervention is not applicable and acceptable by all participants. Different techniques, including traditional psychological interventions, are more suited for some people than others. We do not anticipate that smartphone photography-based interventions would be acceptable by everybody. For example, those who are not familiar with smartphone technology, those who are partaking in a digital detox, or those who dislike photography may not be well suited for this type of intervention. Our aim was to identify an additional form of intervention that might be more suitable for some people who are less inclined to follow existing, writing-based approaches, such as younger, tech-savvy smartphone users. We believe this work makes a strong case that it can be considered as a new intervention technique that would be appropriate for such user groups.

9. Conclusions

In this paper we report on the results of a positive psychology intervention based on smartphone photography as a method to improve mood and affect. Motivated by traditional psychological interventions, participants were encouraged to take photos about positive moments, events and experiences and revisit those photos using the SnapAppy app on their smartphone. We evaluated the effectiveness of the method through common psychological surveys including PANAS, SWLS and daily mood reports. Our results show that regular taking of positive photos, frequent reviewing of photos and taking pictures of people have positive correlations with the change of the participant's mood and affective state. We hope that the positive results of this study will motivate a wider exploration of smartphone photography as a potential instrument to improve people's emotional well-being.

10. Acknowledgements

The authors would like to thank James Rowe for the logo design, Boris Otkhmezuri, Chiara Lunerti, Jake Minns, Jon Baker, Jittrapol Intarasirisawat, Pruet Putjorn and Rina Mashimo for their valuable feedback during the user trial, the RPS team for their support during recruitment and all the SnapAppy participants.

References

[1] T. Vos, et al., Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the global burden of disease study 2013, The Lancet 386 (2015) 743–800.

[2] H. A. Whiteford, et al., Global burden of disease attributable to mental and substance use disorders: findings from the global burden of disease study 2010, The Lancet 382 (2013) 1575–1586.
[3] J. W. Pennebaker, Writing about emotional experiences as a therapeutic process, Psychological science 8 (3) (1997) 162–166.
[4] C. M. Burton, L. A. King, The health benefits of writing about intensely positive experiences, Journal of Research in personality 38 (2) (2004) 150–163.
[5] E. A. Cook, Effects of reminiscence on life satisfaction of elderly female nursing home residents, Health care for women international 19 (2) (1998) 109–118.
[6] K. Otake, S. Shimai, J. Tanaka-Matsumi, K. Otsui, B. L. Fredrickson, Happy people become happier through kindness: A counting kindnesses intervention, Journal of Happiness Studies 7 (3) (2006) 361–375.
[7] R. A. Emmons, M. E. McCullough, Counting blessings versus burdens: an experimental investigation of gratitude and subjective well-being in daily life., Journal of personality and social psychology 84 (2) (2003) 377.
[8] S. Lyubomirsky, R. Dickerhoof, J. K. Boehm, K. M. Sheldon, Becoming happier takes both a will and a proper way: an experimental longitudinal intervention to boost well-being., Emotion 11 (2) (2011) 391.
[9] M. Koo, S. B. Algoe, T. D. Wilson, D. T. Gilbert, It's a wonderful life: mentally subtracting positive events improves people's affective states, contrary to their affective forecasts., Journal of personality and social psychology 95 (5) (2008) 1217.
[10] A. G. Reece, C. M. Danforth, Instagram photos reveal predictive markers of depression, EPJ Data Science 6 (1) (2017) 15.
[11] N. Andalibi, P. Öztürk, A. Forte, Sensitive self-disclosures, responses, and social support on instagram: The case of #depression., in: CSCW, 2017, pp. 1485–1500.
[12] J. Weiser, Phototherapy techniques: Exploring the secrets of personal snapshots and family albums, PhotoTherapy Centre Vancouver, BC, 1999.
[13] M. M. Ginicola, C. Smith, J. Trzaska, Counseling through images: Using photography to guide the counseling process and achieve treatment goals, Journal of Creativity in Mental Health 7 (4) (2012) 310–329.
[14] E. Isaacs, A. Konrad, A. Walendowski, T. Lennig, V. Hollis, S. Whittaker, Echoes from the past: How technology mediated reflection improves well-being, in: Conference on Human Factors in Computing Systems, ACM, 2013, pp. 1071–1080.
[15] J. L. Kurtz, Seeing through new eyes: An experimental investigation of the benefits of photography, Journal of Basic & Applied Sciences 11 (2015) 354.
[16] Y. Chen, G. Mark, S. Ali, Promoting positive affect through smartphone photography, Psychology of well-being 6 (1) (2016) 8.
[17] Y. Chen, G. Mark, S. Ali, X. Ma, Unpacking happiness: Lessons from smartphone photography among college students, in: Healthcare Informatics (ICHI), 2017 IEEE International Conference on, IEEE, 2017, pp. 429–438.
[18] K. Lup, L. Trub, L. Rosenthal, Instagram #instasad?: exploring associations among instagram use, depressive symptoms, negative social comparison, and strangers followed, Cyberpsychology, Behavior, and Social Networking 18 (5) (2015) 247–252.
[19] E. Frison, S. Eggermont, Browsing, posting, and liking on instagram: The reciprocal relationships between different types of instagram use and adolescents' depressed mood, Cyberpsychology, Behavior, and Social Networking 20 (10) (2017) 603–609.
[20] J. Fardouly, L. R. Vartanian, Negative comparisons about one's appearance mediate the relationship between facebook usage and body image concerns, Body image 12 (2015) 82–88.
[21] S. Utz, N. Muscanell, C. Khalid, Snapchat elicits more jealousy than facebook: A comparison of snapchat and facebook use, Cyberpsychology, Behavior, and Social Networking 18 (3) (2015) 141–146.
[22] L. Piwek, A. Joinson, "what do they snapchat about?" patterns of use in time-limited instant messaging service, Computers in Human Behavior 54 (2016) 358–367.
[23] N. M. Punyanunt-Carter, J. De La Cruz, J. S. Wrench, Investigating the relationships among college students' satisfaction, addiction, needs, communication apprehension, motives, and uses & gratifications with snapchat, Computers in Human Behavior 75 (2017) 870–875.
[24] J. B. Bayer, N. B. Ellison, S. Y. Schoenebeck, E. B. Falk, Sharing the small moments: ephemeral social interaction on snapchat, Information, Communication & Society 19 (7) (2016) 956–977.
[25] Apache, Apache Cordova, `https://cordova.apache.org/`, accessed: 2018-01-29 (2018).
[26] J. A. Lee, C. Efstratiou, L. Bai, Osn mood tracking: exploring the use of online social network activity as an indicator of mood changes, in: Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct, ACM, 2016, pp. 1171–1179.
[27] D. Watson, L. A. Clark, A. Tellegen, Development and validation of brief measures of positive and negative

affect: the panas scales., Journal of personality and social psychology 54 (6) (1988) 1063.
[28] E. Diener, R. A. Emmons, R. J. Larsen, S. Griffin, The satisfaction with life scale, Journal of personality assessment 49 (1) (1985) 71–75.
[29] N. L. Sin, S. Lyubomirsky, Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: A practice-friendly meta-analysis, Journal of clinical psychology 65 (5) (2009) 467–487.
[30] S. Narciss, Feedback strategies for interactive learning tasks, Handbook of research on educational communications and technology 3 (2008) 125–144.
[31] A. C. Parks, M. D. Della Porta, R. S. Pierce, R. Zilca, S. Lyubomirsky, Pursuing happiness in everyday life: The characteristics and behaviors of online happiness seekers., Emotion 12 (6) (2012) 1222.
[32] T. Y. Lee, C. Dugan, W. Geyer, T. Ratchford, J. Rasmussen, N. S. Shami, S. Lupushor, Experiments on motivational feedback for crowdsourced workers, in: Seventh International AAAI Conference on Weblogs and Social Media, 2013, pp. 341–350.
[33] J. R. Crawford, J. D. Henry, The positive and negative affect schedule (panas): Construct validity, measurement properties and normative data in a large non-clinical sample, British journal of clinical psychology 43 (3) (2004) 245–265.
[34] LIWC, LIWC linguistic inquiry and word count, `http://www.liwc.net/`, accessed: 2018-01-12 (2018).
[35] S. Lyubomirsky, K. Layous, How do simple positive activities increase well-being?, Current Directions in Psychological Science 22 (1) (2013) 57–62.
[36] IBM, IBM Watson visual recognition, `https://www.ibm.com/watson/services/visual-recognition/`, accessed: 2018-01-12 (2018).